

# International Capital Flows and Credit Market Imperfections: a Tale of Two Frictions <sup>☆</sup>

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## Abstract

The financial crisis of 2007-08 has underscored the importance of adverse selection in financial markets. This friction has been mostly neglected by macroeconomic models of financial imperfections, however, which have focused almost exclusively on the effects of limited pledgeability. In this paper, we fill this gap by developing a standard growth model with adverse selection. Our main results are that, by fostering unproductive investment, adverse selection: (i) leads to an increase in the economy's equilibrium interest rate, and; (ii) it generates a negative wedge between the marginal return to investment and the equilibrium interest rate. Under financial integration, we show how this translates into excessive capital inflows and endogenous cycles. We also extend our model to the more general case in which adverse selection and limited pledgeability coexist. We conclude that both frictions complement one another and show that limited pledgeability exacerbates the effects of adverse selection.

*Keywords:* Limited Pledgeability, Adverse Selection, International Capital Flows, Credit Market Imperfections

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## 1. Introduction

In recent years, two important developments have spurred renewed interest in the macroeconomic effects of financial frictions: global imbalances and the financial crisis of 2007-08. In the case of global imbalances, financial frictions have been invoked to account for the large and persistent capital flows from Asia to the United States and other developed economies (e.g. Caballero et al. 2008). According to this explanation, the ultimate reason behind these capital flows is that – being subject to financial frictions – Asian financial markets have been unable to supply the assets required to channel their high savings towards productive investment. Hence, these savings have flowed to developed financial markets in which these assets could be supplied. In the case of the financial crisis of 2007-08, financial frictions have also been invoked to explain the run-up to the crisis and the unfolding of events during the crisis itself (e.g. Bernanke 2009, Brunnermeier 2009). In most of these explanations, however, financial frictions are cast in an entirely different light: instead of constraining the supply of assets, thereby limiting the amount of resources that can be channeled towards productive investment, they are portrayed as the source of an excessive supply of assets that has channeled too many resources towards unproductive investment.

How can these conflicting views of financial frictions be reconciled with one another? To answer this question, we must begin by acknowledging that each of these views has a different type of friction in mind. On the one hand, underprovision of assets and limited investment are typically attributed to limited pledgeability. This friction arises when the enforcement of contracts is imperfect, in the sense that there are limits to the resources that creditors can seize from debtors in the event of default. On the other hand, overprovision of assets is typically attributed to some form of asymmetric information regarding the quality of borrowers, which fuels investment by unproductive or inefficient individuals. This friction leads to adverse selection, in the sense that it provides incentives for relatively inefficient individuals to invest. Since markets in the real world are jointly characterized by some measure of limited pledgeability and some degree of adverse selection, both views are useful to understand reality. But how do they interact with one another? How does adverse selection affect the size and direction of capital flows in the presence of pledgeability constraints? How do these capital flows in turn affect the inefficiencies associated to adverse selection? Answering these questions is essential to understand recent events. Yet they cannot be addressed with existing macroeconomic models, which focus mostly on limited pledgeability while neglecting adverse selection. To address them, we need a stylized model that brings adverse selection to the foreground.

The goal of this paper is to provide such a model. In particular, we develop a standard growth model in which credit markets intermediate resources between savers and investors in capital accumulation. Individuals are endowed with some resources and an investment project for producing capital, and they

must decide whether: (i) to undertake their project and become entrepreneurs, in which case they demand funds from credit markets, or; (ii) to forego their project and become savers, in which case they supply their resources to credit markets. Crucially, it is assumed that the quality of investment opportunities differs across individuals, so that it is in principle desirable for the most productive among them to become entrepreneurs and for the least productive among them to become savers. To give adverse selection a central role in credit markets, however, we also assume that an individual's productivity is private information and thus unobservable by lenders. What are the main consequences of this assumption for macroeconomic outcomes?

The first-order implication of adverse selection is that, by preventing lenders from distinguishing among different types of borrowers, it induces cross-subsidization between high- and low-productivity entrepreneurs. The reason for this is simple. Precisely because lenders cannot observe individual productivity, all borrowers must pay the same contractual interest rate in equilibrium. This implies that high-productivity entrepreneurs, who repay often, effectively face a higher cost of funds than low-productivity entrepreneurs, who repay only seldom. It is this feature that gives rise to adverse selection by providing some low-productivity individuals, who would be savers in the absence of cross-subsidization, with incentives to become entrepreneurs. There are thus two clear macroeconomic implications of adverse selection: (i) by boosting equilibrium borrowing and investment, it leads to an increase in the economy's equilibrium interest rate, and; (ii) by fostering inefficient entrepreneurship, it generates a negative wedge between the marginal return to investment and the equilibrium interest rate.

We show that both of these implications have important consequences for capital flows when we allow the economy to borrow from and/or lend to the international financial market. First, through its effect on the equilibrium interest rate, adverse selection induces the economy to attract more capital flows than it otherwise would: relative to the full-information economy, then, the presence of adverse selection boosts net capital inflows from the international financial market. In particular, since the marginal return to investment lies below the world interest rate, these capital inflows can lead to a fall in aggregate consumption. Second, since the extent to which it distorts individual incentives depends on the state of the economy, adverse selection exacerbates the volatility of capital flows, capital accumulation and output.

This last point warrants some discussion. In our economy, for a given interest rate, the incentives of less productive individuals to become entrepreneurs are strongest when the capital stock and income are low: it is precisely in this case that they are most heavily cross-subsidized by productive entrepreneurs, since a substantial fraction of investment needs to be financed through borrowing. Under these conditions, then, adverse selection exerts a strong boost on investment, capital accumulation and capital inflows. As the economy's capital stock and income increase, however, the extent of cross-subsidization decreases: individuals become wealthier, an increasing fraction of their investment must be financed with their own resources and entrepreneurship loses its appeal for less productive individuals. Economic growth therefore softens the overinvestment

induced by adverse selection and its impact on investment, capital accumulation and capital inflows languishes. We show how, through this mechanism, adverse selection generates endogenous boom-bust cycles in which capital inflows fuel periods of positive capital accumulation and high growth that are followed by periods negative capital accumulation and economic contraction.

A first contribution of our paper is thus to develop a stylized dynamic model to characterize the macroeconomic effects of adverse selection. And these effects turn out to be the exact opposite of the ones stressed in the literature for the case of limited pledgeability. The latter is the standard friction in existing models, which assume that borrowers are capable of diverting part of the project's proceeds and this places a limit on the resources that creditors can appropriate in the event of a default. There are two clear macroeconomic implications that are recurrent in the literature: (i) by constraining equilibrium borrowing and investment, limited pledgeability leads to a decrease in the economy's equilibrium interest rate, and; (ii) by preventing efficient investment from being undertaken, limited pledgeability generates a positive wedge between the marginal return to investment and the equilibrium interest rate. Clearly, the contrast between these implications of limited pledgeability and our findings for the case of adverse selection extend to the open economy as well. Our results thus complement the existing literature and provide a more accurate picture of the relationship between financial frictions and the macroeconomy.

Real-world credit markets are not characterized solely by adverse selection or by limited pledgeability, however, but rather by a mixture of the two. In this sense, the benchmark models discussed above are particular cases of a more general framework in which both frictions coexist. A second contribution of our paper is to build such a framework by introducing limited pledgeability into our baseline model of adverse selection. Intuition might suggest that, if one friction tends to boost investment while the other one tends to constrain it, both of them should somehow offset one another. We find however that there is a sense in which limited pledgeability and adverse selection exacerbate one another so that, if anything, the inclusion of the former makes the consequences of the latter more severe.

The reason for this “complementarity” between the two frictions is intuitive. Binding pledgeability constraints reduce investment and lower the equilibrium interest rate; but a low interest rate decreases the returns to savings and induces unproductive individuals to become entrepreneurs, exacerbating adverse selection. The ultimate result is the combination of a low interest rate and a large and relatively unproductive pool of potential borrowers, which in our setting requires rationing to attain market-clearing. The interaction of both frictions is therefore more harmful than either one of them on its own, which either boosts or constrains total investment but does not affect the order in which projects are financed. The combination of both frictions instead does, so that – for each given level of investment – the average productivity of financed projects falls. The reason is that, due to credit rationing, those projects actually financed are randomly selected out of a larger pool of potential borrowers.

Our paper is related to the large body of research that studies the macroe-

conomic effects of financial frictions. This literature, which goes back to the contributions of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997), stresses the role of borrowing constraints for macroeconomic outcomes. Of this literature, we are closest in interest and focus to the branch that has extended the analysis to open economies, studying the effects of contracting frictions on the direction and magnitude of capital flows. Most of these papers illustrate how contracting frictions, such as limits to investor protection, can restrict an economy’s ability to borrow from the international financial market, thereby generating capital outflows even in capital-scarce or high-productivity economies. Gertler and Rogoff (1990), Boyd and Smith (1997), Matsuyama (2004) and Aoki et al. (2009) fall within this category. Castro et al. (2004) study how the gains from improving investor protection are affected by financial openness. Similar models have been used recently to account for global imbalances. In Caballero et al. (2008), for example, high-growing developing economies may experience capital outflows due to pledgeability constraints that restrict their supply of financial assets.<sup>3</sup> In Mendoza et al. (2007), it is instead the lack of insurance markets in developing economies that fosters precautionary savings and the consequent capital outflows.<sup>4</sup> To the best of our knowledge, however, we are the first to analyze the implications of adverse selection for international capital flows as well as its interaction with pledgeability constraints.<sup>5</sup>

In its modeling of asymmetric information, our paper is related to the work on adverse selection by Bester (1985, 1987), DeMeza and Webb (1987), and Besanko and Thakor (1987). Of these, our model is closest to DeMeza and Webb (1987), in which adverse selection also fosters overinvestment. In the implications of adverse selection for volatility our model is related to Martin (2008), who also shows how this type of friction can give rise to endogenous cycles.<sup>6</sup>

The paper is organized as follows. Section 2 presents the basic setup. Section 3 studies the dynamics of the closed economy when credit markets are characterized by adverse selection and it extends these results to the inclusion of limited pledgeability. Section 4 studies the dynamics of the economy under

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<sup>3</sup>Ferraris and Minetti (2007) consider economies where foreign lenders do not just supply savings but also bring their own “liquidation” technology to the domestic market. In the interpretation adopted here and in most of the papers mentioned above, the “liquidation” technology is instead considered to be specific to the country of the borrower, capturing the institutional features that govern transactions among all agents operating in that economy.

<sup>4</sup>In a somewhat related vein, Castro et al. (2009) show how weak investor rights might generate underinvestment in the relatively risky production of capital goods thereby reducing output in steady state

<sup>5</sup>Mankiw (1986) shows that asymmetric information can disrupt the functioning of credit markets. Differently from him, adverse selection in our model interacts with limited pledgeability in a dynamic setting, both under financial autarky and international financial integration.

<sup>6</sup>In this regard, our paper is also related to the endogenous cycle literature, albeit less directly. Martin (2008) provides a brief discussion of this literature. Of these papers, perhaps the ones closest to ours are Reichlin and Siconolfi (2004) and Aghion, Bachetta and Banerjee (2004), the last of which stresses the link between financial frictions and volatility in small-open economies.

financial integration, doing it first for the case of pure adverse selection and then extending these results to the inclusion of limited pledgeability. Finally, Section 5 concludes.

## 2. Basic setup

Consider an economy inhabited by overlapping generations of young and old, all with size one. We use  $J_t$  to denote the set of individuals born at time  $t$ . Time starts at  $t = 0$  and then goes on forever. All generations maximize the expected consumption when old so that  $U_t = E_t c_{t+1}$ ; where  $U_t$  and  $c_{t+1}$  are the welfare and the old-age consumption of generation  $t$ .

The output of the economy is given by a Cobb-Douglas production function of labor and capital:  $y_t = F(l_t, k_t) = l_t^{1-\alpha} \cdot k_t^\alpha$  with  $\alpha \in (0, 1)$ , and  $l_t$  and  $k_t$  are the economy's labor force and capital stock, respectively. All generations have one unit of labor which they supply inelastically when they are young, i.e.  $l_t = 1$ . The stock of capital in period  $t + 1$  is produced through the investment made by generation  $t$  during its youth.<sup>7</sup> In order to ensure that financial markets have an important role to play, we assume that individuals differ in their ability to produce capital.

In particular, individuals in each generation are indexed by  $j \in J_t$  and they are uniformly distributed over the unit interval. Each of them is endowed with an investment project of fixed size, which requires  $I$  units of output at time  $t$ . The project of individual  $j \in J_t$  succeeds with probability  $p_j = j \in [0, 1]$ , in which case it delivers  $A \cdot I$  units of capital in period  $t + 1$ . With probability  $1 - p_j$ , the project of individual  $j \in J_t$  fails and it delivers nothing.

In this setting, the capital stock at  $t + 1$  depends not only on the total investment made in period  $t$ , but also on the productivity of such investment. In particular, if we let  $A_t$  denote the average productivity of investment in period  $t$ , we can write the law of motion of capital as:

$$k_{t+1} = A_t \cdot s_t \cdot k_t^\alpha, \quad (1)$$

where  $s_t$  is the investment rate, i.e. the fraction of output that is devoted to capital formation.<sup>8</sup> Markets are competitive and factors of production are paid the value of their marginal product:

$$w_t = w(k_t) = (1 - \alpha) \cdot k_t^\alpha \text{ and } q_t = \alpha \cdot k_t^{\alpha-1}, \quad (2)$$

where  $w_t$  and  $q_t$  are the wage and the rental rate of capital, respectively.

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<sup>7</sup>We assume that that capital fully depreciates in production. We also assume that the first generation found some positive amount of capital to work with, i.e.  $k_0 > 0$ .

<sup>8</sup> $A_t$  denotes the average units of capital produced per each unit invested by the economy's entrepreneurs. Note that  $A_t$  ultimately depends on the expected probability of success among those projects that are undertaken in period  $t$ .

To solve the model, we need to find the investment rate and the expected productivity of investment. In our economy the investment rate is straightforward: the old do not save and the young save all their income. What do the young do with their savings? As a group, they can only use them to build capital. This means that the investment rate equals the savings of the young. Since the latter equal labor income, which is a constant fraction  $1 - \alpha$  of output, the investment rate is constant as in the classic Solow (1956) model:

$$s_t = 1 - \alpha. \quad (3)$$

For a given initial capital stock  $k_0 > 0$ , a competitive equilibrium of our economy is thus a sequence  $\{k_t\}_{t=0}^{\infty}$  satisfying Equations (1) and (3). A full characterization of such an equilibrium clearly requires an understanding of the way in which  $A_t$  is determined: this depends on the workings of credit markets, which intermediate resources among the young in each generation. To save for old age, each young individual must choose between (i) becoming an entrepreneur and undertaking an investment project, which requires credit whenever  $I > w_t$ , and; (ii) lending his wage to others in exchange for an interest payment. We assume that all such borrowing and lending is intermediated through banks. Banks are finite in number, risk neutral and competitive. They act as intermediaries that collect deposits from individuals and offer loan contracts to active entrepreneurs. On the deposit side, they take the gross interest factor on deposits  $r_{t+1}$  as given and they compete on the loan market by designing contracts that take the following form:

**Definition 1.** *Entrepreneurs and banks sign a contract defined by the triple  $(L_t, R_{t+1}, \varepsilon_t)$ , where  $L_t$  is the amount lent for investment at time  $t$ ,  $R_{t+1}$  is the gross contractual interest rate on the loan that must be paid at time  $t + 1$ , and  $\varepsilon_t$  is the probability that an application to the contract is accepted. In the event of success, entrepreneurs pay back the amount borrowed adjusted by the interest factor. Otherwise, they default and the bank gets nothing.*

Definition 1 implies that the expected profit that individual  $j \in J_t$  obtains from applying to loan contract  $(L_t, R_{t+1}, \varepsilon_t)$  is

$$\pi_{jt}(L_t, R_{t+1}, \varepsilon_t) = \varepsilon_t \cdot p_j \cdot [q_{t+1} \cdot A \cdot I - R_{t+1} \cdot L_t] + [w_t - \varepsilon_t(I - L_t)] \cdot r_{t+1}, \quad (4)$$

which reflects that: (i) the equilibrium contract may or may not require the entrepreneur to invest her wealth in the project and; (ii) it is always possible to become a saver if a loan application is denied.<sup>9</sup>

Since competition among banks is usually crucial in determining the types of contracts that are offered in equilibrium, it is important to specify how we

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<sup>9</sup>Alternatively, we could have considered contracts in which banks charge an application fee that is lost by the applicant in the event that the loan is denied. It can be shown that, as under our current assumptions, also in that case the equilibrium would entail pooling of all applicants in a single equilibrium contract.

model it. We follow the traditional model of Rothschild and Stiglitz (1976) and model competition in the credit market as a two-stage game of screening. In the first stage, banks design a menu of loan contracts and, in the second stage, individuals that want to become entrepreneurs apply to the contract that they find most attractive. We focus throughout in symmetric equilibria, in which 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.<sup>10</sup>

### 3. Equilibria in the closed economy

The driving force of our economy lies in the production of capital and hence in the functioning of credit markets. These markets are in turn characterized by competition among banks, which strive to design contracts that attract the economy's most productive entrepreneurs. We want to characterize the equilibrium of this competitive process in the benchmark case of pure adverse selection and also in the more general case in which adverse selection interacts with limited pledgeability. Let  $(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt})$  be the contract to which individual  $j$  applies in equilibrium. A first characteristic that arises immediately is that, in any equilibrium, individuals invest all of their own wealth in the project if they choose to become entrepreneurs.<sup>11</sup> It therefore follows that  $\widehat{L}_{jt} = \widehat{L}_t = I - w_t$  for all  $j \in [0, 1]$ . Taking this into account, there are three conditions that any equilibrium must satisfy:

1. Entrepreneurial participation constraint, which guarantees that individuals choose to become entrepreneurs and apply to loan contracts only if the return of doing so exceeds that of being a depositor in the banking system. Formally,

$$\pi_{jt}(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt}) \geq r_{t+1} \cdot w_t \iff p_j \cdot [q_{t+1} \cdot A \cdot I - \widehat{R}_{jt+1} \cdot (I - w_t)] \geq r_{t+1} \cdot w_t, \quad (5)$$

for all  $j \geq \widehat{p}_t$ .<sup>12</sup> There are two important implications of Equation (5) for what follows. First, it shows that the participation constraint does not depend directly on the probability of loan acceptance  $\varepsilon_{jt}$ : this follows because the expected payoff of applying to a loan  $\pi_{jt}(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt})$  is

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<sup>10</sup>Our banks thus design contracts and compete strategically through screening. The analysis would remain essentially unchanged if, at the cost of additional notation, we replaced these banks with competitive markets as in Dubey and Geanakoplos (2002) and Taddei (2010).

<sup>11</sup>Under asymmetric information, this follows because banks have an incentive to attract higher quality individuals by designing contracts that require them to invest more of their own wealth in the project. Hence, the only equilibrium is one in which all individual wealth is invested in the project. In the absence of asymmetric information, this is inconsequential because individuals are indifferent between investing their own wealth in the project and investing borrowed funds.

<sup>12</sup>In a setting with uncertainty, the participation constraint at time  $t$  would be a function of the expected return to capital at time  $t + 1$ : in our environment, there is perfect foresight and hence the participation constraint depends directly on  $q_{t+1}$ . Naturally, the addition of uncertainty to our economy would be straightforward since all individuals are risk neutral.

simply an average between the payoff of the loan itself and the payoff of becoming a saver. Second, Equation (5) shows that whenever individual  $j$  wishes to become an entrepreneur in equilibrium, so does any individual  $j'$  with  $j' > j$ . This implies that any equilibrium must entail a marginal investor, denoted by  $\hat{p}_t$ , which is defined as the least productive individual that wishes to become an entrepreneur and applies for credit in period  $t$ .

2. Bank zero-profit condition, which requires banks to break even in equilibrium. Formally, noting that  $\int_{\hat{p}_t}^1 \hat{\varepsilon}_{jt} \cdot dj$  represents the total amount of approved loans, bank competition must ensure that

$$\int_{\hat{p}_t}^1 \left( \hat{\varepsilon}_{jt} \cdot j \cdot \hat{R}_{jt+1} \right) \frac{dj}{1 - \hat{p}_t} = r_{t+1} \cdot \int_{\hat{p}_t}^1 \hat{\varepsilon}_{jt} \cdot dj. \quad (6)$$

Equation (6) says that banks must break even on their aggregate loan portfolio in equilibrium, even though it does not rule out the possibility that they make losses on some specific loans. This condition follows directly from the observation that, if there were positive profits made in equilibrium, a bank could deviate profitably by designing slightly more attractive contracts that would attract all entrepreneurs.

3. Market clearing constraint, which guarantees that the supply of savings is matched by an equal internal demand for investment. This condition, which also depends on the productivity of the marginal investor, can be expressed as follows:

$$(I - w_t) \cdot \int_{\hat{p}_t}^1 \hat{\varepsilon}_{jt} \cdot dj = \left( 1 - \int_{\hat{p}_t}^1 \hat{\varepsilon}_{jt} \cdot dj \right) \cdot w_t. \quad (7)$$

Any equilibrium of our economy must therefore satisfy Equations (5)-(7), which jointly determine the triple  $\{\hat{p}_t, r_{t+1}, q_{t+1}\}$ .<sup>13</sup> We now characterize these equilibria, beginning with the benchmark case of frictionless credit markets. We then turn to the case of adverse selection and study its interaction with limited pledgeability.

### 3.1. The frictionless economy

In the absence of frictions, the equilibrium of our economy is straightforward. Banks can observe the type of each potential borrower and equilibrium contracts are thus given by  $(\hat{L}_{jt}, \hat{R}_{jt+1}, \hat{\varepsilon}_{jt}) = (I - w_t, \frac{r_{t+1}}{p_j}, 1)$  for all applicants  $j \in [\hat{p}_t, 1]$ .

<sup>13</sup>Note that  $q_{t+1}$  is a function of  $k_{t+1}$  and it is therefore fully determined by the identity of the marginal investor  $\hat{p}_t$  and the distribution of loan acceptance rates  $\{\varepsilon_{jt}\}_{j \in [\hat{p}_t, 1]}$ .

Banks break even on each type of contract and Equation (6) becomes  $p_j \cdot R_{jt+1} = r_{t+1}$  for  $j \in [\widehat{p}_t, 1]$ . Moreover, there is no rationing and  $\widehat{\varepsilon}_{jt} = 1$  for  $j \in [\widehat{p}_t, 1]$ .<sup>14</sup> Given these contracts, the identity of the marginal investor  $\widehat{p}_t$  follows directly from the participation constraint of Equation (5) and it is given by:

$$\widehat{p}_t = \frac{r_{t+1}}{q_{t+1}} \cdot \frac{1}{A}. \quad (8)$$

In the absence of financial frictions, only those projects that yield a rate of return that is higher than the interest rate are undertaken in equilibrium, i.e. those projects for which  $p_j \cdot q_{t+1} \cdot A \geq r_{t+1}$ . By increasing the opportunity cost of becoming an entrepreneur, higher interest rates on deposits raise the threshold productivity  $\widehat{p}_t$  and lower aggregate investment; on the contrary, by increasing the return of becoming an entrepreneur, a higher future price of capital  $q_{t+1}$  or productivity of investment  $A$  both lower the threshold probability of success  $\widehat{p}_t$  and expand aggregate investment.

Any equilibrium in the credit market must therefore satisfy Equation (8). But it must also satisfy the market clearing condition of Equation (7) with  $\widehat{\varepsilon}_{jt} = 1$  for  $j \in [\widehat{p}_t, 1]$ , which yields

$$\widehat{p}_t = 1 - \frac{w_t}{I}. \quad (9)$$

Equations (8) and (9) jointly determine the credit-market equilibrium of our economy,  $\{\widehat{p}_t, r_{t+1}, q_{t+1}\}$ .<sup>15</sup> It follows directly that, in equilibrium, the average productivity of investment at time  $t$  is given by

$$A_t = A \cdot \left[ 1 - \frac{w_t}{2 \cdot I} \right], \quad (10)$$

which is decreasing in wages. Intuitively, as the economy grows and wages increase, so does investment and less productive projects are therefore undertaken. Equations (8) and (9) also provide the equilibrium interest rate for this economy:

$$r_{t+1} = q_{t+1} \cdot A \cdot \left( 1 - \frac{w_t}{I} \right). \quad (11)$$

Finally, the law of motion of capital follows from replacing Equations (3) and (10) into Equation (1):

$$k_{t+1} = A \cdot \left[ 1 - \frac{(1 - \alpha) \cdot k_t^\alpha}{2 \cdot I} \right] \cdot s \cdot k_t^\alpha, \quad (12)$$

<sup>14</sup>Consider that there is an equilibrium with  $\widehat{\varepsilon}_{jt} < 1$  for some  $j \in (\widehat{p}_t, 1]$ . This means that some of the applicants would strictly prefer to become entrepreneurs and yet they will only do so with a probability  $\widehat{\varepsilon}_t < 1$ . But then, a bank could profitably deviate to an alternative contract that simultaneously entails a higher interest rate and a higher acceptance rate.

<sup>15</sup>Equations (7) and (8) jointly determine  $\widehat{p}_t$  and  $r_{t+1}$ . Since all loan applications are accepted,  $q_{t+1}$  is then directly determined by  $\widehat{p}_t$ .

which can be shown to be increasing and concave as long as wages do not exceed the size of investment projects  $I$ , which is clearly the case of interest to us. We assume that this holds throughout.<sup>16</sup>

### 3.2. Adverse selection

Consider now that we modify the previous setup by introducing a friction in credit markets. In particular, we initially focus on a type of friction that has allegedly been at the heart of the recent turmoil in financial markets: adverse selection. Relative to the model of Section 3.1, the only modification that we make is to assume that individual  $j$ 's probability of success is private information and is thus unobservable to banks. Because this is the only dimension along which projects differ from one another, banks will now offer one "pooling" contract to all applicants so that  $(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt}) = (\widehat{L}_t, \widehat{R}_{t+1}, \widehat{\varepsilon}_t)$  for  $j \in J_t$ .<sup>17</sup>

In any such equilibrium, it is straightforward to show that all applications must be accepted, i.e.  $\widehat{\varepsilon}_t = 1$ .<sup>18</sup> Since all potential borrowers apply to the same loan contract, it must also be true that the contractual interest rate  $\widehat{R}_{t+1}$  adjusts to reflect the average quality of the pool of applicants. If we let  $\widehat{p}_{AS,t}$  denote the identity of the marginal investor under adverse selection, this implies that the bank zero profit condition of Equation (6) can be formally expressed as:

$$\widehat{R}_{t+1} = \frac{r_{t+1}}{1} = 2 \cdot \frac{r_{t+1}}{1 + \widehat{p}_{AS,t}} \quad (13)$$

$$\int_{\widehat{p}_{AS,t}}^1 j \cdot \frac{dj}{1 - \widehat{p}_{AS,t}}$$

To determine the average quality of the potential applicant, we can replace this expression in the participation constraint of Equation (5) and solve implicitly for  $\widehat{p}_{AS,t}$ :

$$r_{t+1} = \frac{\widehat{p}_{AS,t} \cdot q_{t+1} \cdot A \cdot I}{w_t + 2 \cdot \frac{\widehat{p}_{AS,t}}{1 + \widehat{p}_{AS,t}} \cdot (I - w_t)} \quad (14)$$

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<sup>16</sup>A sufficient condition for wages to always lie below  $I$  is that

$$I > \left(\frac{A}{2}\right)^{\frac{\alpha}{1-\alpha}} \cdot (1-\alpha)^{\frac{1}{1-\alpha}}.$$

This comes from considering that the maximum steady-state level of capital of this economy can never exceed  $\left[\frac{A \cdot (1-\alpha)}{2}\right]^{\frac{1}{1-\alpha}}$ , and making sure that even at this steady-state wages do not exceed the size of investment projects  $I$ .

<sup>17</sup>In this sense, our environment is similar to DeMeza and Webb (1987), with the exception that we allow for  $\varepsilon_t < 1$ .

<sup>18</sup>We have already noted that all contracts must entail the same loan sizes  $L_t = I - w_t$ . There remains the possibility, however, that banks try to screen different types of individuals by designing contracts with different values of  $R$  and  $\varepsilon$ . Since individuals differ only in their probability of success, it can be shown that banks will always try to attract the most productive individuals by designing contracts that entail both a higher  $R$  and a higher  $\varepsilon$ . In equilibrium, this means that the pooling contract will entail the highest possible level of  $\varepsilon$ , i.e. in this case  $\varepsilon = 1$ .

Equation (14) defines an increasing relationship between  $\widehat{p}_{AS,t}$  and  $r_{t+1}$  that must be satisfied in equilibrium. A simple comparison with Equation (8) reveals that, for given levels of  $r_{t+1}$  and  $w_t$ ,  $\widehat{p}_{AS,t} < \widehat{p}_t$ . All else equal, adverse selection induces cross-subsidization across different borrowers and it therefore provides incentives for less productive individuals to become entrepreneurs.

Together with the market clearing condition of Equation (7), Equation (14) determines the credit-market equilibrium of the economy  $\{\widehat{p}_{AS,t}, r_{t+1}, q_{t+1}\}$ , which is characterized as follows:<sup>19</sup>

$$\widehat{p}_{AS,t} = 1 - \frac{w_t}{I}, \quad (15)$$

$$r_{t+1} = q_{t+1} \cdot A \cdot \frac{[2I - w_t] \cdot [I - w_t]}{I^2 + [I - w_t]^2}. \quad (16)$$

A direct comparison of Equations (7) and (9) reveals that  $\widehat{p}_{AS,t} = \widehat{p}_t$ , so that adverse selection does not affect the equilibrium productivity of investment in the closed economy. This follows from two special features of our model: (i) since savings are inelastic, investment must equal the economy's labor income at all times, regardless of whether there is adverse selection or not, and; (ii) since projects are of fixed size and all loan applications are accepted, the order in which projects are financed is unaffected and investment is allocated to a measure  $\frac{w_t}{I}$  of the most productive individuals. Adverse selection therefore does not affect the law of motion of the capital stock, which is still given by Equation (12). Although none of our qualitative results depend on it, we believe that this is an appealing feature of our model because it will allow us to isolate (i) the economic effects of the interaction between adverse selection and limited pledgeability, which we address in Section 3.4, and; (ii) the economic effects of adverse selection under financial integration, which we address in Section 4.

But how is it that, despite the presence of adverse selection, we find that  $\widehat{p}_{AS,t} = \widehat{p}_t$  so that no individuals with  $p_j < \widehat{p}_{AS,t}$  are tempted to become entrepreneurs? The answer, as can be seen by comparing Equations (11) and (16), is that the equilibrium interest rate increases in order to discourage this type of entry. Hence,  $r_{t+1} > \widehat{p}_{AS,t} \cdot q_{t+1} \cdot A$  and the marginal productivity of investment lies below the interest rate. The reason is that less productive individuals are effectively cross-subsidized in by the more productive ones: consequently, for any given interest rate on deposits, the demand for credit is larger than it would be in the frictionless economy. In the closed economy, in which total investment must equal the total wage bill, this leads to an increase in the interest rate in order to restore equilibrium. This increase in the interest rate relative to the frictionless economy of Section 3.1 is the sole consequence of adverse selection.<sup>20</sup>

<sup>19</sup>As before, since all applications are accepted,  $q_{t+1}$  follows directly from  $\widehat{p}_{AS,t}$ .

<sup>20</sup>Once again, this result depends on our assumptions regarding the perfectly inelastic supply of total savings and the fixed size of investment projects. If total savings were increasing on the interest rate, for example, adverse selection would lead to an expansion in the equilibrium level of investment. If projects did not have a fixed size, adverse selection might also affect the

Real-world financial markets are not only prone to adverse selection, however. In many instances, lenders might be reluctant to lend despite being able to accurately assess the likely return of their borrowers: the reason is simply that they may find it hard to enforce repayment ex-post. This type of enforcement friction is commonly referred to as limited pledgeability, and it arises when borrowers are capable of diverting part of their ex-post resources away from the reach of creditors.<sup>21</sup> Since it is believed to be a good indicator of the quality of financial institutions in an economy, limited pledgeability has been used as a simple way to model the effect of these institutions on macroeconomic outcomes in general and on capital flows in particular.<sup>22</sup> Of course, both adverse selection and limited pledgeability are prevalent in real financial markets.<sup>23</sup> In this sense, the analysis of pure adverse selection developed in this section can be seen as a useful benchmark on which to build the more realistic case of an economy in which both frictions coexist. Before doing so, we briefly return to the economy of Section 3.1 and use it to recall the standard results of the benchmark case of pure limited pledgeability.

### 3.3. Limited pledgeability

To introduce limited pledgeability in the frictionless benchmark we need only add one more restriction to the equilibrium conditions of Equations (5)-(7): in the event of default, lenders can seize at most a fraction  $\lambda \in [0, 1]$  of the resources of borrowers. This means that any equilibrium contract  $(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt})$  must also satisfy

$$\widehat{R}_{jt+1} \cdot \widehat{L}_{jt+1} = \widehat{R}_{jt+1} \cdot (I - w_t) \leq \lambda \cdot q_{t+1} \cdot A \cdot I. \quad (17)$$

Unlike adverse selection, the main effect of limited pledgeability is to reduce investment. To see this, note that the participation constraint of Equation (5) is slack whenever the pledgeability constraint of Equation (17) holds with equality. This implies that some individuals that would invest in the frictionless

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equilibrium composition of investment. The main feature of adverse selection that we want to capture, however, is that it generates cross-subsidization between different types of borrowers thereby fostering overinvestment by unproductive types. In our setup, this would still be true in equilibrium if we allowed for investment projects of variable size.

<sup>21</sup>See, for example, Bernanke and Gertler (1989), Caballero and Krishnamurthy (2001), Matsuyama (2004), Lorenzoni (2008) and Aoki et al. (2009). This type of friction could arise, for example, when the borrower's output is unobservable by the lender ex post or when it is unverifiable by a court of law.

<sup>22</sup>This is true both in the theoretical and in the empirical literature. In the latter, the quality of financial institutions is usually proxied with the creditor rights index based on La Porta et al. (1998). This index, which is the leading "institutional" predictor of credit market development around the world, measures the powers of secured lenders in bankruptcy and it essentially reflects the ability of these lenders to seize assets in the event of default.

<sup>23</sup>In fact, although we follow the literature and treat both frictions as independent, it seems reasonable to think that they often have a common origin. A dysfunctional court system might give rise to limited pledgeability by being unable to verify a project's outcomes, for instance, but it might also effectively give rise to adverse selection by being unable to enforce the specific type of contracts that make it possible to screen privately informed agents.

economy cannot do so under limited pledgeability because they cannot commit to a repayment that would allow the bank to break even. Formally, the identity of marginal investor under limited pledgeability is given by

$$\widehat{p}_{\lambda t} = \frac{r_{t+1}}{q_{t+1}} \cdot \frac{1}{A} \cdot \max \left\{ 1, \frac{1}{\lambda} \cdot \frac{I - w_t}{I} \right\}, \quad (18)$$

so that  $\widehat{p}_{\lambda t} > \widehat{p}_t$  whenever  $\lambda < 1 - \frac{w_t}{I}$  and the pledgeability constraint binds.

To determine the credit-market equilibrium of the economy  $\{\widehat{p}_{\lambda t}, r_{t+1}, q_{t+1}\}$ , we can combine Equation (18) with the market clearing condition of Equation (7) setting  $\widehat{\varepsilon}_{jt} = 1$  for  $j \in [\widehat{p}_{\lambda t}, 1]$ .<sup>24</sup> This immediately delivers that  $\widehat{p}_{\lambda t} = \widehat{p}_t$ , so that limited pledgeability has no effect on the average productivity of projects that are undertaken. As was the case in the closed economy under adverse selection, the totality of labor income must be ultimately invested regardless of the friction.<sup>25</sup> Thus, the law of motion of capital is still given by Equation (12) and limited pledgeability has the only effect of reducing the equilibrium interest rate, which now fall below the productivity of the marginal investor – to  $r_{t+1} = \lambda \cdot q_{t+1} \cdot A$  – whenever the constraint binds.

#### 3.4. A tale of two frictions

We now extend our analysis of adverse selection to an economy in which credit markets are also characterized by limited pledgeability as modeled in the previous section. In this case, any equilibrium contracts must satisfy Equations (5)-(7) and two additional restrictions: (i) because of adverse selection,  $(\widehat{L}_{jt}, \widehat{R}_{jt+1}, \widehat{\varepsilon}_{jt}) = (\widehat{L}_t, \widehat{R}_{t+1}, \widehat{\varepsilon}_t)$  for  $j \in J_t$  and all potential borrowers apply to the same contract, and; (ii) because of limited pledgeability, it must hold that

$$\widehat{R}_{t+1} \cdot (I - w_t) \leq \lambda \cdot q_{t+1} \cdot A \cdot I. \quad (19)$$

Condition (i) implies that the contractual interest rate  $\widehat{R}_{t+1}$  must adjust to reflect the average quality of the pool of applicants, and the zero profit condition of banks is given once again by Equation (13). Precisely because all borrowers face the same contractual terms, condition (ii) has the novelty that the pledgeability constraint of Equation (19) either binds for all or none of them.

Whether or not this constraint binds in equilibrium depends on the value of  $\lambda$ . We can replace Equations (13), (14) and (15) in Equation (19) to establish that, whenever  $\lambda \geq \frac{2 \cdot (I - w_t)^2}{I^2 + (I - w_t)^2}$ , the constraint is slack and the equilibrium is as in Section 3.2. If  $\lambda$  is lower than this threshold, however, the equilibrium

<sup>24</sup>As in Section 3.1, it is straightforward to show that all applications must be accepted in equilibrium (see Footnote 14). The reason, once again, is that the pledgeability constraint binds only for the marginal investor in equilibrium. Hence, any equilibrium contract with  $\widehat{\varepsilon}_{jt} < 1$  for  $j \in (\widehat{p}_{ASt}, 1]$  will be prone to profitable deviations by banks.

<sup>25</sup>This feature of our model, which closely mirrors Matsuyama (2004), is of course due to the particular set of assumptions that we make (see Footnote 20).

entails a binding constraint: in this case, letting  $\widehat{p}_{AS\lambda,t}$  denote the productivity of the marginal investor, it follows that  $\widehat{p}_{AS\lambda,t} < \widehat{p}_{AS,t}$ .<sup>26</sup> The reason is that if the pledgeability constraint is not satisfied in the original equilibrium, banks are unwilling to extend any loans and the interest rate must decrease. In the presence of adverse selection, this provides incentives for less productive individuals to become entrepreneurs and borrow, enlarging the pool of applicants and generating an excess demand for funds. To attain market clearing, it is therefore necessary that  $\widehat{\varepsilon}_t < 1$  in equilibrium. From the market clearing condition of Equation (7), it follows that

$$\varepsilon_t = \frac{w_t}{I} \cdot \frac{1}{1 - \widehat{p}_{AS\lambda,t}} = \frac{1 - \widehat{p}_{AS,t}}{1 - \widehat{p}_{AS\lambda,t}}, \quad (20)$$

which illustrates that the share of loan applications that are accepted is decreasing in the difference between  $\widehat{p}_{AS,t}$  and  $\widehat{p}_{AS\lambda,t}$ , i.e. between the productivity of the marginal investor in the pure adverse-selection economy and in the economy with both frictions. Equations (14), (19) and (20) then fully characterize the equilibrium  $\{\widehat{p}_{AS\lambda,t}, r_{t+1}, q_{t+1}\}$

But how is this “rationing” of applicants sustained in equilibrium? After all, applicants strictly prefer to borrow and become entrepreneurs. This suggests, as we have argued in previous sections, that banks could make a profit by deviating to alternative contracts with higher acceptance rates and higher contractual interest rates. If the pledgeability constraint is binding, though, such deviations are not feasible because the contractual interest rate cannot be raised beyond its equilibrium level.

This discussion points to a central implication of our model. In our setup, adverse selection *per se* does not have an effect on the law of motion of the economy. Considered separately, it affects the equilibrium interest rate but not the productivity of projects that are financed in equilibrium: one way to think about this is that it does not affect the order in which projects are financed. When it is combined with limited pledgeability, however, this is no longer true. The combination of both frictions leads to low interest rates and a large and relatively unproductive pool of applicants, with  $\widehat{p}_{AS\lambda,t} \leq \widehat{p}_{AS,t}$ , a fraction of which is denied credit in equilibrium. In this sense, limited pledgeability exacerbates and the effects of adverse selection, reducing the average quality of projects that are financed relative to the frictionless economy and thereby slowing down capital accumulation and growth. Formally, the law of motion is now given by:

$$k_{t+1} = \begin{cases} A \cdot \left( \frac{1 + \widehat{p}_{AS\lambda,t}}{2} \right) \cdot s \cdot k_t^\alpha & \text{if } \lambda < \frac{2 \cdot (I - w_t)^2}{I^2 + (I - w_t)^2} \\ A \cdot \left( \frac{1 + \widehat{p}_{AS,t}}{2} \right) \cdot s \cdot k_t^\alpha & \text{if } \lambda \geq \frac{2 \cdot (I - w_t)^2}{I^2 + (I - w_t)^2} \end{cases}, \quad (21)$$

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<sup>26</sup>This follows from replacing Equations (13) and (14) in the constraint of Equation (19), which delivers the critical value of  $\lambda$  as an increasing function of  $\widehat{p}_{AS\lambda,t}$ . Hence, if the constraint is violated in the equilibrium of Section 3.2, it must be that  $\widehat{p}_{AS\lambda,t} < \widehat{p}_{AS,t}$ .

which lies below the law of motion of Equation (12) as long as the pledgeability constraint is binding, i.e. for low levels of wages.

This concludes our characterization of the closed economy. Figure 1 below summarizes our discussion by simulating the dynamic behavior of this economy

[INSERT FIGURE 1 ABOUT HERE]

#### 4. The open economy: capital flows and financial frictions

We now consider that our economy opens its financial markets to the rest of the world, so that individuals  $j \in J_t$  can borrow from and/or lend to the international financial market. Throughout, we assume that this market is willing and able to borrow or lend any amount at an expected gross return of  $r^*$ . Hence, we restrict the analysis to the case of a small open economy. We assume throughout that the international financial market is subject to the same constraints faced by domestic banks.<sup>27</sup>

In the closed economy, aggregate investment is constrained by the availability of domestic resources and the domestic interest rate  $r_{t+1}$  is determined endogenously. In the open economy, investment can be financed with foreign resources and the domestic interest rate equals  $r^*$ . The endogenous variables to be determined are thus  $\hat{p}_t^*$  – where the superscript (\*) indicates that the variable corresponds to the open economy – and  $q_{t+1}$ , and equilibrium contracts need no longer satisfy the market clearing condition of Equation (7). Capital accumulation, and thus  $q_{t+1}$ , follows directly once the value of  $\hat{p}^*$  and the loan acceptance rates  $\hat{\varepsilon}_{jt}$  for  $j \in [\hat{p}_t^*, 1]$  are determined.

##### 4.1. The frictionless economy

In the absence of financial frictions, the equilibrium of the open economy is straightforward. Given the international interest rate  $r^*$ , the level of investment is immediately determined by the participation constraint and the bank zero profit condition of Equations (5) and (6):

$$\hat{p}^* = \frac{r^*}{q} \cdot \frac{1}{A}, \quad (22)$$

where  $q$  denotes the rental price of capital and we have dropped time-subscripts to reflect the fact that there are no state variables in this economy. Equation

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<sup>27</sup>This is in contrast with different strands of literature that assume financial frictions to be more prevalent in international transactions than in domestic ones. This assumption is paramount in the literature on sovereign risk, for example, in which governments are assumed to be opportunistic and they do not value the welfare of foreigners. Dell’Arriccia et al. (1999) and Giannetti (2003) assume that foreigners are less informed than domestic agents regarding the quality of local borrowers. In our competitive setting, however, we conjecture that any informational advantage of domestic agents relative to foreigners would be competed away by banks.

(22) illustrates that, in the absence of financial frictions, capital flows between the small open economy and the rest of the world until the return to domestic investment equals the international interest rate. From the perspective of each generation  $t$ , then, total consumption is maximized when capital flows between them and the international financial market at time  $t$  are unrestricted in any way.<sup>28</sup> Given that  $\hat{\varepsilon}_{jt} = 1$  for  $j \in [\hat{p}^*, 1]$ , Equation (22) uniquely determines the value of  $\hat{p}^*$ .<sup>29</sup> This value is independent of the capital stock  $k_t$  and depends only on the international interest rate  $r^*$ . Hence, the economy converges immediately to its steady state, which is implicitly given by:

$$k^* = \frac{A \cdot I}{2} \cdot [1 - \hat{p}^{*2}] = \frac{A \cdot I}{2} \cdot \left[ 1 - \left( \frac{r^*}{\alpha \cdot (k^*)^{\alpha-1} \cdot A} \right)^2 \right]. \quad (23)$$

With this benchmark in mind, we now turn to the implications of adverse selection for capital flows.

#### 4.2. Adverse selection

In our analysis of Section 3.2, we showed that adverse selection boosted investment by providing unproductive individuals with incentives to become entrepreneurs. In the closed economy, this effect was completely offset by an increase in the equilibrium interest, so that the marginal investor was the same as in the frictionless economy, i.e.  $\hat{p}_{AS,t} = \hat{p}_t$  for all  $t$ . But how does adverse selection affect the direction and magnitude of capital flows when the economy is integrated with the international financial market?

As before, the restriction imposed by adverse selection is that all borrowers face the same contractual terms. Taking this into account, Equations (5) and (13) allow us to obtain an implicit expression for the identity of the marginal investor  $\hat{p}_{AS,t}^*$ ,

$$r^* = \frac{\hat{p}_{AS,t}^* \cdot q_{t+1} \cdot A \cdot I}{w_t + 2 \cdot \frac{\hat{p}_{AS,t}^*}{1 + \hat{p}_{AS,t}^*} \cdot (I - w_t)}. \quad (24)$$

There are two interesting aspects of Equation (24). First, the only variable to be determined in the expression is ultimately  $\hat{p}_{AS,t}^*$ . This follows because, for the same reasons outlined in Section 3.2, it must hold in equilibrium that all applications are accepted ( $\hat{\varepsilon}_t^* = 1$ ) and  $q_{t+1}$  is therefore directly determined by  $\hat{p}_{AS,t}^*$ . Second, it shows that – differently from the frictionless benchmark of the

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<sup>28</sup>From an intergenerational perspective, however, the issue is more complicated. The reason is the usual one in this class of models: greater capital accumulation today, even if costly for the current generation, benefits future generations through higher wages. Although certainly interesting, a full analysis of welfare implications would exceed the scope of this paper and we therefore leave it for future research.

<sup>29</sup>If all loan applications are accepted,  $q$  is immediately determined by  $\hat{p}^*$ . Moreover, we know from our discussion of the closed economy that this will be the case in equilibrium (see Footnote 14).

previous section – the identity of the marginal investor  $\widehat{p}_{AS,t}^*$  is not independent of  $k_t$  and dynamics are therefore influenced by the state of the economy. The reason, of course, is that the capital stock affects wages and thus the incentive of individuals to become entrepreneurs. In particular, differentiation of Equation (24) reveals that there is an increasing relationship between  $\widehat{p}_{AS,t}^*$  and  $w_t$ , so that total investment is decreasing in the economy’s capital stock. It follows from this last point that the law of motion of the economy, which is given by

$$k_{t+1} = \frac{A \cdot I}{2} \cdot \left[ 1 - (\widehat{p}_{AS,t}^*)^2 \right], \quad (25)$$

behaves as in Figure 2 below.

[INSERT FIGURE 2 ABOUT HERE]

The thick line in Figure 2 illustrates a representative law of motion for the capital stock in the small open economy with adverse selection. In the figure,  $k^*$  denotes the steady-state level of capital in the absence of financial frictions. Two important features stand out: (i) the law of motion lies everywhere above the corresponding law of motion for the frictionless economy, and; (ii) it is downward-sloping.<sup>30</sup> We now discuss each of these features separately.

By fostering the cross-subsidization of less productive individuals, adverse selection exacerbates investment. In the closed economy, we have seen how this increase in investment can be counterbalanced by an increase in the equilibrium interest rate. In the open economy, in which the interest rate is given and equals  $r^*$ , there is no such countervailing force. Relative to the frictionless economy, therefore, the adverse selection economy displays the higher levels of investments and of capital inflows. This explains why the law of motion lies everywhere above  $k^*$  so that, if we let  $k_{AS}^*$  denote the steady-state level of capital in this economy, it must necessarily hold that  $k_{AS}^* > k^*$  as depicted in the figure. This implies that, because of adverse selection, the marginal return to investment in the open economy is lower than the international interest rate. Although this might be good for future generations that benefit from arriving to an economy with more capital, it is certainly harmful for the generation that invests in projects yielding a rate of return below  $r^*$ . Consequently, from the perspective of generation  $t$ , aggregate consumption would be maximized by raising the domestic interest rate at time  $t$  so as to eliminate these investments.<sup>31</sup> A government with the

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<sup>30</sup>On the horizontal axis, the figure depicts values of  $k_t$  for which  $w_t < I$ , so that the adverse selection problem is binding throughout. Once this ceases to be the case, the law of motion naturally coincides with that of the frictionless economy.

<sup>31</sup>For a given capital stock  $k_t$ , the total consumption of generation  $t$  can be expressed as follows:

$$c_{t+1} = \alpha \cdot (k_{t+1})^\alpha - r^* \cdot \left[ (1 - \widehat{p}_{AS,t}^*) \cdot I - s \cdot (k_t)^\alpha \right],$$

where:  $k_{t+1}$  is a function of  $\widehat{p}_{AS,t}^*$  as in Equation (25); the first term represents the total capital income of the economy in period  $t+1$ , and; the second term represents the net interest payments made to the international financial market at time  $t+1$ . Since  $\widehat{p}_{AS,t}^* < r^*$  in

ability to levy taxes could implement this through a tax on domestic investment or, equivalently, a tax on capital inflows.

The second important feature of the law of motion depicted in Figure 2 is that it is downward sloping. Once again, this follows from the observation that  $\hat{p}_{AS,t}^*$  is increasing in  $w_t$ . When the capital stock and wages are low, less productive individuals have a strong incentive to become entrepreneurs: since they need to borrow most of the investment from banks, they will be heavily cross-subsidized by the more productive individuals. As the capital stock and wages increase, however, the extent of cross-subsidization decreases and entrepreneurship loses its appeal for less productive individuals. This raises  $\hat{p}_{AS,t}^*$ , depressing investment and capital accumulation.

This last discussion points to an crucial implication of adverse selection in the context of a small open economy: it exacerbates economic volatility. Whereas in financial autarky the economy converges monotonically to its steady state, the open economy necessarily displays oscillatory behavior.<sup>32</sup> The reason, of course, is the same as before. When wages are low, so is  $\hat{p}_{AS,t}^*$  and total investment is therefore high. In this case, even individuals with relatively low productivity are attracted by the extent of cross-subsidization offered by large loan sizes  $I - w_t$ . This surge in investment increases the future capital stock and wages, though, which eventually discourages investment by unproductive individuals and brings about a reduction in output that restarts the economic cycle.<sup>33</sup>

We have thus designed a model in which adverse selection has no real effects under financial autarky. When individuals are allowed to borrow from and/or lend to the international financial market, however, the picture is drastically different. Adverse selection exacerbates investment, capital inflows and capital accumulation and, even in the absence of any type of uncertainty, it generates volatility.<sup>34</sup> This provides a simple benchmark that can be contrasted with the one typically explored in the literature, that of pure limited pledgeability. We briefly summarize it below before turning to the more realistic case in which both frictions interact.

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equilibrium, maximization of  $c_{t+1}$  requires effectively raising the domestic interest rate above  $r^*$  so as to reduce domestic capital accumulation and decrease net interest payments to the international financial market.

<sup>32</sup>The steady state  $k_{AS}^*$  can in principle be either stable or unstable. The economy might display fluctuations in both cases.

<sup>33</sup>To interpret this result, it is best to think of a period in our model not as representing one half of the life of a generation but rather as the average length of a financial contract. A more realistic model, in which agents lived for many periods, would generate an endogenous distribution of wealth and adverse selection would be more prevalent among individuals with lower wealth levels. We conjecture that, in such a model, the types of cycles analyzed here could still arise as long as those individuals represent a sufficiently high fraction of economic activity.

<sup>34</sup>It is important to stress that the existence of these cycles in the presence of adverse selection does not rely on investment projects having a fixed size. In a closely related setting, Martin (2008) shows how similar cycles may arise in an environment in which the size of projects is variable.

### 4.3. Limited pledgeability

Under limited pledgeability,  $\widehat{p}_{\lambda,t}^*$  is determined by Equation (18) plus the restriction that  $r_{t+1} = r^*$ .<sup>35</sup> As in the case of adverse selection, then, the identity of the marginal investor  $\widehat{p}_{\lambda,t}^*$  is not independent of  $k_t$  and dynamics are influenced by the state of the economy. The reason is clear: through its effect on wages, the capital stock affects the leverage of investors and thus the tightness of the pledgeability constraint. Formally, the law of motion of the economy is given by

$$k_{t+1} = \begin{cases} \frac{A \cdot I}{2} \cdot \left[ 1 - \left( \frac{r^*}{q_{t+1} \cdot A} \cdot \frac{1}{\lambda} \cdot \frac{I - w_t}{I} \right)^2 \right] & \text{if } \lambda < 1 - \frac{w_t}{I} \\ \frac{A \cdot I}{2} \cdot \left[ 1 - \left( \frac{r^*}{q_{t+1} \cdot A} \right)^2 \right] & \text{if } \lambda \geq 1 - \frac{w_t}{I} \end{cases}, \quad (26)$$

which is illustrated in Figure 3.

[INSERT FIGURE 3 ABOUT HERE]

The thick line in Figure 3 illustrates a representative law of motion for the capital stock in the small open economy under limited pledgeability. The figure, in which  $\bar{k}$  denotes the capital stock at which the pledgeability constraint ceases to bind, depicts the case of an economy that has one steady state  $k_\lambda^*$  in which investment is constrained. The figure reproduces two features of this law of motion that are commonplace in the literature: (i) as long as the pledgeability constraint is binding, the law of motion lies everywhere below the corresponding law of motion for the frictionless economy, and; (ii) the law of motion is upward-sloping.<sup>36</sup>

When  $\lambda \geq 1 - \frac{w_t}{I}$ , the pledgeability constraint is slack and Equation (26) coincides with the law of motion of the frictionless economy. When  $\lambda < 1 - \frac{w_t}{I}$ , the pledgeability constraint binds, the economy underinvests relative to the frictionless economy and its law of motion lies below  $k^*$ . By preventing some investments that yield a return above  $r^*$ , limited pledgeability reduces the aggregate consumption of the generation that is exposed to it. From the

<sup>35</sup>Once again, since we know that all applications are accepted in equilibrium,  $q_{t+1}$  follows directly from  $\widehat{p}_{\lambda,t}^*$ .

<sup>36</sup>Figure 2 illustrates the law of motion as being strictly concave, which need not be the case. Intuitively, there are two opposing forces that determine the shape of the law of motion: (i) the diminishing marginal productivity of investment and capital, which makes the law of motion concave, and; (ii) the relaxation of the pledgeability constraint as capital and wages increase, which makes the law of motion convex. The exact shape of the law of motion depends on the relative strength of these two forces, which may give rise to multiple steady states in this small-open economy. For a thorough discussion of this point in a related model, see Matsuyama (2004).

perspective of generation  $t$ , total consumption would thus be maximized by lowering the domestic interest rate at time  $t$  below  $r^*$ .<sup>37</sup> A government with the ability to subsidize could implement this through a subsidy on domestic investment or, equivalently, a subsidy on capital inflows.<sup>38</sup> Figure 2 also shows that, whenever the pledgeability constraint is binding, the law of motion is upward sloping and the economy does not converge immediately to the steady state. In this range, increases in the capital stock relax borrowing constraints, thereby reducing  $\widehat{p}_{\lambda,t}^*$  and boosting investment.

This discussion summarizes, in a nutshell, the most common results of the literature on financial frictions and international capital flows. As captured by a binding pledgeability constraint, a low quality of financial institutions tends to restrict investment. In a closed economy, this reduces the equilibrium interest rate. In an open economy, this expands capital outflows (or reduces inflows) relative to the frictionless benchmark. This type of mechanism has been invoked to account for the seeming inability of developing economies to attract capital flows despite the high returns to capital accumulation in many of them: the short answer is that the quality of their financial institutions (i.e. their  $\lambda$ ) is low.<sup>39</sup> A similar mechanism underlies the “asymmetric financial development” view of global imbalances, according to which the large recent capital flows out of many Asian economies (predominantly China) are due to the inability of these economies of supplying financial assets, i.e. of translating a high productivity of physical investment into a high return for lenders.<sup>40</sup>

#### 4.4. *A tale of two frictions: capital flows in the open economy*

The benchmarks of pure adverse selection and pure limited pledgeability are particular cases of the more realistic environment in which both frictions interact. To analyze this case, we return to the economy with adverse selection of Section 4.2 and impose a pledgeability constraint like the one in Equation (19). In equilibrium, the identity of the marginal investor is still determined by Equation (24), which makes sure that the participation constraint and the bank zero profit condition are jointly satisfied. By replacing this last condition and the contractual interest rate of Equation (13) into the pledgeability constraint,

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<sup>37</sup>The analysis in this case is the mirror image of the one carried out for the adverse-selection economy (see Footnote 31).

<sup>38</sup>Clearly, the convenience of adopting such a subsidy depends on the cost of taxation. We assume here that the government can tax lump-sum.

<sup>39</sup>See, for example, Gertler and Rogoff (1990) and Boyd and Smith (1997), among others. Of course, private contracting frictions between borrowers and lenders are not the only reason for which these countries might fail to attract capital, and it is commonly believed that opportunistic behavior by the government plays a substantial role as well. Broner and Ventura (2010) provide a recent view along these lines, while Gennaioli et al.(2010) develop a model in which the government’s incentives to behave opportunistically are affected by the tightness of private pledgeability constraints.

<sup>40</sup>Caballero et al. (2008) provide a theoretical framework along these lines.

it follows that any equilibrium must satisfy the following condition:

$$\widehat{p}_{AS\lambda,t}^* \leq \frac{\lambda \cdot w_t}{2 \cdot (I - w_t) - \lambda(2I - w_t)}, \quad (27)$$

where  $\widehat{p}_{AS,t}^*$  denotes the productivity of the marginal investor.

There are two possible types of equilibria in this economy. The first type arises when the pledgeability constraint is slack and it coincides with the equilibrium of Section 4.2, i.e.  $\widehat{p}_{AS\lambda,t}^* = \widehat{p}_{AS,t}^*$ . As can be seen from Equation (27), this equilibrium is more likely to arise when  $\lambda$  and  $w_t$  are high and when  $r^*$  (and thus,  $\widehat{p}_{AS,t}^*$ ) is low. The second type of equilibrium arises when the pledgeability constraint is binding. In this case, Equation (27) holds with equality and the productivity of the marginal investor  $\widehat{p}_{AS\lambda,t}^*$  lies below that of the Section 4.2, i.e.  $\widehat{p}_{AS\lambda,t}^* < \widehat{p}_{AS,t}^*$ . The reason for this is similar to the one discussed in the context of a closed economy. If the pledgeability constraint is violated, banks are unwilling to extend loans, reducing investment and raising the marginal product of capital in the economy. This increase in the return to investment makes it possible to satisfy the pledgeability constraint but, because of adverse selection, it also provides incentives for less productive individuals to become entrepreneurs and apply for loans. Ultimately, the equilibrium is characterized by a large pool of potential borrowers and a low level of investment, which are reconciled through a low probability of obtaining a loan, i.e.  $\widehat{\varepsilon}_t < 1$ . In this case, rationing of applicants is consistent with equilibrium because a binding pledgeability constraint prevents banks from designing profitable deviations.

This discussion enables us to characterize the dynamics of the economy. If the limited pledgeability constraint is to bind anywhere, it will do so when the capital stock and wages are low.<sup>41</sup> In this range,  $\widehat{p}_{AS\lambda,t}^*$  is determined by Equation (27) with an equality and  $\widehat{\varepsilon}_t$  is then obtained so as to satisfy the pledgeability constraint of Equation (19). The resulting law of motion of the economy is given by

$$k_{t+1} = \begin{cases} \frac{A \cdot I}{2} \cdot \left[ 1 - \left( \frac{\lambda \cdot w_t}{2 \cdot (I - w_t) - \lambda(2I - w_t)} \right)^2 \right] \cdot \widehat{\varepsilon}_t & \text{if } \lambda \leq \frac{2 \cdot (I - w_t) \cdot \widehat{p}_{AS,t}^*}{w + (2I - w_t) \cdot \widehat{p}_{AS,t}^*} \\ \frac{A \cdot I}{2} \cdot \left[ 1 - \left( \widehat{p}_{AS,t}^* \right)^2 \right] & \text{if } \lambda > \frac{2 \cdot (I - w_t) \cdot \widehat{p}_{AS,t}^*}{w + (2I - w_t) \cdot \widehat{p}_{AS,t}^*} \end{cases}, \quad (28)$$

where the conditions on  $\lambda$  simply restate Equation (27). An example of Equation (28) is depicted graphically in Figure 4 below.

[INSERT FIGURE 4 ABOUT HERE]

<sup>41</sup>This follows directly from analyzing the pledgeability constraint of Equation (19). We have established that  $\widehat{p}_{AS,t}^*$  increases with the capital stock: hence, as the capital stock grows and  $w_t$  increases, investment falls and  $q_{t+1}$  rises. Increases in the capital stock thus relax the constraint, so that if it is slack for a capital stock  $k$  it must also be slack for all capital stocks  $k' > k$ .

The thick line in Figure 4 illustrates a representative law of motion for the capital stock in the small open economy with adverse selection and pledgeability constraints. The economy depicted in the figure has a unique steady state, denoted by  $k_{AS}^*$ , in which the pledgeability constraint is no longer binding. Two important features stand out: (i) as long as the pledgeability constraint is binding, the law of motion lies everywhere below the corresponding law of motion for the pure adverse-selection economy, and; (ii) the law of motion is non-monotonic.

We have already argued that a binding pledgeability constraint reduces the production of capital. It might be therefore tempting to think that, by doing so, it is actually helpful to mitigate the overinvestment induced by adverse selection. In fact, it only makes things worse. By limiting the contractual interest rate that can be charged on loans, limited pledgeability provides even greater incentives for inefficient individuals to become entrepreneurs. Thus, just as we found for the case of the closed economy, limited pledgeability exacerbates the effects of adverse selection and it leads to a fall in the average productivity of investment. Although a binding pledgeability constraint does limit investment relative to the pure adverse-selection economy, it does so randomly through rationing and not selectively by weeding out unproductive individuals.

The second important feature of the law of motion depicted in Figure 4 is that it is non-monotonic. When the economy's capital stock is low and the pledgeability constraint is binding, the law of motion is upward sloping. This happens even though, in this region, increases in the capital stock and wages raise the productivity of the marginal investor  $\widehat{p}_{AS\lambda,t}^*$ .<sup>42</sup> But this reduction in the pool of potential borrowers decreases the need for equilibrium rationing and, ultimately, it is this fall in rationing what dominates and makes  $k_{t+1}$  increasing in  $k_t$ . To see this formally, we can replace  $\widehat{p}_{AS\lambda,t}^*$  from Equation (27) into Equation (24) to obtain the following expression for  $q_{t+1}$ ,

$$q_{t+1} = \frac{r^*}{A} \cdot \frac{2 \cdot (I - w_t) - \lambda(2I - w_t)}{I \cdot \lambda \cdot (1 - \lambda)}. \quad (29)$$

Equation (29) illustrates that, as the capital stock and wages increase,  $q_{t+1}$  must fall. This means that the production of capital rises along with the capital stock, so that as the pool of potential borrowers decreases the loan acceptance rate increases more than proportionately. Once the pledgeability constraint ceases to bind and rationing disappears altogether, the law of motion coincides with that of Section 4.2 and it becomes downward-sloping.

The introduction of limited pledgeability therefore enriches the dynamic effects of adverse selection as characterized in Section 4.2. First, it slows down capital accumulation not by mitigating the effects of adverse selection for overinvestment, but rather by exacerbating them to bring about a decrease in the average productivity of investment. From the perspective of generation  $t$ , in

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<sup>42</sup>This follows directly from Equation (27), which holds with equality when the pledgeability constraint binds.

fact, we conjecture that the maximization of total consumption requires a subsidy to the savings of domestic individuals. By raising the interest rate paid on deposits beyond  $r^*$ , such a subsidy mitigates limited pledgeability and adverse selection by providing unproductive individuals with greater incentives to become savers. As these individuals leave the pool of applicants, the contractual interest rate charged on loans drops and the pledgeability constraint is relaxed as well. Eventually, this policy can raise the identity of the marginal investor from  $\hat{p}_{AS\lambda,t}^*$  to  $\hat{p}_{AS,t}^*$  and finally to  $\hat{p}_t^*$ .<sup>43</sup>

A second innovation relative to the adverse selection benchmark of Section 4.2 is that the introduction of limited pledgeability can give rise to multiple steady states.<sup>44</sup> Of these steady states, only one can lie on the downward-sloping part of the law of motion in Figure 3. This implies that institutional reforms that increase  $\lambda$  shift the economy's law of motion upwards and they eventually eliminate all steady states but  $k_{AS}^*$ . In this case, improvements in institutional quality relax borrowing constraints until, in the long run, the pledgeability constraint ceases to bind and the only remaining friction is adverse selection. These increases in  $\lambda$  expand leverage and enhance the productivity of investment but, due to the oscillatory nature of  $k_{AS}^*$ , they must also fuel economic volatility in the long-run.

This concludes our characterization of the small open economy. Figure 5 below summarizes our discussion by simulating how, starting from a common initial condition, this economy evolves over time under different scenarios.

[INSERT FIGURE 5 ABOUT HERE]

The discussion of this section highlights two important implications of our model. The first is that the development of financial markets, as well as the set of policies aimed at improving their efficiency, is not necessarily one-dimensional. When both frictions are present, for example, we have seen how they complement one another: this means that, to improve the allocation of resources, policies that improve creditor rights might be just as useful as policies designed to deal with adverse selection, i.e. that lower the cost of screening borrowers. The relative efficiency of different policies, however, might vary according to the level of economic development. A second and related implication is precisely that some of the problems associated to adverse selection might surface only when the economy surpasses a certain level of wealth or financial development. During the recent financial crisis, for example, economists were taken aback by the difficulties faced by the seemingly developed financial markets of the United States. How could it be that these markets had done such a poor job of allocating credit? Our model highlights that some of these problems, like excessive investment and the resulting volatility associated with it, can only arise precisely where financial markets surpass a minimum level of economic development. In

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<sup>43</sup>Once again, we are assuming throughout that the government can finance these subsidies by taxing lump-sum.

<sup>44</sup>See Footnote 36.

a world in which a substantial fraction of economies are characterized by poor financial institutions, it may well be that the economy where these institutions work best will end up being most visibly affected by the problems of adverse selection.<sup>45</sup>

## 5. Concluding Remarks

The financial crisis of 2007-08 has underscored the importance of adverse selection in financial markets. This friction has been mostly neglected by macroeconomic models of financial frictions, however, which have focused almost exclusively on the effects of limited pledgeability. In this paper, we have attempted to fill this gap by developing a standard growth model with adverse selection. Our main results are that, by fostering unproductive investment, adverse selection: (i) leads to an increase in the economy's equilibrium interest rate, and; (ii) it generates a negative wedge between the marginal return to investment and the equilibrium interest rate. We have shown how, under financial integration, these effects translate into excessive capital inflows and generate endogenous fluctuations in the capital stock and output. We have also extended our model to the more general case in which adverse selection and limited pledgeability coexist, and we have concluded that there is a sense in which both frictions complement one another: if anything, limited pledgeability exacerbates the consequences of adverse selection on the macroeconomy.

Our analysis is incomplete in two important respects. The first one is that we have stopped short of characterizing the full welfare implications of adverse selection and limited pledgeability. Instead, we have referred exclusively to the contemporaneous effects of these frictions on each generation of savers that is exposed to them. This shortcoming of our analysis is not due to lack of interest on our behalf. As we mentioned in the main body of the text, a full welfare analysis is quite involved because it requires the balancing of different effects across generations. There is simply no space for this here.

A second and related shortcoming is that we have restricted our analysis of financial integration to the case of a small open economy. Doing so has been instrumental to simplify the analysis and it has allowed us to portray the effects of adverse selection and limited pledgeability in a very clear manner. It has also, however, prevented us from using the model to directly address the recent turn of events. The prevailing view on global imbalances and financial frictions is that limited pledgeability has been at the heart of capital flows between Asia and the United States. According to this view, the United States has only stood

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<sup>45</sup>Imagine, for example, that the world is made up of two economies like the one analyzed in this section, one of which is characterized by a low level of  $\lambda$ . Under financial integration, capital in this world will tend to flow towards the economy with the most developed markets, which will receive them as a mixed blessing. On the one hand, these inflows will be beneficial because they will lower the cost of financing and allow for an expansion in the capital stock; on the other hand, they may also be costly by fueling inefficient investments and economic volatility.

to gain from these inflows. How is this view affected once the importance of adverse selection is acknowledged? Is it possible that, through their effects on the interest rate, these capital inflows exacerbate adverse selection and lead to inefficient investment in the United States? Can the United States ultimately suffer a welfare loss if the rest of the world uses its financial system to intermediate resources? Addressing these questions should be the exciting next step in this research agenda.

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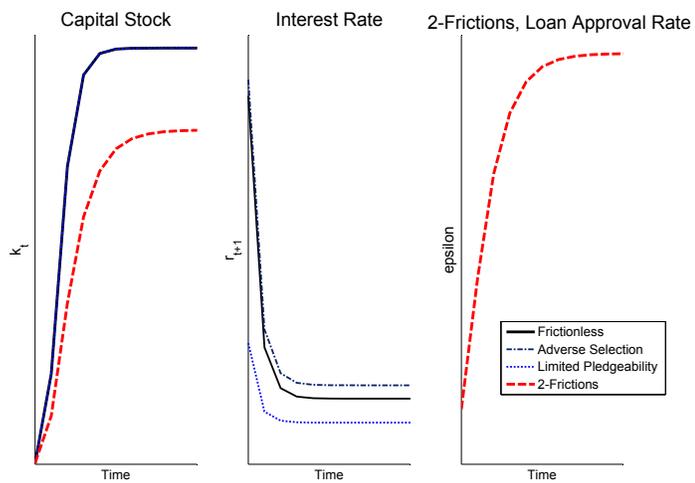


Figure 1: Capital accumulation under financial autarky ( $A = 1, I = 1, \alpha = 0.3, \lambda = 0.3$ )

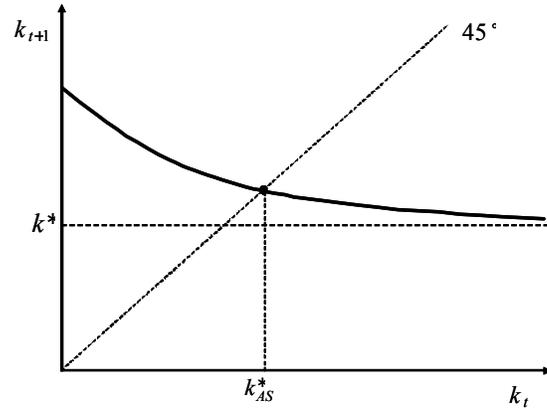


Figure 2: Dynamics of  $k_t$  with adverse selection

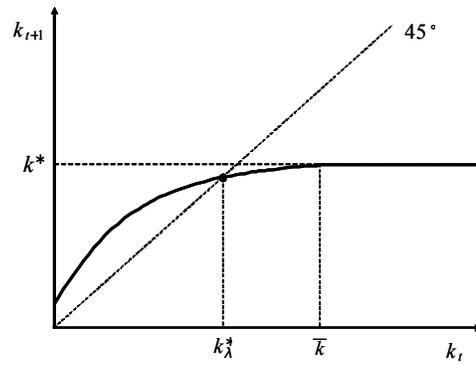


Figure 3: Dynamics of  $k_t$  with limited pledgeability

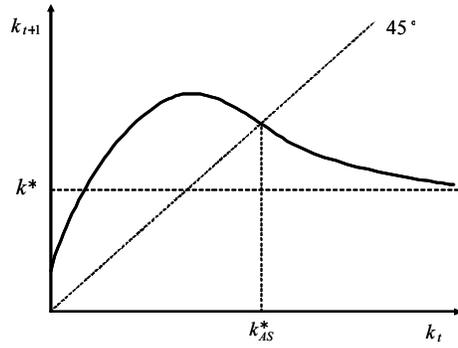


Figure 4: Dynamics of  $k_t$  with both frictions

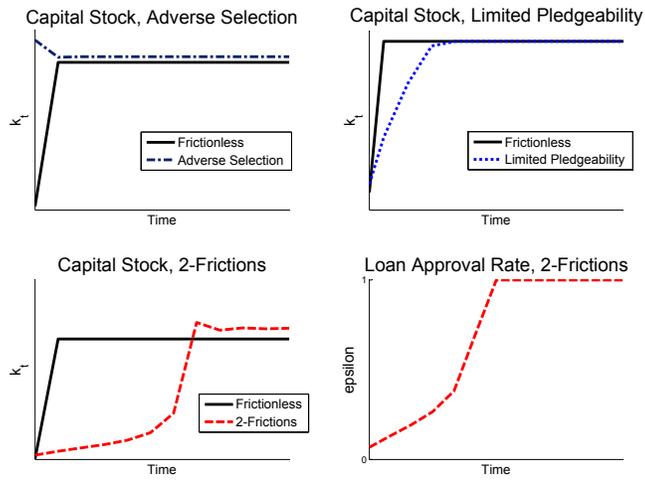


Figure 5: Capital accumulation in the small open economy ( $A = 1, I = 1, \alpha = 0.3, \lambda = 0.3$ )