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Agency Problems and Endogenous Investment Fluctuations

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This article proposes a theory of investment fluctuations in which the source of the oscillating dynamics is an agency problem between financiers and entrepreneurs. In the model, investment decisions depend on entrepreneurs' initiative to select investment projects ex ante, and financiers' incentive to control entrepreneurs ex post. Too much control discourages entrepreneurial incentive to initiate new investment, whereas too little control jeopardizes its productivity. This initiative-control trade-off is capable of generating endogenous reversal of investment booms, induced by an ongoing deterioration of project profitability. Investment fluctuations may arise even though no external shocks hit the economy and agents are perfectly rational. (*JEL* E22, E30, E32, G14, G20)

Starting with the seminal contributions of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997), a large theoretical literature in macroeconomics has studied how agency problems in the credit market shape investment and output dynamics. At the heart of this literature is the inverse relationship between firms' financial assets and the agency costs of investment. In the presence of adverse selection or moral hazard problems, firms' borrowing capacity is constrained by the level of assets that can be pledged to outside lenders. An adverse shock that worsens financial conditions may therefore generate a negative spiral whereby low profits reduce borrowing capacity and hence investment, which further reduces profit, exacerbating the initial negative shock. This mechanism, known as the credit multiplier or the financial

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accelerator, has been extremely influential in explaining why temporary recessionary shocks may become persistent.[1]

A salient feature of models featuring a credit multiplier is that agency problems distort investment decisions in downturn but not in booms, precisely because agency costs are inversely related to firms' net worth, which is procyclical. While in recessions, investment is constrained by the firms' net worth, in booms improved balance sheet conditions mitigate the incidence of agency costs. In this class of models, boom times are always "good" times.

The purpose of this article is to propose a model in which agency problems in the credit market influence investment decisions not only in downturns but also in boom times. The key ingredient of the analysis is that incentive problems pervade both the borrowing and the lending sides. This two-sided incentive problem affects not only the size but also the quality of investment, and boom-and-bust cycles may arise even if the environment is not stochastic and agents are fully rational.

To formalize the idea that agency problems may be a source of endogenous investment fluctuations—and not just a source of propagation of exogenous shocks—I consider a model with the following structure. An entrepreneur borrows money from a competitive investor to start one of several investment projects that differ in terms of verifiable income and nonverifiable private benefits. The entrepreneur may receive nontransferable private benefits from managing a project, but these private benefits reduce the project's profitability. This generates a basic conflict of interest with the investor, since the entrepreneur would like to undertake projects with some private benefits, even if this comes at the expense of lower income. In contrast, the investor can only put her hands on the verifiable income and thus prefers to finance projects that maximize a project's income or minimize private benefits.

Before a project is proposed to the investor, the entrepreneur engages in a costly process of project evaluation. This evaluation enables him to understand the project's characteristics and pick the most preferred one. After the entrepreneur's proposal is made, the investor has the option to exercise control that gives her the right to influence the course of action before a project starts. Interference in the implementation of a project is value enhancing, because it forces the entrepreneur to give more weight to verifiable income and less weight to private benefits. Too much interference, however, comes at the cost of destroying private benefits which, in turn, reduces the entrepreneur's ex ante incentive to evaluate projects. Thus, although control guarantees that only high-income projects make their way, the expectation of too much control stifles the entrepreneur's initiative to propose projects.

The driving force of the analysis is that neither entrepreneurial effort nor investor control are contractible. Thus, the acquisition of information for both

[1] For recent surveys of this literature, see Bernanke, Gertler, and Gilchrist (1999), Tirole (2006, Ch. 13), and Gertler and Kiyotaki (2010).

parties is endogenous and affected by the relative costs and incentives. Under the assumption of perfect competition in the credit market, the investor's incentives to interfere in the entrepreneur's selection of projects depend on her desire to break even. Monitoring incentives are high if the investor's exposure in the entrepreneur's project is large and low if the investor's exposure is limited. When the entrepreneur has low wealth and must rely extensively on outside funds, the investor scrupulously controls the entrepreneur's selection of projects and endorses only projects that maximize verifiable income. By contrast, when the entrepreneur's net worth increases and needs to borrow less, the investor's incentives to engage in monitoring activity are weaker, since she needs to be compensated less for her investment. A wealthier entrepreneur, therefore, acquires independence from the investor and eventually undertakes projects with lower income but higher private benefits—as long as the value of these private benefits is higher than the residual share of income the entrepreneur can retain after repaying the investor.

If such a mechanism is embedded in a simple dynamic model with overlapping generations, interesting endogenous investment dynamics arise. During boom times, when entrepreneurs can supply a large fraction of the initial investment, investors' incentives to control project characteristics are weak. The undesired effect is that entrepreneurs can initiate those (low-productivity-high-private-benefit) projects that would hardly pass investors' approval in periods of "normal" control activity. Thus, at the peak of an economic boom, less productive projects are funded, paving the way for a subsequent downturn. The opposite effect occurs in "bad times" when ruthless income maximization by investors improves the average productivity of projects, promoting a new period of expansion. Tight investor control, however, reduces the prospect of enjoying private benefits and thus destroys entrepreneurs' ex ante incentives to evaluate new projects. As a result, only a few projects are proposed in downturns, but those undertaken are very profitable.

In the model, endogenous fluctuations take place when the cost of control for the investor is neither too high nor too low. Under this condition, the economy either 1) converges to its steady state in an oscillatory manner, or 2) never reaches the steady state and alternates between periods of boom and bust. Conversely, when the cost of control is too high, the economy monotonically converges to a stable steady state, featuring low investment; when the cost of control is too low, the economy reaches the level of investment that prevails in the absence of agency problems. The logic behind these results is the following. Costly monitoring means that borrowing is expensive and thus few projects are initiated, limiting the amount of capital that can be accumulated over time. As a result, entrepreneurs never become rich enough to "escape" investor control. Because control adversely affects entrepreneurs' initiative, the process of "controlled" investment features a stable dynamic with low investment. In contrast, when monitoring is not too costly, more resources remain in the hands of entrepreneurs. As their wealth increases, monitoring intensity falls and entrepreneurs get the option to finance projects with high private benefits but limited profitability, reducing the amount of productive capital available for the following period. However, if monitoring costs become sufficiently small, entrepreneurs keep a larger fraction of their projects' returns and this biases their projects' choice in favor of productivity.

The model I propose not only generates endogenous investment fluctuations but also captures salient features of investment dynamics and lending patterns. The model is, e.g., consistent with the evidence that banks' control is tighter for firms with weak balance sheets and that firms' performance improves with banks' control (see, e.g., Nini, Smith, and Sufi 2009; Gorton and Schmid 2000). The model is also consistent with evidence that bank lending standards are countercyclical and that lending to less productive borrowers increases in good times but decreases in bad times (see Asea and Blomberg 1998; Berger and Udell 2004; Lown and Morgan 2006; Zheng 2009). Finally, in the model, the procyclical nature of investment and its dependence on firms' internal funds is in line with the observation that firms' investments and firms' cash flows are positively correlated (see Hubbard 1998 for a survey).

The agency problem emphasized in this article has three main theoretical implications. First, and most importantly, it suggests that the very nature of the lending activity may generate boom-and-bust cycles, because entrepreneurs and investors' incentives vary in opposite directions over the cycle. Although entrepreneurs internalize more the costs and benefits of their choices when their net worth is high, improved balance sheets reduce investors' control, facilitating waste and misallocation of resources. In some instances, the second effect dominates, and booms are followed by an endogenous deterioration of project profitability. Symmetrically, when entrepreneurs hold a low stake in their projects, the moral hazard in project choice worsens, but investors' incentives to control entrepreneurial behavior improves, which guarantees that high-quality projects are financed during slumps. To the best of my knowledge, this duality of incentives in the lending relationship has not been pointed out by the existing literature, and stems from the assumption that lenders provide funds to firms and also influence the quality of the investment undertaken by limiting—through control—the project choice of entrepreneurs.

Second, the agency problem in this article suggests that increased firm internal finance may reduce, rather than increase, economic efficiency. This implication is in line with Jensen's (1986) theory of "free cash flows" but stands in contrast with a standard model of credit frictions in which more borrower net worth reduces agency costs and thus restores efficiency. In the story of this article, better balance sheets are not necessarily associated with more efficient allocation of resources, because lower investor control impairs project profitability. The symmetric argument—that during periods of low economic activity investors evaluate projects scrupulously, forcing entrepreneurs to shift to more efficient modes of production—is in line with the "pit-stop" view of recessions. According to this view, recessions encourage agents to engage in activities that contribute to future productivity (Aghion and Saint Paul 1998; Hall 2000). In my article, recessions are times when productivity-improving activities are undertaken due to the strengthened incentives of investors to finance only productive projects.

Third, the double moral hazard problem in this article suggests that agency costs may dampen, rather than amplify, exogenous shocks to the economy. This is another point of divergence from standard models based on the credit multiplier and occurs because a firm's net worth is inversely related to investor control, and investor control affects the quality of the investment. After a positive shock to firms' net worth, investors' control weakens and less profitable investments are financed, offsetting the initial positive shock to firms' net worth. A similar but opposite mechanism occurs after a negative shock. Whether the financial sector acts in dampening or amplifying exogenous shocks is still an open question in the theoretical and empirical literature (see, e.g., Kocherlakota 2000; Cordoba and Ripoll 2004; Cooley, Marimon, and Quadrini 2004; House 2006).

This is not the first article that relates agency problems in the credit market with instability and fluctuations. Important antecedents are Aghion, Banerjee, and Piketty (1999) and Matsuyama (2004, 2007). In Aghion, Banerjee, and Piketty, endogenous reversal of booms arises because in the presence of credit frictions, the equilibrium interest rate introduces a pecuniary externality that reduces firms' borrowing capacity in booms but enhances it in recessions. In my article, the interest rate is exogenous, and fluctuations arise because the incentives of investors and entrepreneurs vary asymmetrically over the cycle. In Matsuyama, investment cycles originate because credit constraints bias the flow of credit to projects with different demand spillover. My article is inspired by Matsuyama's emphasis on project heterogeneity, but it proposes a microfounded mechanism—based on entrepreneurial and investor's moral hazard—to generate trade-offs between projects' technologies and returns.[2]

The building block of the analysis that investor's control is value enhancing but stifles entrepreneurial initiative is related to the formal versus real authority analysis of Aghion and Tirole (1997), in which the control of a principal increases project value but is detrimental for the agents' incentives to propose new projects. Burkart, Gromb, and Panunzi (1997) use this trade-off to show that constraints on managers through control may lower firms' performance, because managerial discretion comes with benefits; Philippon (2006) uses

[2] Suarez and Sussman (1997), Azariadis and Smith (1997), and Siconolfi and Reichlin (2004) also study the role of credit market imperfections for endogenous fluctuations. In these models, however, borrowers' net worth plays no role. Martin (2010) and Figueroa and Leukhina (2010) obtain endogenous business cycles in a model with ex ante information asymmetry on entrepreneurs' productivity. In their models, however, investment and firms' net worth are negatively correlated, which is in disagreement with the empirical evidence. Thakor (1996), Ruckes (2004), Dell'Ariccia and Marquez (2006), and Gorton and He (2008) study lending activity and credit fluctuations, but not investment fluctuations. In these articles the screening activity of lenders and their strategic interaction endogenously affect the pool of borrowers. Rajan (1994) derives endogenous credit cycles in a model with managerial short-termism and benchmarking externality across banks.

the same idea to show that firms with little control over managers tend to overinvest in booms, amplifying aggregate shocks.

The rest of the article proceeds as follows. Section 1 presents the model, studies the main trade-off that arises in the investor-entrepreneur relationship, and fleshes out the main implications for investment dynamics. Section 2 embeds the static analysis in an overlapping generation model (OLG) in order to study under which conditions endogenous fluctuations emerge. Section 3 discusses the main testable implications of the model. Section 4 contains a discussion of the key assumptions of the model. Section 5 summarizes the article.

1. The Static Model

This section studies an agency problem between entrepreneurs and investors in a static setup and derives the main implications for investment cycles.

1.1 Technology, information structure, and payoffs

There are two groups of agents: entrepreneurs and investors. Each group consists of a continuum of homogeneous agents with unit mass. All agents are risk neutral and protected by limited liability. A representative entrepreneur has wealth endowment, w, that can be stored at the safe gross return, r, or used to finance an investment project of fixed size $1 > w$. To implement a project, the entrepreneur needs to borrow $1-w$ from an investor. It is assumed that the endowment of an investor is sufficiently large relative to the scale of a project, and investors behave competitively.

1.1.1 Investment projects. An entrepreneur has access to three noncontractible investment projects, denoted as A, B, and C. Each project is characterized by a verifiable income, Π, and nonverifiable private benefits, b, for the entrepreneur, as described in Table 1.

Although income and private benefits differ among projects, projects all look ex ante identical and therefore cannot be distinguished from each other without proper investigation. The entrepreneur learns about the projects' characteristics through a costly evaluation effort. Of the three projects, only A and B are "relevant," meaning that they yield nonnegative income and/or private benefits.

Table 1
Projects' payoffs

	A	B	C
Private benefits	0	b	$-\infty$
Income	Π	0	Π

The remaining project, C, entails a large negative payoff for the entrepreneur. This assumption implies that it is never optimal for the entrepreneur to forsake evaluation and randomly select a project.

Since project A generates only verifiable income and project B only nonverifiable private benefits, a conflict of interest over project's selection may emerge. Private benefits are not transferable and pertain to the entrepreneur only. Thus, if b is higher than the fraction of Π which the entrepreneur retains after repaying the investor, he prefers implementing project B rather than A. In contrast, the investor always prefers project A, because she can only appropriate verifiable income.[3] To make the analysis interesting, I assume that the payoffs associated with the different projects satisfy the following restriction.

Assumption 1. $\Pi > b \geq r$,
which guarantees that if the entrepreneur can self-finance the investment project, he prefers project A to B. This assumption also implies that project A is relatively more productive than B.

1.1.2 Information and control. Because projects' payoffs are ex ante unknown, the entrepreneur has to acquire information before proposing a project to the investor. To become informed, the entrepreneur exerts a nonverifiable effort $e \in (0,1)$ at a cost $(1/2)c_e e^2$. With probability $1 - e$, he learns nothing and views the projects as identical. In this case, he invests his wealth in the storage technology, which guarantees a safe return. Selecting a project at random is not an optimal strategy, given the large negative payoff associated with project C. With probability e, the entrepreneur learns the projects' characteristics, discards the C project, and approaches an investor to borrow $1 - w$.

Depending on the loan's size, the investor decides how much control to exert on the proposed projects. She can exert a nonverifiable monitoring effort $m \in (0,1)$ at a cost $(1/2)c_m m^2$, which allows her to learn the payoffs of all candidate projects with probability m.[4] When the investor is informed, she forces the entrepreneur to pick project A, as this is the only project that produces a verifiable income. With probability, $1 - m$, the investor remains uninformed. In this case, she does not interfere in project selection, giving the entrepreneur the freedom to implement either project A or B. Thus, whereas

[3] At the cost of more involved algebra, one could also assume that project B produces private benefits b with certainty and cash flows Π with probability $q < 1$. If this probability is independent of entrepreneurial effort and the entrepreneurial project's choice is noncontractible, the conflict of interest between the parties would remain the same.

[4] The assumption that both the entrepreneur and investor's evaluation cost are quadratic is made for computational simplicity. What is crucial for the results in this article is that both functions are nondecreasing and convex.

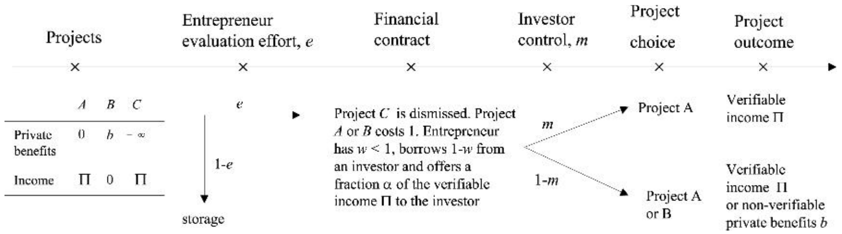

Figure 1
Timing

the investor has control rights over project selection, the entrepreneur retains some discretion if the investor is not fully informed.[5]

1.1.3 Contracts and timing. The relationship between the entrepreneur and the investor is described by the following stage game, summarized in Figure 1.

First, given the set of available projects, the entrepreneur exerts effort to evaluate the projects' characteristics. If the evaluation is successful, he contacts an investor, proposes the financing of a project, and offers a financial contract. A contract specifies how much each side should invest and how much each party should be repaid from the project's outcome. I restrict attention to one arrangement in which 1) the entrepreneur invests all its funds, w, and the investor puts up the difference, $1-w$; 2) the investor is paid a fraction $0<\alpha<1$ of the verifiable income, Π, and the entrepreneur keeps the difference.[6] Next, after the contract is signed and before a project is implemented, the investor chooses her monitoring intensity.[7] Finally, depending on the outcome of the monitoring technology, a project is selected, and the payoffs are realized.

1.1.4 Payoffs. With the proposed timing and a loan agreement that gives a share α of the verifiable income Π to the investor, the entrepreneur's expected utility is

$$u_E(e)=(1-e)rw+e\left\{m(1-\alpha)\Pi+(1-m)\max\left[b,(1-\alpha)\Pi\right]\right\}-c_e e^2/2. \quad (1)$$

Given m and α, the entrepreneur chooses e to maximize (1). The first term is the expected return from storing his endowment at the gross return r, when the

[5] Since monitoring affects the probability that the investor interferes in the selection of projects, I use monitoring and control interchangeably in the rest of the article.

[6] This loan agreement is de facto a profit-sharing contract. Because the project's outcome has a two-point distribution—success or failure—this contract can be interpreted as either a debt or an equity contract (Tirole 2006).

[7] The process of information acquisition for the investor and the entrepreneur could be simultaneous, rather than sequential. This modification would not change the analysis but would lead to no-closed-form solutions. What is important for my results is that control rights are given to the investor so that her interference has an adverse ex ante effect on the entrepreneur's incentives to evaluate projects.

projects' evaluation is not successful. The second term is the expected payoff when he becomes informed about the projects' payoffs with probability e. In this case, his expected utility depends on whether the investor is also informed. With probability m, the investor understands the projects' payoff, and forces the entrepreneur to choose project A. The entrepreneur then receives a fraction $(1-\alpha)$ of Π. With probability $1-m$, the investor remains uninformed and does not interfere in the process of projects selection. In this instance, and depending on the size of b, the entrepreneur has the freedom to propose project A, receiving a fraction of the verifiable income, or project B, enjoying the nontransferable private benefits b. Finally, the third term is the entrepreneur's quadratic cost of projects' evaluation.

The investor's expected utility is

$$u_I(m) = (1-e)r(1-w) + e\left\{m\alpha\Pi + (1-m)\left[\alpha\Pi\mathbf{1}_{b\leq(1-\alpha)\Pi} + 0\mathbf{1}_{b>(1-\alpha)\Pi}\right] - c_m m^2/2\right\}, \quad (2)$$

which is maximized by choosing m, given e and α. The investor's expected utility is equal to the return on the storage technology if she is not approached by the entrepreneur with probability $1-e$. Conditional on e, the investor's payoff, net of the monitoring cost, depends on the fraction α of income Π that she obtains when she is informed with probability m and forces the entrepreneur to pick project A. When the investor remains uninformed, her payoff is positive only if the monetary gains for the entrepreneur are high enough that he foregoes the project with private benefits, i.e., $b \leq (1-\alpha)\Pi$ (in Equation (2), $\mathbf{1}$ denotes the indicator function).

The two payoff functions highlight the different roles played by e and m. Whereas e affects the probability that an investment project is undertaken, m affects the productivity of this investment. For higher m, projects produce more income and less nontransferable resources in the form of private benefits. Because the two actions are noncontractible, the entrepreneur and investor will choose e and m to maximize their own utilities u_E and u_I, respectively. As I show later, when this is the case, total investment and its productivity cannot, in general, be jointly maximized.

1.1.5 Discussion. Two remarks on the model's assumptions are in order. First, for the entrepreneur, private benefits do not need to be interpreted as consumption of perks, diversion of resources, or personal satisfaction. They can be also interpreted as (minus) the disutility for the entrepreneur to adopt new technologies, such as effort to be properly trained, reorganize the firm, or retrain workers. In any interpretation, it is crucial that projects involving private benefits are less productive. Similarly, rather than effort devoted to project valuation, the entrepreneur's effort can be interpreted as a noncontractible firm-specific investment that is individual optimal though socially suboptimal, and exposes the entrepreneur to a hold-up problem with the investor. Second, for the investor, it is key that interference in the selection of projects has the dual effect of limiting the consumption of private benefits and improving project output. This form of control differs from a standard monitoring activity as, e.g., in a costly state verification model. In that model, investor control is passive. Its purpose is to verify firms' ex post performance, and not to affect the quality of the projects implemented. Instead, in this article, investor control is active, in the sense that it increases project value by interfering in the ex ante selection of projects.[8]

1.2 The benchmark case of no-agency problems

I start the analysis with the benchmark case with no-agency problems, which arises if the project choice is contractible. In this case, the equilibrium outcome is straightforward. Since the entrepreneur needs to borrow $1-w$ and the investor does not need to monitor, the entrepreneur chooses e to maximize the expected payoff from implementing project A:

$$\max_{e} \quad u_E = (1-e)rw + e(1-\alpha)\Pi - c_e e^2/2,$$

subject to the constraint that the investor does not make negative profits:

$$(1-e)r(1-w) + e\alpha\Pi \geq r(1-w).$$

With a competitive credit market, the investor's break-even constraint is binding, which pins down α, and the first-best effort is achieved by setting

$$e^{fb} = \min\left\{\frac{\Pi - r}{c_e}, 1\right\}. \tag{3}$$

For a given evaluation cost, this effort increases with project A's return relative to the storage technology and is independent of the entrepreneur's wealth.[9]

1.3 Equilibrium with agency problems

When the project choice is not contractible and private benefits are high enough, i.e., $b > (1-\alpha)\Pi$ for some α to be determined in equilibrium, there is a conflict of interest over the selection of projects. Absent monitoring, the entrepreneur may choose the project involving private benefits, which forces the investor to monitor. In turn, the prospect of investor control leads the

[8] The role of investor's control is similar to the one emphasized in Holmström and Tirole (1997). In their article, however, control reduces entrepreneurial moral hazard—which increases pledgeable income and facilitates financing—but does not affect projects' profitability. In Inderst and Muller (2007) and Allen, Carletti, and Marquez (2011), investors increase the project's value by bringing expertise and advice to the entrepreneur, but their control does not affect the entrepreneur's incentives to propose new projects.

[9] The entrepreneur prefers evaluating the project to storing his wealth straightaway, if $u_E(e^{fb}) \geq rw$ holds. This condition is satisfied if $\Pi \geq r$, which is always true by Assumption 1.

entrepreneur to reduce effort because interference destroys private benefits, reducing the full return on the evaluation effort.

In the presence of a conflict of interest, the equilibrium effort and monitoring, e^* and m^*, are the solution to the following problem:

$$\max_e \,(1-e)rw + e\left\{m^*(1-\alpha)\Pi + (1-m^*)b\right\} - c_e\frac{e^2}{2} \tag{4}$$

subject to

$$m^* = \arg\max_m e^*\left\{m\alpha\Pi + (1-m)\times 0 - c_m\frac{m^2}{2}\right\}, \tag{5}$$

$$e^*\left\{m^*\alpha\Pi + (1-m^*)\times 0 - c_m\frac{m^{*2}}{2}\right\} \geq e^*r(1-w), \tag{6}$$

$$(1-e^*)rw + e^*\left\{m^*(1-\alpha)\Pi + (1-m^*)b\right\} - c_e\frac{e^{*2}}{2} \geq rw, \tag{7}$$

and

$$0 \leq \alpha \leq 1. \tag{8}$$

Equation (4) is the entrepreneur's expected utility. This objective is maximized with respect to the level of effort, subject to the investor's incentive compatibility constraint (5) and break-even condition (6), which is binding in equilibrium because by assumption investors behave competitively. Equation (7) is the participation constraint for the entrepreneur, stating that at the equilibrium level of effort, e^*, and monitoring, m^*, his utility of evaluating and undertaking the project is larger than the utility of storing his wealth straightaway. Finally, (8) is a feasibility constraint: the investor cannot appropriate more than the entire project's income, ensuring limited liability for the entrepreneur.

1.3.1 The basic trade-off. If $b > (1-\alpha)\Pi$, the basic trade-off underlying the entrepreneur-investor relationship follows from inspection of the first-order conditions:

$$e^* = \min\left\{\frac{b - rw - m^*(b-(1-\alpha)\Pi)}{c_e}, 1\right\}, \tag{9}$$

$$m^* = \min\left\{\frac{\alpha\Pi}{c_m}, 1\right\}, \tag{10}$$

and

$$\alpha = \frac{\sqrt{2r(1-w)c_m}}{\Pi}, \tag{11}$$

where the last equation is obtained after substituting the equilibrium level of monitoring, m^*, into the binding investor's break-even condition (6).

According to Equation (9), the entrepreneur's effort depends on the evaluation cost, c_e, and the size of the private benefits relative to the opportunity cost of investing funds, $b - rw$. Crucially, effort is lower the higher the share of the final output that accrues to the investor, $\alpha\Pi$, and the more the likelihood that the investor interferes in the selection of projects, m^*. Equation (10) states that the investor's incentives to monitor increases monotonically with her share in the project's revenue and decreases with the cost of monitoring.[10] Finally, from Equation (11), the investor requires, ceteris paribus, a smaller fraction of the project's income when the entrepreneur supplies a larger fraction of the initial investment.

The first-order conditions (9) and (10) identify the crucial tension between the entrepreneur and investor. When an entrepreneur borrows money, he needs to share a fraction α of the project's income Π with the investor. When this share is high, two forces reduce the entrepreneur's effort. The first is a traditional one in a principal-agent relationship. A lower share of income that accrues to the entrepreneur increases the conflict of interest with the investor—the discrepancy between b and $(1-\alpha)\Pi$—and reduces the incentives of the entrepreneur to exert effort. The second force is more specific to the current setup and is related to the role played by the investor's control. When the investor's exposure in the entrepreneur's project is high, she has strong incentives to control the selection of projects (see (11) and (10)). More control, however, destroys private benefits, reducing the entrepreneur's incentives to evaluate projects ex ante (see (9)).

The fact that the entrepreneur's reaction function is downward sloping in m when $b > (1-\alpha)\Pi$ makes the analysis akin to the initiative-control model of Aghion and Tirole (1997), in which the control of a principal limits the agent's discretion but adversely affects his incentives to propose new ideas. In the context of this article, investor control improves project values by limiting the likelihood that a project generates private benefits at the expense of income. This gain, however, comes at the cost of lower entrepreneurial effort and thus lower investment. Crucially, in this model, the investor's incentive to exert control is endogenous and depends on her stake in the entrepreneur's project.

1.3.2 Equilibrium outcome, investment, and productivity. From the equilibrium conditions (10) and (11), the optimal level of monitoring is

[10] The investor reaction curve is independent of e because she monitors after the entrepreneur has proposed a project.

monotone in α, which is inversely related to w. It follows that the relations between effort and control depend on the level of entrepreneurial wealth. As w increases, investor's control falls via (10) and entrepreneur's effort increases via (9)—and vice versa as w decreases. The exact relation between control and effort as a function of entrepreneurial wealth is spelled out in Lemma 1.

Lemma 1. For given parameters (Π, b, r, c_m, c_e) satisfying Assumption 1 and the condition that project's income is not too high,

$$\Pi \leq \sqrt{2rc_m}, \tag{C1}$$

there exist two cutoff values $\underline{w}$ and $\overline{w}$, with $\underline{w} < \overline{w}$ such that

1. If $0 \leq w \leq \underline{w}$, no investment takes place. In this case, $e = m = 0$.
2. If $\underline{w} < w < \overline{w}$, a project is funded but there is a conflict of interest. Entrepreneurial effort and investor's control are given by (9) and (10), respectively.
3. If $w \geq \overline{w}$, the conflict of interest between the parties vanishes. The investor does not control, and the entrepreneurial effort is given by (3).

Proof. See Appendix. ■

Lemma 1 states that the strategic interaction between the entrepreneur and investor is relevant only for levels of wealth in the range $\underline{w} < w < \overline{w}$. Instead, if entrepreneurial wealth is below the threshold $\underline{w}$, the entrepreneur does not find it convenient to undertake a costly process of project evaluation (or does not have sufficient funds to credibly offer a repayment α to the investor). As a result, there is no investment and the investor does not need to monitor. Conversely, if the entrepreneur is sufficiently wealthy, i.e., $w \geq \overline{w}$, the share of the project income that accrues to the entrepreneur is large enough that he values monetary gains more than private benefits. Therefore, for $w \geq \overline{w}$ we are in the first-best benchmark, where the entrepreneur foregoes private benefits, the entrepreneur selects project A, and there is no conflict of interest with the investor.

The fact that effort and control are inversely related in the relevant range, $\underline{w} < w < \overline{w}$, has interesting implications for the type of investment undertaken. In the model, total investment is equal to

$$i = e, \tag{12}$$

because the setup cost of a project is 1 and no project is implemented unless the evaluation process is successful.[11] The productive share of this investment is

$$p = em\Pi, \tag{13}$$

[11] Since there is a continuum of entrepreneurs, the ex ante probability of discovering a project's type, e, is also the fraction of entrepreneurs that evaluate projects successfully.

given that projects of type A are undertaken only when the entrepreneur approaches the investor with probability e and the investor controls the projects' selection with probability m. However, with probability $1-m$, projects of type B can also be implemented. As a result, total output is equal to

$$y = e\left(m\Pi + (1-m)b\right), \tag{14}$$

comprising the fraction of projects' output that can be shared between entrepreneurs and investors, and the fraction that accrues to entrepreneurs in the form of private benefits.

With these definitions in mind, the main result of this section can be stated as follows,

Proposition 1. When $w \in (\underline{w}, \overline{w})$, the entrepreneur's effort and the investor's control are strictly positive. As w increases in this range, i and y increase monotonically. Moreover, there is a threshold level of net worth, $w^* \in (\underline{w}, \overline{w})$, such that p rises for $w < w^*$ and falls for $w > w^*$.

Proof. See Appendix. ■

With the help of Lemma 1, the mechanism behind Proposition 1 is easy to state. When an entrepreneur has little wealth, the investor's exposure in the entrepreneur's project is high, and she must appropriate a high fraction of the project return to obtain nonnegative profits. Given the underlying conflict of interest with the entrepreneur, the investor needs to monitor to ensure that only projects that generate verifiable income are undertaken. Therefore, at low levels of net worth, high investor control guarantees that only the most profitable projects are implemented, raising p. Monitoring, however, increases interference, which reduces the entrepreneurs' evaluation effort. It follows that at low levels of net worth, investment is low, but its productive share is increasing in monitoring. The beneficial effect of high control on p vanishes when net worth further increases in the range $\underline{w} < w < \overline{w}$. For higher w, the fraction of a project's return that goes to the entrepreneur increases, and thus investor control falls and entrepreneurial effort rises. As w increases in the interval, $\underline{w} < w < \overline{w}$, investment and entrepreneurial private benefits go up at the expense of productive projects. Eventually, as the level of wealth surpasses the threshold w^*, the share of productive investment starts falling until w approaches $\overline{w}$. At this point, the conflict of interest vanishes and investment depends only on the entrepreneur's effort, given by (3).

These comparative statics should be contrasted with those arising from a standard investment model with costly state verification (e.g., Bernanke and Gertler 1989) or entrepreneurial moral hazard (e.g., Holmström and Tirole 1997). In those models, an increase in entrepreneurial wealth mitigates the agency problem, which facilitates financing and raises investment. In this article, investment is also increasing in w, but an additional effect comes into

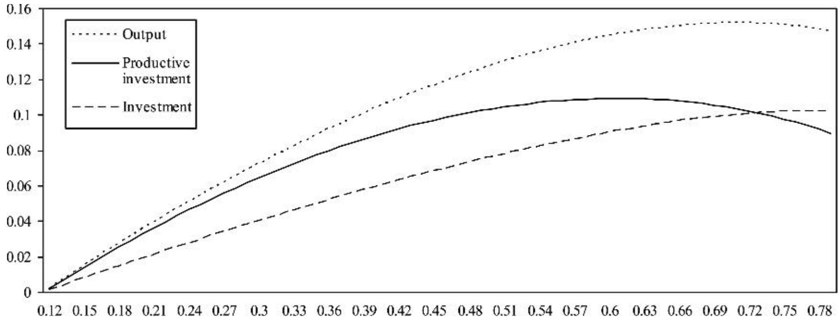

Figure 2
Investment, productive investment, and output

play once the entrepreneur's wealth becomes sufficiently high. A wealthier entrepreneur gains independence from the investor, increasing the likelihood that less productive projects are funded. In other words, although the current setting has the same implications on the level of investment as in standard models with credit frictions, it also has predictions about the quality of investment: The share of productive investment is increasing at low levels of wealth through the value-enhancing effect of investor control and deteriorates when the level of wealth surpasses a certain threshold.

Figure 2 graphically illustrates Proposition 1 through a simple numerical example. I set $\Pi = 2$, $b = r = 1$, and $c_e = c_m = 2.22$ so that Assumption 1 and Condition C1 in Lemma 1 hold and compute the equilibrium value of α that satisfies the investor's break-even constraint, using Equation (11) and alternative values of w in $(\underline{w}, \overline{w})$. Figure 2 plots the level of investment, i, given by (12), the share of productive investment, p, given by (13), and total output, y, given by (14) against the level of entrepreneurial wealth. For the parameter values used in this example, the entrepreneur decides to exert no effort, so no investment takes place, if $w \leq \underline{w} \approx 0.12$. For an intermediate range of wealth, $0.12 < w < 0.6$, investment and its productive share increase monotonically. In this range, investors' control falls gradually, whereas the entrepreneurial effort increases steadily. Initially, the increase in e is enough to compensate for the fall in m so that i and p rise in tandem though at a decreasing rate. As w increases further, i.e., for $w > 0.6$, the control exerted by the investor is so low that only less productive projects are financed. Thus, for high values of w but not too high—that is, before the conflict of interest vanishes, $\overline{w} \approx 0.78$—a rising entrepreneurial effort and a falling investor control lead to higher investment and output but lower productive investment.

At the heart of the nonmonotonic relation between the share of productive investment and entrepreneurial wealth is the decreasing control that the investor exerts on the projects' selection and the concomitant increase in effort of the entrepreneur to initiate investment projects with private benefits. The next section extends this effort-control trade-off in the context of a simple dynamic model to study its implications for investment dynamics.

2. The Dynamic Model

The purpose of this section is to study under which conditions boom-and-bust investment cycles may arise, driven by the endogenous selection of projects with different profitability. To do so, I embed the static analysis of the previous section into a dynamic model. The framework is a modified version of the overlapping generation model (OLG) of Diamond (1965) with agents living for two periods.[12] Although in this model agents' wealth is endogenously determined by the time-path of entrepreneurs' effort and investors' control, the entrepreneur-investor relationship remains static, in the sense that the two parties continue to be related by a financial contract that lasts only one period.

2.1 The model

2.1.1 Agents, preferences, and goods. There is an infinite sequence of two-period lived overlapping generations. Each generation consists of a continuum of agents with unit mass. Agents are born with a fixed endowment of L units of labor. They supply labor inelastically in the first period of life and derive linear utility from consumption in the second period. Within each generation, agents are heterogeneous. An exogenous fraction, η, are potential entrepreneurs, with access to an investment technology. The remaining fraction, $1-\eta$, have no entrepreneurial ability and will be referred to as investors. There are two goods, a capital good and a final good, that are produced with two separate technologies, described in the next two subsections. The capital good is used for the production of the final good, which can be consumed or invested.

2.1.2 Final good production. The final good is produced by means of a Cobb-Douglas production function,

$$Y_t = A_t K_t^{\beta} L_t^{1-\beta},$$

with capital, K_t, and labor, L_t, as inputs. The scale parameter, A_t, measures aggregate productivity that, as in Romer (1986), depends on the aggregate stock of capital,

$$A_t = K_t^{\gamma} \quad \text{with} \quad \gamma = 1-\beta.$$

Input markets are competitive, and capital and labor are remunerated for their marginal productivity, given, respectively, by

$$\rho_t = \beta, \tag{15}$$

[12] Versions of this model are used in Bernanke and Gertler (1989), Azariadis and Smith (1997), Boyd and Smith (1997), and Matsuyama (2004, 2007), among others. As in these articles, the "period" is meant to represent the length of a typical financial contract, rather than a generation of individuals.

and

$$w_t = (1 - \beta)k_t = w(k_t), \tag{16}$$

where, $k_t = K_t/L_t$ is the capital-labor ratio.[13] Equations (15) and (16) imply that as the stock of capital, k, expands, the wage, $w(k_t)$, increases, whereas the price of capital, β, remains constant. For convenience, I normalize the economy-wide labor endowment, L, to unity so that per capita and aggregate quantities are the same.

Labor in period t is supplied inelastically by the young agents of generation t at no utility cost. Because they consume only when old, their labor income, w_t, is saved to finance second-period consumption. Hence, labor income is equal to saving, which is also the wealth of young. Young entrepreneurs can save their wealth through a storage technology, yielding a nonstochastic gross return, r, in units of the final good. Alternatively, they can use w_t to partially finance a capital investment technology. Young investors finance their $t + 1$ consumption either by lending their wealth to the young entrepreneurs or by saving it through the storage technology.

Capital in period t is supplied by the young entrepreneurs of generation $t - 1$, who run a technology that, without the use of labor, converts time $t - 1$ final goods into time-t capital goods (see the next subsection). Thus, capital goods produced at the end of period $t - 1$ become available for the production of the final good only at the beginning of period t.[14] Once capital is combined with labor to produce $y_t = Y_t/L_t$, it fully depreciates. This assumption ensures that at each t aggregate investment is equal to the capital stock. As a result, the period-t wealth depends only on the capital, k_t, brought forward at time t by the $t - 1$ generation of entrepreneurs.[15]

2.1.3 Capital good production. Capital goods are produced by young entrepreneurs, who have access to three investment projects, denoted as A, B, and C. As in the previous section, entrepreneurs do not know the projects' characteristics and thus need to exert some evaluation effort to learn about the payoffs. Each project requires $1 > w(k_t)$ unit of the final good to be activated and produces verifiable and nonverifiable output: the only difference relative to the previous section is that now projects are heterogeneous in terms of how much capital goods they generate. Project A generates Π verifiable units of capital goods, which are available for next-period final good production;

[13] In their study of endogenous investment cycles, Aghion, Banerjee, and Piketty (1999) use a similar production function. In their model, however, the externality depends on the aggregate labor supply. As a result, the real wage is constant, whereas the interest rate varies with k_t. As discussed in Section 5, a model with nonconstant marginal productivity of capital would add more complication to the analysis unrelated to the strategic interaction between investors and entrepreneurs, the main focus of this article.

[14] It is assumed that at $t = 0$ the economy starts with a positive capital endowment, $k_0 > 0$.

[15] The assumption that w_t is independent of the (undepreciated) capital of earlier periods, $k_{t-1}, k_{t-2}, k_{t-3}, \ldots,$ makes the dynamic model tractable and allows for analytical solutions.

Table 2
Projects' payoffs

	A	B	C
Private benefits	0	b	$-\infty$
Capital goods	Π	0	Π

Private benefits are in terms of the final good.

project B generates b nonverifiable units of final goods in the form of private benefits for the entrepreneur, which are available for next-period consumption; and project C entails a large negative payoff for the entrepreneurs that can be avoided if he completes the evaluation process of the projects successfully with probability e. For convenience, the projects' payoffs are reproduced in Table 2.

Because entrepreneurs need external funding to start a new project, a conflict of interest with the investors may arise if the project choice is not contractible. The resulting agency problem implies that at each t, investment may generate capital goods or private benefits, depending on the entrepreneurial incentives to propose new projects and the investor incentives to control the selection of such projects. It is in this sense that the agency problem discussed in the previous section affects the amount of capital goods that can be used for final good production in period $t+1$, and hence the wealth of young agents of generation $t+1$ (see Equation (16)), with obvious implications for wealth and investment dynamics.

Figure 3 summarizes the timing and sequence of events in this OLG economy.

2.1.4 Projects choice and the credit market. The borrowing-lending relationship is the same as in the static model. Entrepreneurs with a negative evaluation of projects store their income at a safe gross return, r, and those that successfully evaluate their projects with probability, e_t, enter in a one-period financial contract with an investor. Because entrepreneurs need to borrow to activate a project, a contract stipulates the loan amount, $(1-\omega_t)$, and the fraction α_t of the project's verifiable output to the investor. Before a project is implemented, an investor controls the set of available projects and dictates the implementation of project A (which generates verifiable output) with probability m_t. With probability $1-m_t$, the investor remains uninformed, and the entrepreneur picks either project A or B, depending on the size of private benefits and monetary incentives.

Following Bernanke and Gertler (1989), the final assumption is that aggregate savings is larger than the measure of the young agents who start a project,

$$\omega_t > \eta e.$$

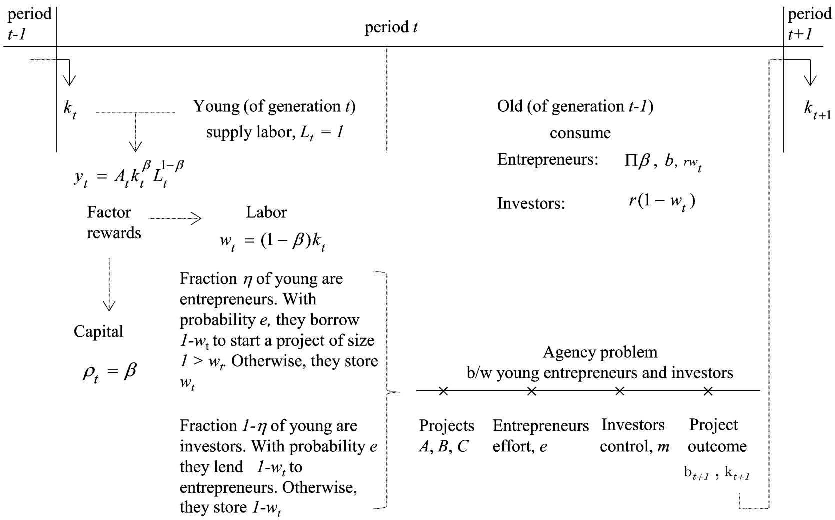

Figure 3
Timing in the OLG economy

This assumption guarantees that storage is always used in equilibrium, and its return pins down the interest rate in this economy. The fact that the supply of funds is perfectly elastic implies that the investment dynamic does not depend on the availability of loanable funds, but only on the investors' incentives to control entrepreneurial behavior.[16]

2.1.5 Payoffs. With the assumption that agents' utility is linear in second-period consumption, the entrepreneurs and investors' expected utilities can be written, respectively, as

$$u_E(e)_t = (1 - e_t)rw_t + e_t \{m_t(1-\alpha_t)\Pi\beta + (1-m_t)\max[b, (1-\alpha_t)\Pi\beta]\} - c_e\frac{e_t^2}{2}, \quad (17)$$

$$u_I(m)_t = (1 - e_t)r(1-w_t) + e_t \left\{m_t\alpha\Pi\beta + (1-m_t)\left[\alpha_t\Pi\beta\mathbf{1}_{b\le(1-\alpha_t)\Pi\beta} + 0\mathbf{1}_{b>(1-\alpha_t)\Pi\beta}\right] - c_m m_t^2/2\right\}. \quad (18)$$

These expressions are the equivalents of (1) and (2), with the difference that $\Pi\beta$ denotes the value of the capital goods produced by project A in terms of final output (in Equation (15), β is the relative price of capital). In this formulation, private benefits and the costs of evaluation and control are

16 Aghion, Banerjee, and Piketty (1999) and Matsuyama (2004, 2007) obtain nonlinear investment dynamics when the interest rate is endogenous and there are imperfections in the credit market. This article complements their work by showing that agency problems can give rise to endogenous cycles even if the interest rate is constant.

expressed in terms of the final good. In order to make the problem interesting and to guarantee that entrepreneurs choose A-projects in absence of agency conflicts, I also impose the following condition.

Assumption 2. $\Pi\beta > b = r$,
which is the analog of Assumption 1 in the static model.[17]

2.2 Equilibrium dynamics with no agency problems

Following the same steps as in Section 1, I first derive the equilibrium outcome in the benchmark case with no agency conflicts. When the projects choice is contractible, the effort level that maximizes entrepreneur's utility (17) subject to the investor's break-even constraint is

$$e_t^{fb} = \min\left\{\frac{\Pi\beta - r}{c_e}, 1\right\}, \tag{19}$$

which is the analog of Equation (3) in the static model. In this benchmark scenario, the equilibrium dynamics are trivial. At any t, aggregate investment is equal to the fraction of entrepreneurs that successfully evaluate the projects' characteristics,

$$i_t = e_t^{fb} \times \eta.$$

Assuming an interior solution for e_t^{fb}, the units of capital available for output good production at the beginning of next period are

$$k_{t+1} = i_t \times \Pi = \frac{(\Pi\beta - r)}{c_e} \times \eta \times \Pi. \tag{20}$$

Hence, when there is no agency conflict, the stock of capital in the economy is constant over time and depends on entrepreneurial effort and the productivity Π of A-type projects. Moreover, since k_{t+1} is independent of period-t variables, there is a unique stable steady state to which the economy converges in one period.

2.3 Equilibrium dynamics with agency problems

When projects are not contractible, the amount of capital that becomes available for $t+1$ final good production will depend on the period-t capital stock. The reason is that k_t determines the wealth $w(k_t)$ of young entrepreneurs, which in turn—given the nature of the agency problem discussed in the previous section—affects entrepreneurs' incentives to evaluate projects and investors' incentives to control the selection of projects. The following Lemma,

[17] The equality $b = r$ is imposed to obtain explicit solutions. None of the results presented below are affected by the weaker condition $b \geq r$ (as in Assumption 1). The reason is that e_t is an increasing and concave function of w_t, even if $b = r$.

which parallels Lemma 1 in Section 1, characterizes the equilibrium effort and control for different levels of entrepreneurial wealth.

Lemma 2. For parameter values (Π, β, b, r, c_m), satisfying Assumptions 2 and the condition that project's A income is not too high,

$$(\Pi\beta - b) \leq \sqrt{rc_m/2}, \tag{C2}$$

there exist two cutoff values,

$$\underline{w} \equiv 1 - \frac{2(\Pi\beta - b)^2}{rc_m} \text{ and } \overline{w} \equiv 1 - \frac{(\Pi\beta - b)^2}{2rc_m},$$

with $0 \leq \underline{w} < \overline{w}$ such that

1. If $0 \leq w_t \leq \underline{w}$, no investment takes place. In this case,
$$e(w_t) = m(w_t) = 0.$$
2. If $\underline{w} < w_t < \overline{w}$, investment takes place and there is a conflict of interest between entrepreneurs and investors. Entrepreneurial effort and investor control are given by
$$e(w_t) = (m_t(w_t) \times (\Pi\beta - b) - r(1 - w_t))/c_e > 0, \tag{21}$$
$$m(w_t) = \sqrt{2r(1 - w_t)/c_m} > 0. \tag{22}$$
3. If $w_t \geq \overline{w}$, the conflict of interest between the parties vanishes. The investor does not monitor, $m(w_t) = 0$, and entrepreneurial effort, $e(w_t)$, is given by (19).

Proof. See the Appendix. ■

Relative to the first-best case (19), entrepreneurial effort depends on w_t both directly and through the investor's control $m_t(w_t)$. From (21) and (22) also follows that whereas control $m_t(w_t)$ is decreasing in w_t, $e_t(w_t)$ is increasing in w_t. The inverse relation between effort and control is key to explaining why changes in $w(k_t)$ may give rise to possibly nonlinear investment dynamics. In fact, in the relevant range, $\underline{w} < w_t < \overline{w}$, the stock of capital that becomes available for final good production in the next period is

$$k_{t+1} = e_t(m_t(w_t(k_t)) \times m_t(w_t(k_t)) \times \Pi \times \eta, \tag{23}$$

given that projects that produce capital goods Π at date t are implemented only if the entrepreneurs evaluate projects successfully with probability $e_t(w(k_t))$ and investors control the selection of projects with probability $m_t(w(k_t))$ (Equation (23) is the equivalent of (13) in the static model of Section 1).

Consequently, when $w(k_t)$ is low, higher investors' control increases the likelihood that A-type projects are implemented, improving the average productivity of investment and the wealth of the next generation of agents. As more wealth becomes available in the next period, $w(k_{t+1})$, investor control falls and the likelihood that less productive projects (B-type projects) are funded goes up, increasing the fraction of projects' output in the form of private benefits that becomes available for next-period consumption,

$$b_{t+1} = e_t(m_t(w_t(k_t)) \times (1 - m_t(w(k_t)) \times b \times \eta.$$

Moreover, since entrepreneurial effort is essential to initiate an investment project—but it is inversely related to investors' control—periods of low but productive investment may be followed by periods of high and unproductive investment.

2.3.1 Wealth dynamics. To study the investment dynamics in this economy, it is convenient to reformulate the law of motion of capital, k_t, implicitly defined in (23), in terms of w_t. Given the one-to-one mapping between wealth and capital implied by (16), this transformation is innocuous and convenient because it reduces notational clutter.

Using Lemma 2, the wealth dynamics can be written as

$$w_{t+1} = \Phi(\mathrm{w_t}) = \begin{cases} 0 & \text{if} \quad w_t \leq \underline{w} \\ \phi(w_t) & \text{if} \quad \underline{w} < w_t < \overline{w}_t \\ w^{fb} & \text{if} \quad w_t \geq \overline{w}_t, \end{cases} \tag{24}$$

where

$$w^{fb} = \lambda\delta \tag{25}$$

is obtained by replacing (16) into (20) and defines the agents' wealth that prevails in absence of agency problems, whereas the function

$$\phi(w_t) = (1 - w_t)\left[\frac{2r}{c_m}\lambda - r\sqrt{\frac{2r}{c_m}(1 - w_t)}\right]\delta, \tag{26}$$

is obtained by substituting the equilibrium investor control and entrepreneurial effort (stated in Lemma 2) into (23) and characterizes the wealth dynamic in the presence of agency problems.

In the expressions above,

$$\lambda \equiv \Pi\beta - b \tag{27}$$

defines the surplus associated to the production of capital goods relative to private benefits and is thus a measure of the severity of the agency problem,[18]

[18] By Assumption 3, λ is also equivalent to $(\Pi\beta - r)$, i.e., the surplus of productive capital relative to storage. Both expressions measure idle savings in the economy, i.e., savings not put into productive investment activity.

and

$$\delta \equiv \frac{(1-\beta)}{c_e} \times \eta\Pi \tag{28}$$

measures the fraction, $(1-\beta)/c_e$, of capital goods, $\eta\Pi$, that is distributed in the form of labor income.

To solve for the wealth dynamic, the mapping $w_{t+1} = \Phi(\mathrm{w_t})$ can be applied iteratively, for any initial condition, w_0. This mapping crucially depends on the shape of the nonlinear function $\phi(w_t)$, which has the following properties.

Lemma 3. The map $\phi(w_t)$ defined in (26) is unimodal with a critical point at $w^* \equiv 1 - \frac{8\lambda^2}{9rc_m} \in (\underline{w}, \overline{w})$ and maximum value $\phi(w^*) = \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta$. Moreover, if

$$c_m < r\delta\lambda, \tag{C3}$$

the mapping $\phi(w)$ has, at most, one interior steady state.

Proof. See the Appendix. ■

Equation (24) and Lemma 3 imply that the dynamics of $\Phi(\mathrm{w_t})$ is nonmonotonic for $w_t \in (\underline{w}, \overline{w})$. Hence, the dynamic system (24) admits at most two steady states: a trivial one, w^{fb}, when $w_t \geq \overline{w}$, and a second one if the map $\phi(w)$ crosses the 45$^{\mathrm{o}}$ line at $\underline{w} < w_t < \overline{w}$. Unfortunately, in this intermediate range, the steady state of $w_{t+1} = \phi(w_t)$, if it exists, does not have a closed-form solution. To characterize its stability and the dynamic trajectories in the neighborhood of the steady state, it is therefore necessary to consider different possible cases, depending on parameter values. In order to do so, it is essential that $\Phi(w_t)$ maps $(\underline{w}, w^{fb})$ onto itself. For this reason, I impose the following condition.

Assumption 3. $\frac{4}{3\sqrt{3}}\lambda \leq c_m$.

This technical assumption simply requires that the maximal wealth, $\phi(w^*)$, attainable in the presence of the agency problem, is less than or equal to the first-best level $w^{fb} = \delta\lambda$. Taken together, Assumptions 2 and 3 and condition (C3) in Lemma 3 require that the following restrictions hold on the cost of monitoring:

$$\max\left\{\frac{2\lambda^2}{r}, \frac{4}{3\sqrt{3}}\lambda\right\} \leq c_m \leq r\delta\lambda.$$[19]

[19] If c_m were higher than $r\delta\lambda$ (so that condition (C3) is violated), the slope of $\Phi(w)$ would never be larger than one at $\underline{w}$, and thus the only (trivial) steady state of the dynamics would be $w^{ss} = \underline{w}$. If c_m were lower than $4\lambda/(3\sqrt{3})$, then $\phi(w^*)$ would be higher than $w^{fb} = \delta\lambda$, and $\Phi(w)$ could not map the interval $(\underline{w}, w^{fb})$ onto itself. Finally, if c_m were lower than $2\lambda^2/r$, $\underline{w} = 1 - \frac{2\lambda^2}{rc_m}$ (the minimum level of wealth above which the entrepreneur decides to invest in the project) would be negative.

Without loss of generality, I assume that $\lambda > 2r/3\sqrt{3}$ so that the above condition is rewritten as

$$\frac{2\lambda^2}{r} \leq c_m \leq r\delta\lambda, \tag{29}$$

which, together with (C3), requires that

$$\frac{2r}{3\sqrt{3}} \leq \lambda \leq \frac{r^2\delta}{2}. \tag{30}$$

2.3.2 Dynamic analysis. Depending on whether $w^*>\phi(w^*)$ or $w^*<\phi(w^*)$, Figures 4A–4D depict four different cases consistent with the restrictions implied by (29) and (30). The first case, shown in Figure 4A, arises when the mapping $\phi(w)$ satisfies the condition

$$w^* > \phi(w^*),$$

which, using Lemma 3 and Equation (26), can be rewritten as

$$1 - \frac{8\lambda^2}{9r\,c_m} > \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta. \tag{31}$$

Under this configuration of parameters, the dynamic is monotonic. Starting from any initial wealth, the economy gradually converges to a (low) steady state w^{ss}. For a given size of the agency conflict, $\lambda \equiv \Pi\beta - b$, condition (31) is satisfied if the cost of monitoring, c_m, is sufficiently high. The well-behaved dynamics and the low level of wealth arise for the following reason. If monitoring costs are high, borrowing costs are also high and the minimum level of wealth, $\underline{w}$, above which entrepreneurs are willing to undertake a new investment project becomes larger. As a result, fewer projects are undertaken, limiting the total wealth that can be accumulated over time. Thus, if c_m is sufficiently high, the agency problem between intermediaries and entrepreneurs constrains wealth dynamics exactly as in a model with standard credit market imperfections. For given c_m, condition (31) is also met when $\lambda \equiv \Pi\beta - b$ is sufficiently low. A low λ occurs if the productivity of the investment, Π, is low or the amount of private benefits, b, is large. In both cases, entrepreneurs are not able to accumulate enough wealth over time. Under this parameter configuration, entrepreneurs never become rich enough to "escape" from investor control. The process of "controlled" investment leads to a stable, though low, steady state.

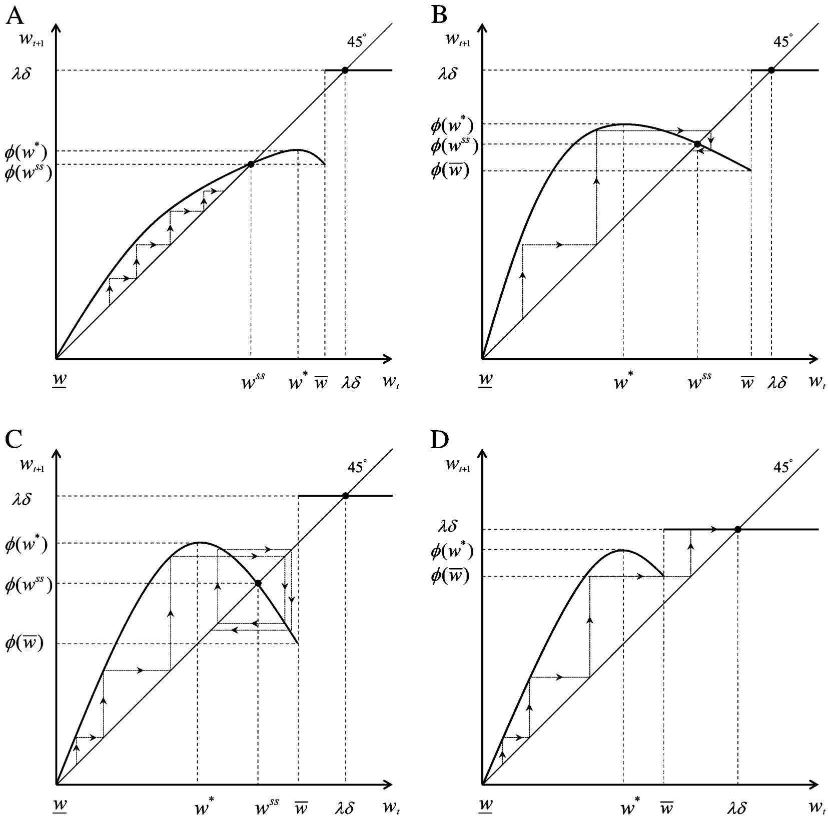

Figure 4
A. Monotonic wealth dynamic; B. Stable oscillatory wealth dynamic; C. Unstable oscillatory wealth dynamic; D. Stable wealth dynamic converging to the first-best equilibrium.

In the other polar case, where

$$w^* < \phi(w^*),$$

the wealth dynamics can be of different types. Figures 4B–4C display the case in which

$$w^* < \phi(w^*) \quad \text{and} \quad \overline{w} > \phi(\overline{w}),$$

which, using Lemmas 2 and 3 and Equation (26), holds when

$$1 - \frac{8\lambda^2}{9rc_m} < \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta \quad \text{and} \quad 1 - \frac{\lambda^2}{2rc_m} > \frac{\lambda^3}{2c_m^2}\delta. \tag{32}$$

Under the parameter restrictions in (32), the map $\phi(w)$ intersects with the 45^{o} line at the downward-sloping part. As a result, the dynamics around the steady state may be oscillatory but stable, in the sense that the economy eventually converges to the steady state, possibly after several periods of fluctuations. This is shown in Figure 4B.

Under the same restrictions in (32), the dynamic can also be unstable with the economy moving back and forth between booms and recessions, as shown in Figure 4C. In that figure, the interval $\left[w^*, \overline{w}\right]$ is a trapping region, i.e., once the economy eventually enters this region it will never leave.[20]

The parameter restrictions in (32) hold under two conditions. First, for a given λ, the cost of monitoring is sufficiently low (so that $w^* < \phi(w^*)$) but not too low (so that $\overline{w} > \phi(\overline{w})$). Second, for a given c_m, λ is sufficiently high but not too high. In this economy, instability arises for the following reason. For a given λ, if the cost of monitoring is low, investor control is high, forcing the selection of productive projects that contribute to increase the level of wealth in the economy. At the same time, since c_m is not very high, an increasing amount of resources remain in the hands of the entrepreneurs, leading to further accumulation of wealth. As next-period wealth rises, lenders' financial exposure shrinks and monitoring intensity falls. Entrepreneurs eventually gain independence from investors and have the option to finance projects involving private benefits that reduce the amount of capital available for next-period production. Hence, capital stock falls, the wealth of future generations deteriorates, and the cycle starts all over again.

Similarly, for a given c_m, a high λ, but not too high to eliminate the agency problem, initially leads to fast wealth accumulation—given the high degree of investor control at low level of wealth and the fact that high λ reflects a high project return, Π, or low private benefits, b. As the amount of wealth accumulated increases, a fall in investor control permits that resources are put to less than optimal use, generating less wealth for future generations of entrepreneurs and, hence, initiating a period of slump.

The final case depicted in Figure 4D arises if

$$w^* < \phi(w^*) \quad \text{and} \quad \overline{w} < \phi(\overline{w})$$

or

$$1 - \frac{8\lambda^2}{9rc_m} < \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta \quad \text{and} \quad 1 - \frac{\lambda^2}{2rc_m} < \frac{\lambda^3}{2c_m^2}\delta. \tag{33}$$

20 Ideally, to examine for which configuration of parameters the dynamics is unstable, one should check the sufficient condition that the slope of the function $\phi(w)$ at the steady state is such that $\left|\phi'(w^{ss})\right| > 1$. Unfortunately, this characterization is not feasible given that the steady state of the mapping, $w_{t+1} = \phi(w_t)$, cannot be explicitly derived. In principle, this case may never arise, but a necessary condition for ruling this possibility out is that the slope of the map $\phi(w)$ at the point $\overline{w}$ is larger than one, in absolute value. Simple algebra shows that

$$\left|\phi'(\overline{w})\right| > 1 \text{ iff } c_m < \frac{r\delta}{2}\lambda,$$

which is evidently possible, given that Equation (29) requires that $\lambda < \frac{r^2\delta}{4}$, and this parameter restriction is compatible with (30). Therefore, limit-cycles cannot be excluded with certainty, but remain a possibility.

The parameter restriction in Equation (33) is stronger than in (32), since it requires a lower c_m and/or higher λ. When (33) holds, the wealth dynamics always converge to the first best. The reason is intuitive. If c_m is very low, monitoring is high, and the process of wealth accumulation is fast. Moreover, a low c_m reduces $\overline{w}$ and thus the range of wealth below which the conflict of interest between entrepreneurs and investors is active. Hence, entrepreneurs internalize more quickly the benefits of choosing projects that generate capital goods, and the dynamic eventually converges to that of an economy without agency problems. Similar effects arise when λ is very high, i.e., the agency problem is unimportant because the project return is sufficiently high or the size of private benefits is low. In this case, entrepreneurs have more to gain from undertaking projects that generate capital goods. Thus, the drop in wealth in the interval $(w^*, \overline{w})$ is not so large as to generate changes in the dynamics of wealth formation.

The following proposition summarizes the central results of this section.

Proposition 2. Assume conditions (29) and (30) hold. Then there exist two cutoffs $\underline{c}_m < \overline{c}_m$ such that for any λ

- **a.** If $c_m \geq \overline{c}_m$, the dynamic of w_t, converges monotonically to a low stable steady state.
- **b.** If $\underline{c}_m < c_m < \overline{c}_m$, the dynamic of w_t either has locally oscillatory convergence to a unique steady state, or equilibrium trajectories that are trapped in the interval $\left[w^*, \overline{w}\right]$.
- **c.** If $c_m \leq \underline{c}_m$, the dynamics of w_t converges to the first-best equilibrium.

Moreover, there exist two cutoffs, $\underline{\lambda} < \overline{\lambda}$, such that for any c_m

- **d.** If $\lambda \leq \underline{\lambda}$, the dynamic is as in a.
- **e.** If $\underline{\lambda} < \lambda < \overline{\lambda}$, the dynamic is as in b.
- **f.** If $\lambda \geq \overline{\lambda}$, the dynamic is as in c.

Proof. See the Appendix. ■

2.3.3 Discussion. Proposition 2 says that the double incentive problem emphasized in this article may lead to instability and fluctuations, depending on the costs of monitoring c_m and the degree of the agency problem, λ. For given initial conditions, small changes in c_m and λ can, therefore, lead to different dynamic patterns. Consider, e.g., the case in which c_m is related to the characteristics of investment technologies so that the cost of monitoring is larger for, say, new technologies than for more mature ones. In this case, Proposition 2 suggests that it is only once the properties of these technologies become properly understood that instability may arise in the economy. Alternatively, if one is willing to assume that monitoring costs are inversely related to the stage of the financial development, then the analysis above suggests that economies with underdeveloped financial markets are not necessarily prone to fluctuations, whereas small improvements in credit markets might lead to instabilities. In Proposition 2, λ also plays a crucial role. Since λ comoves with Π, small shocks to the productivity of investment projects may initiate different dynamics. If λ is low, negative shocks to Π become persistent and low investment leads to further lower activity. On the other hand, starting from a low λ, small but positive shocks may lead to complicated dynamics and instability. If one considers positive shocks to Π as initiated by the adoption of new technologies, or more generally by exogenous technology shocks, the economy may experience periods of fluctuations, unless the increase in projects' productivity is very large.

3. Empirical Implications

Having discussed the static and dynamic implications of the interplay between entrepreneurial effort and investor control, I am now in a position to evaluate some of the predictions of the model. The static model in Section 1 has several interesting comparative static results. The first one is that entrepreneurs with low net worth undertake few investment projects in aggregate because low net worth triggers investor control. which reduces entrepreneur's ex ante incentives to initiate new projects. This prediction stands close to the findings of the large empirical literature on firm investment in the presence of credit frictions that investment depends on firms' internal funds, holding constant investment opportunities (see Hubbard 1998 and Stein 2004 for two recent surveys). The second implication of the static model is that investors' control is weaker if the entrepreneur can supply a large fraction of the initial investment. This prediction is in agreement with the received wisdom in the banking literature (Gorton and Winton 2004) and has large empirical support (Booth 1992; Cantillo and Wright 2000; Nini, Smith, and Sufi 2009). Third, the static analysis predicts that control constraints investment and more restrictions on firms' investment leads to more productive investment. These predictions are consistent with the findings of Nini, Smith, and Sufi (2009) and Chava and Roberts (2008), who study loan covenants, firms' investment, and firms' performance, and find that control through covenants improves performance because covenants restrain borrowers from detrimental actions. The prediction that investor control improves firms' performance is also in line with the evidence for German firms in Gorton and Schmid (2000).

The main results that investor control affects entrepreneurs' incentives and investor control affects firms' productivity are likely to vary across industries and intermediaries. In industries with more pledgeable assets, investors' incentives to control are weaker, and thus investment profitability should be lower and/or the amount of private benefits enjoyed by entrepreneurs larger than in industries with less tangible capital. Similarly, firm's profitability and agency problems should vary with the lender type and their cost of monitoring entrepreneurial activity. Unfortunately, I am not aware of any empirical study relating firms' performance and agency costs to lender type—say, venture capitalists versus banks, or large banks versus small banks, assuming these have different costs of control. There is, instead, some evidence that agency costs are lower when financing occurs through banks. James (1987) and Lummer and McConnell (1989) are among the early empirical articles demonstrating the role of banks in the reduction of agency costs. Ang, Cole, and Lin (2000) also show that banks acting in their role of delegated monitoring on behalf of other shareholders are particularly effective in solving managerial moral hazard.

Interesting predictions also come out of the dynamic model in Section 2. In particular, the varying intensity at which the investor exercises control on the selection of projects suggests that lending standards shape investment dynamics. This is consistent with the anecdotal evidence reported in Rajan (1994) according to which lending standards are relaxed in booms and tightened in recessions. It is also in line with the findings of Asea and Blomberg (1998), Berger and Udell (2004), and Lown and Morgan (2006) that in the United States bank lending standards are important for aggregate economic activity. The countercyclical nature of control, through bank loan covenants, and their influence on firms' performance and default is also documented by Zheng (2009).

A final prediction worth mentioning is that exogenous shocks to firm net worth may be dampened rather than amplified. This result stands in sharp contrast with that arising in a standard model based on the credit multiplier. The reason why this occurs rests, once again, on the crucial role played by the investor in selecting entrepreneur projects. For example, following a recessionary shock, stringent control only allows productive projects to get funding, stabilizing the negative shock. Empirical evidence that the credit market acts in dampening or amplifying shocks is unfortunately scarce. In the literature, there is only microevidence that firms' investment decisions are affected by credit frictions, but no evidence that these frictions actually matter for aggregate dynamics (see House 2006 and Bacchetta and Caminal 2000).

4. Robustness

The results of this article are obtained in a highly simplified representation of the economy. It is therefore worth discussing some of its modeling assumptions.

1. Perhaps the assumption driving most of the results is that entrepreneurs are short lived. By adopting investment projects that generate only private benefits, entrepreneurs do not internalize the consequences of their choice on

the funds available for future investments. If entrepreneurs were long lived, boom periods would last longer and the amplitude of fluctuations would be reduced. In this modified setup, the concept of borrower wealth would have to be extended to include current and expected future income. This extension, however, would not invalidate the logic of the model, as long as investors' expectations of entrepreneurs' wealth are persistent. If entrepreneurs' wealth is high today and expected to remain high in the future, investors will reduce control in a manner similar to what is discussed above. Moreover, in a repeated interaction, the lender break-even constraint needs to be satisfied over a longer horizon rather than period by period, which may further weaken banks' incentives to monitor. Of course, this effect is counterbalanced by the fact that long-lived entrepreneurs internalize the consequences of project choice to a larger extent. Allowing for long-lived entrepreneurs, however, is not an easy task, given that the contracting problem between lenders and borrowers would be one with repeated-double-moral-hazard.[21]

2. Central to the results is the premise that investor control as well as the entrepreneurial effort are essential to generate income, and that entrepreneurial incentive to exert effort is adversely affected by investor control. These assumptions are responsible for the unimodal shape of wealth and investment dynamics in Section 2. Alternatively, one may assume that investors enhance profit maximization directly and independently of the entrepreneur effort by posing, e.g., that verifiable income is generated with probability $(e+m)$ rather than em, as assumed in the text.[22] Such a formulation would kill the possibility that the investment dynamics are hump shaped and hence, that endogenous fluctuations may arise. However, this would only capture one aspect of the problem, namely, that the investor assists the entrepreneur in his venture, but not the role of the investor as a monitor who destroys private benefits and affects entrepreneurial incentives. More generally, one could consider the case where the probability of productive output is $p(e,m) = \left[\gamma e^k + (1-\gamma)m^k\right]^{\frac{1}{k}}$ with $\kappa \leq 1$ and $\gamma \in (0,1)$. In this case, the two actions are perfect substitutes if $\kappa = 1$, and complements otherwise. To generate endogenous fluctuations, it would be necessary that κ is sufficiently low.

3. In the OLG model of Section 2, I assumed that the marginal productivity of capital is constant. This assumption rules out the possibility that entrepreneur's effort also depends on the future price of capital. Though

[21] Carlstrom and Fuerst (1997) and Bernanke, Gertler, and Gilchrist (1999) also recognize the difficulty associated with having long-lived entrepreneurs. In their models, entrepreneurs have de facto a finite horizon, since they face a constant probability of surviving until the next period. This assumption rules out repeated interactions between lenders and borrowers, and allows them to consider the case of financial contracts that last only one period.

[22] The literature on venture capital (see, e.g., Gompers and Lerner 1999; Casamatta 2003; Kaplan and Stromberg 2003, to cite a few) emphasizes, e.g., the role of investors as advisors that bring expertise and advice to implement investment strategies that increase the firm's profitability. In these articles, the investor's value-enhancing action is orthogonal to entrepreneurial effort and thus does not affect the incentive constraints of the entrepreneur.

realistic, such an extension might give rise to multiple equilibria, in which the optimal effort choice of an entrepreneur at time t would directly depend on the investor control, and indirectly on the effort decision of the other entrepreneurs, given that the actions of these entrepreneurs affect the amount of capital available in the economy at $t+1$ and hence, its price. Extending the model in this direction would certainly add another interesting element to the dynamics, but this would be unrelated to the strategic interaction between investors and entrepreneurs, the main focus of this article.

4. Throughout the analysis, I have kept the assumption that the supply of credit is infinitely elastic and hence the interest rate is constant. This is a reasonable assumption if the economy is small and open. Allowing for the interest rate to vary, however, would not invalidate the results provided the supply and the demand of credit increases as entrepreneur's wealth improves and the economy expands.

5. Conclusion

This article has offered an investigation of the link between agency problems in the credit market and endogenous cycles. An extensive literature in macro economics has studied the relation between entrepreneurial net worth and firm investment to explain the persistence and amplification of small shocks to the economy. Little attention has been paid to the possibility that agency problems generate instability and endogenous fluctuations. To highlight this connection, this article has proposed a mechanism based on the joint interaction of borrowers' and lenders' incentives.

Starting with the premise that the profitability of investment projects depends on the joint noncontractible actions of investors and entrepreneurs, the article illustrates how borrowers' and investors' incentives may vary over the cycle. The model is set up in a way that the entrepreneurial initiative is essential for selecting investment projects and the investor control is crucial for selecting only profitable projects. Since there is a basic conflict of interest between the entrepreneur and the investor over the selection of projects, too much control discourages entrepreneurial incentive to initiate investment projects, whereas too little control jeopardizes their productivity. I have shown that the trade-off between entrepreneurial initiative and investor control can generate investment dynamics that mimic those of a standard model with credit frictions, in which more entrepreneurial net worth leads to higher investment. However, the same trade-off can generate endogenous fluctuations, induced by an ongoing deterioration of project profitability. If embedded in a dynamic model with overlapping generations, this trade-off leads to the possibility of endogenous cycles. The condition for endogenous cycle is that the cost of monitoring for the investor (or the degree of the agency problem) is neither too high nor too low. Under this condition, the economy either converges to its steady state in an oscillatory manner, or never reaches the steady state and keeps on cycling between periods of boom and recession.

Investment cycles are inherently complex and the agency problem in this article is certainly much too simple to do full justice to reality. Many important issues deserve a more careful analysis in future research. First, although entrepreneurial private benefits are the source of divergent interests between firms and investors, the nature of these private benefits has been left unspecified. Modeling these benefits in greater detail can open the way to more elaborate theories, with more convincing explanations why entrepreneurs may prefer the adoption of less productive investment technologies at different stages of the economic cycle. Second, the overlapping generation framework is a useful device to single out the dynamic consequences of the agency problem between lenders and borrowers. A framework richer in dynamics may, however, lead to more interesting insights into the source of investment fluctuations. At the moment, the framework is too stylized to permit meaningful quantitative analysis and evaluate the importance of the mechanism emphasized in this article. These extensions are left to future research.

I have also neglected the normative question of what government policy could do to minimize fluctuations. In the dynamic version of the model, however, fluctuations are an efficient equilibrium outcome. This is the case, even though low-productivity projects impair future generations' net worth. In fact, when entrepreneurs select bad projects, they still maximize their utility while keeping the investor on her break-even constraint. Room for government intervention is therefore limited to the case where the welfare of future generations is also taken into account. In this case, the planner could restore efficiency by taxing rich young entrepreneurs so that their independence from investor control would never be gained. Alternatively, the planner could tax investor revenues so as to induce more intensive investor monitoring, and prevent entrepreneurs from selecting bad projects. The exact details of these policy options, however, are intricate and left to future work.

Finally, although the main focus of this article has been on investment cycle, the agency problem between entrepreneurs and investors also has interesting cross-sectional and cross-country predictions. For example, the main implication of the model is that the profitability of investment varies with respect to the lender's ability to monitor entrepreneurial activity. Countries differ extensively in terms of how their financing system works. Bank-based financial systems require a very direct control over the borrower. Similarly, a direct link between investors and entrepreneurs exists in systems where financing occurs through venture capitalists. Conversely, in markets relying more on arm's-length financing, control is less direct. Insofar as banks, venture capitalists, and stock markets are fundamentally different in the way they process information and control borrowers, this article has something interesting to say about the possibility that market-based rather than bank-based economies are more prone to instabilities. A careful empirical examination of these empirical predictions is also left to future work.

Appendix

Proof of Lemma 1

From the entrepreneur's reaction function (9), e^* and m^* are inversely related if $b > (1-\alpha)\Pi$ or $\alpha > \overline{\alpha} \equiv 1 - b/\Pi$. Using

$$\alpha = \frac{\sqrt{2r(1-w)c_m}}{\Pi},$$

this condition holds when

$$w < 1 - \frac{(\Pi - b)^2}{2rc_m} \equiv \overline{w}.$$

Conversely, if $w \geq \overline{w}$, or $\alpha \leq \overline{\alpha} \equiv 1 - b/\Pi$, the share of the project payoff that accrues to the entrepreneur, $1-\alpha$, is large enough that he values monetary income more than private benefits. For $w > \overline{w}$, the entrepreneur selects only project A, and there is no conflict of interest with the investor.

For a given Π, the feasibility constraint

$$0 \leq \alpha \leq 1$$

also determines a lower bound on entrepreneur's wealth below which the entrepreneur cannot credibly offer a repayment α to the investor. Specifically,

$$\alpha \leq 1 \iff w \geq 1 - \frac{\Pi^2}{2rc_m} \equiv \widehat{w}.$$

If $\Pi \leq \sqrt{2rc_m}$ holds, which is condition C1 in the Lemma, then $\widehat{w}$ is not negative.

Finally, the entrepreneur's participation constraint determines the minimum level of wealth, $\widetilde{w}$, above which he is willing to undertake a costly process of project evaluation,

$$e^* \left\{m^*(1-\alpha)\Pi + (1-m^*)b\right\} + (1-e^*)r\widetilde{w} - c_e\frac{e^{*2}}{2} \geq r\widetilde{w}.$$

After substituting for the equilibrium values of m^*, e^*, and α, the expression above holds whenever $e(\widetilde{w}) \geq 0$ or

$$e(\widetilde{w}) = \frac{(b-r) + (\Pi - b)\sqrt{\frac{2r(1-\widetilde{w})}{c_m}} - r(1-\widetilde{w})}{c_e} \geq 0.$$

It can be shown that $e(\overline{w}) > 0$ for the parameter values satisfying Assumption 1, and $e(\widehat{w}) < 0$, if $\Pi < 2b$ and $(b-r) + (\frac{\Pi}{2} - b)\frac{\Pi}{c_m} < 0$. Since $e(\widetilde{w})$ is an increasing and concave function of w and reaches a maximum at $\overline{w}$, there always exists a $\widetilde{w} \geq \widehat{w}$ such that $e(\widetilde{w}) = 0$, and the entrepreneur with $w < \widetilde{w}$ prefers not to borrow. $\widetilde{w}$ is equal to $\widehat{w}$ if $b = r$ and $\Pi = 2b$. Denoting with $\underline{w} = \max\{\widehat{w}, \widetilde{w}\}$, we have the results summarized in the Lemma.

Proof of Proposition 1

(i) Proof that $m > 0$ and $e > 0$ in $w \in (\underline{w}, \overline{w})$.
Using the value of α given by (11) in the equilibrium level of monitoring (10), we have

$$m = \frac{\alpha\Pi}{c_m} = \sqrt{\frac{2r(1-w)}{c_m}} = \sqrt{\sigma(1-w)}, \quad \text{where } \sigma = \frac{2r}{c_m}.$$

It follows that m is a decreasing function of w in the interval $(\underline{w}, \overline{w})$. Moreover, at $\underline{w} = 1 - \frac{\Pi^2}{2rc_m}$, and $\overline{w} = 1 - \frac{(\Pi-b)^2}{2rc_m}$, monitoring is such that

$$m(\underline{w}) = \frac{\Pi}{c_m} > \frac{\Pi - b}{c_m} = m(\overline{w}) > 0.$$

Using (11) in (9), the equilibrium effort level is equal to

$$\begin{aligned} e(w) &= \frac{(b - rw + m(\Pi - b) - m\alpha\Pi)}{c_e} \\ &= \frac{((b-r) + (\Pi - b)\sqrt{\sigma(1-w)} - r(1-w))}{c_e}. \end{aligned}$$

Under Assumption 1, $e(w)$ is a concave and increasing function of w in $(\underline{w}, \overline{w})$,

$$e'(w) = r - \frac{(\Pi - b)\sqrt{2r/c_m}}{2\sqrt{1-w}}, \quad e'(\underline{w}) > 0, \quad e'(\overline{w}) = 0,$$

$$e''(w) = -\frac{(\Pi - b)r^2/c_m^2}{((1-w)2r/c_m)^{3/2}} < 0.$$

Moreover under Assumption 1, $e(\widehat{w}) \geq 0$ if $\Pi \geq 2b$, $e(\widetilde{w}) \geq 0$ by definition, and at $\overline{w}$,

$$e(\overline{w}) = \frac{(b-r)}{c_e} + \frac{(\Pi - b)^2}{2c_m c_e} > 0.$$

(ii) Proof that p is concave in $(\underline{w}, \overline{w})$, and has a maximum at $w^* \in (\underline{w}, \overline{w})$.
The level of productive investment is

$$p(e(w), m(w)) = em\Pi,$$

which, after replacing the equilibrium value of $m(w)$ and $e(w)$, can be written as

$$p(w) = \left((\Pi - b)\sigma(1-w) + (b-r)\sqrt{\sigma(1-w)} - r(1-w)\sqrt{\sigma(1-w)}\right)\frac{\Pi}{c_e}$$

or, more conveniently, as

$$p(w) = \left(\lambda\sigma(1-w) + \kappa\sqrt{\sigma(1-w)} - r(1-w)\sqrt{\sigma(1-w)}\right)\frac{\Pi}{c_e}, \qquad \text{(A1)}$$

where, by Assumption 1,

$$\lambda = (\Pi - b) > 0 \text{ and } \kappa = (b - r) \geq 0.$$

Equation (A1) is increasing in $\left[0, w^*\right]$ and decreasing in $\left[w^*, \overline{w}\right]$, where w^* is the root of

$$\frac{\partial p}{\partial w} = \left[\frac{3}{4} c_m \sqrt{\sigma(1-w)} - \left(\lambda + \frac{\kappa}{2\sqrt{\sigma(1-w)}}\right)\right] \frac{\Pi\sigma}{c_e} = 0,$$

i.e.,

$$w^* = \frac{9c_m^2\sigma^2 - 6c_m\sigma\kappa - 8\sigma\lambda^2 - 4\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4}}{9c_m^2\sigma^2} \equiv w^*(\underset{+}{c_m}, \underset{+}{r}, \underset{+}{b}, \underset{-}{\Pi}).$$

$p(w)$ is also a concave function in $w \in (0, \overline{w})$ since

$$\frac{\partial^2 p}{\partial w^2} = -\left(\frac{3c_m\sigma}{8\sqrt{\sigma(1-w)}} + \frac{\kappa}{4(\sigma(1-w))^{3/2}}\right) < 0.$$

I now show that for parameter values satisfying Assumptions 1 and 2,

$$\underline{w} < w^* < \overline{w}.$$

(iia) Proof that $w^* < \overline{w}$.
Recall that $\overline{w} = 1 - \frac{\lambda^2}{2rc_m}$. Hence,

$$w^* < \overline{w} = 1 - \frac{\lambda^2}{2rc_m},$$

if and only if

$$\frac{6c_m\sigma\kappa + 8\sigma\lambda^2 + 4\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4}}{9c_m^2\sigma^2} > \frac{\lambda^2}{2rc_m}$$

or

$$6c_m\sigma\kappa + 4\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4} > \lambda^2\sigma,$$

which is always true because

$$4\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4} > \lambda^2\sigma.$$

(iib) Proof that $w^* > \underline{w} = \max\{\widehat{w}, \widetilde{w}\}$.
It suffices to prove that $w^* > \widetilde{w}$, since by Assumption 1, $\widetilde{w} \geq \widehat{w}$.
$\widetilde{w}$ is the root of the entrepreneur's participation constraint,

$$(b-r) + (\Pi - b)\sqrt{\frac{2r(1-\widetilde{w})}{c_m}} - r(1-\widetilde{w}) = 0$$

or

$$\kappa + \lambda\sqrt{\sigma(1-\widetilde{w})} - \frac{c_m\sigma}{2}(1-\widetilde{w}) = 0,$$

which has the following solution:

$$\widetilde{w} = \frac{c_m^2\sigma^2 - 2c_m\sigma\kappa - 2\sigma\lambda^2 - 2\sqrt{2c_m\sigma^2\kappa\lambda^2 + \sigma^2\lambda^4}}{c_m^2\sigma^2} \equiv \widetilde{w}(\underset{+}{c_m}, \underset{+}{r}, \underset{+}{b}, \underset{-}{\Pi}).$$

Hence, $\widetilde{w} < w^*$ if

$$\frac{2c_m\sigma\kappa + 2\sigma\lambda^2 + 2\sqrt{2c_m\sigma^2\kappa\lambda^2 + \sigma^2\lambda^4}}{c_m^2\sigma^2} > \frac{6c_m\sigma\kappa + 8\sigma\lambda^2 + 4\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4}}{9c_m^2\sigma^2}$$

or

$$6c_m\sigma\kappa + 5\sigma\lambda^2 + 9\sqrt{2c_m\sigma^2\kappa\lambda^2 + \sigma^2\lambda^4} > 2\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4},$$

which holds true because $\sigma > 0$, $\kappa > 0$, $\lambda > 0$, and

$$9\sqrt{2c_m\sigma^2\kappa\lambda^2 + \sigma^2\lambda^4} > 2\sqrt{2}\sqrt{2c_m\sigma^2\kappa\lambda^2 + 2\sigma^2\lambda^4}.$$

(iii) Proof that $i = e$ and $y = em\Pi + e(1-m)b$ are monotonically increasing in $w \in \left(\underline{w}, \overline{w}\right)$.
It follows directly from (i) and (ii).

Proof of Lemma 2

When

$$b > (1-\alpha_t)\Pi\beta, \tag{A2}$$

Equations (17) and (18) imply that the optimal level of entrepreneurial effort and investor control are obtained by maximizing

$$u_E = (1-e_t)rw_t + e_t\left[m_t(1-\alpha_t)\Pi\beta + (1-m_t)b\right] - c_e\frac{e_t^2}{2} \tag{A3}$$

and

$$u_I = e_t\left\{m_t\alpha_t\Pi\beta + (1-m_t)\times 0 - c_m\frac{m_t^2}{2}\right\}.$$

The first-order conditions are

$$e_t = \min\left\{\frac{(b-rw_t) - m_t(b-(1-\alpha_t)\Pi\beta)}{c_e}, 1\right\} \tag{A4}$$

and

$$m_t = \min\left\{\frac{\alpha_t\Pi\beta}{c_m}, 1\right\}, \tag{A5}$$

where α_t is pinned down by the binding investor's break-even condition

$$\left\{m_t\alpha_t\Pi\beta + (1-m_t)\times 0 - c_m\frac{m_t^2}{2}\right\} = r(1-w_t)$$

or

$$\alpha_t(w_t) = \frac{\sqrt{2r(1-w_t)c_m}}{\Pi\beta} \leq 1. \tag{A6}$$

Replacing (A6) in (A5) and (A4), and assuming interior solutions, the equilibrium values of $m_t(w_t)$ and $e_t(m(w_t), w_t)$ can be rewritten as

$$m_t(w_t) = \sqrt{\sigma(1 - w_t)} > 0$$

and

$$e_t(m_t(w_t), w_t) = \frac{m_t\lambda - r(1 - w_t)}{c_e} > 0,$$

where $\sigma = \frac{2r}{c_m}$, and $\lambda = \Pi\beta - b > 0$.

In order to have positive investment, the entrepreneur's effort must be positive, which occurs when the level of net worth is not too low,

$$w_t > 1 - \frac{2\lambda^2}{rc_m} \equiv \underline{w}.$$

Moreover, an agency problem between the investor and the entrepreneur exists if the entrepreneur's net worth is not too high,

$$w_t < 1 - \frac{\lambda^2}{2rc_m} \equiv \overline{w}, \tag{A7}$$

where (A7) is obtained using (A2) and (A6). Condition (C2) in the Lemma ensures that $\underline{w} > 0$ and $\overline{w} < 1$. The conflict of interest vanishes when

$$b \le (1 - \alpha_t)\Pi\beta, \tag{A8}$$

or, using the expressions above, when $w_t \ge \overline{w}$. When (A8) holds, $m(w_t) = 0$ and maximization of (A3) subject to the investor's break-even condition leads to (19) in the text.

Proof of Lemma 3

The map

$$\phi(w_t) = (1 - w_t)\left[\sigma\lambda - r\sqrt{\sigma(1 - w_t)}\right]\delta \tag{A9}$$

is zero at $\underline{w} = 1 - \frac{2\lambda^2}{rc_m}$,

$$\phi(\underline{w}) = \frac{2\lambda^2}{rc_m}\left[\frac{2r}{c_m}\lambda - r\sqrt{\frac{2r}{c_m}\frac{2\lambda^2}{rc_m}}\right]\delta = 0.$$

Moreover, its first derivative

$$\phi'(w_t) = \left[\sqrt{(1 - w_t)}\frac{3r\sigma}{2\sqrt{\sigma}} - \sigma\lambda\right]\delta,$$

evaluated at $\underline{w}$

$$\phi'(\underline{w}) = \frac{r\lambda\delta}{c_m},$$

is larger than one if

$$c_m < r\lambda\delta,$$

which is condition (C3) in the Lemma. Hence, under this parameter restriction, the mapping starts at zero at $\underline{w}$ with a slope larger than one. Simple differentiation of (A9) gives $w^* = 1 - \frac{8\lambda^2}{9rc_m}$ as its critical point. Thus, $\phi(w_t)$ is strictly increasing for $w_t < w^*$ and strictly decreasing for $w_t > w^*$. At the maximum,

$$\phi(w^*) = \frac{8\lambda^2}{9rc_m}\left[\frac{2r}{c_m}\lambda - r\sqrt{\frac{2r}{c_m}\frac{8\lambda^2}{9rc_m}}\right]\delta = \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta.$$

The existence of at most one steady state of the map $w_{t+1} = \phi(w_t)$ in the range $(\underline{w}, \overline{w})$ is guaranteed by condition (C3), i.e., $c_m < r\lambda\delta$, and the fact the the function is single peaked.

Proof of Proposition 2

c_m and λ must satisfy conditions (29) and (30), which are rewritten for convenience:

$$\frac{2\lambda^2}{r} \leq c_m \leq r\delta\lambda, \qquad \text{(A10)}$$

$$\frac{2r}{3\sqrt{3}} \leq \lambda \leq \frac{r^2\delta}{2}. \qquad \text{(A11)}$$

(i) Proof of (a)–(c).
Condition (a), or equivalently Figure 4A, obtains if

$$1 - \frac{8\lambda^2}{9rc_m} > \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta,$$

which can be rewritten as

$$c_m^2 - \frac{8}{9}\frac{\lambda^2}{r}c_m - \frac{16}{27}\lambda^3\delta > 0. \qquad \text{(A12)}$$

Disregarding the negative root, the solution of (A12) is given by

$$c_m > \overline{c}_m,$$

where

$$\overline{c}_m = \frac{4}{9r}\left(\lambda^2 + \lambda^{3/2}\sqrt{\lambda + 8\delta r^2}\right). \qquad \text{(A13)}$$

Notice that

$$\overline{c}_m < r\delta\lambda \quad \text{for} \quad \lambda < \frac{81}{200}r^2\delta,$$

which is compatible with (A11).
Condition **(**b**)**, or Figures 4B and 4C, obtains if

$$1 - \frac{8\lambda^2}{9rc_m} > \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta \quad \text{or} \quad c_m < \overline{c}_m \qquad \text{(A14)}$$

and

$$1 - \frac{\lambda^2}{2r c_m} > \frac{\lambda^3}{2c_m^2}\delta,$$

which can be rewritten as

$$c_m^2 - \frac{\lambda^2}{2r}c_m - \frac{\lambda^3\delta}{2} > 0. \tag{A15}$$

Disregarding the negative root, the solution to (A14) and (A15) is given by

$$\underline{c}_m < c_m < \overline{c}_m,$$

where

$$\underline{c}_m = \frac{1}{4r}\left(\lambda^2 + \lambda^{3/2}\sqrt{\lambda + 8\delta r^2}\right) < \overline{c}_m. \tag{A16}$$

Condition **(c)**, or Figure 4D, is obtained if

$$1 - \frac{8\lambda^2}{9r c_m} > \frac{16}{27}\frac{\lambda^3}{c_m^2}\delta \quad \text{or} \quad c_m < \overline{c}_m$$

and

$$1 - \frac{\lambda^2}{2r c_m} < \frac{\lambda^3}{2c_m^2}\delta \quad \text{or} \quad c_m < \underline{c}_m.$$

Hence, condition (c) holds if

$$\frac{2\lambda^2}{r} < c_m < \frac{1}{4r}\left(\lambda^2 + \lambda^{3/2}\sqrt{\lambda + 8\delta r^2}\right),$$

where $\frac{2\lambda^2}{r}$ is the lower bound in (A10).

Notice that

$$\frac{2\lambda^2}{r} < \frac{1}{4r}\left(\lambda^2 + \lambda^{3/2}\sqrt{\lambda + 8\delta r^2}\right) \quad \text{for} \quad \lambda < \frac{r^2\delta}{6},$$

which is compatible with (A11).

(ii) Proof of (d)–(f).

Case **(d)** holds when (A12) is satisfied, which, rewritten in terms of λ, gives

$$\lambda^3 + \frac{3}{2}\frac{c_m}{\delta r}\lambda^2 - \frac{27}{16}\frac{c_m^2}{\delta} < 0. \tag{A17}$$

Similarly, case **(e)** holds when, rewritten in terms of λ, (A14)

$$\lambda^3 + \frac{3}{2}\frac{c_m}{\delta r}\lambda^2 - \frac{27}{16}\frac{c_m^2}{\delta} > 0$$

and (A15)

$$\lambda^3 + \frac{c_m}{\delta r}\lambda^2 - 2\frac{c_m^2}{\delta} < 0 \tag{A18}$$

hold.

Because it is not possible to obtain explicit solutions of (A17) and (A18), it is useful to consider the following graph, which plots c_m as a function of λ, for a given δ and r. In Figure 1A, the two tick lines refer to the upper and lower bounds

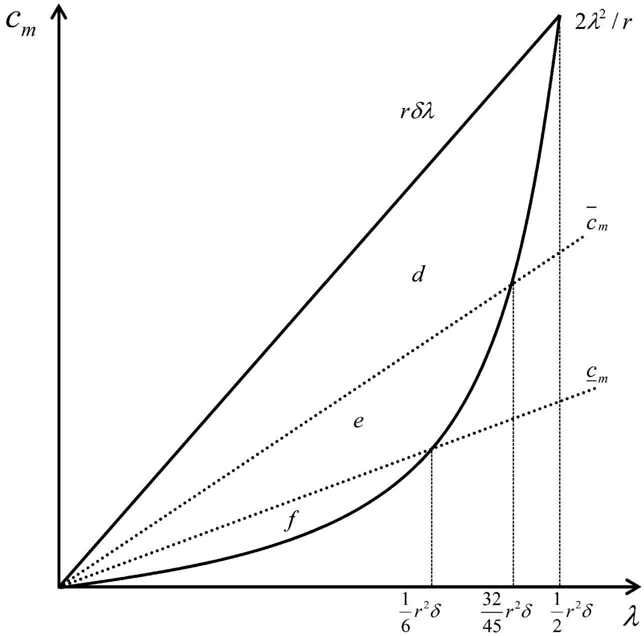

Figure 1A
Graphic proof of Proposition 2

on c_m, given by (A10). The two dotted lines refer to (A13) and (A16). As can be seen from the picture, fixing c_m in the admissible range and increasing λ, the economy moves from region (d) corresponding with Figure 4A (or case (d) in the Proposition) to region (e), corresponding with Figures 4B and 4C (or case (e) in the Proposition), eventually reaching region (f) discussed in Figure 4D (or case (f) in the Proposition).

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