Financial System Architecture and Systematic Risk

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Abstract

This paper classifies different types of financial architecture in an economy with investment complementarities and imperfect information. Classification is done according to the roles played by direct and intermediated finance. When the return on assets traded in financial markets is more volatile than the returns offered by intermediaries, financial intermediation improves the coordination among investors, thereby enhancing efficiency and stabilizing the economy against macroeconomic shocks. However, the position of the intermediary is fragile since competition from financial markets can cause the collapse of the intermediation sector. Possible solutions to this problem are proposed.

Keywords: Banking, Financial System, Systematic Risk, Global Games.

JEL Classification Numbers: G21, E44, G28, C72, O16.

"What we perceived in the United States in 1998 may reflect an important general principle: Multiple alternatives to transform an economy's savings into capital investment act as backup facilities should the primary form of intermediation fail. In 1998 in the United States, banking replaced the capital markets. Far more often it has been the other way around, as it was most recently in the United Sates a decade ago."

Alan Greenspan (1999).

1 Introduction

In the early nineteen-nineties several OECD countries were adversely affected by a credit crunch. In particular this shock had a dramatic effect on the amount of borrowing in the U.S.. As illustrated in figure 1, the value of real loans decreased but, surprisingly, the collapse of intermediated credit did not affect the debt securities market. In the 1998, during the Russia/LTCM crisis, the situation was reversed. While the real value of debt securities issued in the U.S. fell by almost half, there was a strong turnaround in intermediate lending. Somehow the banking system was able to smooth the turbulence in the debt securities market. Looking at figure 1, there is a broad pattern of compensation by the market less

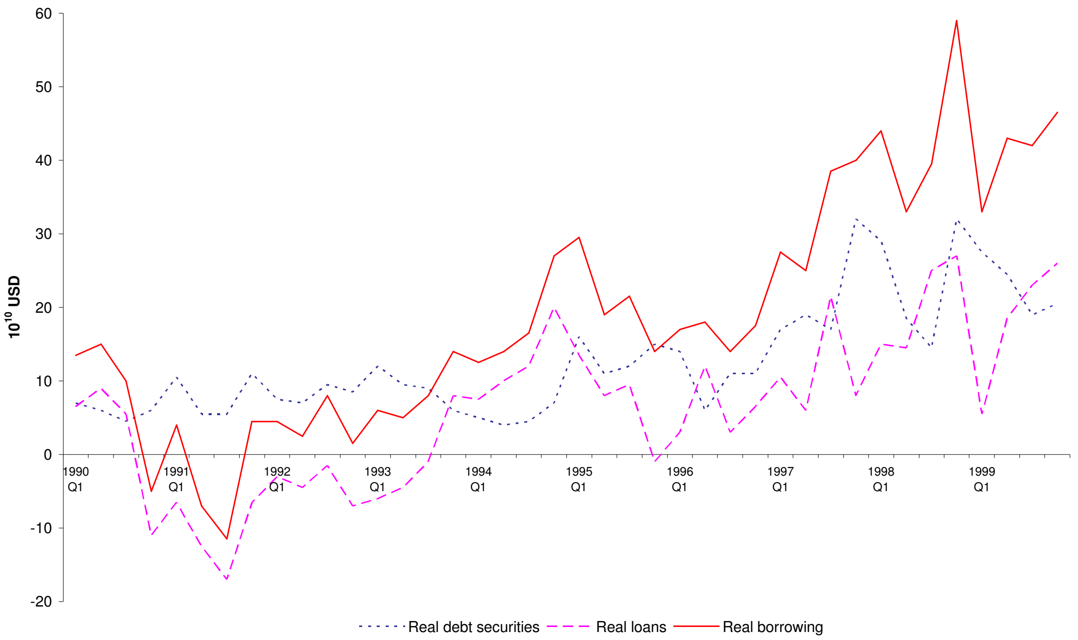

Figure 1: U.S. corporate debt securities issuance and intermediated borrowing (1995 prices). Notes: "Real debt securities" is corporate bond issuance plus commercial paper deflated by the CPI, while "real loans" is bank lending, mortgages and other loans to companies, similarly deflated. Real borrowing is the sum of these two components. Source: Davis (2001) used data from the "Flow of Funds Accounts of the United States" published by the Federal Reserve Board.

severely affected by the turbulence.

Alan Greenspan (1999, 2000) has suggested that multiple sources of finance help to protect economies against systemic problems affecting financial markets. Davis (2001) presents empirical evidence suggesting that the existence of active securities markets alongside banks is indeed beneficial to the stability of corporate financing, both during cyclical downturns and during financial crisis. Arguably, the low correlation between the volumes of intermediated funds and market-based finance contributes to smooth aggregate financial flows. The purpose of this paper is to propose a framework that explains how the architecture of the financial system interacts with systematic risk and affects economic efficiency.

In this paper I examine an economy with investment complementarities, where the return from investing in the real sector is determined by the state of the fundamental variables in the economy and by an externality associated with the mass of investors. This externality arises because there are synergies among investment projects and, therefore, the returns will improve if the number of investors is large. This framework raises the issue of coordination among investors as they take into consideration the behavior of other players when deciding whether to invest or not. The level of coordination has direct implications over aggregate investment and the model predicts an equilibrium characterized by underinvestment and volatile macroeconomic variables.

Traditional financial theory says little about hedging *nondiversifiable* risks. It assumes that the set of assets is fixed and focuses on the efficient sharing of risks through exchange. Diversification does not eliminate aggregate shocks which affect all assets in a similar way. In an Arrow-Debreu world, risk sharing is done automatically because markets are complete and institutions play little role in hedging risks. In practice, though, markets may not be complete for a variety of reasons, namely imperfect information. None of the traditional approaches provides much insight into the relationship between the institutional structure of the financial system, the stock of real assets and asset returns. The contribution of this paper, with respect to the traditional approaches, is to consider a setup in which there is heterogeneous information and the stock of assets, as well as their returns, are endogenous. In this framework, public information serves as a focal point for the beliefs of the group of investors as a whole and becomes extremely effective in influencing the individuals' actions. As a result, the available structure of information partially determines the level of systematic risk.

This paper assesses the role of an institution called "financial intermediation" for hedging *nondiversifiable* risks. The key idea is that financial intermediation expands the available investment set beyond the set available through direct finance. Intermediation can be seen as a *coordination device* that modifies the relationship between private and public information, thus improving coordination among agents. This mitigates the underinvestment problem and reduces the externality loss, thereby affecting the level and volatility of macroeconomic variables. A central issue is related to whom appropriates the efficiency gains generated by the intermediation sector.

This contribution implies a set of empirical predictions for each possible financial architecture. In all types of architecture investment is procyclical and, for certain types, financial intermediation acts as a buffer against shocks to the fundamentals. As a result, intermediaries stabilize aggregate output and reshape systematic risk. However, competition from financial markets can lead to the collapse of the intermediation sector. I discuss possible solutions to this problem as, for example, deposit insurance. Yet, deposit insurance leads to an overinvestment problem that can be minimized by adding uncertainty to this mechanism, which justifies a strategy of *constructive ambiguity* by the regulator.

This analysis relates to a number of strands in the literature. On the game theoretical side, I build upon recent work focusing on the mechanisms through which agents make decisions when information is imperfect and coordination is important for the final payoffs. This literature had its origin in the study of *global games* by Carlsson and van Damme (1993) and was fostered by Morris and Shin (1998). Although this literature has been extensively applied to finance, it has been less used in other fields of economics. Interesting applications to macroeconomics were made by Morris and Shin (2001) and Angeletos and Pavan (2004). Recently, Hellwig et al. (2005) and Angeletos and Werding (2006) have highlighted the importance of endogenous information and, in particular, the role of asset prices as a public signal aggregating dispersed private information. I do not pursue this line of research, as it would unnecessarily complicate the analysis without producing new insights. Instead, I investigate whether financial institutions have incentives to modify the structure of *public information* by enlarging the investment set available to investors.

I am not the first to aim at building a framework that helps to explain financial architecture. This effort adds to a small amount of recent literature concerned with the coexistence of direct and intermediated finance. Previous papers have modeled the choice between market and bank finance by considering an entrepreneurial moral hazard problem that can be ameliorated through (costly) bank monitoring. Holmstrom and Tirole (1997) and Repullo and Suarez (2000) examine the role of the net worth of firms in the distribution of external finance. Probably the most complete model explaining the demand for finance is the one by Bolton and Freixas (2000). By assuming that bank debt is easier to renegotiate and the existence of dilution costs, they justify why firms demand bank loans, private debt and equity. Yet, most studies concentrate solely on the choice of finance by the firm, while I am mainly concerned with the supply of finance. Some authors offered an integrated view of the demand and supply of funds, namely Boot and Thakor (1997) and Gorton and Pennacchi (1990). For Boot and Thakor, financial markets permit noncolluding informed agents to compete and convey valuable information to the firms. Banks do not have any informational advantage. Nonetheless they coordinate uninformed traders and resolve moral hazard problems. Gorton and Pennacchi argue that informed agents collude to exploit liquidity traders. Liquidity traders break the informed traders coalition by creating a bank. Banks mitigate informational asymmetries by splitting the cash flows of the assets in the economy. I borrow from Gorton and Pennacchi the security design approach and the fact that financial intermediaries may provide safer securities to their depositors. In contrast with the literature that I have mentioned so far, I impose weaker requirements to justify the existence of financial intermediation. I claim that informational heterogeneity is enough to justify the existence of financial intermediation since it can improve coordination among potential investors.

Another body of literature justifies the existence of financial intermediaries based on their role in liquidity creation, where liquid funds are those that can be immediately used for consumption. Here financial intermediaries help to solve a coordination problem related to the best allocation of resources across technologies. These models, based on Diamond and Dybvig (1983), had difficulties in explaining the coexistence between direct and indirect finance. Diamond (1997) shows that limited participation by some agents in some markets is a sufficient condition to guarantee coexistence. In his model, financial intermediaries emerge endogenously to solve the coordination problems generated by limited participation and I borrow this idea from him. My argument complements Kashyap et al. (2002), who argue that there are synergies between the deposit taking and lending activities of a bank. This happens as long as the demands for liquidity from depositors and borrowers are not perfectly correlated. I justify endogenously this assumption because, in the model presented, financial intermediation becomes important when direct finance dries up. Unlike them, I focus on systematic risk. In this line of research, Gatev and Strahan (2006) study the commercial paper market and document that banks provide firms with insurance against *market-wide* liquidity shocks because deposit inflows provide a hedge for loan demand shocks. Like them, I explore the insurance role of financial intermediaries but, unlike them, I analyze more general implications regarding financial architecture.

This paper is also related to the literature which highlights the importance of the financial system for economic growth. More specifically, it is helpful to assess the relative advantages and disadvantages of bank-based financial systems *vis-à-vis* market-based systems. It also sheds some light on the debate regarding the role of financial services for economic growth. Levine (1997) among others stress that financial arrangements arise to provide key financial services. This view suggests that financial instruments, markets and institutions arise to mitigate the effects of information and transactions costs. Demirgüç-Kunt and Levine (1999), Demirgüç-Kunt and Maksimovic (1998), Levine (1999, 2002) and others show that differences in how well financial systems reduce information and transaction costs influence savings rates, investment decisions, technological innovation, and long-term growth. The model that I present addresses most of these issues and encompasses the *financial services view* once we take into account that financial institutions shape the structure of information concerning the return on investments.

I borrow from Allen and Gale (1997) the idea that there are institutions which use their capital to hedge *nondiversifiable* risks. Like them, I find that financial intermediation is vulnerable to a market-based system, unless it possesses special investment opportunities. Although my main concern is the role of intermediaries in financial architecture, the results presented here carry over to a more general framework with different securities (for example, debt versus equity). The role of coordination distinguishes my work from the literature dealing with models of multi-asset securities markets under heterogeneous beliefs, as in Admati (1995).

The paper is organized as follows: I devote the next section to present the basic model and justify the main assumptions. I proceed by showing the resulting equilibrium and exhibit the different types of financial architecture that may emerge. Section 4 completes the description of the equilibrium, alludes to the policy implications suggested by the model and is followed by a short conclusion. The proofs of the most important results are given in the appendix.

2 The Model

The model has three types of agents:

- A continuum of households with unit mass, indexed by $i \in [0, 1]$, each with one unit of funds. Households must decide whether to invest their funds in any of the assets available in the economy, or not to invest at all.
- A continuum of identical firms, with unit mass, which have access to the same technology.
- A representative Financial Intermediary (hereafter FI) held by households.

Households receive two types of information, which I define later, about the state of the economy: *public* and *private information*. There are three dates in the economy: initial, interim and final. *Public information* is revealed at the initial date. At the interim date *private information* is given to each household, investment decisions are made and financial contracts are signed. At the final date investment returns are realized and financial claims are settled. All parties are risk neutral, there is no limited liability and I assume no discounting. I do not allow for short selling.

2.1 The Real Sector

Each firm has one project which requires one unit of funds and yields an uncertain payoff. Firms have no funds of their own and need to fully finance their project by resorting to external funds either through direct or intermediated finance. Hence the total demand for funds is one.

Let n be the mass of investors in the economy. If $1-n$ households become investors then, each household that invests directly in the firm sector, receives a net return equal to $r_D - n$. The risk factor r_D would have been the return, had every household decided to invest. Nonetheless, non-investors impose a negative externality on returns and this effect is captured by the factor n. I call this effect *externality loss* and the literature has presented justifications for such externalities based on: (*i*) premature liquidation of real assets as in Morris and Shin (2001, 2004) and Rochet and Vives (2004); (*ii*) financial assets sold at fire sale prices due to asymmetric information. An alternative explanation for such externalities concerns the existence of a production function that displays increasing returns to scale at the aggregate level. The factor r_D is a random variable with normal distribution $N\left(\overline{r}_D, \sqrt{1/\alpha}\right)$, where $0 < \overline{r}_D < 1$ and $\sqrt{1/\alpha}$ is the standard deviation. The distribution of r_D is common knowledge.

2.2 The Financial System

The financial system is composed of two forms of finance (see Figure 2). Households may decide to invest their funds directly in the firm or deposit their funds in the FI. At the interim date, the FI offers a security to households with a return different from the security issued by firms. This security has a net return equal to $r_B - n$. I assume that the factor r_B has a normal distribution $N(\overline{r}_B, \sigma_B)$ with $0 < \overline{r}_B < 1$ and is perfectly correlated with the risk factor r_D.[1] The distribution of r_B is common knowledge.

[1] This assumption plays no substantial role in what follows. I could allow for imperfect correlation and the results obtained would be identical.

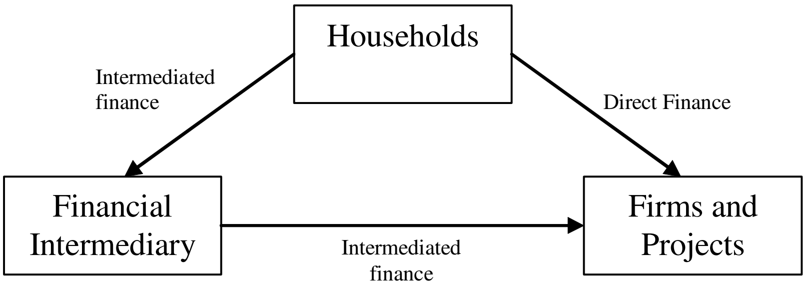

Figure 2: The Structure of the Financial System.

The FI receives an amount ι_B of funds from households and invests it in the firms. Since the FI is risk neutral and there is no limited liability, its incentive rationality condition is given by $E\left[\iota_B\left(r_D - r_B\right)\right] \geq 0$.

2.3 Households

Households must decide between investing their funds in direct or intermediated finance, in which case the payoffs are the respective returns, or not investing, in which case the payoff is zero. When investment decisions are made, households know neither the values taken by the risk factors, r_D and r_B, nor the mass of investors, $1 - n$. To decide whether to invest or not, they guess the values taken by these variables, relying on the information they possess. Households receive three pieces of information:

- *Public information* on the risk factor r_D, which consists of the probability distribution of the random variable r_D. I call α the precision of *public information*.

- *Public information* on the risk factor r_B, which consists of the probability distribution of the random variable r_B.

- *Private information*: each household i receives a private signal ω_i about the true value of the risk factor r_D, where

$$\omega_i = r_D + \varepsilon_i \quad \text{with} \quad \varepsilon_i \sim N\left(0, \sqrt{\frac{1}{\beta}}\right)$$

  where ε_i is identically and independently distributed across agents. I call β the precision of *private information*.

Given the information received, households update their (public) priors with their *private information*. Let $\rho_i = E\left[r_D|\omega_i\right] = \frac{\alpha\overline{r}_D+\beta\omega_i}{\alpha+\beta}$ be the updated belief of r_D upon observing the signal ω_i. Then the posterior distribution of r_D is the following:

$$r_D|\omega_i = r_D|\rho_i \sim N\left(\rho_i, \sqrt{\frac{1}{\alpha+\beta}}\right).$$

Conditioning on ω_i or ρ_i is equivalent because $\rho_i = E[r_D|\rho_i] = E[r_D|\omega_i]$ and, when convenient, I condition the random variables on ρ_i. Households also use *private information* to update their expectations about the realization of factor r_B.

$$E[r_B|\rho_i] = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D). \quad (1)$$

Consult Appendix A.1 for details on derivations. Intuitively, households use their information about economic conditions to infer the payoffs of the securities issued by the FI. In order to state the results more economically I assume that, when investing and refraining yield the same expected payoff, households prefer to invest, and, when indifferent between direct and intermediated finance, investors choose the former.

3 Investment and Financial System Architecture

When there is no financial intermediation, there is one single security available. Morris and Shin (2001) have solved a problem similar to this particular case. I present their result adapted to the current setup. The cumulative density function of a standard normal distribution is denoted by $\Phi(.)$ and let $\gamma = \frac{\alpha^2(\alpha+\beta)}{\beta(\alpha+2\beta)}$.

Theorem 1 *(Morris and Shin) When only direct finance is available, provided that $\gamma \leq 2\pi$, there is a unique equilibrium. In this equilibrium, every household i refrains from investing if and only if $\rho_i < \rho'$, where ρ' is the unique solution to*

$$\rho' = \Phi\left(\sqrt{\gamma}\left(\rho' - \overline{r}_D\right)\right).$$

The upper bound for γ is a sufficient condition for a unique equilibrium and guarantees that the precision of *private information* is large enough when compared with the precision of *public information*. Consult Morris and Shin (2001) for details.

As of this point, I investigate the case in which there is financial intermediation. In equilibrium, the mass of depositors in the FI could potentially reveal the true realization of the variable r_D. If there were information aggregation, and the representative FI disclosed the value for r_D, we would obtain fully revealing equilibria. In this case, *public information* would "destroy" *private information* and we would obtain multiplicity of equilibria, a well known feature in global games.[2] I dismiss the case for a fully revealing equilibrium and I assume that

[2] The model that I present can accommodate the case in which the FI is able to use the mass of depositors to infer the realization of r_D, and there is imperfect aggregation of information (for example because there are *noise traders* or unobservable supply shocks as in Grossman and Stiglitz (1976)). When there is noise in the mass of depositors, the FI is not able to derive

the representative FI is unable to derive the value of the fundamentals from the information contained in the mass of depositors. Presumably this happens because the representative FI is a useful theoretical simplification for a continuum of small financial intermediaries which do not hold a well diversified portfolio of depositors and are unable to derive the realization of the fundamentals from the mass of depositors. For the sake of completeness, I present the case in which only intermediated finance is available to households.

Proposition 1 *When only intermediated finance is available, provided that* $\gamma \leq 2\pi\alpha\sigma_B^2$, *there is a unique equilibrium. In this equilibrium, every household* i *refrains from investing if and only if* $\rho_i < \rho''$, *where* ρ'' *is the unique solution to*

$$\overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho'' - \overline{r}_D\right) = \Phi\left(\sqrt{\gamma}\left(\rho'' - \overline{r}_D\right)\right).$$

Proof. See the appendix. ■

Intermediation changes the structure of *public information* and this raises the issue of multiplicity of equilibria. Hence, with respect to the Morris and Shin

the true realization of r_D. If the FI discloses this new piece of information, it is making public information more precise. Whether we obtain multiplicity of equilibria or not, depends on the amount of aggregate noise, that is, it depends on the final precision of public information. Consult Hellwig et al. (2005) and Angeletos and Werding (2006) for more on this issue and, in particular, Angeletos and Werding study the case in which agents can observe one another's actions.

Theorem, a new condition for uniqueness of equilibrium is required.

The most interesting case happens when intermediated finance exists alongside market-based finance. In this case, there are two securities and households evaluate the expected net returns from investing in a portfolio against the payoff of not investing. The net return in a portfolio has two components: (i) the gain derived from the risk factors r_D and r_B; (ii) the externality loss associated with n. The following lemma characterizes the expected gain from investing in an optimal portfolio.

Lemma 1 *Denote by $G(\rho_i)$ the maximum expected gain from investing, for an agent with updated belief ρ_i. Then*

$$G(\rho_i) = \max\left\{\rho_i, \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D)\right\}.$$

Graphically, the function $G(\rho_i)$ is the upper envelope of two straight lines which intersect at $\rho^I = \frac{\overline{r}_B - \sqrt{\alpha}\sigma_B \overline{r}_D}{1-\sqrt{\alpha}\sigma_B}$.

Proof. Note that $G(\rho_i) = \max_{\lambda\in[0,1]} E[\lambda r_D + (1-\lambda) r_B|\rho_i] = \max_{\lambda\in[0,1]} \lambda E[r_D|\rho_i] + (1-\lambda) E[r_B|\rho_i]$, where $E[r_D|\rho_i] = \rho_i$ and $E[r_B|\rho_i] = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D)$. Under our assumptions, we obtain $\lambda = 1$ if $E[r_D|\rho_i] > E[r_B|\rho_i]$ and $\lambda = 0$ if

$E[r_D|\rho_i] < E[r_B|\rho_i]$. When $E[r_D|\rho_i] = E[r_B|\rho_i]$ then $\lambda \in [0,1]$. Hence the result. ■

The significance of this lemma rests on the simple characterization of the expected gains. Since $E[r_D|\rho_i] = \rho_i$ and $E[r_B|\rho_i] = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D)$, it is easy to confirm that, except for $\rho_i = \rho^I$, the optimal portfolio is constituted by one single security. The next proposition is the main result in this paper.

Proposition 2 *Let $\psi = \min\{1, \alpha\sigma_B^2\}$. Provided $\gamma \leq 2\pi\psi$ there is a unique equilibrium. In this equilibrium, every household i refrains from investing if and only if $\rho_i \leq \rho^*$, where ρ^* is the unique solution to*

$$G(\rho^*) = \Phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right).$$

Given its updated belief ρ_i, each investor invests its funds in the security with the highest expected return.

Proof. The economic problem presented can be represented as a game with four stages. In the first stage, nature withdraws a realization from the distribution of the random variable r_D. In the second stage, nature withdraws the private signals. At the third stage, each household decides whether to invest or not. At the final stage, those households that decided to become investors, choose the best security in which to invest. Treating each realization of household i's signal as a possible "type", we solve for a Bayesian Equilibrium.

I use backwards induction. First, I determine the optimal action at the final stage of the game. Since households are risk neutral, investors invest their whole amount of savings in the security with the highest expected return. Given that the factor related to the externality loss is common to both securities, investors select the security with the highest expected gain. Then I proceed to the next to last decision stage and determine if each household should invest or not. This decision problem has been thoroughly discussed in the global games literature and, in particular, I apply the ideas presented by Morris and Shin (2001). The full proof of the argument is given in the appendix. ■

As in the cases of a single security, the uniqueness of equilibrium requires an upper bound on the precision of *public information*. When the FI issues securities safer than the securities issued by firms, then it is as if the precision of *public information* increases, and this raises the issue of multiplicity of equilibria. Hence, with respect to the Morris and Shin Theorem, a stronger condition for uniqueness of equilibrium is required. Formally, when $\sigma_B < \sqrt{\frac{1}{\alpha}}$ then $\psi = \alpha\sigma_B^2 < 1$ and the upper bound for γ must be reduced. As of now I assume that $\gamma \leq 2\pi\psi$.

I call ρ', ρ'' and ρ^* the *investment thresholds*. According to the structure of the financial system, households use different *investment thresholds* to take their investment decisions. The next result quantifies the aggregate level of investment.

Corollary 1 *The level of investment, in an economy with investment threshold equal to* ρ^T, *equals*

$$\iota\left(r_D;\rho^T\right) = \Phi\left(\sqrt{\beta}\left(r_D - \frac{\alpha+\beta}{\beta}\rho^T + \frac{\alpha}{\beta}\overline{r}_D\right)\right).$$

Proof. The mass of investors is equal to the probability that any particular household invests. Given the realization of the factor r_D, this is the probability that the household's updated belief falls above ρ^T. Since

$\rho_i|r_D \sim N\left(\frac{\alpha\overline{r}_D+\beta r_D}{\alpha+\beta}, \frac{\sqrt{\beta}}{\alpha+\beta}\right)$, then $\iota\left(r_D;\rho^T\right) = prob\left[\rho_i > \rho^T|r_D\right] =$

$= 1-\Phi\left(\sqrt{\beta}\left(\frac{\alpha+\beta}{\beta}\rho^T - \frac{\alpha}{\beta}\overline{r}_D - r_D\right)\right) = \Phi\left(\sqrt{\beta}\left(r_D - \frac{\alpha+\beta}{\beta}\rho^T + \frac{\alpha}{\beta}\overline{r}_D\right)\right)$. ■

From the *ex ante* point of view, equilibrium is characterized by underinvestment in the financial systems that have been described. It is worth emphasizing that the values for the *investment thresholds* and the extent of the underinvestment problem depend on the precision of *public* and *private information*. Inasmuch as financial arrangements and services change the structure of information in the economy, this model provides a rationale for the *financial services view* of the finance-growth relationship.

3.1 Financial System Architecture

In the next proposition, four types of financial architecture are presented according to the values taken by the key parameters that characterize financial intermediation, which are the expected return ($\overline{r}_B$) and the standard deviation of the returns (σ_B) offered by the FI. Let $\widehat{r}_B$ be the threshold for $\overline{r}_B$ such that $\rho^I = \rho'$, that is, it is the maximum value for $\overline{r}_B$ such that the size of the intermediation sector is zero. Formally, $\widehat{r}_B = \rho' + \sqrt{\alpha}\sigma_B\left(\overline{r}_D - \rho'\right)$.

Proposition 3 *When parameters are such that:*

- $\sigma_B < \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B > \widehat{r}_B$ *then there is coexistence between direct and intermediated finance. If* $\sigma_B < \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B \leq \widehat{r}_B$ *then only direct finance is feasible.*

- $\sigma_B > \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B > \widehat{r}_B$ *then only intermediated finance is feasible. If* $\sigma_B > \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B \leq \widehat{r}_B$ *then there is coexistence between direct and intermediated finance.*

- $\sigma_B = \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B \leq \overline{r}_D$ *then only direct finance is feasible. If* $\sigma_B = \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B > \overline{r}_D$ *then only intermediated finance is feasible.*

Proof. See the appendix. ■

Recall that $\sqrt{1/\alpha}$ is the amount of risk attached to the assets issued by firms. When $\sigma_B < \sqrt{1/\alpha}$, the FI smooths the primitive payoffs available in the economy. Whether agents invest through a FI depends on the average return provided by the FI. When $\overline{r}_B > \widehat{r}_B$, households with updated beliefs belonging to the set $\left[\rho^*, \rho^I\right)$ deposit their funds in the FI and those with higher updated beliefs invest directly in the firm.

When $\sigma_B > \sqrt{1/\alpha}$, the FI issues a security with riskier returns than the returns from securities issued by firms. When $\overline{r}_B$ is sufficiently high, financial intermediation leads to an extreme reallocation of funds by absorbing all the funds from investors. When $\overline{r}_B \leq \widehat{r}_B$, households with updated beliefs belonging to the set $\left[\rho^*, \rho^I\right]$ invest directly in the firm while more optimistic households deposit their funds in the FI.

When $\sigma_B = \sqrt{1/\alpha}$, the only distinction between direct and intermediated finance is the average return, and investors choose the security with the highest expected return.

Figure 3 presents a classification of the different types of financial architecture, according to the values taken by the parameters $\overline{r}_B$ and σ_B, when $\rho' < \overline{r}_D$.

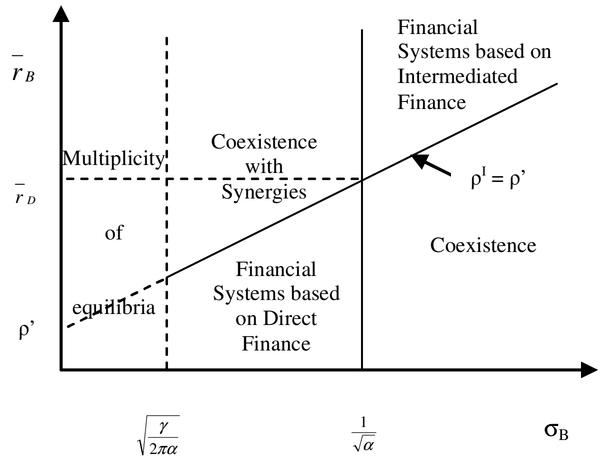

Figure 3: Classification of Financial Systems when $\rho' < \overline{r}_D$.

4 Equilibrium and Regulation

As of now I study the case $\sigma_B < \sqrt{1/\alpha}$ and $\overline{r}_B > \widehat{r}_B$. I consider this case as the most interesting for two reasons. First, we observe that the returns on assets that are traded on financial markets are more volatile than the returns offered by intermediaries such as banks and insurance companies and this case shares these features. Second, in this case, there is coexistence with synergies between both sources of finance. To see this, consider the next result.

Corollary 2 *When* $\sigma_B < \sqrt{\frac{1}{\alpha}}$ *and* $\overline{r}_B > \widehat{r}_B$*, comparison between financial systems yields* $\rho^* < \rho'$.

Proof. We obtain $\rho^* < \rho'$ because, when $\sigma_B < \sqrt{\frac{1}{\alpha}}$ and $\rho^* < \rho^I$, we have $G(\rho^*) > \rho^*$. This means that $\Phi\left(\sqrt{\gamma}\left(\rho^* - \overline{r}_D\right)\right) > \rho^*$. Given that $\rho' = \Phi\left(\sqrt{\gamma}\left(\rho' - \overline{r}_D\right)\right)$ and $0 < \phi\left(\sqrt{\gamma}\left(\rho - \overline{r}_D\right)\right)\sqrt{\gamma} < 1$ for all ρ, then $\rho^* < \rho'$. ■

Intermediation is important because it mitigates the underinvestment problem. By lowering the *investment threshold* below the level which exists in financial systems based solely on direct finance, the FI raises the level of investment reducing the externality loss and augmenting efficiency. This result derives from the fact that the FI perform a risk transformation role, thereby facilitating coordination across households. Financial intermediation changes the structure of *public information* and Morris and Shin (2001, 2002) and Svensson (2006) have pointed out that agents use *public information* to coordinate their actions. They show that the precision of *public information* has a large disproportionate effect on the *investment threshold* ρ'. When *public information* is very precise, households are confident that other households have received good private signals and are willing to invest. This reduces the expected externality loss and creates an environment favorable to investment. When the FI offers securities with low risk, the effect over aggregate confidence is similar. Households believe that pessimistic agents do not refrain from investing because they can invest their funds in safe securities issued by the FI. This reduces the expected externality loss, raises expected returns and spurs investment.

It is interesting to analyze the case in which the FI performs a pure risk transformation role, that is, it issues securities to households with the same expected return and less risk than the securities issued by firms. Formally, $r_B = \overline{r}_D + \sqrt{\alpha}\sigma_B (r_D - \overline{r}_D)$ with $\sqrt{\alpha}\sigma_B < 1$. The FI uses its own funds to offset deviations of factor r_D from its mean, smoothing the returns from households who chose intermediated finance. This means that the FI holds back some profits in good states of the world in order to make up the difference in bad states when projects have performed poorly. Ultimately the owners of the FI must pay or receive the difference between r_D and r_B. Were the FI alone in the financial markets, and its activity would be profitable. To see this more clearly, I present the following result:

Proposition 4 *When only intermediated finance is available, provided that $\overline{r}_D = \overline{r}_B$ and $\sigma_B < \sqrt{\frac{1}{\alpha}}$, then the expected profits of the financial intermediary are positive. Moreover, if the parameters are such that $\rho'' < \overline{r}_D$, then $\rho'' < \rho'$.*

Proof. When intermediated finance is the only option available to investors, aggregate investment equals $\iota(r_D; \rho'')$. We have $r_B = \overline{r}_D + \sqrt{\alpha}\sigma_B (r_D - \overline{r}_D)$. The expected profit of the FI is equal to $E[\iota(r_D; \rho'')(r_D - r_B)]$ and, substituting for r_B

and using Stein's Lemma, the expected profit equals $(1-\sqrt{\alpha}\sigma_B)\, E\left[\frac{\partial\iota(r_D;\rho'')}{\partial r_D}\right]\frac{1}{\alpha} > 0$. As for the second part of the proof, note that $\rho^I = \overline{r}_D$, when $\overline{r}_D = \overline{r}_B$. We obtain $\rho'' < \rho'$ because, when $\sigma_B < \sqrt{\frac{1}{\alpha}}$ and $\rho'' < \rho^I$, we have $\overline{r}_B + \sqrt{\alpha}\sigma_B\,(\rho'' - \overline{r}_D) > \rho''$. This means that $\Phi\left(\sqrt{\gamma}\,(\rho'' - \overline{r}_D)\right) > \rho''$. Given that $\rho' = \Phi\left(\sqrt{\gamma}\,(\rho' - \overline{r}_D)\right)$ and $0 < \phi\left(\sqrt{\gamma}\,(\rho - \overline{r}_D)\right)\sqrt{\gamma} < 1$, then $\rho'' < \rho'$. ■

Without competition from market-based finance, the FI reduces the underinvestment problem and appropriates the efficiency gains generated by its insurance activity. However, when intermediation coexists with financial markets, the contract issued by the FI suffers from a *winner's curse*. As a result, the net transfers to depositors are positively correlated with the mass of depositors and the gains and losses of the FI are asymmetric in good and bad states of the world so that, setting $\overline{r}_B = \overline{r}_D$, does not guarantee positive expected profits for the FI.[3] As in the work by Allen and Gale, financial intermediaries are vulnerable to a market-based system, unless they possess special investment opportunities. In our case, if the FI has access to a monitoring technology which reduces the dispersion of the returns in the firm, then it is possible to have profitable intermediation coexisting with financial markets.

[3] I have numerically simulated the case in which a FI coexists with market-based finance, and I have not been able to find any equilibrium in which the incentive rationality condition of the FI is satisfied. The Matlab codes for the simulations in this paper can be found at [add address of website].

The second reason why financial intermediation has beneficial effects over investment is that, for some parameters, the existence of financial intermediation stabilizes the behavior of investment. Under the current setup, after a bad shock, many investors abandon decentralized financial markets and invest through a FI, while in systems based on direct finance these households would not invest at all. This result is coherent with Greenspan's view about the functioning of the financial system.

4.1 Policy and Regulatory Implications

From the above discussion, we can see that the model has implications regarding two criteria relevant for economic policy: efficiency and stability. First, the level of efficiency is related to the underinvestment problem. The size of this problem is determined by the value of the *investment threshold*. I have highlighted that the FI can reduce the value of ρ^* below the level of ρ'. I have also pointed out that financial intermediation may not be profitable and, when profitable, a profit maximizing FI may not be willing to set ρ^* below the level of ρ'.

In principle, from the *ex ante* point of view, households are willing to subsidize investment in order to reduce the size of the externality loss. This justifies the creation of an institution that provides incentives to invest and, one possibility, would be to subsidize the creation of a safe security. This could be implemented through transfers to investors in the bad states of the world. At the individual level, this institution would act in a way similar to a deposit insurance agency: it would transfer funds to depositors when the realization of the fundamentals is bad. In the case in which banks perform a risk transformation role, this amounts to making transfers in those states in which the FI faces more difficulties. At the aggregate level, this institution would consist of interventions by the authorities when there are systemic crisis in the financial intermediation sector.

With protective deterministic interventions, the mass of investors equals one irrespective of the value taken by the fundamentals and there is an overinvestment problem. A mechanism which incorporates some uncertainty about the final returns in the bad states of the world is better than a deterministic scheme. Ambiguity about whether investors in a FI receive non-negative returns in the bad states of the world, prevents households with bad signals from investing and reduces investment in the bad states of the world. Arguably, the strategies of *constructive ambiguity* followed by central banks (that is, the regulator of the financial intermediation sector) can be seen as ideal to minimize the overinvestment problem. Nonetheless, the level of uncertainty in such a mechanism is conditioned by the multiplicity of equilibria problem. A random mechanism with too little uncertainty could prove to be destabilizing, an issue already discussed by Rochet and Vives.

The second dimension of potential concern for the regulator is systematic risk and the stability of aggregate output. Since output and investment are positively correlated, the pursuit of output stability amounts to promoting a stable investment. It is not difficult to find a constellation of parameters under which lowering the level of ρ^* reduces the variance of aggregate investment, $\iota(r_D; \rho^*)$.[4] I conclude that the regulator should consider the value of the *investment threshold* as an intermediate goal for economic policy.

5 Conclusion

The role of financial intermediation in financial architecture is twofold: it affects the levels of aggregate output and systematic risk. When financial intermediaries coexist with direct finance and insure aggregate risk, intermediation improves the coordination among investors. Financial intermediation is beneficial to the economy since, on the one hand, it lowers the *investment threshold*, reduces the externality loss and increases efficiency and, on the other hand, intermediation

[4] Again, consult the Matlab codes for the simulations in this paper.

stabilizes aggregate output, reducing systematic risk. Yet, such activity might be difficult to be profitably performed. Hence, in order to exist, either financial intermediaries have access to a new investment set or must be subsidized.

There are several interesting extensions for the present work. First, it would be interesting to consider explicitly the role of prices as a source of *public information*. Alternatively, one could consider the case in which the amount of deposits conveys information about the realization of the fundamentals.

Second, I have assumed that the mass of non-investors, n, has a common effect on both securities which implies that the externality loss does not depend on the type of investment made. One interesting extension of the model is to consider explicitly different externality losses generated by non-investors for each of the securities in the economy. On the one hand, intermediated finance diverts resources from markets for direct finance, diminishing their liquidity. On the other hand, when markets for direct finance are incipient, financial intermediation might reveal itself as the most efficient mechanism to channel funds from agents into the productive activity. As a consequence, encompassing these features in the model would indicate both the virtues of financial intermediaries when markets are illiquid (as in the Japanese and German types of financial architecture) and the virtues of fully fledged security markets when externalities are limited and liquidity is high. Again, my ideas run close to the arguments expressed by Allen and Gale.

Finally, it would be interesting to apply the framework presented in this paper to examine explicitly the role of financial services for economic growth. In this line of research, note that the implications of competition for the equilibrium were not studied in this paper.

A Appendix

A.1 Derivation of Expression (1)

The joint distribution of the variables in the model is

$$\begin{pmatrix} r_D \\ \varepsilon_i \\ \omega_i \\ r_B \\ \omega_{-i} \end{pmatrix} \sim N\left(\begin{pmatrix} \overline{r}_D \\ 0 \\ \overline{r}_D \\ \overline{r}_B \\ 0 \end{pmatrix}, \begin{pmatrix} \frac{1}{\alpha} & 0 & \frac{1}{\alpha} & \sqrt{\frac{1}{\alpha}}\sigma_B & \frac{1}{\alpha} \\ 0 & \frac{1}{\beta} & \frac{1}{\beta} & 0 & 0 \\ \frac{1}{\alpha} & \frac{1}{\beta} & \frac{1}{\alpha}+\frac{1}{\beta} & \sqrt{\frac{1}{\alpha}}\sigma_B & \frac{1}{\alpha} \\ \sqrt{\frac{1}{\alpha}}\sigma_B & 0 & \sqrt{\frac{1}{\alpha}}\sigma_B & \sigma_B^2 & \sqrt{\frac{1}{\alpha}}\sigma_B \\ \frac{1}{\alpha} & 0 & \frac{1}{\alpha} & \sqrt{\frac{1}{\alpha}}\sigma_B & \frac{1}{\alpha}+\frac{1}{\beta} \end{pmatrix}\right)$$

where ω_{-i} is the distribution of the signal of a player different from player i. We can compute

$$E\left[r_B|\omega_i\right] = \overline{r}_B + \frac{\sqrt{\frac{1}{\alpha}}\sigma_B}{\frac{1}{\alpha}+\frac{1}{\beta}}\left(\omega_i - \overline{r}_D\right)$$

and, using the definition of ρ_i, we obtain $E\left[r_B|\omega_i\right] = \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i - \overline{r}_D\right)$ which yields expression (1).

A.2 Proof of Proposition 1

I define *switching strategy* (SS hereafter) around $\widehat{\rho}$ as a strategy that prescribes not investing if the household receives a signal which makes its updated belief inferior to $\widehat{\rho}$ and, when its belief falls above the threshold $\widehat{\rho}$, then the agent decides to invest. Formally

$$s^{\widehat{\rho}}\left(\rho_i\right) = \begin{cases} \text{invest} & if\ \rho_i \geq \widehat{\rho} \\ \text{not invest} & if\ \rho_i < \widehat{\rho} \end{cases}.$$

Let S be the set of possible strategies, s_i the strategy followed by agent i and s_{-i} the profile of strategies chosen by all other households except i. Let $H\left(\rho_i\right) = E\left[r_B|\rho_i\right]$. Agents start by computing the expected net return that they obtain when they invest in a FI, which is equivalent to $H\left(\rho_i\right) - E\left[n|\rho_i, s_{-i}\right]$. In this expression, it is possible to identify both components of the expected net return. Let us study the externality loss. First note that household i, given its information, may also compute the posterior for the updated belief that he believes other agents have:

$$\rho_{-i}|\rho_i \sim N\left(\frac{\alpha\overline{r}_D + \beta\rho_i}{\alpha+\beta}, \sqrt{\frac{\beta(\alpha+2\beta)}{(\alpha+\beta)^3}}\right)$$

because $\rho_{-i} = \frac{\alpha\overline{r}_D+\beta\omega_{-i}}{\alpha+\beta}$, $E[\rho_{-i}|\rho_i] = E[\rho_{-i}|\omega_i]$ and $Var[\rho_{-i}|\rho_i] = Var[\rho_{-i}|\omega_i]$.

Let

$$L_1(\rho_i) \equiv E\left[n \mid \rho_i, s_{-i}^{\rho_i}\right] = prob\left[\rho_{-i} < \rho_i|\rho_i\right] = \Phi\left(\sqrt{\gamma}\left(\rho_i - \overline{r}_D\right)\right).$$

This function represents the expected externality loss from underinvestment, for an agent who receives ρ_i and believes every other agent is using a SS around ρ_i. The first equality holds because the noise in private information is independent of the true value of r_D, which makes the expected proportion of non-investors equal to the probability that any particular household does not invest. Since everyone follows a SS around ρ_i, the probability that any particular household does not invest, is given by the probability that this household's updated belief falls below ρ_i, and this justifies the second equality. Note that $0 < L(\rho_i) < 1$.

Define

$$U_1(\rho_i) = H(\rho_i) - L_1(\rho_i)$$

as the expected net return, given ρ_i, when every other agent is using a SS around ρ_i. Our assumptions imply the following lemmas:

Lemma 2 *Both functions, $H(\rho_i)$ and $L_1(\rho_i)$, are continuous.*

Proof. Trivial. ■

Lemma 3 *The function $H(\rho_i)$ is upward sloping and there is a unique value $\underline{\rho}_1$ which solves $H\left(\underline{\rho}_1\right) = 0$.*

Proof. Trivial. ■

Lemma 4 *If $\gamma \leq 2\pi\alpha\sigma_B^2$, then there is a unique solution ρ'' to $U_1(\rho'') = 0$.*

Proof. The slope of $U_1(\rho_i)$ is $\sqrt{\alpha}\sigma_B - \sqrt{\gamma}\phi\left(\sqrt{\gamma}(\rho_i - \overline{r}_D)\right)$. Since the density function has a maximum value of $\sqrt{\frac{1}{2\pi}}$, then the slope of $U_1(\rho_i)$ is positive when $\gamma < 2\pi\alpha\sigma_B^2$, and zero if $\gamma = 2\pi\alpha\sigma_B^2$. Since $U_1(\rho_i)$ takes both positive and negative values, then there is at most one solution to $U_1(\rho_i) = 0$. When $\gamma = 2\pi\alpha\sigma_B^2$, then the point at which the slope may be zero is at $\rho_i = \overline{r}_D$. At this point, though the second derivative of $U_1(\rho_i)$ is zero, the third derivative is positive which implies that there is one single solution. ■

From these results follow the statement in proposition 1. The argument goes as follows. Let

$$L_2(\rho_i, \widehat{\rho}) \equiv prob\left[\rho_{-i} < \widehat{\rho} | \rho_i\right] = \Phi\left(\sqrt{\gamma}\left(\widehat{\rho} - \overline{r}_D + \frac{\beta}{\alpha}(\widehat{\rho} - \rho_i)\right)\right)$$

represent the expected externality loss from underinvestment, for an agent who receives ρ_i and believes every other agent is using a SS around $\widehat{\rho}$. Define

$$U_2(\rho_i, \widehat{\rho}) = H(\rho_i) - L_2(\rho_i)$$

as the expected net return, conditional on posterior ρ_i, when every other agent is using a SS around $\widehat{\rho}$. Note that

$$U_2(\rho_i, \rho_i) = U_1(\rho_i). \tag{2}$$

I start by stating the following lemmas:

Lemma 5 *$U_2(\rho_i, \widehat{\rho})$ is increasing in its first argument and decreasing in its second.*

Proof. Trivial. ■

Lemma 6 *Let $\widetilde{\rho}$ be a solution to $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0$. Then $\widetilde{\rho}$ is unique and $\underline{\rho}_1 < \widetilde{\rho}$.*

Proof. Note that $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0 \Longleftrightarrow U_1(\widetilde{\rho}) = 0$. Hence $\widetilde{\rho} = \rho''$ and this is unique. Moreover, it is possible to define $\underline{\rho}_1$ as the solution to $\lim_{\widehat{\rho} \to -\infty} U_2\left(\underline{\rho}_1, \widehat{\rho}\right) = 0$. By $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0$ and lemma 5 the result follows. ■

Under our assumptions there is a single point ρ'' that satisfies $U_1(\rho'') = 0$. This point defines the unique (symmetric) equilibrium existing in this game, in which every player follows an SS around ρ''. The marginal investor who receives posterior ρ'', and believes that others use an SS around ρ'', is indifferent between investing or not. No other posterior has this property. It is easy to see, from lemma 5, that if every agent believes others use an SS around ρ'', then agents with $\rho_i \geq \rho''$ decide to invest while other agents decide not to invest.

Having proved the existence of a unique equilibrium in SS, I will show that there can be no other equilibrium, in the spirit of the proof by Morris and Shin (2001).

If ρ_i is sufficiently unfavorable, then $H(\rho_i) < 0$, and not investing is the dominant action irrespective of what other agents do. Note that $\underline{\rho}_1$ is the threshold for the posterior, below which not investing is the dominant action.

If agents believed that others were following an SS around $\underline{\rho}_1$, then their best reply would be an SS around $\underline{\rho}_2$, where $\underline{\rho}_2$ solves $U_2\left(\underline{\rho}_2, \underline{\rho}_1\right) = 0$.

The most optimistic investor believes that the proportion of non-investors is higher or equal than that implied by an SS around $\underline{\rho}_1$. Since the payoff from investing is decreasing in the mass of non-investors, we rule out every strategy that prescribes investing for posteriors inferior to $\underline{\rho}_2$ since they are dominated.

Proceeding this way, we construct an increasing sequence of thresholds $\underline{\rho}_k$ (using lemma 5) which do not survive k iterations of deletion of dominated strategies.

$$\underline{\rho}_1 < \underline{\rho}_2 < ... < \underline{\rho}_k < ...$$

Since ρ'' is the unique solution to $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0$ (because of expression (2)), then it is the least upper bound of the sequence of thresholds (again by lemma 5) and hence its limit. Any strategy that dictates investing for $\rho_i < \rho''$ does not survive iterated deletion of dominated strategies.

On the other hand, there is a symmetric argument for $\rho_i > \rho''$. From this argument I derive that any strategy that decides not to invest for $\rho_i > \rho''$ does not survive iterated deletion of dominated strategies.

Thus, there is one single strategy surviving iterated elimination of dominated strategies, which is the SS around ρ''. ■

A.3 Proof of Proposition 2

Redefine *switching strategy* around $\widehat{\rho}$ as

$$s^{\widehat{\rho}}(\rho_i) = \begin{cases} \text{invest in the security with the highest expected return} & if\ \rho_i \geq \widehat{\rho} \\ \text{not invest} & if\ \rho_i < \widehat{\rho} \end{cases}.$$

This means that, when the belief on an agent is above the threshold $\widehat{\rho}$, then he decides to invest in the security with the highest expected return.

Agents start by computing the maximum expected net return that they can make in the available portfolios

$$\max_{\lambda \in [0,1]} E\left[\lambda \left(r_D - n\right) + \left(1 - \lambda\right)\left(r_B - n\right) | \rho_i, s_{-i}\right]$$

which is equivalent to

$$G(\rho_i) - E\left[n | \rho_i, s_{-i}\right]$$

by lemma 1. The rest of the proof is similar to the proof of proposition 1. With respect to the externality loss, let

$$L_1(\rho_i) \equiv E\left[n \mid \rho_i, s_{-i}^{\rho_i}\right] = prob\left[\rho_{-i} < \rho_i | \rho_i\right] = \Phi\left(\sqrt{\gamma}\left(\rho_i - \overline{r}_D\right)\right)$$

and define $U_1(\rho_i) = G(\rho_i) - L_1(\rho_i)$. Our assumptions imply the following lemmas:

Lemma 7 *Both functions, $G(\rho_i)$ and $L_1(\rho_i)$, are continuous.*

Proof. Trivial. ■

Lemma 8 *The function $G(\rho_i)$ is upward sloping and there is a unique value $\underline{\rho}_1$ which solves $G\left(\underline{\rho}_1\right) = 0$.*

Proof. Trivial. ■

Lemma 9 *If $\gamma \leq 2\pi\psi$, then there is a unique solution ρ^* to $U_1(\rho^*) = 0$.*

Proof. The slope of $U_1(\rho_i)$ is $G'(\rho_i) - \sqrt{\gamma}\phi\left(\sqrt{\gamma}(\rho_i - \overline{r}_D)\right)$. Since the density function has a maximum value of $\sqrt{\frac{1}{2\pi}}$ and $G'(\rho_i) \geq \min\{1, \sqrt{\alpha}\sigma_B\}$, then the slope of $U_1(\rho_i)$ is positive when $\gamma < 2\pi\psi$, and zero if $\gamma = 2\pi\psi$. Since $U_1(\rho_i)$ takes both positive and negative values, then there is at most one solution to $U_1(\rho_i) = 0$. When $\gamma = 2\pi\psi$, then the point at which the slope may be zero is at $\rho_i = \overline{r}_D$. At this point, though the second derivative of $U_1(\rho_i)$ is zero, the third derivative is positive which implies that there is one single solution. ■

From these results follow the statement in proposition 2. Let

$$L_2(\rho_i, \widehat{\rho}) \equiv prob\left[\rho_{-i} < \widehat{\rho} | \rho_i\right] = \Phi\left(\sqrt{\gamma}\left(\widehat{\rho} - \overline{r}_D + \frac{\beta}{\alpha}(\widehat{\rho} - \rho_i)\right)\right)$$

and define $U_2(\rho_i, \widehat{\rho}) = G(\rho_i) - L_2(\rho_i)$. Note that $U_2(\rho_i, \rho_i) = U_1(\rho_i)$. I state the following lemmas:

Lemma 10 *$U_2(\rho_i, \widehat{\rho})$ is increasing in its first argument and decreasing in its second.*

Proof. Trivial. ■

Lemma 11 *Let $\widetilde{\rho}$ be a solution to $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0$. Then $\widetilde{\rho}$ is unique and $\underline{\rho}_1 < \widetilde{\rho}$.*

Proof. Note that $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0 \Longleftrightarrow U_1(\widetilde{\rho}) = 0$. Hence $\widetilde{\rho} = \rho^*$ and this is unique. Moreover, it is possible to define $\underline{\rho}_1$ as the solution to $\lim_{\widehat{\rho} \to -\infty} U_2\left(\underline{\rho}_1, \widehat{\rho}\right) = 0$. By $U_2(\widetilde{\rho}, \widetilde{\rho}) = 0$ and lemma 10 the result follows. ■

Under our assumptions there is a single point ρ^* that satisfies $U_1(\rho^*) = 0$. This point defines the unique (symmetric) equilibrium existing in this game, in which every player follows an SS around ρ^*. The marginal investor who receives posterior ρ^*, and believes that others use an SS around ρ^*, is indifferent between investing or not. No other posterior has this property. It is easy to see, from lemma 10, that if every agent believes others use an SS around ρ^*, then agents with $\rho_i \geq \rho^*$ decide to invest while other agents decide not to invest.

Having proved the existence of a unique equilibrium in SS, it remains to show that there can be no other equilibrium. Following the same argument used in lemma 1 it is easy to prove that there is one single strategy surviving iterated elimination of dominated strategies, which is the SS around ρ^*. ■

A.4 Proof of Proposition 3

First, consider the cases in which in which $\sigma_B < \sqrt{\frac{1}{\alpha}}$.

Corollary 3 *When parameters are such that* $\sigma_B < \sqrt{\frac{1}{\alpha}}$ *and* $\rho^* < \rho^I$*, there is coexistence between direct and intermediated finance. Households with an updated belief below* ρ^* *do not invest, households with updated beliefs belonging to the set* $\left[\rho^*, \rho^I\right)$ *deposit their funds in the FI and those with higher updated beliefs invest directly in the firm.*

Proof. Households with updated beliefs above ρ^* expect positive returns. Their expected gain is equal to (i) ρ_i if they choose direct finance; and (ii) $\overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i + \overline{r}_D\right)$ if they choose intermediated finance. Investors with updated beliefs in the interval $\left[\rho^*, \rho^I\right)$ have $\rho_i < \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i + \overline{r}_D\right)$ and they choose intermediated finance. Agents with updated beliefs above or equal to ρ^I have $\rho_i \geq \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i + \overline{r}_D\right)$ and choose direct finance. ■

Corollary 4 *When parameters are such that* $\sigma_B < \sqrt{\frac{1}{\alpha}}$ *and* $\rho^* \geq \rho^I$*, financial intermediation is not feasible. Every investor chooses direct finance.*

Proof. When $\rho^* \geq \rho^I$ and $\sigma_B < \sqrt{\frac{1}{\alpha}}$, the expected gain on direct finance is higher than the expected gain on intermediated finance for those households with updated beliefs above ρ^*. ■

I now show that the two types of equilibria exist. The next result implies that the size of the intermediation sector depends on the value of the parameter $\overline{r}_B$.

Lemma 12 *When* $\sigma_B < \sqrt{\frac{1}{\alpha}}$, *then* $\frac{\partial(\rho^I - \rho^*)}{\partial \overline{r}_B} > 0$.

Proof. Two cases are possible. First, when $G(\rho^*) = \rho^*$, then $\frac{\partial(\rho^I - \rho^*)}{\partial \overline{r}_B} = \frac{1}{1-\sqrt{\alpha}\sigma_B} > 0$. Second, when $G(\rho^*) = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho^* + \overline{r}_D)$, then $\frac{\partial(\rho^I - \rho^*)}{\partial \overline{r}_B} = \frac{1}{1-\sqrt{\alpha}\sigma_B} - \frac{1}{\phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right)\sqrt{\gamma} - \sqrt{\alpha}\sigma_B}$. Since $\gamma \leq 2\pi\psi$, then $\phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right)\sqrt{\gamma} < \sqrt{\alpha}\sigma_B$ and the result follows. ■

Proposition 5 *When* $\sigma_B < \sqrt{\frac{1}{\alpha}}$, *there is a threshold for* $\overline{r}_B$ *equal to* $\widehat{r}_B$ *above which intermediation exists and below which intermediation is not feasible.*

Proof. When $\rho^I > \rho^*$ financial intermediation exists and, when $\rho^I \leq \rho^*$, financial intermediation is not possible. For $\overline{r}_B > 1$ we obtain $\rho^I > 1 \geq \rho^*$. Using the definition of ρ^I, it is easy to confirm that $\rho^I > 1$. As for $\rho^* \leq 1$ note that: (i) if $G(\rho^*) = \rho^*$ then $\rho^* \leq 1$ because $\Phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right) \leq 1$; (ii) if $G(\rho^*) = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D)$ then $\rho^* = \frac{\Phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right) - \overline{r}_B}{\sqrt{\alpha}\sigma_B} + \overline{r}_D < 1$.

For $\overline{r}_B < 0$ we obtain $\rho^I < 0 \leq \rho^*$. It is easy to check that $\rho^I < 0$. As for $\rho^* \geq 0$, note that: (i) If $G(\rho^*) = \rho^*$ then $\rho^* \geq 0$ because $\Phi\left(\sqrt{\gamma}\left(\rho^* - \overline{r}_D\right)\right) \geq 0$; (ii) If $G(\rho^*) = \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i - \overline{r}_D\right)$ then $\rho^* = \frac{\Phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right) - \overline{r}_B}{\sqrt{\alpha}\sigma_B} + \overline{r}_D > 0$.

Hence $\rho^I - \rho^* < 0$ for $\overline{r}_B < 0$ and $\rho^I - \rho^* > 0$ for $\overline{r}_B > 1$. The functions $\rho^*(\overline{r}_B)$ and $\rho^I(\overline{r}_B)$ are continuous and, given lemma 12, there is a unique threshold for $\overline{r}_B$ such that $\rho^I = \rho^*$ above which intermediation exists and below which intermediation is not feasible.

It remains to show that having $\rho^I = \rho^*$ is equivalent to having $\overline{r}_B = \widehat{r}_B$. To see this, consider the case in which $\rho^I = \rho^*$. Then $\rho^I = \overline{r}_B + \sqrt{\alpha}\sigma_B + \left(\rho^I - \overline{r}_D\right)$ and $\rho^I = \rho^* = \rho'$. From this expression, it is easy to derive that $\rho^I = \rho' \Leftrightarrow \overline{r}_B = \widehat{r}_B$. We can also obtain that $\rho^I \lesseqqgtr \rho^* \Leftrightarrow \overline{r}_B \gtreqqless \widehat{r}_B$ and the result follows. ■

Hence we have proved the first part of the proposition. Second, consider the cases in which $\sigma_B > \sqrt{\frac{1}{\alpha}}$.

Corollary 5 *When parameters are such that* $\sqrt{\frac{1}{\alpha}} < \sigma_B$ *and* $\rho^* \leq \rho^I$*, there is coexistence between direct and indirect finance. Households with an updated belief below* ρ^* *do not invest, households with updated beliefs belonging to the set* $\left[\rho^*, \rho^I\right]$ *invest directly in the firm, and those with higher updated beliefs deposit their funds in the FI.*

Proof. Investors with updated beliefs belonging to the set $\left[\rho^{*},\rho^{I}\right]$ find direct finance more attractive since $\rho_i \geq \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i + \overline{r}_D\right)$, while more optimistic investors prefer direct finance. ■

Corollary 6 *When parameters are such that* $\sqrt{\frac{1}{\alpha}} < \sigma_B$ *and* $\rho^{*} > \rho^{I}$*, every investor chooses intermediated finance.*

Proof. We have $\rho_i < \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i + \overline{r}_D\right)$ for all investors. ■

Lemma 13 *When* $\sqrt{\frac{1}{\alpha}} < \sigma_B$*, then* $\frac{\partial\left(\rho^{I}-\rho^{*}\right)}{\partial \overline{r}_B} < 0$*.*

Proof. Similar to the proof of lemma 12. ■

Proposition 6 *When* $\sqrt{\frac{1}{\alpha}} < \sigma_B$*, there is a threshold for* $\overline{r}_B$ *equal to* $\widehat{r}_B$ *above which only intermediation exists and below which there is coexistence between direct and intermediated finance.*

Proof. When $\rho^{I} \geq \rho^{*}$, there is coexistence and when $\rho^{I} < \rho^{*}$ direct finance is not possible. For $\overline{r}_B > \sqrt{\alpha}\sigma_B$ we obtain $\rho^{I} < \rho^{*}$. First note that, with the definition of ρ^{I}, we can show that $\rho^{I} < 0$. Hence (i) if $G\left(\rho^{*}\right) = \rho^{*}$ then $\rho^{*} \geq 0$ and $\rho^{I} < \rho^{*}$; (ii) if $G\left(\rho^{*}\right) = \overline{r}_B + \sqrt{\alpha}\sigma_B\left(\rho_i - \overline{r}_D\right)$ then $\rho^{*} = \left(1 - \frac{1}{\sqrt{\alpha}\sigma_B}\right)\rho^{I} + \frac{\Phi\left(\sqrt{\gamma}\left(\rho^{*}-\overline{r}_D\right)\right)}{\sqrt{\alpha}\sigma_B} > \rho^{I}$.

For $\overline{r}_B < 1 - \sqrt{\alpha}\sigma_B$ we obtain $\rho^I > 1 \geq \rho^*$. First note that, by the definition of ρ^I we obtain $\rho^I > 1$. Hence (i) if $G(\rho^*) = \rho^*$ then $\rho^* \leq 1$ and $\rho^* < \rho^I$; (ii) if $G(\rho^*) = \overline{r}_B + \sqrt{\alpha}\sigma_B(\rho_i - \overline{r}_D)$ then $\rho^* = \rho^I + \frac{1}{\sqrt{\alpha}\sigma_B}\left[\Phi\left(\sqrt{\gamma}(\rho^* - \overline{r}_D)\right) - \rho^I\right] < \rho^I$.

The functions $\rho^*(\overline{r}_B)$ and $\rho^I(\overline{r}_B)$ are continuous and, given lemma 13, there is a threshold for $\overline{r}_B$ such that $\rho^I = \rho^*$. The proof that $\rho^I = \rho' \Leftrightarrow \overline{r}_B = \widehat{r}_B$ is identical to the proof in proposition 5. ■

Finally, consider the case in which $\sqrt{\frac{1}{\alpha}} = \sigma_B$. When $\overline{r}_B \leq \overline{r}_D$, the expected gain on direct finance is higher or equal to the expected gain on intermediated finance for every household and every investor chooses direct finance. When $\overline{r}_B > \overline{r}_D$ the expected gain on direct finance is inferior to the expected gain on intermediated finance and every investor chooses intermediated finance. ■

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