

# Endogenous Credit Cycles\*

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## Abstract

I develop an overlapping-generations framework in which changes in lending standards generate endogenous cycles. In my economy, entrepreneurs who are privately informed about the quality of their projects need to borrow funds. Intermediaries screen entrepreneurs both through the amount of investment undertaken and through the level of entrepreneurial net worth.

I show that endogenous regime switches in financial contracts –from pooling to separating and vice-versa– may generate fluctuations even in the absence of exogenous shocks. When the economy is in the pooling (separating) regime, lending standards seem “lax” (“tight”) and investment is high (low). Differently from the existing literature, my model does not require entrepreneurial net worth to be counter cyclical or inconsequential for determining aggregate investment.

*Keywords: Adverse Selection, Cycles, Endogenous Fluctuations, Lending Standards, Screening*

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# 1 Introduction

Over the past two decades, a substantial body of research has sought to study the relationship between financial markets and macroeconomic fluctuations. Although encompassing a variety of different perspectives, this research has almost exclusively focused on the channels through which the financial system may amplify the effect of exogenous shocks. By focusing on the particular role of the financial system as an amplifier, this literature has been unable to account for a commonly expressed view among economists and policy makers: namely, that periods characterized by lax credit and rapid expansion of output and investment may themselves sow the seeds of a future downturn.

The goal of this paper is to provide a stylized model in which, absent any type of shocks, imperfections in financial markets are themselves a source of macroeconomic fluctuations. I study an overlapping-generations economy in which credit markets are characterized by the presence of adverse selection. Differently from the existing literature, my environment can be consistent with two widely accepted empirical regularities: greater net worth of borrowers leads on average to greater investment, and net worth is pro-cyclical. My main result is that, despite the absence of exogenous shocks, the economy can exhibit fluctuations that are purely generated by changes in lending standards. More precisely, the economy may exhibit periods of expansion in credit, investment, and entrepreneurial net worth that are followed by downturns in which investment, output, and entrepreneurial net worth contract.

In my economy, each generation is composed of households and entrepreneurs. Entrepreneurs need to borrow in order to finance their investment opportunities, regarding which they possess private information. Financial intermediaries seek to mitigate the asymmetry of information by offering a menu of contracts. In particular, financial intermediaries try to screen entrepreneurs through the amounts of collateral that they provide and of investment that they undertake. Depending on the level of entrepreneurial wealth, the credit market equilibrium may either entail pooling, so that all entrepreneurs borrow indistinctly at the same terms, or separation, so that different entrepreneurs borrow at different rates of collateralization, pay different rates of interest, and undertake different levels of investment. It is precisely these switches of regime, from pooling to separation and vice-versa, which may generate aggregate fluctuations even in the absence of exogenous perturbations.

When entrepreneurial wealth is low, screening is relatively costly in my economy since it must be predominantly done by restricting the amount of investment undertaken by good entrepreneurs. Hence, there is a strong tendency to pool all projects and have good entrepreneurs cross-subsidize

their bad counterparts. Whereas cross-subsidization implies that the pooling equilibrium is costly for good entrepreneurs, it also benefits them by allowing them to expand their investment. If the average quality of investment in the economy is above a certain threshold, pooling contracts yield a relatively high level of investment, future output and –more specifically– future entrepreneurial wealth.

As entrepreneurial wealth increases, though, the screening possibilities of intermediaries are enhanced, since they can increasingly screen through collateralization requirements. Eventually, intermediaries are able to design profitable contracts tailored to attract the most productive entrepreneurs from the pool. In this way, there is a “flight of quality” phenomenon by which the best entrepreneurs are lured away from the pooling equilibrium, which unravels into a separating regime and –in so doing– leads to a decrease in investment, future output, and future entrepreneurial net worth. Why does investment fall when the economy switches from a pooling to a separating regime? The investment of bad entrepreneurs must surely fall in this case, since they overinvest in the pooling equilibrium. As for good entrepreneurs, they must also decrease their level of investment: by definition, these entrepreneurs are indifferent between the pooling and the separating regimes at the switching point. But it is cheaper for them to borrow through separating contracts, because these contracts do not entail cross-subsidization. Hence, the only way in which good entrepreneurs can be indifferent between both regimes is if the separating contracts entail a lower level of investment than the pooling contracts do. When the economy switches from a pooling to a separating regime, then, investment and future output fall: if this fall is sufficiently large, the economy may revert to a pooling equilibrium and the process starts again.

It must be stressed that fluctuations in my setting are deterministic and arise in a fully rational environment. Evidently, this is in contrast to views by which fluctuations or instability are generated by some form of irrational behavior, as in the Keynesian concept of “animal spirits” or Kindleberger’s (1996) account of financial crises. It is interesting to note, however, that due to the pro-cyclicality of net worth, fluctuations in my economy could be observationally equivalent to some form of irrationality: an outside observer would see investment decrease in a context of increasing output and net worth and in the absence of any exogenous shock. In my model, though, regime switches between pooling and separating contracts may induce rational entrepreneurs to contract investment even as net worth increases.

Although the main objective of this paper is conceptual in nature, the mechanism behind endogenous fluctuations in my model is consistent with different strands of stylized evidence. In the first place, booms may revert into recessions in my framework even if entrepreneurial wealth is pro-cyclical and investment is on average increasing in net worth, both features that seem consistent with

empirical evidence.<sup>1</sup> This is in contrast with previous models dealing with endogenous reversion mechanisms in the presence of financial frictions, which require net worth to be either counter-cyclical or inconsequential for the allocation of credit.

An additional feature of my model that is consistent with stylized evidence is that my endogenous reversion mechanism is driven by changes in lending standards. For a long time, both policy makers and bankers have expressed the view that changes in bank lending standards play a crucial role in macroeconomic fluctuations,<sup>2</sup> and empirical studies tend to confirm this view. Although mostly interested in business cycle dynamics, the studies by Asea and Blomberg (1998) and Lown and Morgan (2006) document that bank lending standards in the United States change over the cycle and seem to have a significant effect on the dynamics of the latter. The former study, in particular, finds that “during booms asymmetric information in credit markets may cause good projects to draw in bad ones”, generating “the opposite of Akerlof’s celebrated Lemon’s principle.” This is consistent with the mechanism in my model, by which lending booms are possible insofar good projects cross-subsidize their bad counterparts.

## 1.1 Related Literature

This paper is related to different strands of literature. The modeling of adverse selection in credit markets is based on Martin (2008), which is in turn related to the work by Bester (1985, 1987), De Meza and Webb (1987), and Besanko and Thakor (1987). The crucial role played by the relationship between the net worth of borrowers and aggregate investment also relates this paper to Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). Both of these papers rest on the notion that, in the presence of asymmetric information regarding borrowers, loan contracts will entail the use of collateral and credit rationing. Thus, to the extent that net worth is pro-cyclical, shocks to the economy have a direct impact on the balance sheets of borrowers, thereby affecting the degree to which borrowing is constrained and the aggregate level of investment.

Recent work has analyzed mechanisms through which asymmetric information in credit markets may not just lead to the amplification of exogenous shocks, but may itself be a source of endogenous fluctuations. The papers by Suarez and Sussman (1997), Azariadis and Smith (1993), and Reichlin and Siconolfi (2004) fall within this category. In all of these models, though, fluctuations rely either on generating counter-cyclical dynamics for entrepreneurial net worth or on assuming that the latter plays no role in determining the equilibrium level of investment.

In the paper by Suarez and Sussman (1997), the emergence of endogenous cycles requires net

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<sup>1</sup>For evidence of procyclicality on profit margins and cash flows in UK manufacturing see Small (1997, 2000). For a survey on the evidence regarding the impact of net worth on investment, see Hubbard (1998).

<sup>2</sup>See, for example, Weinberg (1995).

worth to be counter-cyclical: when output is high, the relative price of the good produced by entrepreneurs falls and –along with it– so does their net worth in terms of inputs.<sup>3</sup> As Reichlin (2004) notes, however, net worth is thought to be pro-cyclical and empirical evidence on asset prices, profit margins, and cash flows supports this notion. In the papers by Azariadis and Smith (1993) and Reichlin and Siconolfi (2004), on the other hand, entrepreneurs either have no endowment or it plays no role in determining the allocation of credit. Once again, this is at odds with empirical findings by which investment seems to be significantly affected by firms’ net worth.

Two exceptions to the previous observations are Matsuyama (2007) and Figueroa and Leukhina (2008). Matsuyama (2007) studies an OLG economy in which credit-constrained entrepreneurs may choose to undertake different investment projects. One type of project yields a high return that is difficult to pledge, whereas another yields a low return that is highly pledgeable. When the net worth of entrepreneurs is very low, credit constraints tend to bind regardless of the type of project that is chosen: hence, entrepreneurs choose the high-return project. As the economy grows and net worth increases, though, the credit constraint ceases to bind first for the low-return project. For some parameter configurations, this might lead all entrepreneurs to undertake the low-return project when a certain level of net worth is reached, thereby generating a decrease in future output and net worth and possibly giving rise to endogenous fluctuations. As in my framework, then, the source of fluctuations in Matsuyama is the changing composition of investment. Differently from Matsuyama, though, the composition of investment in my economy varies not because of differences in the pledgeability of output across different technologies, but because of changes in lending standards brought about by competition among lenders. More recently, Figueroa and Leukhina (2008) develop a model in which –similarly to this paper– regime switches between pooling and separating equilibria give rise to endogenous fluctuations.

To conclude, I believe that the mechanism behind endogenous fluctuations in my framework arises naturally in a standard setting of adverse selection. Besides the aforementioned considerations regarding net worth, it is also the case that my mechanism does not rely on particular relative price changes or on assumptions regarding the mix of adverse selection and moral hazard. There are many similarities between my model and that of Reichlin and Siconolfi (2004), for example: the latter, however, relies on a particular mix between these two types of asymmetric information, which ultimately makes it difficult to identify the underlying assumptions that generate different effects. In this sense, my framework complements the existing literature by highlighting a new reversion mechanism that arises in the presence of adverse selection.

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<sup>3</sup>Although very different in its objective, the model by Aghion, Bacchetta and Banerjee (2004) relies on a similar mechanism.

The paper is structured as follows. Section 2 discusses the baseline model of the credit market. It contains a complete characterization of separating and pooling equilibria and of some properties of regime switches. Section 3 then embeds the model in an OLG framework, analyzes the dynamics of the economy under asymmetric information, and proves that shocks may be dampened or amplified by the financial system. Section 4 introduces a simplified version of the dynamic model and shows how the presence of asymmetric information may generate fluctuations in a setting that is otherwise characterized by a complete lack of dynamics. Finally, Section 5 presents a discussion on the main assumptions of the model and Section 6 concludes.

## 2 Basic Setup

Consider an economy with overlapping generations that live two periods: young and old. At any point in time, a new generation of measure one is born. The lifetime goal of the young is to maximize the expected old-age consumption of the economy's only final good. The young are endowed with one unit of labor, which they supply inelastically: hence, they work and save all of their labor income. In a manner that will be explained shortly, these savings are invested in the production of capital. For simplicity, capital is assumed to depreciate fully. The old, therefore, own the capital stock and live off their capital income. In each period, the labor supplied by the young is combined with the capital owned by the old to produce a consumption good according to a constant returns to scale technology denoted by

$$y_t = \theta g(1, k_{t-1}), \quad (1)$$

where  $g$  is a continuously differentiable and concave constant returns to scale function,  $k$  is per-capita stock of capital (and aggregate stock, due to the normalization on population size) and its subscript denotes the date of birth of the generation that owns it.

Both old and young are paid a competitive price for supplying their factors of production, so that the young receive,

$$w_t(k_{t-1}) = \theta [g(k_{t-1}) - k_{t-1}g'(k_{t-1})], \quad (2)$$

for their labor while the old receive

$$q_t(k_{t-1}) = \theta g'(k_{t-1}), \quad (3)$$

per unit of capital, where  $q_t$  denotes the marginal productivity of capital in the production of the final good at time  $t$ . Since the young save their entire income while the old consume it, total savings

and consumption in this economy are respectively equal to  $w_t$  and  $\theta g'(k_{t-1}) \cdot k_{t-1}$ .

The key aspect of the economy lies in the production of capital. Only a subset of the young population, that I refer to as entrepreneurs, has access to a technology for transforming the consumption good at time  $t$  into productive capital at  $(t + 1)$ . In particular, each generation is divided into a measure  $\lambda^G$  of “good” entrepreneurs, a measure  $\lambda^B$  of “bad” entrepreneurs, and a measure  $1 - (\lambda^G + \lambda^B)$  of households. Assumptions on entrepreneurial technology are as follows:

**Assumption 1** (Technology). *Entrepreneurs, which are uniformly distributed in the interval  $[0, (\lambda^G + \lambda^B)]$ , may be either of type  $B$  (“Bad”) or  $G$  (“Good”) depending on their technology. Entrepreneurs of each type are distributed over intervals of length  $\lambda^j$ ,  $j \in \{B, G\}$ , where  $\lambda^G + \lambda^B < 1$ . An entrepreneur of type  $j$  who is young at time  $t$  has a successful (unsuccessful) state at time  $(t + 1)$  with probability  $p^j$  ( $1 - p^j$ ), where  $p^G > p^B$ . If successful (unsuccessful), an entrepreneur of type  $j$  who invests  $I$  units of the consumption good at time  $t$  obtains a gross return of  $\alpha^j f(I)$  (zero) units of capital at time  $(t + 1)$ , where  $\alpha^G < \alpha^B$  and  $p^G \alpha^G > p^B \alpha^B$ . It is assumed that  $f(\cdot)$  is increasing, concave, and satisfies Inada conditions.*

There is then, in every period, a need for credit markets to channel resources to investment. Whereas entrepreneurs can invest their wage directly in the production of capital, households need to lend theirs if they are to consume anything during old age. This is potentially problematic if, as I assume shortly, an entrepreneur’s type is private information. It therefore becomes crucial to specify the workings of credit markets.

### 3 Credit Markets

In order to invest their savings, households need to lend to entrepreneurs. They do so indirectly through banks. There exists a finite number of banks that collect deposits from individuals and entrepreneurs and offer loan contracts to entrepreneurs. Banks are assumed to be risk neutral and competitive. On the deposit side, they take the gross interest factor on deposits  $r_t$  as given, and they Nash compete in the loan market by designing contracts that take the following form:

**Assumption 2** (Loan Contracts). *Entrepreneurs and banks sign a contract of the form  $(I_t, R_t, c_t)$ , where  $I_t$  is the amount of the consumption good borrowed and invested at time  $t$ ,  $R_t$  is the interest factor on the loan and  $c_t$  is the percentage of the loan that entrepreneurs must collateralize by using their own wealth. In the event of a successful state at time  $(t + 1)$ , entrepreneurs pay back the amount borrowed adjusted by the interest factor: otherwise, they default and the bank keeps the goods put up as collateral, the interest borne by them, and the residual value of the project. Finally,*

and without loss of generality, it is assumed that entrepreneurs do not invest their wage directly in the project: instead, they deposit it in the bank for a gross interest factor of  $r_t$ . This implies that the expected profit that a  $j$ -type entrepreneur obtains from loan contract  $(I_t, R_t, c_t)$  is given by

$$\pi^j(I_t, R_t, c_t) = p^j \cdot [q_{t+1}^e \cdot \alpha^j f(I_t) - R_t \cdot I] - (1 - p^j) \cdot (c_t \cdot I) \cdot r_t + r_t \cdot w_t, \quad (4)$$

where  $q_{t+1}^e$  denotes the expectations regarding  $q_{t+1}$  formed at time  $t$ .

I follow the adverse selection literature in making two assumptions regarding bank competition in the loan market. The first is a condition of no cross-subsidization, by which banks are not allowed to offer contracts that lose money in expectation. The second assumption is that of exclusivity, by which entrepreneurs can apply to at most one of the contracts offered. This assumption implies that entrepreneurs borrow only from one bank, implicitly assuming that banks can monitor contract applications made by entrepreneurs. It is also assumed that each bank gets the same share of total deposits and, if they design the same contract, they get the same share and composition of loan applications. Given Assumption 2, a bank's expected profit of accepting an application for a contract  $(I_t, R_t, c_t)$  from a type  $j$  entrepreneur are given by

$$p^j \cdot (R_t \cdot I_t) + (1 - p^j) \cdot (c_t \cdot I_t) \cdot r_t - r_t \cdot I_t. \quad (5)$$

### 3.1 Main Properties of Loan Contracts

In the present section, I discuss the main properties of loan contracts in a partial equilibrium setting, i.e., taking the interest rate  $r$  and the expected rental price of capital  $q^e$  as given.<sup>4</sup> In the absence of asymmetric information, the equilibrium is trivial. Letting  $\{(I_t^{B*}, R_t^{B*}, c_t^{B*}), (I_t^{G*}, R_t^{G*}, c_t^{G*})\}$  denote the equilibrium contracts under full information, it is straightforward to verify that they satisfy

$$\left. \begin{aligned} f(I_t^{j*}) &= \frac{r}{q^e \cdot \alpha^j p^j} \\ p^j \cdot R_t^{j*} + (1 - p_t^j) \cdot c_t^{j*} \cdot r &= r \end{aligned} \right\} \text{for } j \in \{G, B\}. \quad (6)$$

Hence, under full information, good entrepreneurs invest more than bad ones and banks break even in both contracts. Investment is independent of entrepreneurial wealth  $w_t$ : if entrepreneurs have no wealth, they simply repay everything in the event of success by setting  $R_t^{j*} = (r/p^j)$  for  $j \in \{G, B\}$ .<sup>5</sup>

<sup>4</sup>This section is based on Martin (2008), which contains all of the formal proofs. For the convenience of the reader, I reproduce much of the discussion regarding the main results and their implications.

<sup>5</sup>To be precise, the economy under full information displays many equilibria, all of which entail the same level of investment and are equivalent in terms of efficiency (see Martin (2008)).



Now consider the case of asymmetric information, in which banks are not able to distinguish among different types of borrowers. As in Besanko and Thakor (1987) and Reichlin and Siconolfi (2004), it is assumed that borrowers' types cannot be observed either directly or through realized project returns. Hence, all agents other than the owner of the project can only verify whether the latter was successful or not. In such a scenario it is known that the optimal contractual form is that of debt as assumed in Assumption 2.<sup>6</sup>

Under asymmetric information, I follow Hellwig (1987) and model competition in the credit market as having three stages. In the first stage, banks design contracts: in the second stage, entrepreneurs apply for these contracts and, in the third stage, banks decide whether to accept or reject these applications. This specification is useful because it avoids problems of existence that may otherwise arise in games of screening à la Rothschild-Stiglitz. As Hellwig shows, it implies that the allocation most preferred by good entrepreneurs emerges as the robust sequential equilibrium of the model. In other words, the most robust outcome of the aforementioned game form will be the separating contracts insofar as they provide good entrepreneurs with higher profits than any pooling contracts. On the contrary, if there are pooling contracts that are Pareto superior to the separating contracts, the one mostly preferred by good entrepreneurs will emerge as the most robust equilibrium of the model.

Keeping this in mind, I now characterize the equilibrium contracts for an economy indexed by a triple  $(r, q^e, w_t)$ . As will be shown, entrepreneurial wealth plays a crucial role in determining whether the resulting equilibrium entails separation or pooling of all entrepreneurs in the loan market.

### 3.1.1 Separating Equilibria

Under the assumptions of exclusivity and no cross-subsidization, a separating equilibrium is defined as follows.

**Definition 1.** *Given  $(r, q^e, w_t)$ , a separating equilibrium is a set of contracts  $C^{SEP}(r, q^e, w_t) = \{(I_t^B, R_t^B, c_t^B), (I_t^G, R_t^G, c_t^G)\}$  satisfying the following conditions:*

1. *Feasibility: contracts must respect the collateralization constraint,*

$$c_t^j \in [0, \frac{w_t}{I_t^j}] \text{ for } j \in \{B, G\}. \quad (7)$$

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<sup>6</sup>In a more general environment, Boyd and Smith (1993) show that debt can arise as the optimal contractual form under adverse selection and costly state verification provided that verification costs are sufficiently high.

2. *Incentive Compatibility: each entrepreneur applies to the contract designed for his type,*

$$\pi^j(I_t^j, R_t^j, c_t^j) \geq \pi^j(I_t^i, R_t^i, c_t^i) \text{ for } i \neq j, i, j \in \{B, G\}. \quad (8)$$

3. *Zero profit condition for banks: each contract must yield banks zero profits in expectation,*

$$r = p^j R_t^j + (1 - p^j) r c_t^j \text{ for } j \in \{B, G\}. \quad (9)$$

4. *No bank can profit by offering alternative contracts.*

Definition 1 is completely standard. The following proposition, adapted from Martin (2008), characterizes the resulting contracts:

**Proposition 1.** *Given  $(r, q^e, w_t)$ , the separating equilibrium is characterized by a pair of contracts  $C^{SEP}(r, q^e, w_t) = \{(I_t^B, R_t^B, c_t^B), (I_t^G, R_t^G, c_t^G)\}$  satisfying,*

$$(I_t^B, R_t^B, c_t^B) = (I_t^{B*}, \frac{r}{p^B}, 0), \quad (10)$$

$$\alpha^G p^G f'(I_t^G) > \frac{r}{q^e} \Rightarrow c_t^G = \frac{w_t}{I_t^G}, \text{ and}, \quad (11)$$

$$c_t^G = \frac{[q^e \cdot \alpha^B p^B f(I_t^G) - \frac{p^B}{p^G} I_t^G \cdot r] - [q^e \cdot \alpha^B p^B f(I_t^B) - I_t^B \cdot r]}{(1 - \frac{p^B}{p^G}) I_t^G \cdot r} \leq 1. \quad (12)$$

Proposition 1 contains a well-known result: in a separating equilibrium, the allocation of bad entrepreneurs will not be distorted. It is the good entrepreneurs, in order to access a lower interest rate, who must bear the cost of separation. How is this done? In this model, separation can be attained either by asking good entrepreneurs to provide higher levels of collateral or by restricting the amount of investment that they undertake.

Consider first the case of collateral. To the extent that it is available, it provides a costless way of screening entrepreneurs. This is because different types of entrepreneurs differ in their willingness to accept a higher interest factor in exchange for a lower collateral requirement. As long as the constraint in Equation 7 is slack, banks can always decrease  $R_t^G$  and increase  $c_t^G$  while keeping the expected profit of the contract unchanged for good entrepreneurs: such a modification, though, increases the cost of the contract for bad entrepreneurs because they stand to lose their collateral more often. In fact, it can be easily verified that –for any level of  $r$  and  $q^e$ – the marginal rate of substitution between the interest factor  $R$  and the collateral requirement  $c$  is equal to  $[r(1 - p^j)/p^j]$  for an entrepreneur of type  $j$ .

Hence, a separating equilibrium in this economy has good entrepreneurs pledging all of their wealth as collateral and then borrowing the maximum amount that they can in an incentive-compatible manner. Naturally, if entrepreneurs have no wealth, separation becomes very costly since it must be solely attained by restricting the investment of good entrepreneurs.<sup>7</sup> By the same token, increases in entrepreneurial wealth enhance the possibility of separating through rates of collateralization and therefore lead to an expansion in  $I_t^G$ . Eventually, for high enough values of  $w_t$ , there is enough collateral to attain separation without distorting investment and  $I_t^G = I_t^{G*}$ .

### 3.1.2 Pooling Equilibria

Of course, the equilibrium does not necessarily entail separation. I have already mentioned that Hellwig's characterization allows for the existence of a pooling equilibrium whenever it Pareto dominates the separating contracts of Proposition 1. A pooling equilibrium is defined as follows,

**Definition 2.** *Given  $(r, q^e, w_t)$ , a pooling equilibrium is a contract  $C^{POOL}(r, q^e, w_t) = \{(\bar{I}_t, \bar{R}_t, \bar{c}_t)\}$  satisfying the following conditions:*

1. *Feasibility: the pooling contract must respect the collateralization constraint.*
2. *Zero profit condition for banks: when offered to a pool of applicants representative of the population, the contract must yield banks zero profits in expectation.*
3. *No bank can profit by offering alternative contracts.*

Pooling equilibria entail cross-subsidization from good types to bad types. The extent of such transfers, though, ultimately depends on the wealth of entrepreneurs and on the rate of collateralization. Proposition 2, adapted from Martin (2008), characterizes pooling equilibria in my economy.

**Proposition 2.** *Given  $(r, q^e, w_t)$ , a pooling equilibrium is given by a contract  $C^{POOL}(r, q^e, w_t) = \{(\bar{I}_t, \bar{R}_t, \bar{c}_t)\}$  satisfying,*

$$p^G \alpha^G f'(\bar{I}_t) = \frac{p^G}{\bar{p}} \cdot \frac{r}{q^e}, \quad (13)$$

$$\bar{R}_t = r \cdot \left[ \frac{1 - (1 - \bar{p})\bar{c}_t}{\bar{p}} \right], \quad (14)$$

$$\bar{c}_t = \frac{w_t}{\bar{I}_t}, \quad (15)$$

where  $\bar{p} = (\lambda^G p^G + \lambda^B p^B) / (\lambda^G + \lambda^B)$  denotes the average probability of success of all projects in the economy.

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<sup>7</sup>It can be shown that when  $w_t = 0$ ,  $I_t^G < I_t^B$ .

Equation (15) implies that a pooling equilibrium must entail a binding collateralization constraint and, consequently, that the degree of cross-subsidization it exhibits depends on entrepreneurial wealth. This follows from the fact that higher rates of collateralization decrease the average cost of funds for good entrepreneurs and hence increase their profits. Entrepreneurial wealth does not, however, affect the level of investment undertaken in the pooling equilibrium. The reason for this is that the marginal cost of borrowing an extra unit is always  $[p^G/\bar{p}] \cdot r$  for good entrepreneurs, and therefore Equation (13) must hold.

### 3.1.3 Equilibrium Contracts and Investment

Let  $C^{EQ}(r, q^e, w_t)$  denote the equilibrium contracts for an economy indexed by  $(r, q^e, w_t)$ : will these contracts be pooling or separating? As discussed before, the answer to this question depends on the profits that each type of contract yields good entrepreneurs. And this, in turn, depends on the level of entrepreneurial wealth.

When entrepreneurial wealth is low, separation is particularly costly because it must be attained by distorting  $I^G$ . Indeed, it can be shown that, insofar as the mix of good to bad entrepreneurs is above a certain threshold, the equilibrium will be pooling when entrepreneurs have no wealth. In particular, this is the case whenever  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$ . If entrepreneurial wealth is increased, though, the cost of separation decreases until eventually a separating equilibrium emerges.

What happens to aggregate investment when the economy switches from pooling to separation? As long as  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$ , investment drops when the switch takes place. The intuition for this is rather simple. If good entrepreneurs are relatively abundant in the economy, investment in the pooling equilibrium tends to reflect their technology: in particular, investment in the pooling equilibrium is higher than the optimal investment of bad entrepreneurs, so that  $\bar{I}_t(r, q^e) > I_t^B(r, q^e)$ . Hence, a switch from a pooling to a separating equilibrium contracts the investment undertaken by bad entrepreneurs. But it contracts the investment undertaken by good entrepreneurs as well. At the switching point, good entrepreneurs are by definition indifferent between the pooling and the separating contracts. The pooling contract, however, provides funds at a higher cost, since it entails cross-subsidization. Hence, indifference can only hold if the separating contract provides a lower amount of funds: formally, if  $w^*(r, q^e)$  denotes the switching point or level of wealth at which the equilibrium switches from pooling to separating, it must be the case that  $\bar{I}_t(r, q^e) > I_t^G(r, q^e, w^*(r, q^e))$ . Under the assumption that  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$  the investment function is thus discontinuous at the switching point.

The following lemma, adapted from Martin (2008), summarizes this discussion.

**Lemma 1.** *If  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$  then,*

1.  $C^{EQ}(r, q^e, 0) = C^{POOL}(r, q^e, 0)$  for all values of  $r$  and  $q^e$ .
2. For each pair  $(r, q^e)$ , there exists a unique switching point  $w^*(r, q^e)$  such that,

$$\begin{aligned} w_t < w^*(r, q^e) &\Leftrightarrow C^{EQ}(r, q^e, w_t) = C^{POOL}(r, q^e, w_t), \\ w_t > w^*(r, q^e) &\Leftrightarrow C^{EQ}(r, q^e, w_t) = C^{SEP}(r, q^e, w_t). \end{aligned}$$

3. Aggregate investment is discontinuous at the switching point  $w^*(r, q^e)$ , so that,

$$\bar{I}_t(r, q^e) > I_t^G(r, q^e, w^*(r, q^e)) > w^*(r, q^e) > I_t^B(r, q^e, w^*(r, q^e)).$$

## 4 Regime Switching and Endogenous Cycles

Building on the previous analysis of the credit market, it is now possible to characterize the equilibrium of the overlapping generations economy. In any given period, the timing of events is assumed to be as follows: at the beginning of the period, the projects undertaken by the old yield the economy's stock of capital. Production of the final good then takes place by combining this capital with the labor of the young. Finally, the old pay back their debts and the young make their savings and investment decisions, where composition of investment is determined according to the equilibrium contracts analyzed in the previous section.

Before proceeding, I make three additional assumptions:

1. Under full information, the economy has a unique, stable steady state. Although it is well known that this need not be the case in economies with overlapping generations, the reasons for this are irrelevant for the purpose of this paper.
2. It is assumed that  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$ , so that all of the results in Lemma 1 apply.
3. The economy may borrow or lend any amount of the consumption good at a fixed rate given by  $r$ . This assumption, which delivers a framework nearly identical to that used in Bernanke and Gertler (1989) for analyzing the financial accelerator, is useful in simplifying the analysis.<sup>8</sup> As I will explain shortly, it implies that both the full information economy and

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<sup>8</sup>Alternatively, I could have directly followed Bernanke and Gertler (1989) and assumed that; a) the economy has a storage technology with a return of  $r$  and; b) that the proportion of entrepreneurs in the total population is sufficiently small so as to guarantee that –for any level of  $q$ – aggregate supply of funds exceeds aggregate demand. This would also deliver a cost of funds fixed at  $r$ .

the asymmetric information economy under the pooling regime exhibit no dynamics. The former implication is useful because it provides a clear benchmark against which to compare my results, whereas the latter greatly simplifies the analysis of regime switches and allows for a clearer presentation of the mechanism at work.

With this basic setup in mind, I will now formalize the discussion by defining an intertemporal equilibrium.

**Definition 3.** *For a given initial value  $w_0$ , an intertemporal equilibrium of the asymmetric information economy is defined as a trajectory*

$$\{k_t, w_t, q_{t+1}^e, r_t, C^{EQ}(w_t, q_{t+1}^e) : t \geq 0\}$$

such that, for all  $t$ :

1. *Contracts are given by  $C^{EQ}(r_t, q_{t+1}^e, w_t)$  as characterized in Section 3.1.3*
2. *Labor and capital market clearing conditions (i.e., Equations (2) and (3)) are satisfied*
3.  $q_{t+1}^e = q_{t+1}$

The present section proceeds as follows. First, I show that neither the full information benchmark or the asymmetric information economy under the pooling regime exhibit dynamics. I then characterize the dynamics of the asymmetric information economy under the separating regime. Finally, I analyze the properties of regime switches and show how the adverse selection economy may fluctuate in the absence of exogenous perturbations.

#### 4.1 Full Information Benchmark and Pooling Regime Dynamics

Under full information, the equilibrium of the economy is trivial. At any point in time  $t$ , investment in both sectors must satisfy Equation (6), so that their marginal productivities are equalized,

$$\alpha^G p^G f'(I_t^{G*}) = \alpha^B p^B f'(I_t^{B*}) = \frac{r_t}{q_{t+1}^e}.$$

By perfect foresight,  $q_{t+1}^e$  must satisfy

$$q_{t+1}^e = \theta g'(k_t^*(r_t, q_{t+1}^e)),$$

while  $k_t^*(q_{t+1}^e, r_t)$  is defined as

$$k_t^*(r_t, q_{t+1}^e) = \lambda^G \alpha^G p^G f(I_t^{G*}(r_t, q_{t+1}^e)) + \lambda^B \alpha^B p^B f(I_t^{B*}(r_t, q_{t+1}^e)).$$

The previous conditions show that the amount of investment at time  $t$  and the resulting stock of capital are independent of state variables. Consequently, my assumption regarding the existence of a unique, stable steady state in the full information economy implies that the latter converges in one period to the said steady state regardless of initial conditions. I henceforth denote the steady state values of capital and factor prices in the full information economy by  $\{k^*, w^*, q^*\}$ .

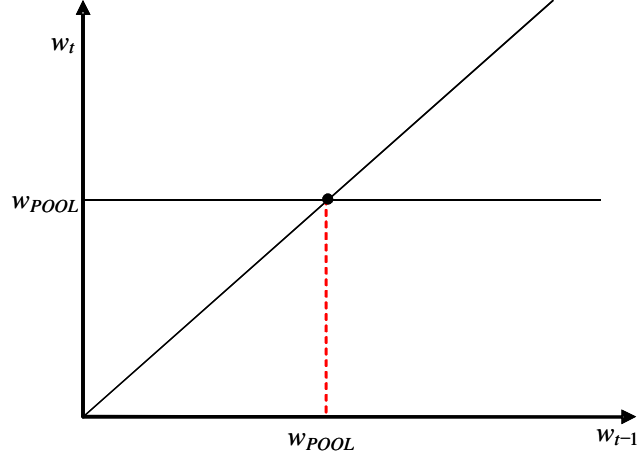
This consideration also applies to the asymmetric information economy under the pooling regime. In fact, time  $t$  wages do not play any role in determining the size of the pooling loan at time  $t$ , which from Equation (13) is defined implicitly by

$$\alpha^G p^G f'(\bar{I}_t) = \frac{r}{q_{t+1}^e} \frac{p^G}{\bar{p}},$$

where  $q_{t+1}^e$  and  $k_{t,POOL}(q_{t+1}^e, r_t)$  must satisfy

$$\begin{aligned} q_{t+1}^e &= \theta g'(k_{t,POOL}(r_t, q_{t+1}^e)), \\ k_{t,POOL}(r_t, q_{t+1}^e) &= [\lambda^G \alpha^G p^G + \lambda^B \alpha^B p^B] f(\bar{I}_t(r_t, q_{t+1}^e)). \end{aligned}$$

Since the size of the pooling loan depends only on parameters of the economy and on  $q_{t+1}^e$ , once again, the capital stock of an economy in the pooling regime is immediately pinned down. Thus, as in the case of the full-information economy, there is a unique, stable steady state to which the economy converges in one period: I denote the steady state values of capital and factor prices in the asymmetric information economy under the pooling regime by  $\{k_{POOL}, w_{POOL}, q_{POOL}\}$ . The following figure displays the pooling dynamics in the  $(w_{t-1}, w_t)$  space: for any value of  $w_{t-1}$ ,  $w_t = w_{POOL}$  and the economy therefore “jumps” to the steady state regardless of initial conditions.



Wage Dynamics under Pooling Contracts

## 4.2 Separating Regime Dynamics

In both the full information economy and the asymmetric information economy under the pooling regime, investment is independent of wages. Under a separating regime, current investment in the good technology is increasing in current wages, and future wages are in turn increasing in the former. This generates a direct relationship between current and future wages.

In this scenario, loan sizes  $\{I_{t,SEP}^B(r_t, q_{t+1}^e), I_{t,SEP}^G(r_t, q_{t+1}^e, w_t)\}$  must be such that  $I_{t,SEP}^B(r_t, q_{t+1}^e)$  is implicitly defined by

$$\alpha^B p^B f'(I_{t,SEP}^B) = \frac{r}{q_{t+1}^e},$$

while  $I_{t,SEP}^G(r_t, q_{t+1}^e, w_t)$  is determined by the incentive compatibility and zero profit conditions as in Proposition 1. Once again,  $q_{t+1}^e$  and  $k_{t,SEP}(r_t, q_{t+1}^e, w_t)$  must satisfy

$$\begin{aligned} q_{t+1}^e &= \theta g'_k(1, k_{t,SEP}(r_t, q_{t+1}^e, w_t)), \\ k_{t,SEP}(r_t, q_{t+1}^e, w_t) &= [\lambda^G \alpha^G p^G f(I_{t,SEP}^G(r_t, q_{t+1}^e, w_t)) + \lambda^B \alpha^B p^B f(I_{t,SEP}^B(r_t, q_{t+1}^e))]. \end{aligned}$$

In the separating regime, then, the asymmetric information economy displays dynamics because the equilibrium level of investment depends on wages and hence on the capital stock. It can be readily shown that, under the separating regime, the economy might display a unique, stable steady state or multiple steady states: I focus on the former case for simplicity, although my results are not restricted to this scenario. I denote the steady state values of capital and factor prices in the asymmetric information economy under the separating regime by  $\{k_{SEP}, w_{SEP}, q_{SEP}\}$ .

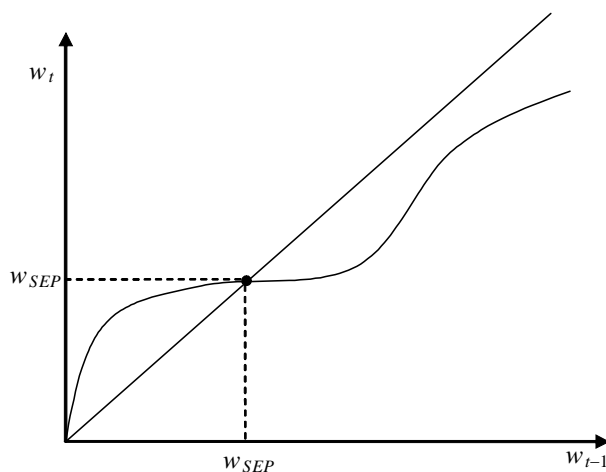
The following figure illustrates the dynamics of the asymmetric information economy under the



separating regime. Throughout the analysis, it is assumed that

$$w_{SEP} < w_{POOL}, \tag{16}$$

meaning that the steady state of the economy under the separating regime is lower than that under the pooling regime. Such an economy always exists, since Equation (16) basically implies that the pooling regime is highly productive with respect to the separating regime. This is a natural outcome, for example, in an environment with a high average quality of entrepreneurs and a low proportion of entrepreneurs with respect to the total population.<sup>9,10</sup> This last feature makes the separating allocation relatively unproductive since it minimizes the importance of wages as collateralizable wealth.



Wage Dynamics under Separating Contracts

#### 4.2.1 Switch of Regimes and Cycles

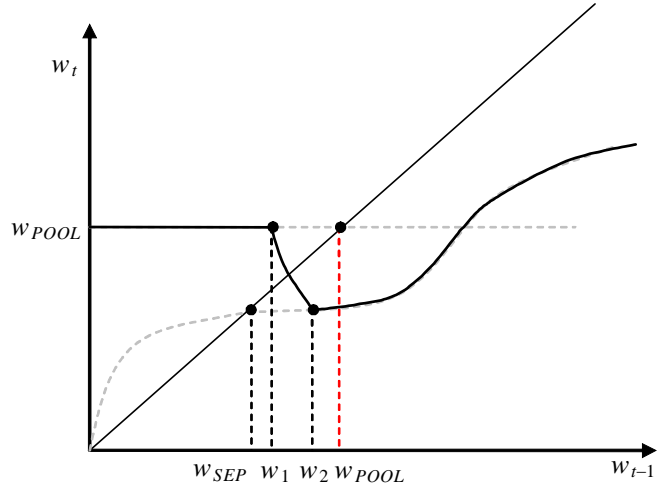
I now address the issue of regime switches. The following proposition identifies their existence. In particular, it establishes that there is a partition of the wage space into three distinct regions and that the economy either pools, separates or mixes between both regimes depending on the region at which it finds itself. It is of interest to remark that the proposition is independent of the

<sup>9</sup>If entrepreneurs represent a small fraction of the total population, entrepreneurial wealth tends to be very low relative to investment: in such an economy, the pooling equilibrium tends to be substantially more productive than the separating one.

<sup>10</sup>Although my results regarding fluctuations do require the existence of one steady state under the separating regime for which Equation (16) is satisfied, they would not be substantially affected by the existence of additional steady states for which this is not the case. If these additional steady states were to exist, they would clearly affect the global dynamics of the economy. However, the existence of the oscillatory steady state to which I refer in the following section would still be possible.







Wage Dynamics under Case 3:  $w_{SEP} < w_2$  and  $w_{POOL} > w_1$

Case 3 is the one that is of interest to us. In such a scenario, an economy that has no dynamics under full information displays fluctuations in the presence of adverse selection. The main intuition behind this case is fairly simple: for low levels of wages, the separating contracts yield relatively low profits to good entrepreneurs and hence the economy will pool loans. By pooling, investment and hence future output and wages expand, increasing the future level of entrepreneurial wealth: if this increase is sufficiently large with respect to the switching wages of the economy, the resulting equilibrium will entail partial or total separation in the loan contracts and a consequent fall in output. The latter, in turn, will decrease entrepreneurial wealth thereby increasing the degree of pooling, which in turn expands output and so on.

In order to better characterize my result, I must prove that an economy satisfying Case 3 does in fact exist. I do so by showing that such an economy can be constructed from any economy originally satisfying Cases 1 or 2. This is possible because the mapping specifying switching points, which determines the price of capital at which good entrepreneurs are indifferent between the pooling and separating contracts for a given wage level, is independent of the production function of the final good and of the absolute measure of the population. The steady state levels of wages under the pooling and separating regimes, on the other hand, are not. By exploiting this feature it is then possible to transform any original economy into an alternative one satisfying  $w_{SEP} < w_2$  and  $w_{POOL} > w_1$ .

**Proposition 4.** *There is a nonempty set of economies for which  $w_{SEP} < w_2$  and  $w_{POOL} > w_1$ .*

*Proof.* See Section 7.3 in the Appendix. □

I provide an economic intuition for the way in which the proof works. Suppose first that I start from an economy in Case 1: loosely speaking, wage levels are relatively low in terms of equilibrium investment, so that it is optimal to pool loans for a wide range of wages. This feature can be altered by perturbing the production function of the final good so as to make labor more productive with respect to capital. Such a modification tends to increase the level of entrepreneurial wealth with respect to the optimal level of investment and, in so doing, increases the relative appeal of separating contracts. Consequently  $w_1$  diminishes relative to the steady state levels of wages.

An opposite exercise can be done in the case of an economy satisfying Case 2: in such a scenario, steady state wages are high relative to the equilibrium level of investment and hence separating contracts are particularly appealing. A possible perturbation of this economy consists in expanding the labor supply by increasing the measure of households in the economy while preserving that of entrepreneurs. Such a modification induces an increase in the equilibrium price of capital and a decrease in equilibrium wages or—in terms of my contracts—entrepreneurial wealth tends to decrease with respect to the optimal level of investment. Consequently,  $w_1$  expands as pooling contracts become relatively more attractive while the steady state levels of wages contract.

The intuition behind this discussion is clear: fluctuations in my setting arise from regime switches in the credit market. To the extent that—in the underlying economy—entrepreneurs are consistently “too poor” (Case 1) or “too wealthy” (Case 2) in relation to the optimal level of investment, no regime switches will take place. As is usually the case in this class of models, then, the most interesting dynamics arise for intermediate levels of wealth. I have thus constructed an environment in which the full information economy exhibits no dynamics. Once I introduce asymmetric information, though, there is a class of economies that will exhibit fluctuations: some will converge to the steady state in an oscillatory manner, whereas others will fluctuate permanently.

## 5 Robustness

In this section, I would like to briefly discuss the implications of relaxing the main simplifying assumptions adopted throughout the paper. For simplicity of exposition and in order to compare my results with a well-known benchmark, I have analyzed the possibility of endogenous cycles in an economy in which the interest rate is fixed. Allowing for a variable interest rate would not invalidate my qualitative results, although it would be necessary for the supply of savings to display a positive elasticity with respect to the interest rate. The reason for this is intuitive: if all of the economy’s resources are invested regardless of the interest rate, an increase in wages must necessarily lead to an increase in investment and in future wages. Hence, cycles cannot arise endogenously. If, on

the other hand, savings are increasing in the interest rate, this need not be the case. When an increase in wages brings about a switch of regime, the interest rate falls and with it the amount of funds available for investment, giving rise to the possibility of endogenous cycles similar to the ones analyzed in Section 4.

Perhaps the most important assumption made throughout the paper is that agents live only for two periods. If they were to be infinitely lived, the results would greatly depend on the assumption regarding the persistence of entrepreneurial types. If entrepreneurial types were assumed to be persistent across time, constrained optimal contracts would be substantially more complicated than the ones analyzed here. In this case, it is not clear which of my results could still be valid. I could, however, adopt a more conventional approach in which entrepreneurs are randomly assigned a new type each time they undertake a new project or, as in Bernanke, Gertler and Gilchrist (1999), that the level of anonymity in the credit market is sufficiently high as to preclude long-term contracts. In such a specification of the model, my results could be valid although some additional issues would have to be considered:

1. First, an economy populated by infinitely lived entrepreneurs would endogenously generate a distribution of entrepreneurial wealth. In terms of my contracting problem, I conjecture that this would not pose great difficulties. It could be dealt with by expanding the set of equilibrium contracts to a continuum indexed by levels of collateral. Hence, it would be the case in equilibrium that some wealth levels entailed pooling whereas others entailed separation.
2. Second, the existence of endogenous cycles would require substantial qualifications in the case of infinitely lived agents. In the OLG specification, there is a pecuniary externality at work, by which today's entrepreneurs do not take into account the effect of their investment decisions in tomorrow's net worth. In a model with infinitely lived agents, a switch from pooling to separating would have an ambiguous impact on net worth, increasing the net revenues stemming from current production but decreasing those derived from tomorrow's labor. In order for my results to go through without any modifications, the second effect should outweigh the first. A different approach would consist in eliminating all labor income so that, at each point in time, entrepreneurial net worth is given by past profits. Such a specification would, in principle, still allow for the possibility of endogenous cycles, since a contraction in investment at the switching point would increase the wealth of good entrepreneurs but decrease that of their bad counterparts, thus having an ambiguous effect on total entrepreneurial wealth and hence on investment.

## 6 Discussion and Concluding Remarks

Before concluding, I briefly discuss some implications of the general model. As the analysis of Section 2 has shown, when the economy is in the separating regime, investment is increasing in entrepreneurial net worth. This prediction, which is consistent with the empirical evidence relating credit frictions to investment, arises in my setting because of adverse selection.<sup>11</sup> This latter feature has the additional implication that, unlike traditional models of the financial accelerator, the link between net worth and investment may vary according to the state of the economy. Bernanke, Gertler and Gilchrist (1999), for example, document that the investment of firms is more sensitive to net worth or internal finance when the economy is in a recession: this is consistent with the dynamic model developed in Section 3, in which drops in output coincide with a separating regime in the credit market.

An additional implication of the dynamic model developed in Section 3 is that changes in lending standards should be closely related to changes in the level of economic activity. This, as I mentioned before, is in line with the empirical evidence documented by Asea and Blomberg (1998) and –more recently– by Lown and Morgan (2006), both of which find that changes in bank lending standards are significant determinants of economic activity. This view has also been expressed by policy makers and bankers in general, including the President of the Federal Reserve Board and the Comptroller of the Currency.<sup>12</sup>

Asea and Blomberg, for example, provide evidence on the pro-cyclicality of loan sizes and the counter-cyclicality of rates of collateralization. An interesting aspect of their paper is that they associate periods of “lax” lending standards with periods in which the variance of interest rates charged by banks is low: on the contrary, periods of “tight” credit are associated with a higher variance on the interest rates charged by banks. It is an interesting feature of this model that interest rates behave in this manner, not because of exogenous changes in the quality of investment opportunities, but as a consequence of endogenous regime switches in the credit market.

To conclude, I refer to two aspects of the model that I consider particularly interesting. The first is that, even if I abstract from regime switches, the financial system may dampen exogenous shocks in this model. Although not developed formally for lack of space, this result hinges on the following observation.<sup>13</sup> Consider a closed economy that is in the separating regime, and that is exposed to a positive productivity shock:<sup>14</sup> in such an economy, both entrepreneurial net worth

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<sup>11</sup>Once again, for a survey on the evidence regarding the impact of net worth on investment, see Hubbard (1998).

<sup>12</sup>See Weinberg (1995).

<sup>13</sup>A discussion on financial dampening in the context of this model can be found in a previous version of this paper (Martin (2005)).

<sup>14</sup>Consider, for example, that the economy developed in Section 3 is exposed to an increase of TFP in the production

and total savings will increase. Whereas the former effect makes it possible for good entrepreneurs to expand their investment (thereby amplifying the positive shock) the latter effect may go in the opposite direction. The reason is that, in a closed economy, the new savings must be absorbed by someone. If the investment of good entrepreneurs cannot expand fast enough due to a binding incentive compatibility constraint, the investment of bad entrepreneurs will have to expand –in so doing– will decrease the average productivity of investment and dampen the effect of the shock.

What is particularly interesting about this result is that it can only arise in the context of a closed economy, in which contracts must not only be incentive compatible but must also clear the market for loans. In the previous example, it is the need for market clearing that may lead to a more than proportional expansion in bad investment and to the subsequent decrease in average productivity. In an open economy with an exogenously given interest rate this can never happen and the traditional result, by which shocks are amplified through the financial system, is restored. Thus, in this framework, it is possible for the financial system to change from a dampener to an amplifier of shocks when a small economy opens its capital market. I believe this feature of the model to be potentially appealing in light of the recent debate regarding financial liberalization and macroeconomic instability.<sup>15</sup>

A second aspect of interest that I would like to mention, and that is consistent with previous research, is that fluctuations in this framework are ultimately driven by the presence of perfect competition in credit markets.<sup>16</sup> Regime switches in my economy are generated by competitive banks that stand to gain by “luring” good entrepreneurs either to pooling or to separating contracts. It can be shown that, if the financial system were made up of a single monopolist intermediary, such regime switches would never occur in equilibrium. The reason is that a monopolist bank could offer contracts that, while separating between good and bad entrepreneurs, would nonetheless entail cross-subsidization from the former to the latter:<sup>17</sup> since these contracts would be neither purely pooling nor purely separating, there would be no stark regime switches between these two allocations. On the contrary, changes in entrepreneurial net worth would lead a monopolist bank merely to adjust the optimal degree of cross-subsidization.

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of the final good.

<sup>15</sup>See, for example, Kose, Prasat and Rogoff (2003).

<sup>16</sup>Similar results that rely on the ability of monopolistic banks to extract the entire borrower surplus can be found in Besanko and Thakor (1987) and in Dell’Aricia and Marquez (2006).

<sup>17</sup>It can be shown that a monopolist could maximize profits by offering a loan in two steps. It would first lend a given amount to all entrepreneurs. Once entrepreneurs have received this, it would separate among them by asking those who want additional funds to pledge the ones they have already received as collateral. Note that, when all funds are considered, both cross-subsidization and separation would be present in such an allocation.



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## 7 Appendix

### 7.1 Proof of Proposition 3

*Proof.* The proof is constructive and is divided into four steps. I first evaluate the pairs  $(w_t, q_{t+1}^e)$  that constitute an equilibrium under the separating regime. I then analyze the combinations of  $w_t$  and  $q_{t+1}^e$  that make good entrepreneurs indifferent between the pooling and separating contracts. Finally, I characterize the pairs  $(w_t, q_{t+1}^e)$  that constitute an equilibrium under the pooling regime and I use my construction to prove the proposition.

**Step 1:** Suppose first that at time  $t$  equilibrium loan contracts are separating. From Proposition 1, separating contracts define a monotonically decreasing function:

$$q_{t+1}^e = S^{EQ}(w_t)$$

which determines the equilibrium price of capital tomorrow as a function of today’s wage. Let

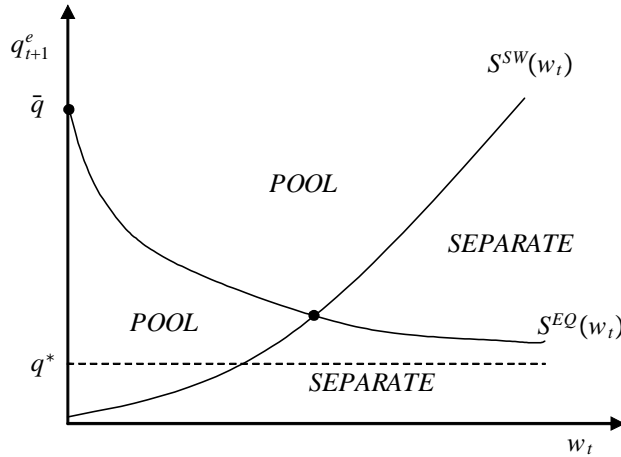
$$\begin{aligned} \bar{q} &= S^{EQ}(0) \\ q^* &= S^{EQ}(\bar{w}) \end{aligned}$$

so that  $\bar{q}$  denotes the equilibrium price of capital at time  $t+1$  under the separating contracts without any entrepreneurial wealth and  $q^*$  denotes the equilibrium price of capital under full information.

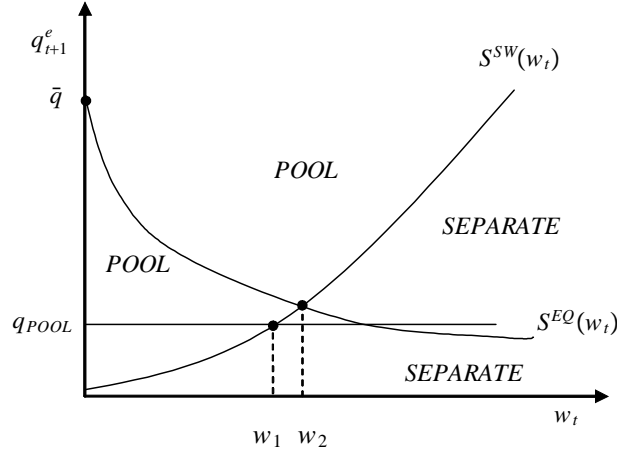
**Step 2:** A second relationship between  $(w_t, q_{t+1}^e)$ , which I denote by

$$q_{t+1}^e = S^{SW}(w_t)$$

determines, for each wage level  $w_t$ , the expected price of capital at which good entrepreneurs are indifferent between the pooling and the separating regimes. From Lemma 1, this mapping is a function. As is shown below (Section 7.2), moreover, it is an increasing function since at the switching points; a) higher values of wages increase the relative profitability of separating contracts, while; b) from Lemma 1,  $\bar{I} > I_{SEP}^G$  so that a higher expected price of capital increases the relative profitability of pooling contracts. Given  $w_t$ , good entrepreneurs prefer pooling contracts whenever  $q_{t+1}^e > S^{SW}(w_t)$  and prefer separating contracts otherwise. The following figure summarizes the discussion so far.



**Step 3:** I characterize the pooling equilibrium in terms of the previous figure. From my previous discussion, the price of capital under the pooling equilibrium is constant and equal to  $q_{POOL}$ . Suppose that the expected price of capital under the separating regime is also  $q_{POOL}$ : I argue that, in such a case, the optimal contracts must be separating. This stems from the observation that, if the supply of capital is the same under the pooling and the separating regimes, the latter must entail greater (lower) investment by good (bad) entrepreneurs and no cross subsidization: hence, the separating regime must yield good entrepreneurs higher profits and must therefore be an equilibrium. Graphically, then,  $q_{POOL}$  must lie below the intersection of  $S^{EQ}(w_t)$  and  $S^{SW}(w_t)$ , as the following figure shows:



Determination of Switching Wages ( $w_1, w_2$ )

**Step 4:** I define  $w_1$  and  $w_2$  implicitly by

$$\begin{aligned} q_{POOL} &= S^{SW}(w_1) \\ S^{EQ}(w_2) &= S^{SW}(w_2) \end{aligned}$$

and prove the proposition by using my construction.

For any wage below  $w_1$  the equilibrium contracts can only be pooling. For any such wage level, the equilibrium price of capital lies above  $S^{EQ}$  under both the pooling and separating regimes, and hence pooling contracts constitute in fact an equilibrium.

For any wage above  $w_2$ , on the other hand, the equilibrium contracts can only be separating. Once again, for any such wage level, the equilibrium price of capital lies below  $S^{EQ}$  under both the pooling and separating regimes, and hence separating contracts constitute in fact an equilibrium.

Consider now wage levels between  $w_1$  and  $w_2$ . In such a scenario, equilibrium contracts can be neither pooling nor separating, and will involve randomization between the two. To see this, note that if contracts are separating, the equilibrium price of capital is such that there are incentives to pool. On the other hand, if contracts are pooling, the equilibrium price of capital is such that there are incentives to separate. Thus, the only possible equilibrium involves randomization between both contracts so that –at the expected price of capital– good entrepreneurs are indifferent between the two. I follow Reichlin and Siconolfi (2004) and define random contracts as an array

$$\{\omega, (I^B, R^B, c^B), (I^G, R^G, c^G), (\bar{I}, \bar{R}, \bar{c})\},$$

where  $\omega \in [0, 1]$  and the contract triples are as previously defined. With randomization, competition can be modeled as follows:

1. Firms apply to a lottery that randomizes between a pooling contract and pair of separating contracts.
2. The lottery realization determines whether the applicant is entitled to a pooling or a separating contract.
3. If the lottery realization determines that the applicant is entitled to a separating contract, the applicant decides whether to receive the  $G$ - or the  $B$ -type contract.

The introduction of random contracts does not change the characteristics of optimal contracts. Whenever the optimal contract is separating (pooling) among the set of deterministic contract, so it is in the set of random contracts. For the switching value of  $q_{t+1}^e$  that yields as optimal both the pooling and the separating contracts, the set of optimal contracts coincides with the latter together with an indeterminate probability  $\omega$ . Hence, the introduction of random contracts is, from an efficiency point of view, irrelevant. It is, however, relevant from an equilibrium point of view, because the indeterminacy of  $\omega$  and the law of large numbers provide a natural randomization device that restores market clearing.  $\square$

## 7.2 Slope of Indifference Mapping $S^{SW}(w_t)$

In the present subsection I show that there is a positive relationship between the levels of entrepreneurial wealth and the expected rental prices of capital that make good entrepreneurs indifferent between pooling and separating contracts. I start from this indifference condition,

$$\begin{aligned} q^e \alpha^G p^G f(I^G(q^e, r, W^*(r, q^e))) - r I^G(q^e, r, W^*(r, q^e)) = \\ q^e \alpha^G p^G f(\bar{I}(r, q^e)) - r \bar{I}(r, q^e) \frac{p^G}{\bar{p}} - [1 - \frac{p^G}{\bar{p}}] r W^*(r, q^e), \end{aligned}$$

which allows us to obtain the following expression for  $W^*(r, q^e)$ :

$$\frac{q^e \alpha^G p^G f(I^G(q^e, r, W^*(r, q^e))) - r I^G(q^e, r, W^*(r, q^e)) - q^e \alpha^G p^G f(\bar{I}(r, q^e)) + r \bar{I}(r, q^e) \frac{p^G}{\bar{p}}}{[\frac{p^G}{\bar{p}} - 1]r} = W^*(r, q^e).$$

Differentiation yields

$$\frac{r[q^e \alpha^G p^G f'(I^G) - r] \frac{\alpha^B p^B [f(I^B) - f(I^G)]}{q^e \alpha^B p^B f'(I^G) - \frac{p^B}{p^G} r} + \alpha^G p^G [f(I^G) - f(\bar{I})]}{r[\frac{p^G}{\bar{p}} - 1] - [q^e \alpha^G p^G f'(I^G) - r] \frac{dI^G}{dW}} = \frac{dW^*}{dq^e}$$

When  $\bar{I} > I^G$  (as at the switching point under my assumptions) the numerator in the previous Equation is negative. The denominator can be signed by noting that, at the switching point,

$$\alpha^G p^G f'(I^G) > \frac{p^G}{\bar{p}} \frac{r}{q^e}$$

whereas incentive compatibility implies that

$$\frac{dI^G}{dW} = \frac{[1 - \frac{p^B}{p^G}]r}{q^e \alpha^B p^B f'(I^G) - \frac{p^B}{p^G} r} \gtrless 1 \Leftrightarrow I^G \gtrless I^B$$

These two conditions jointly imply that the denominator is negative whenever  $\bar{I} > I^G$ , which allows us to conclude that

$$\bar{p} > \frac{\alpha^B p^B}{\alpha^G} \Leftrightarrow \frac{dW^*}{dq^e} > 0.$$

### 7.3 Regime Switching and Fluctuations

*Proposition 4.* In order to prove the proposition, I start as in the main body of the paper by assuming an arbitrary economy in which  $w_{POOL} > w_{SEP}$ . I perturb this economy by changing the productivities of capital and labor in the production of the final good and the measure of households. Both of these modifications affect the relationship between  $w$  and  $q$  at equilibrium without affecting the mapping  $S^{SW}(w_t)$ , which characterizes the pairs  $(w_t, q^e)$  that make good entrepreneurs indifferent between the pooling and separating contracts.

In order to simplify the presentation, I assume that the final good is produced by a Cobb-Douglas production function of the form

$$Y_t = \theta K_t^{1-\alpha} L_t^\alpha, \tag{17}$$

and consider first an economy that is initially in Case 1, so that  $w_{POOL} \leq w_1$ . I show that we can construct an alternative economy in which  $w_{SEP} < w_1 < w_{POOL}$ . I perturb Equation (17) by increasing the productivity of labor  $\alpha$  and the total factor productivity parameter  $\theta$  so as to keep capital demand constant. Since the demand for capital is given by its marginal productivity, note

that it is increasing in  $\theta$  and decreasing in  $\alpha$ . Hence, I choose pairs  $(\alpha_n, \theta_n)$  so that

$$\alpha_n > \alpha \text{ and } \theta_n > \theta,$$

for all  $n$  while also satisfying

$$\left[ \frac{\theta_n(1 - \alpha_n)}{\theta(1 - \alpha)} \right]^{\frac{1}{\alpha_n - \alpha}} = \left( \frac{K_{POOL}}{L} \right)$$

so that the marginal productivity of capital is preserved at  $K = K_{POOL}$ , and therefore the equilibrium of the capital market under the pooling regime is not altered. In the labor market,  $w_{POOL}$  must necessarily increase, since the price of labor relative to capital must increase and the latter is kept constant. Note additionally, that  $w_{POOL}$  can be increased arbitrarily in this manner, since at equilibrium it must be that

$$\frac{w_{POOL}}{q_{POOL}} = \frac{\alpha_n}{(1 - \alpha_n)} \left( \frac{K_{POOL}}{L} \right)$$

An economy perturbed in this way will then experience an increase in the steady state value of wages under the pooling regime while keeping constant  $w_1$ , which is unaffected since neither  $q_{POOL}$  nor the relationship  $S^{SW}(w_t)$  as defined in the main body of the paper are modified.

The only thing left to verify is that  $w_{POOL}$  can in this way be increased beyond  $w_1$  while preserving the ordering of steady states by which  $w_{POOL} > w_{SEP}$ . It is easy to verify that a perturbation of the economy like the one proposed above can either decrease or increase  $w_{SEP}$ . In the former case there is no problem, since the relative ordering of the steady state wages are preserved. In the latter case, though, it must be checked that  $w_{POOL}$  increases beyond  $w_1$  before  $w_{SEP}$  does. This I argue by contradiction: suppose, to the contrary, that in carrying out the perturbation  $w_{SEP}$  increases to the level of  $w_{POOL}$  before the latter surpasses  $w_1$ . This cannot be the case, since it would imply that there is an economy with a steady state wages

$$\tilde{w} = w_{SEP} = w_{POOL} < w_1$$

so that both regimes produce the same amount of capital but good entrepreneurs prefer nonetheless to pool. Due to my assumption by which  $\bar{p} > \frac{\alpha^B p^B}{\alpha^G}$ , however, this can never happen, since a scenario in which both regimes produce the same amount of capital must necessarily imply that the separating contracts are preferred by good entrepreneurs.

On the other hand, consider an economy that is initially in Case 2, so that  $w_{SEP} > w_2$ . In this case, I perturb the economy by increasing the measure of households while preserving those of good and bad entrepreneurs. By doing so, I expand the supply of labor which –at equilibrium–



decreases wages and increases the price of capital  $q$  by expanding the demand for this factor. Consequently,  $w_{SEP}$  and  $w_{POOL}$  are contracted whereas  $q_{SEP}$  and  $q_{POOL}$  increase. Note once again that increasing the measure of households has no effect on the pairs  $(w_t, q_{t+1})$  of switching points, so that the increase in  $q_{POOL}$  and  $q_{SEP}$  unambiguously increases  $w_1$  and  $w_2$ . By perturbing the economy in this manner, both steady state wages can be reduced below the switching wages: eventually, it must then be that

$$w_{SEP} < w_{POOL} < w_1 < w_2$$

since otherwise there would be wage levels  $w < w_1$  for which separating contracts produce higher levels of capital but are nonetheless dominated by their pooling counterparts. Such a perturbation would then transform a Case 2 economy into a Case 1 economy, which as I showed before can itself be perturbed to yield a Case 3 economy.  $\square$