Financial System Architecture And The Co-evolution Of Banks And Capital Markets*

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Abstract

We study how financial system architecture evolves through the development of banks and financial markets. The predominant existing view is that banks and markets compete, which often contradicts actual patterns of development. We show that banks and markets exhibit three forms of interaction: they compete, they complement each other, and they co-evolve. The co-evolution loop is generated by two elements missing in previous analyses of financial system architecture: securitization and bank equity capital. As banks evolve via improvements in credit screening, they securitize higher-quality credits in the capital market. This encourages greater investor participation and spurs capital market evolution. And, if capital market evolution is spurred by exogenous shocks that cause more investors to participate in the market, banks find it cheaper to raise equity capital to satisfy endogenously-arising risk-sensitive capital requirements. This enables banks to serve previously-unserved high-risk borrowers, expanding banking scope and spurring bank evolution. Numerous additional results and empirical predictions are drawn out, and the implications of the analysis for bank governance and regulation are discussed.

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1 Introduction

A fundamental question in comparative financial systems concerns the most efficient way to organize the transfer of capital from savers to investors. In particular, the question is whether the emphasis should be on markets or on banks.[1] This question is important because of its potential implications for aggregate credit extension and growth in the real sector. Even though there is strong evidence that financial system development positively affects growth, there is less consensus on whether the effect comes from bank or market development, or even whether the specifics of how the financial system evolves matter for the real sector.[2] Thus, there is much we do not know. In particular, we have only begun to understand how the *architecture* of the financial system – the relative roles of banks and financial markets – affects the functioning of the financial system, and the effect of the financial system on the real sector. There are numerous unanswered or partially answered questions. What is the relationship between borrower credit attributes and the borrower's choice of financing source when banks themselves are financing partly from the capital market, a competing financing source for borrowers? Is the emergence of one sector of the financial system (either banking or financial markets) always at the expense of the other? In particular, how does the development of banks affect the development of the capital market, and how does the development of the capital market affect banks? Our objective in this paper is to address these questions.

The key theoretical findings on these issues in the literature can be summarized as follows. First, market-based financial systems are not better than bank-based financial systems; they simply behave differently. For example, market-based systems provide better cross-sectional risk sharing, whereas bank-based systems provide better intertemporal risk sharing (Allen and Gale (1997)). Market-based systems have an advantage over bank-based systems in committing not to refinance unprofitable projects (Dewatripont and Maskin (1995)), and markets may also provide managers valuable information through the feedback effect of prices (e.g., Boot and Thakor (1997a), and Subrahmanyam and Titman (1999)). Bilateral financing, common in bank-based systems, is better at protecting borrower proprietary information and at providing R&D incentives for firms to undertake costly project search than multilateral financing that characterizes market-based systems (Bhattacharya and Chiesa (1995), and Yosha (1995)). Market-based systems create stronger financial innovation incentives (Boot and Thakor (1997b)), and are better at funding innovative projects subject to diversity of opinion (Allen and Gale (1999)), but bank-based systems resolve asset-substitution moral hazard more effectively (Boot and Thakor (1997a)). Second, the dominant view in the

[1]Financial systems have been broadly classified as being bank-based or market-based, based on the share of banks and other intermediaries in total financing provided by the financial system. A common example of a bank-based system is Germany where banks emerged as the dominant financing source due to relatively few restrictions on their activities. The most commonly-cited example of a market-based system is the U.S. where Glass-Steagall restrictions on banks were at least partly responsible for banks achieving lesser dominance. An international comparison of financial system architecture appears in Tadesse (2002).

[2]Beck and Levine (2002), Demirgüç-Kunt and Levine (2001), and Levine (2002) show that the positive impact of financial system development on economic growth is unaffected by whether the evolution of the financial system is due to bank or financial market development. Deidda and Fattouh (2008) find, however, that a change from a bank-dominated system to one with both banks and markets can hurt economic growth.

literature is that, with some exceptions that will be discussed later, banks and markets *compete*, implying that the development of one is at the expense of the other (e.g., Allen and Gale (1997, 1999), Boot and Thakor (1997a), and Dewatripont and Maskin (1995)), an observation that seems buttressed by anecdotes such as the shrinkage of depository institutions in the U.S. in the 1980s when (market-based) mutual funds emerged.[3]

The result that banks and markets compete has potentially powerful policy implications, but does not seem entirely consistent with the findings of several empirical studies.[4] Demirgüç-Kunt and Maksimovic (1996) find that stock market development engenders a higher debt-equity ratio for firms and thus generates more business for banks in developing countries. Sylla (1998) provides a description of the complementarity between banks and capital markets in fostering the growth of the U.S. economy from 1790 to 1840, suggesting that it is important to "take a broad view of financial development and pay attention to the manifold ways in which components of a financial system, such as banks and securities markets, can complement and reinforce one another."

We study how banks and markets affect each other – and thus how financial system architecture affects which borrowers are financed and the source of this financing – by developing a model of their interaction within an evolving financial system. In our model, the borrower chooses its financing source from the following menu: (i) non-intermediated, direct capital market financing in which it borrows directly from the capital market; (ii) securitization in which it lets the bank screen and certify its creditworthiness first and then borrows from the capital market; and (iii) a relationship loan from the bank. There are two key frictions that impede the borrower's ability to obtain financing. One is "certification," a friction that arises from the fact that the borrower pool consists of observationally identical but heterogeneous borrowers, some creditworthy and some not. This creates the likelihood that even a creditworthy borrower may be denied credit, and the more severe this friction the greater the likelihood of credit denial. The other friction is "financing," which arises from the dissipative costs of external financing, which include costs related to the fact that those seeking financing and those providing financing may value differently the surplus from the project being financed, leading to the cost of financing rising above the first best. We show that banks are better at diminishing the certification friction, whereas banks and markets differ in terms of how they resolve the financing friction. *Exclusive* bank or market finance does well at diminishing one friction, at the expense of *not* diminishing the other. As long as both frictions are relevant, technological improvements

[3] There is also a growing body of empirical research on financial system architecture as well as its impact on growth (e.g., Beck and Levine (2002), Deidda and Fattouh (2008), Levine (2002), Levine and Zervos (1998), and Tadesse (2002)).

[4] In addition to the empirical studies, we can also see that the evolution of banks and capital markets in the United States, United Kingdom, Germany and Japan during 1960 – 2003 shows complementarity between banks and markets most of the time with occasional spurts of competition. This can be seen using data from *The World Bank Group* and defining bank development as *Bank Credit*, which is the value of loans made by commercial banks and other deposit-taking banks to the private sector divided by GDP (Levine and Zervos (1998)), defining *Stock Market Size* as the value of listed domestic shares on domestic exchanges divided by GDP, and *Bond Market Size* as the ratio of the total amount of outstanding domestic debt securities issued by private or public domestic entities to GDP (Beck, Demirgüç-Kunt and Levine (2000)). In all four countries over this time period, one observes *Bank Credit*, *Stock Market Size* and *Bond Market Size* growing together except over a few short periods.

in either bank or market finance lead to borrowers shifting toward one source of financing and away from the other. This is the standard result in the literature that banks and markets compete.

There are two ingredients in our analysis that enable us to go beyond this standard result and generate numerous new results. One is securitization and the other is bank capital. With securitization, the bank provides certification and the capital market provides financing. That is, securitization creates the possibility of letting each sector of the financial system operate where it is best. Moreover, securitization acts as a channel through which technological improvements in the bank's certification technology not only reduce the certification friction but are also transmitted to the financial market and lead to a better resolution of the financing friction. Since the certification and financing frictions complement each other in impeding the borrower's access to efficient funding, banks and markets are not in competition, but complementary to each other.

Bank capital connects banks and markets in a different way. Capital market development reduces the financing friction for the bank and lowers its cost of equity capital, which makes it privately optimal for the bank to raise the additional capital needed to meet the higher capital requirements associated with riskier loans that the bank may have otherwise chosen not to make. Thus, it is through bank capital that capital market advances that lead to a more effective resolution of the financing friction end up being transmitted to the banking sector, permitting the bank to more effectively resolve the certification friction for some borrowers and expand its lending scope. That is, bank capital is the device by which capital market advances benefit banks and even borrowers who take *only* bank loans.

In addition to the complementarity between banks and markets, our analysis also yields several additional results that speak to the questions raised earlier. First, borrowers with high creditworthiness opt for non-intermediated, direct capital market financing; borrowers with intermediate creditworthiness raise funds via bank securitization; borrowers with low creditworthiness take relationship loans; and borrowers with extremely low creditworthiness are excluded from the credit market.[5] Second, bank evolution – due to an improvement in the bank's screening/certification technology – expands the bank's relationship lending scope from below in that the bank now also lends to (previously unserved) riskier borrowers, expands the bank's securitization scope from below, and leads to capital market evolution by enhancing investor participation. Third, capital market evolution expands the bank's lending scope from below, leading it to serve more low-quality borrowers, and hence plants the seeds for bank evolution. That is, there exists a virtuous circle in which banks and capital markets, even though they represent alternative and competing sources of financing, also act as collaborators and *co-evolve* with each other. Numerous empirical predictions are also extracted from the analysis.

All of these results are derived in a fairly general setting, but one in which the cost of capital market financing, deposit insurance, and prudential capital requirements for banks as well as the costs associated

[5]The result that the least risky borrowers go to the market, the riskier borrowers go to banks and the riskiest borrowers are rationed is familiar; see, for example, Holmstrom and Tirole (1997). A key difference is that, unlike our model, the bank does not itself raise funds from the capital market to finance itself. Another key difference is the absence of securitization in the previous studies.

with these requirements are all taken as exogenous. After deriving our main results, we add more structure to the model to endogenize these elements.

The essence of our analysis is that banks and markets exhibit three types of interaction: *competition*, *complementarity*, and *co-evolution*. This three-dimensional interaction sets our paper apart from the literature. In particular, our thesis that banks and capital markets complement and co-evolve is a departure from the existing viewpoint that they compete and hence the growth of one is at the expense of the other. For example, Allen and Gale (1997) show that while banks can provide more effective intertemporal risk smoothing than markets, their effectiveness in doing so depends on the degree of competition from the markets, with sufficiently strong competition resulting in disintermediation and impeded provision of intertemporal risk smoothing by the bank. In Boot and Thakor (1997a), the capital market improves firms' real decisions through its information feedback from equilibrium prices of securities, while banks are superior in resolving post-lending asset-substitution moral hazard. The choice between a bank-based system and a market-based system is essentially a tradeoff between the improvement of real decisions from the market's feedback function on the one hand and the attenuation of moral hazard by the bank on the other. Thus, capital market evolution, as represented by increasingly efficient price feedback, diminishes bank lending in that paper. Similarly, in Allen and Gale (1999), Bhattacharya and Chiesa (1995), and Dewatripont and Maskin (1995), the borrower's choice is between financing from one source or the other, so as borrowers show a preference for one financing source, they essentially shift away from the other financing source.

Our analysis clarifies that banks and markets have different comparative advantages, and that they are competing with each other only when they are viewed in isolation – with no instruments that allow banks and markets to specialize in their respective advantages – *not* when they interact with each other. Securitization provides one such vehicle, creating a benefit flow from banks to markets. Bank capital provides another vehicle, creating a benefit flow from markets to banks.

On the complementarity between banks and markets, two previous contributions are related to our work, although neither of them examines co-evolution. Allen and Gale (2000) note that intermediaries may complement markets rather than substituting for them. In their analysis, intermediaries are able to provide individuals insurance contracts against unforseen contingencies in "obscure states" that eliminate the need for these individuals to acquire costly information about these states, thereby reducing their costs of participating in markets. Unlike our analysis, however, bank equity capital and securitization are absent in their analysis and there is not a feedback loop from banks to markets and another from markets to banks such that both co-evolve as they do in our analysis. That is, their focus is entirely different. Holmstrom and Tirole (1997) develop a model of financial intermediation in which firms as well as banks are capital constrained. Firms with adequate (equity) capital can access the market directly, whereas those with less capital borrow partly from banks and partly from the market ("mixed financing"). The bank needs capital of its own to be induced to monitor the borrowers, which is in turn necessary to enable some borrowers to obtain (indirect) market finance. "One-way complementarity" arises from the fact that the presence of banks permits some borrowers to access the market, just as insurance intermediaries facilitate individual market participation in Allen and Gale (2000). However, there are no benefit feedback loops of the sort we have, so there is no examination of the co-evolution of banks and markets as in our analysis. Rather, their focus is on the effects of reductions in different types of capital on investment, interest rates and forms of financing.

The rest of the paper is structured as follows. Section 2 describes the basic model. Section 3 analyzes the borrower's choice of funding sources, highlighting the competition dimension of bank-market interaction. Section 4 generates our main results about the complementarity and co-evolution dimensions of bank-market interaction. In Section 5 we put additional structure on the model to endogenize the cost of capital market financing, deposit insurance and a regulatory capital requirement. The empirical predictions emerging from the analysis of the model as well as the implications for the evolution of financial system architecture and bank governance are discussed in Section 6. Section 7 concludes. All proofs are relegated to the Appendix.

2 The Basic Model

In this section, we describe a simplified model that illustrates our main argument.

2.1 The Agents and Economic Environment

Consider a three-date ($t = 0, 1, 2$) economy with universal risk neutrality and a zero riskless interest rate. There are five agents: the borrower, the bank, the depositors, the investors in the capital market, and the regulator. The borrower may be either authentic or a crook. Both types of borrowers have access to the same investment opportunity set in terms of projects. The project needs a \$1 investment at $t = 1$, and generates a cash flow of $X > 1$ for sure at $t = 2$. However, only an authentic borrower is interested in investing in the project. A crook who raises financing for the project will abscond with the funds, leaving the financier with nothing.[6] The common prior knowledge at $t = 0$ is that with probability $q \in [0, 1]$ a borrower is authentic, and with probability $1 - q$ a borrower is a crook. However, only the borrower itself knows its true type. Thus, the informational problem faced by a financier here is *adverse selection*. The capital market is comprised of finitely many investors, $\bar{N}$ in number. A subset of these investors, N in number, with $N \leq \bar{N}$, will be participants in any particular security. While $\bar{N}$ is exogenous, N will be endogenously determined for every security financed in the capital market. Investors are atomistic and behave as price takers. Each investor suffers a disutility, ω, if the borrower he has financed ends up defaulting, so this disutility is experienced only when a crook is financed. We can think of this disutility as the cost the investor suffers because of the cash flow shortfall he experiences when he does not receive repayment from

[6] This can be either an issue of "character" or skill in developing the project or the cost of personal effort for the borrower in implementing the project. That is, the crook may have a "character flaw" that makes absconding with the funds attractive based on preferences, or may be unskilled in developing the project or may simply be too lazy, i.e., may perceive a personal cost to develop the project that is too high.

the borrower on the market security he has purchased.[7] We assume ω differs across investors, and is distributed uniformly on support $[0, \bar{\omega}]$.[8] We refer to those seeking financing as "borrowers" because they are assumed to finance with debt contracts.[9]

The aggregate supply of deposit funding exceeds the maximum possible loan demand; the same is true for the aggregate supply of funding from the capital market, either through securitization or through direct market financing. Each borrower also has multiple *a priori* identical banks to choose from, although each bank transacts in equilibrium with only one borrower.

2.2 Deposit Insurance and Regulatory Capital Requirement

The regulator determines the bank's deposit insurance coverage and capital requirement at $t = 0$. We limit the regulator's deposit insurance coverage to either zero or full deposit insurance.[10] Suppose the capital requirement set by the regulator is $E \in [0, 1]$. Then, if the bank wants to lend, it needs to raise E in equity from the capital market at $t = 1$ and borrow the remaining $1 - E$ from depositors *afterwards*.[11] In the basic model, both deposit insurance and bank capital are treated as being exogenously given; they will be endogenized in the complete model.

2.3 The Borrower's Choice of Financing Source

At $t = 0$, the borrower has three potential choices to finance its project: (i) borrow directly from the capital market via non-intermediated debt financing; (ii) let the bank screen and (noisily) certify its type first and then borrow from the capital market via bank securitization; and (iii) take a relationship loan from the bank. With *direct capital market access*, the borrower completely bypasses the bank and hence there is no "screening certification" provided to the borrower by the bank.

[7] This assumption is reminiscent of Diamond's (1984) assumption of a non-pecuniary default penalty on the borrower that defaults, except that here this penalty is suffered by the investor who purchases security from a crook. A simple way to interpret this is to think of investors having their own personal borrowing, with each investor's ability to repay personal debt being predicated upon the repayment he receives on the borrower's securities he purchases in the market. Borrower default can thus trigger default by the investor on his personal debt, with attendant default costs (as in Diamond (1984)) that vary in the cross-section of investors. Alternatively, the inability to collect on the borrower's repayment obligation triggers a liquidity problem for the investor, forcing him to sell personal assets at firesale prices to satisfy a liquidity need. These liquidity-related costs will also typically vary cross-sectionally among investors.

[8] The assumption of heterogenous disutility is not crucial to our main argument as long as there is some heterogeneity among the investors in some (other) dimension that affects the cost of their providing financing to the borrower. Moreover, the uniform distribution assumption for ω is made merely for algebraic simplicity.

[9] Using equity would not change anything since there is no uncertainty about the project payoff here.

[10] This is to simplify the analysis to focus on the main issues. Our main results remain qualitatively unchanged under an assumption of partial deposit insurance.

[11] The idea is that the bank must ensure that it is in compliance with regulatory capital requirements *before* it can lend. Deposits are raised afterwards when the loan is actually financed. Whenever we refer to "bank capital," we will mean the bank's equity capital.

With *securitization*, the bank screens the borrower first, and then decides whether to seek capital market financing for the borrower at $t = 1$ based on the screening outcome. Because the entire funding for the loan is provided by the market, there is no need for the bank to keep any capital against the loan. We assume, however, that securitization involves the bank setting up a bankruptcy-remote special purpose trust to which the loan is sold. This trust is set up at $t = 1$ after the bank knows the screening outcome. The bank provides credit enhancement for the loan via collateral, which is available to investors in case the loan defaults. This collateral is equal to a fraction, $\delta \in (0, 1)$, of the initial promised repayment of the securitized debt to investors. The bank incurs a fixed cost, $Z > 0$, to set up a trust for securitization.

That is, the bank sets up a trust which sells the loan to capital market investors and collects \$1 in proceeds that get passed along to the bank, which then allows the bank to provide funding to the borrower. The bank sets the borrower's repayment obligation as R_{sec}, but the trust promises investors a repayment of $\hat{R}_{\text{sec}} < R_{\text{sec}}$. The investors' recourse to the bank in the event of borrower default is $\delta \hat{R}_{\text{sec}}$. We assume that the bank surrenders control over the loan to the trust so that the securitization counts as a loan under the rules of securitization accounting, and does not require the bank to keep any capital to support the loan.[12]

With a *relationship loan*, the bank screens the borrower first, and then based on the screening outcome decides whether to raise equity capital and deposits to fund the loan. Prior to screening, the bank posts a loan interest rate it will charge if it decides to lend to the borrower. This is a precommitment by the bank. A borrower that approaches the bank for a relationship loan precommits to accepting a loan offer at that price. The role of the two-sided precommitment will be explained later. Deposit gathering is costly. Think of it as the cost of setting up branches, employing tellers and so on. Although this cost has both fixed and variable elements, we simplify by setting the fixed cost at zero and letting the variable cost be $\tau > 0$ per dollar of deposit. Since the borrower learns whether it is authentic or a crook before making its financing choice, its choice of financing source can potentially convey information about its type.

2.4 The Bank's Screening and Its Private Signal about the Borrower's Type

The bank specializes in a noisy but informative pre-lending screening technology that reveals the borrower's type at $t = 0$. This screening occurs if the borrower approaches the bank for a relationship loan or securitization. The screening yields a private signal $s \in \{s_a, s_c\}$ to the bank, where s_a is a good signal and s_c is a bad signal. Let

$$\Pr(s = s_a|\text{authentic}) = \Pr(s = s_c|\text{crook}) = p, \tag{1}$$

where $p \in [1/2, 1]$ is the precision of bank screening. If the bank extends credit to the borrower only when the screening signal $s = s_a$, then p is simply the probability that an authentic borrower receives credit. We treat p as being common knowledge and exogenously given for now; we will endogenize it later when we

[12]FAS 140 is the accounting rule in the U.S. for whether a specific securitization structure qualifies as a loan sale. See Greenbaum and Thakor (1987) for a discussion of securitization. We will see later, when we endogenize capital requirements, that the securitization structure we use will not require any capital to be posted.

study the co-evolution of banks and capital markets. The cost to the bank of screening, when the precision is p, is $cp^2/2$, where $c > 0$ is a constant. Each bank can screen only one borrower. Assuming that both the authentic borrower and the crook choose to approach the bank for financing, the bank's posterior beliefs about the borrower's type after observing its private signal s are:

$$\Pr(\text{authentic}|s = s_a) = \frac{qp}{qp + [1-q][1-p]} \equiv q^A \in [q, 1], \tag{2}$$

$$\Pr(\text{authentic}|s = s_c) = \frac{q[1-p]}{q[1-p] + [1-q]p} \equiv q^C \in [0, q], \tag{3}$$

where $\Pr(\text{crook}|s) = 1 - \Pr(\text{authentic}|s)\ \forall s \in \{s_a, s_c\}$.

The bank then decides whether to accept the borrower (agree to extend a relationship loan or obtain the financing via securitization) or reject it. As in Stiglitz and Weiss (1983), we assume that the bank's acceptance/rejection decision is public, so a rejected borrower will be unable to get credit anywhere else.[13] The capital market does not possess such a screening technology, an assumption motivated by the existing financial intermediary literature that banks are specialists in credit screening (e.g., Allen (1990), Boyd and Prescott (1986), Coval and Thakor (2005), and Ramakrishnan and Thakor (1984)). In particular, the bank is a specialist in processing soft information (e.g., Stein (2002)) about the borrower's character, which is one of the "five C's of credit," and corresponds to the bank's screening permitting it to noisily distinguish crooks from authentic borrowers.[14] In case the bank lends to a crook that is mistakenly identified as authentic by the screening, we assume that the bank's payoff is zero and depositors are paid off by the deposit insurer.[15]

2.5 Market Structure and the Pricing of Securities

When the bank raises equity capital from the market, the equity contract stipulates that the bank's initial shareholders and the new investors (who purchase the equity issued by the bank) share what is left over

[13] Bhattacharya and Thakor (1993) discuss how one can justify this assumption in a setting in which the bank's rejection decision conveys adverse information about the borrower, as it does here. This assumption simplifies the analysis, but is not essential. For example, if a bank can soly noisily learn whether a borrower was previously rejected, it can adjust its posterior belief accordingly. We will see later that the bank's participation constraint will be binding in equilibrium given its *prior* belief, p, about the borrower's type. Even noisy information that the borrower was rejected by another bank will lower the bank's belief that the borrower is authentic below p and it will wish to reject the borrower without screening because incurring the screening cost will violate the bank's participation constraint. As will be made clear later (Lemma 2), the bank's public acceptance/rejection decision acts as a credible mechanism by which the bank certifies the borrower's creditworthiness.

[14] The capital market also has mechanisms with which to screen borrowers, such as bond ratings issued by credit rating agencies. Moreover, public listing comes with significant information disclosure requirements that reveal information about the borrower to investors, so the no-certification assumption in the public market should not be taken literally. Rather, it is a statement about what happens with bank lending *relative* to direct market finance. In particular, the contemporary theory of banking as well as the related empirical evidence strongly suggest that bank screening generates *incremental* payoff-relevant information that goes beyond what is available from other sources in the capital market. The evidence provided by James (1987) is particularly compelling. He finds that the announcement of a bank loan generates an abnormally positive stock price reaction for the borrower, but an announcement of any other kind of external financing triggers an abnormally negative stock price reaction.

[15] Assuming that the bank too suffers a disutility from financing a crook does not qualitatively affect the analysis.

after the bank's repayment to depositors is subtracted from the authentic borrower's loan repayment, L, to the bank.[16] The fraction of ownership in the bank sold to the new investors, $1-\alpha$, is such that the bank is able to raise the equity capital E that it needs to support the loan. The equity market is competitive, so that $1-\alpha$ is determined to yield the marginal investor purchasing equity a competitive expected return of zero. The bank's initial shareholders obtain a share α of the bank's terminal payoff. With multiple banks pursing each borrower, banks are Bertrand competitors for borrowers in the loan market, so L is endogenously determined such that the bank earns zero profit in equilibrium.[17] We also assume a perfectly competitive capital market, which implies that the debt and equity contracts between the capital market and those seeking financing (the borrower and the bank) are designed such that the participation constraint for the marginal investor in the capital market is binding in equilibrium.[18] The deposit market is perfectly competitive as well (depositors are simply promised a competitive expected return equal to zero, the riskless interest rate), implying that the expected repayment on a \$1 deposit is \$1.

2.6 Summary of the Sequence of Events

At $t=0$, the regulator sets the deposit insurance and capital requirement for the bank. At that time, the borrower learns its type (i.e., whether it is authentic or a crook). The borrower then decides whether to raise its financing directly from the capital market, or via securitization, or through a relationship loan from a bank. If the borrower opts for either a relationship loan or securitization, it approaches a bank and the bank conducts screening to determine the borrower's creditworthiness. The bank then makes its acceptance/rejection decision.

At $t=1$, with direct capital market financing, investors must decide whether to finance the borrower, and they must do so without the benefit of bank screening that (noisily) sorts out crooks from authentic borrowers. With securitization, bank screening nosily sorts out crooks at $t=0$, so funding is provided by investors if the bank screened the borrower affirmatively and accepted the borrower at $t=0$. With a relationship loan, lending will occur if the bank screened and accepted the borrower at $t=0$. In that case, the bank raises the equity capital to satisfy the regulatory capital requirement, E, on the loan, and then borrows the remaining $1-E$ from depositors. With both securitization and relationship lending, the bank has a choice to screen or not to screen. So incentives to screen must be provided.

At $t=2$, if the borrower turns out to be authentic, its project payoff is realized and observed by all, and financiers are paid off. If the borrower turns to be a crook, financiers are left with nothing. This sequence of events is summarized in *Figure 1.*

[Figure 1 goes here]

[16] Recall that the crook absconds with the funds.

[17] That α share of ownership covers the bank's costs of screening, $cp^2/2$, and deposit gathering, $\tau[1-E]$.

[18] We will explain later (Section 3.1.2) what we mean by a marginal investor, and show how his (binding) participation constraint determines equilibrium investor participation in the capital market, and hence the cost of capital market financing.

3 The Analysis of the Basic Model: Choice of Funding Sources

In this section, we present a simple, reduced-form version of our model to succinctly convey the interactions of the main forces that generate our key results. In this analysis, several elements of the model are taken as exogenous in order to simplify. These elements are endogenized later in the complete model.

Assumption 1. ***Valuation Discount:*** *For any borrower seeking financing from the capital market through either direct market borrowing or securitization, the investors' valuation of the expected debt repayment is a fraction $\lambda(N) \in (0,1)$ of the borrower's valuation, where N is investor participation in that security (non-intermediated debt or securitized debt) in the market. When the bank raises equity capital from the market, the investors' valuation of the bank's terminal payoff shared between them and the bank is also a fraction $\lambda(N)$ of the bank's valuation, where N is investor participation in the bank's equity in the market. Moreover, $\lambda'(\cdot) > 0$ and $\lambda''(\cdot) < 0$.*

The existence of a valuation discount means that capital market financing is costly not only because of the friction arising from the fact that the borrower pool consists of crooks, but also those seeking financing (the borrower and the bank) and those providing financing (investors) value differently the surplus from the project being financed. While taken as an assumption for now, we endogenize this in Section 5 (see Proposition 5) using a heterogeneous-priors setup in which a public signal about the borrower's project is observed prior to the borrower's actual investment in the project. Due to heterogeneous priors, investors and the borrower end up with possibly different posterior beliefs about the value of the project. Since investors do not directly control project choice, the resulting possibility of disagreement over project value endogenously generates a valuation discount of $1 - \lambda(N)$ on a \$1 expected debt repayment or bank's terminal payoff (for bank equity). The discount $1 - \lambda(N)$ is a decreasing function of investor participation in a given security (non-intermediated debt, securitized debt, or bank equity) in the market. The intuition is that a capital market with greater investor participation (larger N) in a given security has more depth, thereby decreasing the valuation discount associated with the project. We endogenize this in the complete model by showing that greater investor participation in the capital market results in lower disagreement between investors and those seeking financing *in equilibrium* and hence a lower valuation discount due to disagreement.[19]

[19] The idea is as follows. Suppose there are N investors participating in a particular security in the capital market. In the complete model, each investor's likelihood to agree with the borrower about the value of the project, call it $\rho \in [0,1]$, is an independent random draw from some probability distribution. The capital market provides a mechanism whereby investors with the highest valuation are able to bid for the security and, given investor risk neutrality, these investors are willing to purchase all of the security at their valuations. That is, the security is purchased by investors with the highest ρ among the N investors; since ρ's are random ex ante, the highest ρ among N investors can be viewed ex ante as the N^{th} order statistic of ρ. It is clear that the N^{th} order statistic of ρ (i.e., the expected likelihood of agreement between investors and the borrower in terms of project valuation), and hence $\lambda(N)$, are increasing in N. A numerical example is useful for illustration. Suppose ρ is uniformly distributed on support $[0,1]$. If $N = 1$, the expected agreement (1st order statistic) is simply $1/2$. If $N = 2$, then the expected agreement (2nd order statistic) is $2\int_0^1 x^2 dx = 2/3 > 1/2$.

Assumption 2. ***Deposit Insurance and Capital Requirement:*** *The regulator provides full deposit insurance to the bank. The regulatory capital requirement is $E \in [0,1]$, which is decreasing in borrower credit quality, i.e., $\partial E/\partial q < 0$.*

The intuition for the assumption that $\partial E/\partial q < 0$ is as follows. Since the borrower should be charged a lower loan interest rate when its credit quality is higher, it follows that the equilibrium loan repayment is decreasing in borrower quality (i.e., $\partial L/\partial q < 0$). Since the bank's asset-substitution moral hazard due to deposit insurance is more severe when the loan repayment is higher (this will be formally shown in the complete model), the regulatory capital requirement is also decreasing in borrower quality. While we take both deposit insurance and bank capital as exogenously given for now, they will be endogenized in the complete model, at which time we will prove that the optimal risk-sensitive capital requirement, E, is strictly decreasing in borrower quality, q.

3.1 The Authentic Borrower's Payoffs from Various Funding Sources

Before analyzing the borrower's choice of funding source, we state a result about the sharing of the project surplus between the bank, the borrower and the depositors/investors. We then examine the borrower's payoffs from these various sources. Our focus is on an authentic borrowers. We shall assume for now that a crook will make exactly the same financing choice as the authentic borrower. We will verify this formally later as a feature of the equilibrium.

Lemma 1. *When the loan market, capital market and deposit market are perfectly competitive in the sense that the providers of finance act as Bertrand competitors in these markets, contracts are designed in equilibrium to maximize the borrower's expected share of the project surplus subject to the participation and incentive compatibility constraints of the financiers.*

This result will be useful in the subsequent analysis to derive the properties of contracts and characterize equilibrium surplus allocations. The intuition is that since all financiers are acting as Bertrand competitors for the borrower, all forms of finance – deposits, equity and bank loans – are competitively priced to yield financiers an expected return that they compute to be equal to the riskless rate (zero in our model).[20]

This result is in sharp contrast to Yanelle (1997), who builds upon Stahl (1988) to show that when intermediaries compete for both loans and deposits, the competitive outcome involving the bank earning zero expected profit need not obtain. The main reason for this difference can be seen as follows. Yanelle (1997) studies intermediation using Diamond's (1984) model, in which there are increasing returns to scale from intermediation; on the asset side the intermediary experiences increasing returns to scale because of the reduction of duplicated monitoring as the intermediary grows in size, and on the liability side it is

[20]Our notion of competition whereby contracts are designed to satisfy the participation constraints of investors, depositors and the bank's shareholders and maximize the borrower's surplus subject to these participation constraints plus incentive compatibility constraints can also be found in various other papers (e.g., Besanko and Thakor (1987a, b) and Holmstrom and Tirole (1997)).

because of the diversification benefits of size in reducing the risk of uninsured depositors. Intermediaries thus have an incentive to corner either the deposit or the loan market to achieve a monopoly outcome. By contrast, there are no such increasing returns to scale in our model. Each bank deals with only one borrower – there is no advantage in dealing with multiple borrowers – and deposits are fully insured. In the absence of increasing returns to scale, even two-sided Bertrand competition for loans and deposits yields zero profit for the bank in equilibrium.

3.1.1 The Bank's Acceptance/Rejection Decision

We start by analyzing the bank's decision to accept or reject the borrower based on its screening at $t = 0$, when the borrower approaches the bank for either a relationship loan or securitization. If the bank extends a loan, then perfect competition in the loan market implies that, conditional on the information revealed by the screening, the bank's equilibrium loan pricing maximizes the authentic borrower's expected payoff subject to the bank's participation constraint. With securitization, the terms of credit for the borrower are determined by the market's perception of the borrower's credit quality, which is affected by the bank's publicly-observable acceptance/rejection decision.

Lemma 2. *In both securitization and relationship lending, the equilibrium must involve the bank accepting the borrower if screening yields a good signal, $s = s_a$, and rejecting the borrower if screening yields a bad signal, $s = s_c$.*

If the bank makes its decision based on the screening outcome by accepting when $s = s_a$ and rejecting when $s = s_c$, then the bank can "certify" the borrower's creditworthiness to the market, which enables an affirmatively-certified borrower to obtain better credit terms with securitization than would be available absent the certification. Absent such certification, securitization will not be viable.[21] Recall that investors who purchase the securitized debt have recourse to the bank for a δ fraction of the securitized debt if the borrower defaults. The key is that δ is set to be sufficiently high such that in equilibrium the bank finds it not profitable to securitize a borrower without screening it first (otherwise, securitization will not be viable as discussed before). Now, conditional on screening, if the bank were to also accept the borrower when $s = s_c$, the bank's expected payment to investors under the recourse agreement would be so high that the bank's expected payoff would be negative.[22] Thus, securitization with recourse ensures that the bank's acceptance/rejection decision is signal-contingent and therefore the certification provided by the bank's decision to securitize the loan is credible. The intuition for relationship borrowing is similar.

The upshot of this is that if a borrower with prior credit quality q is accepted by the bank for either securitization or for a relationship loan at $t = 0$, it is certified by the bank to be authentic with probability $q^A > q$.

[21] If such certification is not provided with securitized debt, then the credit terms that an authentic borrower obtains from the capital market in securitization are the same as those from direct (non-intermediated) market borrowing. But there is a securitization cost, Z, that is fully absorbed by the borrower. Thus, direct market financing strictly dominates securitization if the latter involves no bank certification.

[22] Note that the bank's expected payoff in this case is even less than that from securitizing the borrower without screening.

3.1.2 The Authentic Borrower's Payoffs

We now compute the authentic borrower's net expected payoff at $t = 0$ associated with each financing source, which will then help us to determine which source the borrower will prefer at $t = 0$. These expected payoffs are computed prior to any bank screening of the borrower.

Direct Capital Market Access: We first analyze the equilibrium investor participation, N_{dir}, for any borrower with prior credit quality q borrowing directly from the capital market via a debt contract. The authentic borrower chooses the debt repayment obligation, R_{dir}, to maximize its expected payoff, denoted as π_{dir}:

$$\pi_{\text{dir}} = X - R_{\text{dir}}, \tag{4}$$

subject to the marginal investor's participation constraint:

$$\lambda(N_{\text{dir}})[qR_{\text{dir}}] - [1-q]\omega = 1, \tag{5}$$

where ω is the marginal investor's disutility of financing a crook, given by:

$$\omega/\bar{\omega} = N_{\text{dir}}/\bar{N}. \tag{6}$$

In (4), $X - R_{\text{dir}}$ is the net payoff to the authentic borrower. As for (5), note that the probability that a borrower receiving direct market financing is authentic is q, in which case the investors are repaid. The expected debt repayment is thus qR_{dir} as valued by the borrower, but $\lambda(N_{\text{dir}})[qR_{\text{dir}}] < qR_{\text{dir}}$ as valued by the investors (see Assumption 1). The probability is $1 - q$ that a crook will be funded, in which case the investors suffer a disutility of ω. The expected payoff across those two states must equal 1, the financing provided. To understand (6), note that only investors with disutility less than or equal to ω, defined in (5), will lend to the borrower. The investor with disutility equal to ω is the marginal investor. From the uniform distribution assumption for that disutility, we know that the fraction of investors with disutility not exceeding ω is $\omega/\bar{\omega}$, which equals $N_{\text{dir}}/\bar{N}$.

Securitization: Next, consider a borrower with prior credit quality q whose bank loan is securitized. With securitization, what we need to make sure of is that: (i) the bank will indeed screen the borrower, and (ii) it will securitize only a borrower on which the screening outcome is $s = s_a$. If this can be ensured, then investors will be assured that with probability $q^A > q$ the borrower is authentic (see Lemma 2). The equilibrium investor participation for securitization, denoted as N_{sec}, can be analyzed in the same way as N_{dir}.

The three choice variables, R_{sec} (the borrower's repayment obligation), $\hat{R}_{\text{sec}}$ (the portion of the repayment passed along to investors), and δ (the fraction of the promised repayment for which investors have recourse to the bank via collateral), are chosen to maximize the authentic borrower's expected payoff from securitization, denoted as π_{sec}, which is the probability that bank screening reveals such a borrower to be creditworthy, p, times the borrower's net payoff conditional on being funded, which is the project payoff, X, minus the debt repayment to the bank, R_{sec}, i.e.,

$$\pi_{\text{sec}} = p[X - R_{\text{sec}}], \tag{7}$$

subject to the marginal investor's participation constraint:

$$\lambda(N_{\text{sec}})\{[q^A\hat{R}_{\text{sec}}] + [1-q^A][\delta\hat{R}_{\text{sec}}]\} - [1-q^A]\omega = 1, \tag{8}$$

and the bank's participation constraint (prior to screening):

$$[pq][R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-p][1-q][\delta\hat{R}_{\text{sec}}] - \{qp + [1-q][1-p]\}[Z] - [cp^2/2] = 0, \tag{9}$$

where ω is the marginal investor's disutility of financing a crook, given by $\omega/\bar{\omega} = N_{\text{sec}}/\bar{N}$. As for (8), $\lambda(N_{\text{sec}})[1-q^A][\delta\hat{R}_{\text{sec}}]$ is the investors' valuation of their recourse to the cash collateral in case of default. Note that $\lambda(N_{\text{sec}})$ reflects the effect of bank screening on the market, since N_{sec} is influenced by the fact that a securitized credit has been screened and certified first by the bank. To undersand (9), the bank's participation constraint, note that the bank only securitizes the borrower when $s = s_a$ (this will be verified shortly). The bank's valuation of its expected payoff is the probability that the borrower is authentic and screening reveals it to be so, i.e., Pr(authentic) $\times$ Pr($s = s_a$|authentic) $= pq$, times the bank's net payoff in that case, $R_{\text{sec}} - \hat{R}_{\text{sec}}$.[23] The expected cost to the bank of providing recourse, is the probability that the borrower is a crook but screening mistakenly yields a good signal, i.e., Pr(crook) $\times$ Pr($s = s_a$|crook) $=$ $[1-p][1-q]$, times the recourse, $\delta\hat{R}_{\text{sec}}$. With probability $\Pr(s = s_a) = qp + [1-q][1-p]$ the bank sets up a trust, so the bank's expected cost of setting up securitization is $\{qp + [1-q][1-p]\}[Z]$. Finally, $cp^2/2$ is the bank's screening cost.[24]

We also need to check the incentive compatibility (IC) constraints in (i) and (ii) above. Consider (i) first. We need to ensure that the bank's net payoff from screening and securitizing, given by (9), is no less than that from: (a) not screening and not securitizing, and (b) securitizing without screening. Since the bank's payoff associated with (a) is zero, that constraint is obviously satisfied. As for (b), the IC constraint is that the bank's net payoff from securitizing without screening is non-positive (recall q is the prior belief about borrower quality):

$$q[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q][\delta\hat{R}_{\text{sec}}] - Z \leq 0, \tag{10}$$

where we recognize that the bank will have to set up a securitization trust in order to securitize, whether it screens or not prior to securitization. Since (10) is binding in equilibrium, we solve it to obtain:

$$\delta = \frac{q[R_{\text{sec}} - \hat{R}_{\text{sec}}] - Z}{[1-q]\hat{R}_{\text{sec}}}. \tag{11}$$

Now consider (ii) – the bank should prefer to securitize only if $s = s_a$. Securitizing after $s = s_a$ yields a net payoff of zero, according to (9), so this will satisfy the participation constraint. To ensure that the bank does not securitize when $s = s_c$, we need:

$$q^C[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q^C][\delta\hat{R}_{\text{sec}}] - Z - [cp^2/2] \leq -cp^2/2, \tag{12}$$

[23]Note that the valuation discount, measured by $1 - \lambda(N_{\text{sec}})$, only exists between investors in the capital market and the borrower, but not between the bank and the borrower.

[24]Note that (9) is equivalent to: $q^A[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q^A][\delta\hat{R}_{\text{sec}}] - Z - \frac{cp^2/2}{qp+[1-q][1-p]} = 0$.

where the left-hand-side is the bank's net payoff if it screens and securitizes a borrower for which $s = s_c$, and the right-hand-side is the bank's payoff if it screens and decides not to securitize. Solving this yields:

$$\delta \geq \frac{q^C[R_{\text{sec}} - \hat{R}_{\text{sec}}] - Z}{[1 - q^C]\hat{R}_{\text{sec}}}. \tag{13}$$

Since $q > q^C$, we know that the δ given by (11) will satisfy (13). Thus, the equilibrium δ is given by (11).

Relationship Loan: Finally, consider an authentic borrower with prior credit quality q financing via a relationship loan from the bank. Its expected payoff, denoted as π_{loan}, is:

$$\pi_{\text{loan}} = p[X - L]. \tag{14}$$

Given Lemma 1, the bank's equilibrium choice of the loan repayment obligation, L, maximizes π_{loan} subject to the bank's own participation constraint (prior to screening):

$$[qp][\alpha]\{L - [1 - E]\} - \{qp + [1 - q][1 - p]\}\{\tau[1 - E]\} - [cp^2/2] = 0, \tag{15}$$

and the marginal investor's participation constraint in the capital market:

$$[1 - \alpha]\lambda(N_{\text{loan}})[q^A]\{L - [1 - E]\} - [1 - q^A]\omega = E, \tag{16}$$

where N_{loan} is the equilibrium investor participation in the market providing equity capital to the bank, and ω is the marginal investor's disutility of financing a crook, given by $\omega/\bar{\omega} = N_{\text{loan}}/\bar{N}$.

These expressions can be understood as follows. The authentic borrower's expected payoff in (14) is the probability, p, that such a borrower will receive credit (be affirmatively screened by the bank) times the borrower's net payoff, which is the project payoff, X, minus the loan repayment, L. To understand (15), note that if the loan is extended, the bank obtains a share α of the terminal payoff, $\{L - [1 - E]\}$, and the probability of loan repayment is the probability of extending the loan to an authentic borrower, so the bank's ex ante expected payoff prior to screening is $[\Pr(s = s_a) \times \Pr(\text{authentic}|s = s_a)][\alpha]\{L - [1 - E]\} = [qp][\alpha]\{L - [1 - E]\}$. The bank's participation constraint (15) equates that expected payoff to the expected cost of deposit gathering, $[\Pr(s = s_a)]\{\tau[1 - E]\} = \{qp + [1 - q][1 - p]\}\{\tau[1 - E]\}$, plus the cost of screening, $cp^2/2$.[25] The bank raises equity capital E to make its relationship loan. The marginal investor's participation constraint (16) equates the investor's expected payoff from providing capital to E, the amount of capital provided.[26] The investor's share of the bank's expected terminal payoff is $[1-\alpha]$, and the expected

[25]It is easy to verify, based on the similar argument as in the case of securitization, that in relationship lending the bank will indeed screen and only lend to a borrower when screening yields $s = s_a$. Note that (15) is equivalent to: $\alpha[q^A]\{L - [1 - E]\} - \tau[1 - E] - \frac{cp^2/2}{qp+[1-q][1-p]} = 0$.

[26]Note that in this analysis, it has been assumed that the cost of deposit gathering, $\tau[1-E]$, and the cost of screening, $cp^2/2$, are entirely borne by the bank but not shared by the investors who provide E. This is because of the investors' valuation discount of the bank's expected terminal payoff. Take the cost of deposit gathering for example. Note that for every unit cost of deposit gathering shared by the investors, from the bank's perspective it needs to yield more than one unit of its terminal payoff to the investors to compensate them for bearing the deposit gathering cost. To see this more concretely, note that it can be derived from (15) and (16) that:

$$L = [1 - E]\left[1 + \frac{\tau}{q^A}\right] + \frac{[1 - q^A][\bar{\omega}/\bar{N}][N_{\text{loan}}] + E}{q^A\lambda(N_{\text{loan}})} + \frac{cp}{2q},$$

terminal payoff itself is $\lambda(N_{\text{loan}})[q^A]\{L - [1-E]\}$ as valued by the marginal investor, which is smaller than the bank's valuation, $[q^A]\{L - [1-E]\}$.

Solving these three optimization problems in (4) – (16), we have the following lemma:

Lemma 3. *The equilibrium investor participation and the expected payoffs to an authentic borrower from the three financing choices, non-intermediated debt, securitization, and relationship borrowing, are all increasing in borrower credit quality, q, and the number of investors in the capital market, $\bar{N}$. For securitization and relationship borrowing, the equilibrium investor participation is also increasing in the precision of bank screening, p; for each of these two financing choices, there exists a value of p that maximizes the authentic borrower's expected payoff.*

This lemma says the following. First, as borrower credit quality improves (larger q), the probability of financing a crook decreases and hence more investors are willing to participate when the borrower opts for direct market financing (lager N_{dir}) or securitization (larger N_{sec}), and when the bank raises equity capital from the market in relationship lending (larger N_{loan}). Second, for non-intermediated debt and securitization, higher borrower credit quality not only leads to a lower debt repayment but also to a lower cost of market borrowing because it elevates investor participation in the market; recall $\lambda'(N) > 0$. Thus, the authentic borrower's expected payoffs in direct market financing (π_{dir}) and securitization (π_{sec}) are both increasing in borrower quality. Turning to relationship lending, since the bank operates in a competitive loan market, the equilibrium loan repayment only reflects the bank's cost of providing a relationship loan, part of which is the cost of raising equity capital from the market.[27] Higher borrower quality increases investor participation in bank equity in the capital market. This reduces the cost of raising equity capital for the bank, thereby lowering the borrower's equilibrium loan repayment and in turn increasing the authentic borrower's expected payoff from relationship borrowing (π_{loan}). Third, a capital market with more investors (larger $\bar{N}$) leads to greater investor participation in any security in equilibrium, and hence a greater expected payoff for the authentic borrower regardless of its financing choice. Finally, in securitization and relationship borrowing, the probability of financing a crook also decreases when bank screening becomes more precise (larger p), which leads to the result that investor participation increases with the precision of bank screening; the authentic borrower's expected payoff consequently increases as well when p is low. However, as p further increases, the convex cost of screening ($cp^2/2$), which is borne by the authentic borrower in equilibrium, becomes sufficiently high so that further

when the bank bears the entire cost of deposit gathering. Instead, if $\varsigma \in (0,1)$ fraction of the deposit gathering cost is shared by the investors, the bank's and the marginal investor's participation constraints become $\alpha[q^A]\{L' - [1-E]\} - [1-\varsigma]\tau[1-E] - [cp^2/2] = 0$ and $[1-\alpha]\lambda(N_{\text{loan}})[q^A]\{L' - [1-E]\} - [1-q^A]\omega - [\varsigma]\tau[1-E] = E$, respectively, where L' is the loan repayment. Straightforward calculations show that:

$$L' = [1-E]\left[1 + \frac{[1-\varsigma]\tau}{q^A}\right] + \frac{[1-q^A][\bar{\omega}/\bar{N}][N_{\text{loan}}] + E + \varsigma\tau[1-E]}{q^A\lambda(N_{\text{loan}})} + \frac{cp}{2q},$$

which is larger than L, since $\lambda(N_{\text{loan}}) < 1$. That is, π_{loan} will be *ceteris paribus* smaller if the bank's equity contract stipulates the deposit gathering cost to be shared by the investors, which is suboptimal. The case for screening-cost sharing can be analyzed in the same way.

[27] The others are screening cost and the cost of deposit gathering.

increases in p cause the authentic borrower's payoff to decrease. Thus, there exists a payoff-maximizing $p \in (1/2, 1)$ for securitization and another for relationship borrowing.

3.2 The Authentic Borrower's Choice of Funding Source

In this section, we establish a proposition that characterizes the authentic borrower's choice of funding source. It is useful to describe the intuition underlying this proposition before we present the formal details. We begin at the lowest end of the borrower credit quality spectrum. As the authentic borrower's prior credit quality declines, its loan repayment obligation L increases and its payoff from relationship borrowing decreases (Lemma 3). Since L increases without bound as q decreases to 0, L becomes prohibitively high for a sufficiently low q as no bank wishes to finance a borrower who is almost certainly a crook. Thus, there exists a credit quality cutoff, call it $q_l > 0$, below which borrowers cannot obtain bank financing. This cutoff defines the bank's lending scope, with a broader lending scope being associated with a lower cutoff.

Now, for the lowest-quality authentic borrowers that qualify for credit ($q \geq q_l$), a relationship loan provides the highest benefit from bank screening. For such borrowers, going directly to the capital market is relatively inefficient because the low q combined with the absence of bank screening means that investor participation is quite low and the cost of market financing is very high. Bank financing with a relationship loan, which consists of bank equity and deposits, has its costs too. One is the cost of deposit gathering, $\tau[1 - E]$, but this is relatively low for low-q borrowers because the bank's capital requirement, E, is relatively high for such borrowers. The other is the cost of equity capital the bank raises from the market to support the loan, which the borrower must absorb in equilibrium. This cost, measured at the margin by $1 - \lambda(N)$, arises due to the valuation discount with market financing – investors value the borrower's project lower than the bank does. Although this cost is also incurred with direct capital market access, it is incurred over the entire loan amount ($1) with direct market finance rather than over only the bank capital ($E < 1$) used to support the relationship loan. Thus, for the qualifying low-q borrowers, a relationship loan dominates direct capital market access. These borrowers could, of course, choose securitization, whereby they get the same benefit of bank screening that a relationship loan provides, but face different costs. These costs include the fixed securitization cost Z, the bank's cost of providing recourse to investors, and the valuation discount on the capital market financing for the loan. For low-q borrowers, the cost of recourse and valuation discount are high, so the sum of Z and the recourse and valuation discount with securitization is also high. By contrast, because the bank's capital requirement, E, for such borrowers is high, the deposit-gathering cost with a relationship loan, $\tau[1 - E]$, is low. The cost of equity associated with the capital requirement is high for low-q borrowers, but this cost arises from the valuation discount, and this discount applies to only the portion of the relationship loan funded by bank equity capital. By contrast, the valuation discount applies to the entire loan with securitization. Thus, for low-q borrowers, the total cost of a relationship loan is exceeded by the total cost of securitization. These borrowers therefore prefer relationship loans.

As the borrower's credit quality increases further, the tradeoff changes as the bank's capital requirement against a relationship loan, E, declines and the deposit-gathering cost, $\tau[1-E]$, increases. The bank's cost of providing recourse with securitization for such a borrower as well as the valuation discount on capital market funding both decrease and the fixed cost of securitization, Z, is unaffected. Thus, there exists a quality cutoff, say q_m, such that borrowers with prior credit quality $q \geq q_m$ prefer securitization over a relationship loan.

These intermediate-quality borrowers ($q \geq q_m$) also compare their payoff from securitization to that from direct capital market access. The benefit of securitization relative to direct market finance for such borrowers inheres in the bank screening that accompanies securitization. The posterior belief about the quality of a screened borrower receiving credit via securitization, q^A, exceeds the prior belief, q, but this posterior belief with direct market finance stays at q. Securitization thus leads to higher investor participation in the market and a lower valuation discount than direct market finance. Moreover, the certification value of bank screening also enables the borrower to obtain better credit terms with securitization than with direct market finance. Partially offsetting these benefits of securitization are the noise in bank screening that may cause an authentic borrower to be wrongly rejected by the bank, and the sum of the bank's securitization cost Z and the cost of recourse that must be absorbed in equilibrium by the borrower. The noise in bank screening means that an authentic borrower is denied access to securitization with probability $1-p$, which is the probability with which bank screening mistakenly identifies such a borrower as a crook. Both Z and the cost of being erroneously denied credit do not vary with borrower quality, q, but the benefit of securitization gets smaller as q increases, vanishing asymptotically as $q \uparrow 1$. By contrast, the cost of going directly to the market, as reflected in the valuation discount, is also getting smaller as q increases.[28] Thus, among borrowers with prior credit quality $q \geq q_m$, there will be a cutoff, say $q_h > q_m$, such that those with $q < q_h$ will prefer securitization and those with $q \geq q_h$ will prefer direct market access. The proposition given below formalizes this intuition.

Proposition 1. *Suppose the securitization cost $Z < \bar{Z}$, and the marginal cost of deposit gathering $\tau \in (\underline{\tau}, \bar{\tau})$, where $\bar{Z}$, $\underline{\tau}$ and $\bar{\tau}$ are exogenous constants defined in the Appendix. An authentic borrower chooses its funding source in equilibrium as follows.*

1. *There exists a low credit-quality cutoff, $q_l > 0$, such that an authentic borrower with $q < q_l$ cannot obtain financing from the bank. Moreover, q_l is decreasing in the number of investors in the capital market, $\bar{N}$.*

2. *There exists a high credit-quality cutoff, $q_h > q_l$, such that an authentic borrower with $q \geq q_h$ borrows directly from the capital market and the one with $q \in [q_l, q_h)$ approaches the bank. The cutoff q_h is determined such that $\pi_{\text{dir}}|_{q=q_h} = \pi_{\text{sec}}|_{q^A=1}$. Moreover, q_h does not depend on p.*

[28]So is the cost of recourse with securitization, but that decline affects just a portion of the loan, whereas the effect on market financing is greater because it affects the entire loan.

3. There exists a medium credit-quality cutoff, $q_m \in (q_l, q_h)$, such that an authentic borrower with $q \in [q_l, q_m)$ prefers a relationship loan and the one with $q \in [q_m, q_h)$ prefers securitization. Moreover, q_m is decreasing in p.

It is a unique universally divine sequential equilibrium (Banks and Sobel (1987)) for every crook within a prior credit quality q cohort to choose the same financing source as the authentic borrower in that cohort. This equilibrium is supported by the out-of-equilibrium belief that any borrower who makes a financing source choice other than that described above is a crook with probability one.

Note that q_h is determined such that the direct-market-financing payoff to an authentic borrower with prior quality $q = q_h$, $\pi_{\text{dir}}|_{q=q_h}$, is the same as the highest possible payoff that the borrower can get from securitization when it is believed by the market to be authentic with probability one, $\pi_{\text{sec}}|_{q^A=1}$. Define q'_h as the prior credit quality at which the borrower is indifferent between securitization and direct market financing, i.e., $\pi_{\text{sec}} = \pi_{\text{dir}}$ for $q = q'_h$, $\pi_{\text{sec}} > \pi_{\text{dir}}$ for $q < q'_h$, and $\pi_{\text{sec}} < \pi_{\text{dir}}$ for $q > q'_h$. It is clear that $q'_h < q_h$. The authentic borrowers with $q \in (q'_h, q_h)$ would be better off with direct market financing than with securitization (see Figure 2), and yet they borrow via securitization in equilibrium. This efficiency loss arises from the universal divinity refinement of the sequential equilibrium. To understand this, suppose the authentic borrowers with $q \in (q'_h, q_h)$ chose direct market financing. Note that *ceteris paribus* a crook strictly prefers direct market financing over securitization because bank screening associated with securitization diminishes the likelihood of the crook obtaining funding. Thus, if a borrower with $q \in (q'_h, q_h)$ defects from direct market financing to securitization, it would be understood by investors that the borrower is more likely to be an authentic borrower rather than a crook, so by universal divinity the defector would be perceived by the market as authentic with probability one. This would create an incentive for all authentic borrowers with $q \in (q'_h, q_h)$ to switch from direct market financing to securitization, so all non-defectors would be perceived as being crooks with probability one. This unravels the equilibrium, and no borrower with $q \in (q'_h, q_h)$ will be able to receive direct market financing. In a universally divine sequential equilibrium then, authentic borrowers with $q \in (q'_h, q_h)$ must choose securitization. It is clear that the precision of bank screening, p, has no effect on q_h.

As for the choice between securitization and relationship borrowing, more precise bank screening invites greater investor participation in the market both for securitization and for the bank's raising of equity to support its loan. This lowers the costs of both bank equity and securitized debt. But the effect on securitized debt exceeds that on bank equity. The reason is that more funding is raised from the market with securitized debt than by the bank when it raises equity capital ($E < 1$). Hence, securitization becomes more attractive as the precision of bank screening improves, i.e., $\partial q_m / \partial p < 0$.

Authentic borrowers with prior credit quality $q < q_l$ are unable to obtain funding because of prohibitively high loan repayment obligations with relationship borrowing. A larger number of investors ($\bar{N}$) elevates investor participation in the market, thereby lowering the cost of bank equity. Due to the competitive structure of the loan market, this cost reduction is passed on in equilibrium to the authentic borrower receiving a relationship loan. Thus, a larger $\bar{N}$ allows more authentic borrowers with relatively low prior credit qualities to be able to finance their projects, thereby expanding the bank's lending scope.

This proposition also states that in equilibrium the crooks mimic the authentic borrowers in their choice of financing source. The reason is that any deviation from the choice of the authentic borrowers reveals the crook noiselessly. This means that the equilibrium pools authentic borrowers and crooks, and financiers learn nothing about a borrower's type by observing its financing choice.

These effects are graphically illustrated in *Figure 2*.

[Figure 2 goes here]

As our analysis thus far has revealed, there are two frictions that are complementary in the sense that both impede the borrower's access to credit. One is a friction introduced by a lack of information about borrower credit quality ("certification friction"), and the other is a friction that arises from the dissipative costs of external financing, including the cost of the valuation discount ("financing friction"). The certification friction manifests itself in the exclusion of creditworthy borrowers from credit, whereas the financing friction manifests itself in a higher cost of capital for the borrower. Banks are better at resolving the certification friction because of their superior screening technology. The financing friction is resolved in different ways by banks and markets. Banks resolve it by funding themselves with insured deposits, but do so by incurring a deposit-gathering cost. Markets resolve it by achieving a lower valuation discount via greater investor participation.[29] These different ways of resolving the financing friction generate benefits that differ across borrowers based on borrower quality. The relative advantages of banks and capital markets described here are linked to the roles ascribed to these financing sources in the literature, as we show later when we endogenize our key assumptions.

We end this section with a comment on the role of the two-sided commitment. The bank needs to precommit to an interest rate it will charge a borrower that it wishes to lend to because otherwise the bank ends up with an ex post monopoly *after* having screened the borrower affirmatively. Thus, if some banks make binding precommitments and others don't, borrowers will go to the banks that precommit. This also corresponds to what we see in practice – a borrower cannot be sure the bank will agree to lend, but it knows the rate on the loan if the bank agrees to lend. Similarly, borrowers need to precommit that if offered the loan at the posted price, they will take the loan. This is necessary because the bank earns an ex post rent when $s = s_a$ and it does lend; this rent covers the ex post loss the bank suffers when $s = s_c$ and it does not lend, thereby being unable to recoup its screening cost.[30]

[29] Allen and Gale (1999) develop a model in which markets are superior to banks in aggregating the heterogeneous beliefs of investors. This is similar in spirit to our setup.

[30] This two-sided precommitment only simplifies the analysis and is unnecessary for the results. A competitive credit market model in which there is no precommitment and borrowers choose how many banks to apply to and be screened simultaneously is developed in Thakor and Callaway (1983). Our assumption here allows us to side-step the complications that arise in that analysis, since these are quite peripheral to our paper.

4 The Analysis of the Basic Model: Co-evolution of Banks and Markets and Financial System Architecture

In this section we analyze the implications of our previous analysis for the co-evolution of banks and capital markets, followed by an examination of the implications of the analysis for financial system architecture.

4.1 Co-evolution of Banks and Capital Markets: Preliminary Remarks

We now examine how the evolution of the bank affects the capital market, and how the evolution of the capital market affects the bank. That is, we are going back to $t = -1$ to solve for the bank's choice of screening precision, p. A preliminary result is useful for this analysis.

Lemma 4. *At $t = -1$, the bank will choose a screening precision that maximizes the expected surplus of the borrower at $t = 0$.*

The intuition is as follows. At $t = 0$, banks are engaged in Bertrand competition and hence each bank chooses credit contracts to maximize the expected surplus of the borrower subject to incentive compatibility and participation constraints. Thus, all surplus goes to borrowers. Any bank that chooses a p at $t = -1$ that does not maximize expected borrower surplus at $t = 0$ will be unable to attract a borrower away from a bank that chose the surplus-maximizing p at $t = -1$.[31]

Consider now a borrower with prior credit quality q, which is drawn from a uniform distribution over support $[0, 1]$.[32] The bank's problem at $t = -1$ is to choose p that maximizes borrower surplus given below:

$$\int_{q_l}^{q_m} \pi_{\text{loan}} dq + \int_{q_m}^{q_h} \pi_{\text{sec}} dq + \int_{q_h}^{1} \pi_{\text{dir}} dq. \tag{17}$$

We now define bank evolution and capital market evolution.

Definition (Bank Evolution and Capital Market Evolution): *Bank evolution is defined as a decrease in the cost, c, of achieving precision in bank screening. We define capital market evolution as greater investor participation in the capital market and hence a lower capital market financing cost for the borrower.*

Our definitions of bank and capital market evolution are consistent with the traditional view of the functions of a financial system. A primary function of a financial system is to acquire and process information. In our model, bank evolution is synonymous with investment in the bank's screening technology becoming more efficient (lower c), possibly due to advances in information technology and credit screening

[31] Note that the bank is choosing p at $t = -1$ before it knows the borrower's q which becomes common knowledge only at $t = 0$. Thus, p is not chosen for a specific q. However, assuming that the bank chooses p after observing q of the borrower it faces will not qualitatively affect our results. Borrowers with $q \in [q_h, 1]$ will not approach the bank, so the bank will not invest in screening precision if the borrower has such a q. Faced with a borrower with $q \in [q_l, q_h)$, the bank will choose p depending on the q it faces. Capital market evolution will still lower the bank's equity cost of capital and induce the bank to deal with borrowers with lower values of q than before (see Proposition 3).

[32] The uniform distribution assumption for q is made for mathematical simplicity.

models, so the bank is able to acquire and process information more effectively. Another function of a financial system is to mobilize savings by pooling capital from disparate individual investors and facilitating trading. This corresponds to our definition of capital market evolution, since a capital market with greater investor participation is able to perform this function with a lower financing cost.

4.2 The Effects of Bank Evolution on Capital Market Evolution

We now analyze the effects of bank evolution on capital market evolution and the borrower's financing choice. Bank evolution has two effects. First, as shown in Lemma 3, bank evolution causes investor participation in the capital market for relationship borrowing to increase, thereby lowering the bank's cost of equity to meet its capital requirement. Second, bank evolution also causes investor participation in the capital market for securitization to increase. Thus, bank evolution plants the seeds for capital market evolution by generating greater investor participation in the capital market. The following proposition summarizes the effects of bank evolution on capital market evolution and the authentic borrower's financing choice.

Proposition 2. *Bank evolution has the following effects: (i) it expands the bank's relationship lending scope from below (q_l decreases); (ii) it expands the bank's securitization scope from below (q_m decreases); and (iii) it enhances investor participation in the capital market for both relationship borrowing and bank securitization, thereby leading to capital market evolution.*

This proposition can be understood as follows. First, bank evolution generates relationship-loan availability for authentic borrowers with low prior credit qualities who previously had no access to credit. That is, bank evolution expands the bank's lending scope at the lower end of the credit quality spectrum. Second, bank evolution not only broadens the scope for securitization (q_m decreases), but also increases its volume by increasing investor participation in the capital market for securitization. If we include both securitization and the capital market for non-intermediated, direct borrowing in our view of "markets," then bank evolution invites greater investor participation in capital markets. Taken together, we note that bank evolution can cause relationship banking to lose business to securitization at the top of the credit quality spectrum (q_m decreases), but gain market share at the bottom by extending its lending scope (q_l decreases). Hence, the overall effect of bank evolution on the banking sector itself is somewhat surprisingly not unambiguous, but bank evolution is unambiguously beneficial to the capital market.

Relative to previous models of the borrower's choice between a bank loan and direct capital market financing (e.g., Berlin and Mester (1992), Boot and Thakor (1997a), and Rajan (1992)), what our analysis adds is securitization in which the bank facilitates the borrower's financing from the capital market through an informative screening technology that enhances the creditworthiness of the securitized borrower pool and thereby lowers the borrower's financing cost. However, the introduction of securitization in our model is not merely adding an element to the borrower's financing choice menu for descriptive completeness. Rather, securitization generates an important interaction between the bank and the capital market that profoundly affects financial system architecture. It propagates banking advances to the capital market, permitting capital market evolution to be driven by bank evolution. To see this clearly, it is useful to examine what would happen if we excluded securitization, as has been typically done in analyses of financial system architecture.

Corollary 1. *Suppose there is no securitization. Then bank evolution expands the bank's relationship lending scope both from below and above, and the capital market loses borrowers to banks.*

This result shows that when securitization, the conduit through which the benefits of bank evolution flow through to the capital market, is excluded, we return to the standard result that banks and markets compete. A technological improvement in the screening technology employed by banks leads to an increase in the market share of banks at the expense of the capital market.

Of course, our analysis has ignored the role of non-bank financial intermediaries like credit rating agencies in this certification process. If such intermediaries were introduced in the model, then improvements in the certification technologies of these non-bank financial intermediaries would enhance investor participation in the capital market independently of securitization and what banks do. However, a key difference between banks and rating agencies and certification intermediaries is that banks commit their own equity capital to the loan in their role as lenders, whereas rating agencies do not. Thus, banks have both financial and reputational capital at stake (e.g., Boot, Greenbaum and Thakor (1993)), and rating agencies have only reputational capital at stake.[33]

4.3 The Effects of Capital Market Evolution on Bank Evolution

We now analyze the effects of capital market evolution. Suppose there is some exogenous shock so that more investors enter the capital market, thereby increasing $\bar{N}$. How will this affect banks?

Proposition 3. *Capital market evolution expands the bank's lending scope from below, and increases the bank's investment in the screening technology, thereby leading to bank evolution.*

The intuition is as follows. Increased investor participation due to capital market evolution makes equity cheaper for the bank and allows it to lend to borrowers with low qualities that were previously denied credit (q_l decreases). Thus, capital market evolution does *not* necessarily cause the bank's business to shrink as predicted by the existing models. Rather, in addition to the usual competitive effect, the evolution of the capital market opens up segments of the credit market that were previously inaccessible to the bank.[34] Moreover, the marginal value of bank screening increases as the bank serves borrowers with lower credit qualities, which consequently induces the bank to invest more in the screening technology. This leads to a more precise bank screening technology and hence bank evolution.

[33] This may be one reason why James (1987) finds that the borrower's average announcement effect for a bank loan is positive and for capital market financing is negative.

[34] This result depends critically on the assumption that bank capital requirements are increasing in credit risk, something we will endogenize later.

In our model, there are potentially creditworthy borrowers being rationed by banks.[35] That is, those authentic borrowers with $q < q_l$ are not served by the financial system. Capital market evolution makes bank equity capital cheaper, making it optimal for the bank to raise more equity capital. This additional equity capital permits the bank to serve *low-quality* borrowers that were previously unserved, thereby expanding the bank's lending scope. The key role played by bank equity capital in our model is that it enables the universe of the borrowers served by banks to grow larger with capital market evolution, so that banks and markets need *not* compete in a static domain. This connects capital market evolution to bank evolution, and allows market advances to positively affect banks. To the best of our knowledge, such a role of bank equity capital has not been previously examined in the literature.

Numerous papers have examined bank capital. For example, Morrison and White (2005) study the impact of bank capital requirements and regulatory auditing on financial crises. Gorton and Winton (2000) examine the liquidity cost associated with bank equity capital. These papers are concerned primarily with the more traditional roles assigned to bank capital, in contrast to our paper where it acts as a conduit for the propagation of capital market advances to the banking sector. Of course, such a propagation would not occur if we either excluded bank capital from the analysis or simply fixed the cost of bank capital exogenously, as the corollary below shows.

Corollary 2. *Suppose bank equity capital is exogenously fixed and the cost of this capital is also exogenously fixed. Then capital market evolution causes the bank to lose some borrowers to the market.*

Again, when we remove the channel by which the benefits of capital market evolution flow through to banks, we get the standard result that a technological improvement in the market causes banks to lose business to the market.

This part of our analysis highlights another key difference between our model and previous research on financial system architecture. In previous studies, banks and markets interact in a *fixed* universe of those seeking credit. In our analysis, capital market evolution lowers the cost of bank capital and *increases* the set of creditworthy borrowers, so that banks and markets do *not* interact in a static domain. It is bank capital that creates a benefit flow from markets to banks.

4.4 Co-evolution

We now show that not only do banks and capital markets complement each other, they also co-evolve. We know from Proposition 3 that capital market evolution induces the bank to invest more in screening, enabling the bank to increase the precision of its screening technology and consequently facilitating bank evolution. Moreover, as bank screening becomes more precise, investor participation in the capital market also increases (see Proposition 2), which consequently spurs capital market evolution. This co-evolution dynamic is stated in our next result.

[35] This is credit rationing in the sense of Stiglitz and Weiss (1983), since the bank is unwilling to grant credit to the borrower even if the borrower offers to pay a higher price for that credit.

Proposition 4. *Bank evolution spurs capital market evolution, and capital market evolution spurs bank evolution. That is, banks and the capital market co-evolve with each other.*

We saw earlier that instead of the usual result that the two are pure competitors, banks and markets *complement* each other. More importantly, Proposition 4 shows that the complementarity extends to co-evolution as there are circumstances in which there is a virtuous cycle in which each sector benefits from the development of the other. This goes well beyond the one-way complementarity results in papers like Holmstrom and Tirole (1997) that bank monitoring can improve capital market access for borrowers.

The intuition behind Proposition 4 is as follows. Bank evolution enhances the bank's screening technology, which improves the quality of bank certification and facilitates resolution of the certification friction. Capital market evolution invites greater investor participation in the market, which lowers the cost of capital market financing for the borrower and facilitates resolution of the financing friction. As we discussed earlier, securitization provides a device through which the resolution of the certification friction facilitates the resolution of the financing friction, thereby allowing bank evolution to benefit the capital market. Bank capital is a device through which resolution of the financing friction enables the bank to expand its lending scope, thereby helping resolve the certification friction for previously unserved borrowers and permitting capital market evolution to benefit the banking sector.

5 The Complete Model

We now complete the model by endogenizing: (i) deposit insurance and bank equity capital; and (ii) the valuation discount in market financing. We maintain the same setting for the agents and economic environment as in the basic model, except that we now assume the borrower's project can be one of two types: good (G) and bad (B). If the project is good, its payoff at $t = 2$ is $X > 1$ for sure. A bad project always pays off zero at $t = 2$. The common prior belief at $t = 0$ is that the project is G with probability $\theta \in (0, 1)$, and is B with probability $1 - \theta$. We assume $\theta X < 1$, i.e., the project has negative NPV *a priori*. In what follows, we introduce a new element to the model: heterogenous prior beliefs. While this additional structure is special, it should be noted that its main role is to endogenize Assumptions 1 and 2. In particular, heterogeneous prior beliefs allow us to *simultaneously* endogenize a valuation discount ($\lambda(N)$) that is increasing and concave in investor participation (N) and justify complete deposit insurance in a model without coordination failures. Alternatives to heterogeneous priors may deliver some of what we need, but we have been unable to find an alternative that delivers all that we need to endogenize. For example, heterogeneous transaction costs or risk aversion among investors may be able to generate a valuation discount, but the important property that this discount is endogenously increasing and concave in N would be lost. Moreover, transaction costs or risk aversion would not help us endogenize complete deposit insurance without coordination failures.

5.1 Additional Model Structure: The Public Signal about Project Type and the Potential for Disagreement Among the Agents

For any borrower with prior credit quality q, a public signal regarding the type of its project is observed by all the agents at $t = 1$ just *before* deposits are raised. The signal is $\varphi \in \{\varphi_G, \varphi_B\}$, where φ_G is a good signal and φ_B is a bad signal. Everybody sees the same signal, i.e., there is no disagreement regarding the signal itself. Moreover, we assume that the common-knowledge prior probabilities are $\Pr(\varphi = \varphi_G) = \theta$ and $\Pr(\varphi = \varphi_B) = 1 - \theta$ for all projects regardless of the borrower's true type, since both the crook and the authentic borrower have the same project access. That is, while the bank's private signal s is about the borrower's type, the public signal φ is about the type of the project that the borrower has.

Although all the agents see the *same* signal and have the same prior beliefs about the values (φ_G or φ_B) the signal will take, they have different priors about the precision of the signal. More specifically, the signal precision, which we denote as υ, can take one of two values: the signal can either be precise (I) or uninformative (U). The probabilities of drawing I and U are $\mu \in [0, 1]$ and $1 - \mu$, respectively. A precise signal is viewed as perfect and causes the receiver of the signal to arrive at a posterior belief that puts all of the probability weight on the value of the signal, and an uninformative signal has no incremental information content, so it is disregarded and the posterior belief about the project's type stays at the prior belief.

To see this concretely, consider the case in which the signal is φ_G. When the prior belief about the signal precision is I, the agent's belief about the project's type is $\Pr(G|\varphi = \varphi_G, \upsilon = I) = 1$; when the prior belief about the signal precision is U, the agent's belief about the project's type remains at its prior, i.e., $\Pr(G|\varphi = \varphi_G, \upsilon = U) = \theta$. If the signal is φ_B, it is clear that a precise signal leads the agent to believe that the project is bad almost surely, and an uninformative signal does not change the agent's prior belief about the NPV of the project, which is again negative. Thus, a signal realization $\varphi = \varphi_B$ results in agreement among all the agents at $t = 1$ that the project has negative NPV, regardless of prior beliefs about signal precision.

The agents randomly draw prior beliefs about the precision of φ. We assume that the signal precision drawn by an agent is privately observed by that agent and not verifiable by others. To focus on the main issues, we assume the borrower, the bank and the regulator always agree with each other regarding the precision of the signal, denoted as υ_b.[36] Even though there are possibly multiple depositors, we assume that their prior beliefs about signal precision, denoted as υ_d, are perfectly correlated, so that depositors act as a monolithic group.[37] We model potential divergence of prior beliefs between the borrower/bank/regulator

[36]Dropping the assumption that there is no disagreement between the bank and the borrower will not qualitatively change the analysis as long as we continue to assume that depositors may disagree with the bank. The key to the analysis is that depositors may be unwilling to provide finance even when the bank finds the borrower creditworthy. Our assumption that the bank and the regulator agree with each other helps to simplify the analysis of deposit insurance and capital requirement that is presented later.

[37]As we will show later, assuming heterogenous beliefs across depositors does not change our analysis.

on the one hand and depositors on the other hand regarding the signal precision via the following structure of conditional probabilities:

$$\Pr(\upsilon_d = I|\upsilon_b = I) = \rho_d \in [0,1], \tag{18}$$

$$\Pr(\upsilon_d = U|\upsilon_b = I) = 1 - \rho_d. \tag{19}$$

Let υ_i denote the investors' prior belief about signal precision. We model potential divergence of prior beliefs between the borrower/bank/regulator on the one hand and investors on the other hand regarding the signal precision via the following structure of conditional probabilities:

$$\Pr(\upsilon_i = I|\upsilon_b = I) = \rho \in [0,1], \tag{20}$$

$$\Pr(\upsilon_i = U|\upsilon_b = I) = 1 - \rho. \tag{21}$$

Moreover, we introduce heterogeneity among investors by assuming that the value of ρ varies in the cross-section of investors in the capital market, which will be made clear in Section 5.2.

From the standpoint of beliefs, we model depositors as homogeneous and investors as heterogeneous. The reason for assuming homogeneous beliefs across depositors is that (insured) bank deposits represent a single financial security that is likely to attract a homogeneous group of investors. By contrast, the capital market offers a variety of risk-return tradeoffs and will attract a greater diversity of investors; we will say more about this later. Coval and Thakor (2005) show how investors with different beliefs self-select and invest in different securities.[38] See also Allen and Gale (1988) for a related argument in a state-preference framework.

The value of ρ_d (ρ) measures the degree of agreement between the borrower/bank/regulator and depositors (investors). The higher is ρ_d (ρ), the greater is the agreement between the borrower/bank/regulator and depositors (investors) in the sense that the higher is the probability that their prior beliefs about the signal precision will coincide. A value of $\rho_d = 1$ ($\rho = 1$) indicates perfect agreement and a value of $\rho_d = 0$ ($\rho = 0$) indicates perfect disagreement. The agreement parameter ρ_d (ρ) is affected by the attributes of the borrower's project and/or its business characteristics. If a project involves a radically new product or business design, there may be very little hard historical data to gauge the probability of the project succeeding in the future. Project evaluation may thus have to be based largely on soft information that is inherently subjective in nature (e.g., Stein (2002)), possibly causing ρ_d (ρ) to be low. By contrast, for a project that is somewhat more familiar in the sense that similar projects have been tried in the past, there may be a more balanced mix of hard historical data and soft information, so the value of ρ_d (ρ) may be relatively high.

We assume that all agents have "rational beliefs" as defined by Kurz (1994a,b), who provides a theoretical foundation for heterogenous priors. Although Kurz's theory of rational beliefs has many aspects, the two aspects most relevant for our analysis are that agents have different priors and that all these priors are consistent with the data in the sense that none can be precluded by historical data. In a situation such

[38] In that paper, financial intermediation arises endogenously as an institutional response to the beliefs irrationality of some agents. We assume here, however, that all beliefs are rational, even though they are heterogenous.

as the setting we have for projects with a paucity of hard historical data and non-stationary distributions, agents will *not* be able to *uniquely* derive the precision of the signal from historical data, so that many different distributions of precision may be consistent with the data.[39]

5.2 Additional Model Structure: Investor Heterogeneity in the Capital Market

Each investor's agreement parameter with the borrower, ρ, is an independent random draw from a continuous probability distribution $F(\cdot)$, with the associated density function $f(\cdot)$ and support $[0,1]$ $\forall q$. The equilibrium agreement parameter between the capital market and the borrowing agent is determined by investor participation in the market. The capital market provides a mechanism whereby investors with the highest valuation are able to bid for the security and, given investor risk neutrality, these investors are willing to purchase all of the security at their valuations. As shown in Boot, Gopalan and Thakor (2008), if there are N investors participating in the capital market in a given security for a borrower, the market-clearing mechanism ensures that the security is purchased by investors with the highest agreement parameter ρ among the N investors, which is the N^{th} order statistic of ρ, denoted as $\bar{\rho} \equiv \max_{\{1\leq i\leq N\}} \rho_i$, where ρ_i is the agreement parameter between the ith investor and the borrowing agent regarding the signal precision for the project. We call those investors "maximal investors."[40] Denote $\mathbf{E}(\bar{\rho}) \equiv \rho_M$, the equilibrium agreement parameter in capital market financing for the borrower when there are N investors participating in the market. The following result characterizes the relation between the equilibrium agreement parameter and investor participation in capital market financing.

Lemma 5. *The equilibrium agreement parameter, ρ_M, is increasing in the equilibrium investor participation with capital market financing, N.*

The intuition is that the N^{th} order statistic of the agreement parameter is increasing in N, the number of investors participating in the market.[41] We will explicitly characterize ρ_M when we analyze the equilibrium investor participation N for different modes of capital market financing. For analytical tractability, we assume henceforth that ρ follows a uniform distribution on support $[0,1]$.

[39]Technically, what we are modeling is a setting in which the economic observables based on which agents form beliefs are "stable" but not "stationary" (see Kurz (1994a,b)). In this case, the rational expectations hypothesis requires agents to have information about underlying processes that cannot be derived from historical data, whereas the rational beliefs hypothesis requires only that their beliefs be consistent with the data.

[40]It is useful to distinguish between a maximal investor and a marginal investor. As explained earlier in the basic model (Section 3.1.2), the marginal investor is the investor with the highest disutility of financing a crook (i.e., highest ω) among all the investors participating in any particular security. This investor determines investor participation in the security. A maximal investor is the one with the highest valuation of that security (i.e., highest ρ) among all the participating investors. If all investors have the same ρ, the maximal investor is also the marginal investor. But this need not be so when ρ's vary across investors. In that case only the maximal investors will hold the security in equilibrium.

[41]This has also been shown by Boot, Gopalan and Thakor (2008).

5.3 Discussion of the Model for the Borrower

As described above, we model each borrower as being distinct in terms of its credit quality q, and the agreement parameter ρ, which represents the extent to which capital market investors will agree with the borrower regarding the value of the project. The credit-quality dimension reflects the usual post-lending moral hazard on the part of the borrower, arising in our model from the possibility that the borrower is a crook.[42] The investor-agreement parameter ρ, however, represents a departure from the usual common-priors assumption in that we permit heterogeneous priors not only between the borrower and the investors, but also among the investors themselves (recall the value of ρ varies across investors).

Our choice of heterogenous priors for modeling disagreement is motivated by the fact that assessments of the value of techological or product innovations are typically associated with a diversity of opinions, as observed by Allen and Gale (1999). When something is new and unfamiliar, it is common for different agents to have different beliefs about its future potential, and a paucity of historical data impedes convergence of these beliefs (see Schumpeter (1934)). This stands in sharp contrast to investments in established industries where there is an abundance of historical data drawn from stationary distributions of underlying economic variables, and divergent beliefs can thus converge.

It is important to distinguish between disagreement and cash-flow risk. One may argue that innovations are inherently riskier in a cash flow sense, so would it not suffice to model innovative projects as simply being riskier than projects in established industries, rather than invoking heterogeneous priors and disagreement? The answer is no. While innovative projects *may* involve high cash flow uncertainty, this kind of risk is an inappropriate way to distinguish between innovative and established projects. For example, the U.S. credit card business, which is well established, involves relatively high default risk, with annual default rates of 30% – 40%. However, there is little disagreement over what these default rates are and how credit cards should be priced. The key distinction between the old and the new stems not from cash flow risk but from Schumpeter's (1934) observation that "...the new is only the figment of our imagination," which means it is difficult to bring hard data to bear on the problem of resolving differences of opinion.

5.4 Endogenizing Capital Market Valuation Discount, Deposit Insurance and Bank Capital

We now use the additional model structure described above to endogenize the exogenous elements in Assumptions 1 and 2 in Section 3.

[42]Although we don't model legal systems formally, we can think of an economy dominated by borrowers with low q as an economy with weak legal contract enforcement, while an economy populated with borrowers with high q as one with strong legal contract enforcement. That is, the strength of contract enforcement in the legal system may affect the fractional representation of crooks in the pool of those seeking financing.

5.4.1 Capital Market Valuation Discount

Consider an authentic borrower financing from the capital market via either direct borrowing or securitization. From the investors' perspective, the borrower may invest in a project with negative NPV as perceived by the investors but positive NPV as perceived by the borrower when they have different prior beliefs about signal precision; this occurs when $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = U\}$. That is why the investors' valuation of the expected debt repayment from the borrower is always lower than the borrower's valuation. The case for bank capital is similar. The degree of such valuation discount is determined by the level of agreement between the borrower and the "maximal investor" in the capital market, which in turn is determined by investor participation in the market (see Lemma 5). The following proposition endogenizes what was stated in Assumption 1.

Proposition 5. *Suppose the equilibrium investor participation in the capital market is N for direct market financing, securitization, or the bank raising equity capital. Then, the investors' valuation of the expected payoff made by the borrowing agent to them is a fraction $\lambda(N)$ of the borrowing agent's valuation, where $\lambda(N)$ is increasing and concave in N and is given by:*

$$\lambda(N) = \frac{\theta + N}{1 + N} \in (0, 1). \tag{22}$$

The intuition for this result is that an increase in the number of investors increases the equilibrium agreement parameter (Lemma 5), and the consequently lower disagreement between the borrower and the investors leads to a higher valuation by the investors.

5.4.2 Deposit Insurance

We now provide a rationale for deposit insurance within the context of our model. Suppose there is no deposit insurance and the regulator sets no capital requirement for the bank (i.e., $E = 0$). Consider a borrower with prior credit quality q choosing a relationship loan and suppose the bank finds the borrower creditworthy and decides to finance it. The bank has to borrow the entire \$1 from depositors at $t = 1$. Without deposit insurance, depositors will only lend when they consider the project to be worth funding, i.e., $\{\varphi = \varphi_G, \upsilon_d = I\}$. Thus, depositors may withhold funding even though the bank and the regulator believe the project is profitable. This occurs when $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_d = U\}$, so the bank and the regulator believe the project is worth funding whereas depositors believe the project is a bad bet. Conditional on the borrower being authentic, this state occurs with probability $\theta\mu[1 - \rho_d] > 0$ as long as there is some disagreement between the bank/regulator and depositors regarding the public signal's precision. It represents a *perceived* social welfare loss of $\theta\mu q^A[1 - \rho_d][X - 1]$ to the regulator.[43]

[43] This is because the regulator has the same prior belief of signal precision with the bank. This assumption is not crucial. As long as there is some disagreement between the regulator and depositors, deposit unavailability at $t = 1$ always represents a perceived social welfare loss to the regulator. Also, in a model with divergent beliefs, it is not possible to talk about social welfare without determining who has the "right" beliefs. Thus, we refer to "perceived" social welfare. Note that the assumption of homogeneous beliefs across depositors is also not critical: as long as there exist some depositors disagreeing

In the absence of deposit insurance, a capital requirement $E \in (0,1)$ cannot eliminate this perceived social welfare loss to the regulator. The reason is that as long as the deposits are not fully protected by deposit insurance, the amount of deposits needed for the project to be financed, $1-E$, will be unavailable whenever there is disagreement between the bank/regulator and depositors at $t=1$.[44] To eliminate this perceived inefficiency, the regulator will provide full deposit insurance, which causes depositors to ignore their potential disagreement with the bank/regulator regarding the project payoff and provide financing whenever the bank raises deposits from them. This eliminates the possibility of a deposit shortage.[45] We thus have an endogenous justification for the full deposit insurance assumption stated in Assumption 2.

5.4.3 Bank Capital

Bank's Asset-Substitution Moral Hazard: Assuming the regulator does not impose a bank capital requirement, the introduction of deposit insurance generates an asset-substitution moral hazard problem in that the bank may invest in a negative-NPV project due to the well-known deposit-insurance put option effect. To see this, let us first write down the bank's expected profit with a relationship loan when it faces a capital requirement of E and invests only in a positive-NPV project:[46]

$$\{qp+[1-q][1-p]\}\big\{[\alpha]\{\theta\mu q^A[L-1]+[1-\theta\mu+\theta\mu q^A][E]\}-\theta\mu\tau[1-E]\big\}-cp^2/2. \tag{23}$$

In equilibrium, this expected profit is zero. Now consider the bank's project investment decision with full deposit insurance and a zero capital requirement. In equilibrium, the regulator would want the bank to not invest if the bank (hence also the regulator) perceives the project to have negative NPV. We will show, however, that this equilibrium cannot occur without a capital requirement. Suppose the loan repayment obligation is $L>1$ in this conjectured equilibrium. In the state in which the signal is good but the bank's signal is uninformative, $\{\varphi=\varphi_G, \upsilon_b=U\}$, the project is perceived to have negative NPV by both the bank and the regulator, and should be rejected. However, since deposits are fully insured, depositors are always willing to provide funds with the deposit repayment being \$1. Thus, if the bank invests in this

with the bank, they will not provide financing, causing the deposit financing to be lower than \$1, which again prevents the bank from investing in the project and represents a perceived social welfare loss to the regulator.

[44]The assumption of homogeneous beliefs across depositors simplifies but is not necessary for this result: as long as disagreement exists between the bank/regulator and some depositors, there will be perceived social welfare loss with some probability.

[45]Note that in this setting with heterogeneous beliefs, providing deposit insurance does not represent a *perceived* cost to the regulator conditional on the borrower being authentic, since the regulator (like the bank) believes that when the authentic borrower invests in the project, it must be G (we will verify that this is true in equilibrium later) and depositors get full repayment. That is, deposit insurance is a promise that represents real protection for depositors against crooks *and* disagreement with the bank, and the only contingent liability it creates for the insurer is that the bank may unwittingly finance a crook. Consequently, complete deposit insurance is a better strategy for the regulator than partial deposit insurance that exposes the bank to a non-zero probability of not receiving deposit funding.

[46]Note that from the bank's perspective, conditional on screening yielding $s=s_a$, the net terminal payoff shared between the bank and investors is:

$$\underbrace{\Pr(\varphi=\varphi_G,\upsilon_b=I)[q^A]\{L-[1-E]\}}_{\text{project invested}}+\underbrace{[\Pr(\varphi=\varphi_B)+\Pr(\varphi=\varphi_G,\upsilon_b=U)][E]}_{\text{no project invested}}=\theta\mu q^A[L-1]+[1-\theta\mu+\theta\mu q^A][E].$$

Equation (23) is the bank's ex ante expected payoff prior to screening.

negative-NPV project, with probability θq^A the authentic borrower's project will pay off X and it will repay L to the bank, whereas with probability $1 - \theta q^A$ the project will pay off zero (either because the borrower is a crook with probability $1 - q^A$, or with probability $q^A[1 - \theta]$ the borrower is authentic but the project turns out to be bad), leaving the bank with nothing, and the repayment to depositors (\$1) in this state is covered by deposit insurance. The bank's expected profit from this investment is $\theta q^A[L - 1] > 0$. This breaks the conjectured equilibrium. That is, complete deposit insurance creates an asset-substitution moral hazard problem.

Capital Requirement with Relationship Loan: We now endogenize E, the regulatory capital requirement that resolves the asset-substitution moral hazard associated with the bank's overlending propensity in the presence of complete deposit insurance.[47] The time line here is as follows. The bank first screens the borrower and then decides whether to accept or reject the borrower for a loan. If the loan is given to the borrower, the bank raises E. After that, the bank receives the signal φ with precision υ_b, based on which the bank decides whether to accept or reject the project. If the project is rejected, the equity capital E is shared between the bank and those investors who provided E. If the project is accepted and the borrower is given a loan, then the bank proceeds to raise deposits and any surplus from the project is also shared between the bank and those investors who provided E.[48]

The intuition behind why a capital requirement attenuates asset-substitution moral hazard is as follows. Consider the bank's investment decision for a negative-NPV project in the face of capital requirement $E > 0$. If the bank rejects the project, E remains on the bank's balance sheet and the bank retains a share of that capital. If the bank invests in the project and it subsequently fails, the bank loses its share of E, and the expected cost of losing capital increases with both the amount of capital the bank is required to pledge against the loan and the default probability of the loan. Thus, a sufficiently high capital requirement deters the bank from investing in a negative-NPV project. Another way to see this is that the bank's *equilibrium* expected profit is always zero. Without a capital requirement, the bank's shareholders can earn a positive expected profit *out of equilibrium* by lending to the borrower that has a negative-NPV project. What a capital requirement of E does is that it makes the bank's expected profit from this out-of-equilibrium strategy negative. The bank's cost of raising equity capital from the market partially offsets this moral-hazard-attenuation benefit of capital, and introduces a tradeoff that determines the equilibrium bank capital requirement.[49] The following proposition endogenizes what was stated in Assumption 2.

Proposition 6. *The regulator provides full deposit insurance, and sets the bank's capital requirement* $E \in (0, 1)$,[50] *which is decreasing in the borrower's prior credit quality, q.*

[47] Overlending refers to the bank deliberately financing negative-NPV projects.

[48] This setting is more complex than the one in the basic model. In Section 3.1.2 when we analyze relation loan, once the bank accepts the borrower after its screening, E is raised and always invested. What is shared between the bank and those investors who provided E is thus the surplus from the project investment. That is, E is left idle on the balance sheet.

[49] Various other papers have shown how capital requirements facilitate prudential regulation by reducing the risk-taking propensity of the bank. See, for example, Merton (1977), Morrison and White (2005), and Repullo (2004).

[50] Its mathematical expression is in the Appendix.

The regulatory capital requirement is lower for higher-quality (higher q) borrower pools because the asset-substitution moral hazard is less severe for such borrowers. The reason is that higher borrower quality leads to a lower equilibrium loan repayment obligation and makes overlending less attractive for the bank, thereby ameliorating asset-substitution moral hazard.

This result provides a new rationale for deposit insurance and bank capital regulation in the context of heterogeneous agents. In our model, deposit insurance arises endogenously to eliminate a perceived social welfare loss from the standpoint of the bank regulator. A bank capital requirement then emerges as an endogenous response to the asset-substitution moral hazard induced by deposit insurance. What is familiar about this rationale is that deposit insurance does indeed seek to protect depositors as in the usual justification, but this protection is motivated by the regulator's desire to ensure a dependable supply of deposits for the bank and to preclude underinvestment in real projects due to divergent beliefs, rather than to prevent bank runs due to coordination failures. We do *not* view this as a competing explanation for deposit insurance, but rather as a complement to existing theories. It is somewhat similar to the rationale in Morrison and White (2006) who show that, even without coordination failures, deposit insurance enhances welfare when adverse selection is sufficiently severe.

Securitization: The analysis now also clarifies why no capital requirement is needed with securitization. In the state in which the signal is good but the bank's signal is uninformative, $\{\varphi = \varphi_G, \upsilon_b = U\}$, the project has negative NPV. Unlike the relationship loan case, however, the bank will be unable to securitize the loan because investors will not purchase any claims against it. Thus, there is no asset-substitution moral hazard.

6 Empirical Predictions and Governance and Regulation Implications

In this section, we first discuss the empirical predictions of our analysis, including those that have empirical support as well as those that remain to be tested, and then examine the governance and regulation implications of the analysis.

6.1 Empirical Predictions

1. Our analysis implies that riskier firms prefer bank financing, while safer firms tap capital markets (see Proposition 1). This is consistent with the existing literature (e.g., Bolton and Freixas (2000), and Petersen and Rajan (1995)).

2. Recent empirical evidence on cross-country differences in economic performance based on financial system architecture (i.e., the degree of bank orientation versus market orientation) indicates that economic performance seems unaffected by financial system architecture (e.g., Beck and Levine (2002), and Levine (2002)). These findings cast doubt on the usefulness of the "banks *versus* markets" debate, and suggest that it is the *overall* "ability of the financial system to ameliorate information and

transaction costs," not "whether banks or markets provide these services" (Beck and Levine (2002)), that is of first-order importance. This view of financial system architecture is consistent with the analysis in this paper. That is, since banks and markets co-evolve, a financial system with strength in one sector will also display strength in the other (see Propositions 2, 3 and 4). Thus, financial system classification as either bank-dominated or market-dominated based on banking scope permitted by regulators will not necessarily generate differences in economic performance across different classifications.

3. A third implication of our analysis is that as the capital market develops, banks start to lend to riskier borrowers, thereby expanding lending scope within a given financial system (see Proposition 3). Hence, economies with better-developed capital markets should have banks that lend to riskier and smaller firms. That is, capital market development opens up previously inaccessible markets for banks. We are not aware of any existing empirical evidence on this prediction, but believe it is testable.

4. Securitization and bank equity capital play key roles in generating a co-evolution loop in our analysis. Without these elements, we get pure competition between banks and markets (see Corollaries 1 and 2). Thus, our analysis implies that competition was more characteristic of the interaction between banks and the capital market prior to the advent of securitization, whereas complementarity describes this interaction more effectively now. Moreover, there are many countries in which securitization is either virtually non-existent or in its infancy. One should expect competition to dominate the interaction between banks and markets in these countries. This prediction too remains to be tested.

5. The role played by banks will be diminished if non-bank financial intermediaries such as credit rating agencies develop the screening technology needed for certification of borrower credit quality (see the discussion following Corollary 1). Thus, our analysis suggests that in economies where credit rating agencies play a bigger role, the impact of bank evolution on capital market evolution (via securitization) should be weaker. This prediction awaits testing as well.

6. The valuation discount experienced by borrowers will decline and assets will rise in market value as the capital market evolves (see Proposition 5). The co-evolution of banks and markets means that this benefit will also be experienced as banks evolve.

6.2 Governance and Regulation Implications

Our analysis raises some issues that deserve further discussion within the context of bank governance and regulation. The first issue is the relationship between capital market evolution and bank governance and regulation. Capital market evolution leads banks to lend to riskier borrowers, and causes banks to enter previously-untapped markets. This change in the bank's asset portfolio may significantly alter the bank's payoff distribution, which suggests that the way the board of directors judges the bank's CEO may have to change since the board's payoff-dependent inferences about the CEO's ability should adapt to changes in the bank's asset payoff distribution. Moreover, as the bank's payoff distribution is altered, so might the incentives of the bank's CEO to share information with the board, thereby affecting how corporate governance functions (see, for example, Adams and Ferreira (2007), and Song and Thakor (2006)).

Bank regulation may also be affected by capital market evolution. One implication of our analysis is that, as the capital market evolves, the prospect of raising bank capital requirements to deal with riskier lending should be less unattractive to regulators since the cost of bank equity capital decreases with capital market development. Moreover, our analysis shows that capital market development induces banks to lend to riskier borrowers. So, to the extent that the determination of bank capital requirements is influenced by asset portfolio risk as well as the cost of bank equity capital, an implication of our analysis is that capital requirements ought to be dependent on the evolution of the banking sector itself. This seems to militate against the adoption of uniform capital requirements across countries with different levels of development of banks and capital markets.

7 Conclusion

We have developed the thesis that banks and capital markets exhibit three forms of interaction: competition, complementarity, and co-evolution. The key conditions for this three-dimensional interaction are securitization and bank capital requirements. Securitization creates a vehicle by which bank evolution is good for markets since the improved bank screening that accompanies bank evolution enhances the credit quality of borrowers going to the capital market via securitization, thereby increasing capital market investor participation. And bank capital generates a mechanism by which the evolution of markets is good for banks since such evolution reduces the cost of bank equity capital, incenting banks to hold more capital, thereby diminishing the rationing of potentially creditworthy relationship borrowers and increasing bank lending scope. Besides providing a sharp departure from the existing theoretical notion of banks and markets as competitors for a *fixed* pool of firms seeking financing, our analysis also generates a number of testable predictions. A key insight of our analysis is that when banks and markets evolve, one *cannot* think of the pool of borrowers as static; this pool endogenously evolves as well. This has implications for bank governance and regulation.

Further research could go in various directions. One would be to empirically test the various new predictions of our analysis. Another would be to formally introduce non-bank financial intermediaries like credit rating agencies and examine the evolution of financial system architecture in a setting with richer institutional detail.

Appendix

Define

- $y(x) \equiv \frac{\lambda(x)}{\lambda'(x)} - x$, and denote y^{-1} as the inverse function of y;[51]
- $\bar{x} \equiv \frac{pk_1}{pk_1+[1-p][1-k_1]}$, with k_1 being defined such that $1 + Z = \frac{1+[1-k_1][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}}{[1-k_1]\bar{\omega}}\right)}{k_1\lambda\left(y^{-1}\left(\frac{\bar{N}}{[1-k_1]\bar{\omega}}\right)\right)}$;
- k_2, such that $\frac{1+[1-k_2][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}}{[1-k_2]\bar{\omega}}\right)}{k_2\lambda\left(y^{-1}\left(\frac{\bar{N}}{[1-k_2]\bar{\omega}}\right)\right)} = H - Z/p$.

Parametric Restriction 1.

$$Z < \bar{Z} \equiv p\left[X - \frac{1+[1-\bar{x}][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}}{[1-\bar{x}]\bar{\omega}}\right)}{\bar{x}\lambda\left(y^{-1}\left(\frac{\bar{N}}{[1-\bar{x}]\bar{\omega}}\right)\right)}\right]. \tag{A1}$$

Parametric Restriction 2.

$$\tau \in (\underline{\tau}, \bar{\tau}), \tag{A2}$$

where

$$\underline{\tau} \equiv \frac{\bar{x}Z + p\left[\frac{1+[1-\bar{x}][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}}{[1-\bar{x}]\bar{\omega}}\right)}{\lambda\left(y^{-1}\left(\frac{\bar{N}}{[1-\bar{x}]\bar{\omega}}\right)\right)} - \frac{[1-\bar{x}][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}E}{[1-\bar{x}]\bar{\omega}}\right)+E}{\lambda\left(y^{-1}\left(\frac{\bar{N}E}{[1-\bar{x}]\bar{\omega}}\right)\right)}\right]}{p[1-E]} - \bar{x},$$

$$\bar{\tau} \equiv \frac{k_2X - \frac{[1-k_2][\bar{\omega}/\bar{N}]y^{-1}\left(\frac{\bar{N}E}{[1-k_2]\bar{\omega}}\right)+E}{\lambda\left(y^{-1}\left(\frac{\bar{N}E}{[1-k_2]\bar{\omega}}\right)\right)}}{1-E} - k_2.$$

Proof of Lemma 1: For direct market financing, it's clear that in equilibrium the borrower's repayment obligation with a non-intermediated debt is stipulated such that the expected payoff to the lending investor just equals 1, the financing provided: if the lender's participation constraint were not binding, the borrower would borrow from another investor charging a lower debt repayment. The same argument applies to securitized debt. Consider relationship lending. Note that financial intermediation here has a constant-returns-to-scale technology and each bank deals with only one borrower. Now, it is clear that the participation constraints for depositors and investors in the capital market (who provide equity capital to the bank) will be binding in equilibrium. If the bank were to obtain funds at rates that slackened these participation constraints, the borrower would be better off going to a bank that procured less expensive financing. Moreover, the bank loan repayment, L, will also be stipulated such that the bank's expected payoff just covers its cost (deposit gathering and screening): if this were not the case, the borrower would opt for another bank charging a lower interest rate (lower L). □

Proof of Lemma 2: With securitization, suppose the borrower's repayment obligation to the bank is R_{sec}, but the securitization trust passes only $\hat{R}_{\text{sec}} < R_{\text{sec}}$ to investors who purchase the securitized debt. That is, investors' recourse to the bank in the case of borrower default is $\delta\hat{R}_{\text{sec}}$. In equilibrium, R_{sec}, $\hat{R}_{\text{sec}}$ and δ are set such that it is incentive compatible for the bank to not securitize without screening (otherwise, securitization will not be viable), i.e., $q[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q][\delta\hat{R}_{\text{sec}}] - Z \leq 0$. Now, conditional on screening (after the cost $cp^2/2$ is incurred), if $s = s_c$ and the bank were to accept the borrower, its expected payoff would be $q^C[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q^C][\delta\hat{R}_{\text{sec}}] - Z - [cp^2/2]$, whereas if the bank rejects the borrower, the bank cannot recoup its screening cost and its payoff is simply $-cp^2/2$. Note that $q^C[R_{\text{sec}} - \hat{R}_{\text{sec}}] - [1-q^C][\delta\hat{R}_{\text{sec}}] - Z - [cp^2/2] < -cp^2/2$, since $q^C < q$. Thus, in equilibrium the bank will reject the borrower if screening yields $s = s_c$.

We now prove the case for relationship lending. We first claim that if there were no bank certification provided to the borrower in relationship lending, relationship loan would be strictly dominated by direct market financing. This is because: (i) the part of the loan raised from the capital market (E) involves the same cost as in direct market borrowing if there were no bank certification associated with relationship lending, and (ii) the other part of the loan raised from depositors ($1-E$) entails deposit-gathering cost. Thus, in order for relationship lending to be viable, it must be accompanied by bank certification. Similar to the case for securitization, the equilibrium loan repayment obligation (L) and the bank's share of project net payoff (α) in relationship lending are set such

[51] It is straightforward to check that $y' > 0$ and hence y is invertible.

that it is incentive compatible for the bank to not lend without screening, i.e., $\alpha q\{L-[1-E]\}-\tau[1-E]\leq 0$. Now, conditional on screening, if $s=s_c$ and the bank were to accept the borrower, its expected payoff would be $\alpha q^C\{L-[1-E]\}-\tau[1-E]-cp^2/2$, which is smaller than the payoff if the bank rejects the borrower, $-cp^2/2$, since $q^C<q$. These arguments prove the lemma. □

Proof of Lemma 3: Direct Market Financing: Substituting R_{dir} and ω into the borrower's objective function, we can rewrite the borrower's problem as:

$$\max_{\{N_{\text{dir}}\}} \pi_{\text{dir}} = X - \frac{1+[1-q][\bar{\omega}/\bar{N}][N_{\text{dir}}]}{q\lambda(N_{\text{dir}})}.$$

The equilibrium investor participation, N_{dir}, is given by the following first-order-condition (FOC):

$$\frac{\lambda(N_{\text{dir}})}{\lambda'(N_{\text{dir}})} - N_{\text{dir}} = \frac{\bar{N}}{[1-q]\bar{\omega}}. \tag{A3}$$

It is straightforward algebra to check that the second-order-condition (SOC) is satisfied. Note that the left-hand-side (LHS) of (A3) is increasing in N_{dir}: $\frac{\partial \text{LHS}}{\partial N_{\text{dir}}} = -\frac{\lambda(N_{\text{dir}})\lambda''(N_{\text{dir}})}{[\lambda'(N_{\text{dir}})]^2} > 0$ since $\lambda''(N_{\text{dir}})\lambda(N_{\text{dir}}) < 0$. The right-hand-side (RHS) of (A3) is increasing in q and $\bar{N}$. Thus, we have $\partial N_{\text{dir}}/\partial q > 0$ and $\partial N_{\text{dir}}/\partial \bar{N} > 0$. The equilibrium debt repayment obligation is:

$$R_{\text{dir}} = \frac{1+[1-q][\bar{\omega}/\bar{N}][N_{\text{dir}}]}{q\lambda(N_{\text{dir}})}, \tag{A4}$$

where N_{dir} is given by (A3). Using the Envelope Theorem, we have $\partial\pi_{\text{dir}}/\partial q = -\partial R_{\text{dir}}/\partial q > 0$, and $\partial\pi_{\text{dir}}/\partial\bar{N} = -\partial R_{\text{dir}}/\partial\bar{N} > 0$.

Securitization: Using straightforward algebra we can show from (8), (9) and (11) that:

$$R_{\text{sec}} = \hat{R}_{\text{sec}} + Z + \left[\frac{1-q}{q^A-q}\right]\left[\frac{cp^2/2}{qp+[1-q][1-p]}\right] = \frac{1+[1-q^A][\bar{\omega}/\bar{N}][N_{\text{sec}}]}{q^A\lambda(N_{\text{sec}})} + \frac{Z}{q^A} + \frac{cp}{2q}.$$

Thus, the borrower's optimization problem is equivalent to:

$$\min_{\{N_{\text{sec}}\}} \frac{1+[1-q^A][\bar{\omega}/\bar{N}][N_{\text{sec}}]}{q^A\lambda(N_{\text{sec}})}.$$

The equilibrium investor participation, N_{sec}, is given by the following FOC:

$$\frac{\lambda(N_{\text{sec}})}{\lambda'(N_{\text{sec}})} - N_{\text{sec}} = \frac{\bar{N}}{[1-q^A]\bar{\omega}}. \tag{A5}$$

It can be verified that the SOC is satisfied. It is clear that the LHS of (A5) is increasing in N_{sec}, and the RHS of (A5) is increasing in q, p and $\bar{N}$. Thus, we have $\partial N_{\text{sec}}/\partial q > 0$, $\partial N_{\text{sec}}/\partial p > 0$ and $\partial N_{\text{sec}}/\partial\bar{N} > 0$. Moreover, for each fixed q, the RHS of (A5) is greater than the RHS of (A3). Thus, we have $N_{\text{sec}} > N_{\text{dir}}$, $\forall q$. The proof of the comparative statics of π_{sec} with respect to q and $\bar{N}$ is similar to that for direct market financing by using the Envelope Theorem. Finally, note that $\pi_{\text{sec}} = -\frac{cp^2}{2q} + p\left[X - \frac{1+[1-q^A][\bar{\omega}/\bar{N}][N_{\text{sec}}]}{q^A\lambda(N_{\text{sec}})}\right] - [Z/q]\{qp+[1-q][1-p]\}$, which is concave in p. Thus, there exists a p that maximizes π_{sec}.

Relationship Loan: From the bank's and the marginal investor's participation constraints, we have:

$$L = [1-E]\left[1+\frac{\tau}{q^A}\right] + \frac{[1-q^A][\bar{\omega}/\bar{N}][N_{\text{loan}}]+E}{q^A\lambda(N_{\text{loan}})} + \frac{cp}{2q}. \tag{A6}$$

The bank's problem can be rewritten as:

$$\min_{\{N_{\text{loan}}\}} L.$$

The equilibrium investor participation, N_{loan}, is given by the following (FOC):

$$\frac{\lambda(N_{\text{loan}})}{\lambda'(N_{\text{loan}})} - N_{\text{loan}} = \left[\frac{E}{1-q^A}\right]\left[\frac{\bar{N}}{\bar{\omega}}\right]. \tag{A7}$$

Again, it can be verified that the SOC is satisfied. The LHS of (A7) is increasing in N_{loan}, and the RHS of (A7) is increasing in q, p and $\bar{N}$. Thus, we have $\partial N_{\text{loan}}/\partial q > 0$, $\partial N_{\text{loan}}/\partial p > 0$ and $\partial N_{\text{loan}}/\partial\bar{N} > 0$. The proof of the comparative statics of π_{loan} with respect to q and $\bar{N}$ is similar to that for direct market financing by using the

Envelop Theorem. Finally, the existence of a payoff-maximizing p follows from the same argument as in the case for securitization by observing that π_{loan} is concave in p. $\square$

Proof of Proposition 1: *Bank Lending Scope:* Note that $L \uparrow \infty$ as $q \downarrow 0$ (see (A6)). Thus, the existence of the low cutoff, q_l, is clear based on the discussion in the text. Note that q_l is determined as $\pi_{\text{loan}}|_{q=q_l} = 0$. Thus, $\partial q_l/\partial \bar{N} = -\frac{\partial \pi_{\text{loan}}/\partial \bar{N}}{\partial \pi_{\text{loan}}/\partial q} < 0$, since $\partial \pi_{\text{loan}}/\partial \bar{N} > 0$ and $\partial \pi_{\text{loan}}/\partial q > 0$ (see Lemma 3).

Financing Choice: We first examine the authentic borrower's choice of funding source, assuming that the crook chooses the same funding source as the authentic borrower with the same prior credit quality q; we will show later that this indeed is a universally divine sequential equilibrium.

First, we analyze the cutoff q_h. Define q_h such that $\pi_{\text{sec}}|_{q^A=1} = \pi_{\text{dir}}|_{q=q_h}$, i.e.,

$$X - 1 - Z = X - \frac{1 + [1 - q_h][\bar{\omega}/\bar{N}][N_{\text{dir}}]}{q_h \lambda(N_{\text{dir}})}, \tag{A8}$$

where N_{dir} is given by $y(N_{\text{dir}}) \equiv \frac{\lambda(N_{\text{dir}})}{\lambda'(N_{\text{dir}})} - N_{\text{dir}} = \frac{\bar{N}}{[1-q_h]\bar{\omega}}$. The parametric assumption that Z is not too large (see (A1)) guarantees that $\pi_{\text{sec}}|_{q=q_h} > 0$ and hence securitization is viable at $q = q_h$. It is clear that $\pi_{\text{dir}}|_{q=q_h} > \pi_{\text{sec}}|_{q=q_h}$. Note that (A8) is not a function of p. Thus, $\partial q_h/\partial p = 0$.

Next, we analyze the cutoff q_m. The existence of such a cutoff, based on the discussion in the text, can be guaranteed by the parametric assumption in (A2) that τ is neither too large nor too small. More specifically, the assumption that $\tau < \bar{\tau}$ guarantees that $\pi_{\text{sec}}|_{q=q_l} < \pi_{\text{loan}}|_{q=q_l} = 0$, and the assumption that $\tau > \underline{\tau}$ guarantees that $\pi_{\text{sec}}|_{q=q_h} > \pi_{\text{loan}}|_{q=q_h}$. Combining these with the fact that both π_{loan} and π_{sec} are increasing and concave functions of q establishes the existence of the cutoff, $q_m \in (q_l, q_h)$. To prove the comparative statics of q_m, note that q_m is determined by the following equation:

$$\pi_{\text{sec}}|_{q=q_m} - \pi_{\text{loan}}|_{q=q_m} = 0. \tag{A9}$$

We have:

$$\frac{\partial q_m}{\partial \tau} = \frac{\partial \pi_{\text{loan}}/\partial \tau}{\partial \pi_{\text{sec}}/\partial q - \partial \pi_{\text{loan}}/\partial q} < 0,$$

since a higher τ only decreases π_{loan} but not π_{sec}, thereby making securitization a better funding choice than relationship borrowing for the authentic borrower (i.e., q_m decreases). Since $\partial \pi_{\text{loan}}/\partial \tau < 0$, we must have $\partial \pi_{\text{sec}}/\partial q - \partial \pi_{\text{loan}}/\partial q > 0$, $\forall q$. Then, we have:

$$\frac{\partial q_m}{\partial p} = -\frac{\partial \pi_{\text{sec}}/\partial p - \partial \pi_{\text{loan}}/\partial p}{\partial \pi_{\text{sec}}/\partial q - \partial \pi_{\text{loan}}/\partial q} \propto \partial \pi_{\text{loan}}/\partial p - \partial \pi_{\text{sec}}/\partial p < 0,$$

where the last inequality can be proved as follows. Note that:

$$\partial \pi_{\text{sec}}/\partial q - \partial \pi_{\text{loan}}/\partial q = \left[\partial \pi_{\text{sec}}/\partial q^A - \partial \pi_{\text{loan}}/\partial q^A\right]\left[\partial q^A/\partial q\right] > 0.$$

Thus, it must be true that $\partial \pi_{\text{sec}}/\partial q^A - \partial \pi_{\text{loan}}/\partial q^A > 0$, since $\partial q^A/\partial q > 0$. We have:

$$\partial \pi_{\text{loan}}/\partial p - \partial \pi_{\text{sec}}/\partial p = \left[\partial \pi_{\text{loan}}/\partial q^A - \partial \pi_{\text{sec}}/\partial q^A\right]\left[\partial q^A/\partial p\right] < 0,$$

since $\partial q^A/\partial p > 0$.

We now show that it is a universally divine sequential equilibrium (Banks and Sobel (1987)) that the crook will choose the same funding source as the authentic borrower with the same prior credit quality. We begin by noting that it is transparent that the equilibrium is sequential (Kreps and Wilson (1982)). Next, consider the choice between securitization and direct market financing. For $q \in [q_m, q_h)$, the expected payoff from securitization to an authentic borrower is π_{sec}, and the expected payoff from securitization to a crook is $1-p$. Consider a defection to direct capital market borrowing. Define $\mathbb{N}_d(a|\text{direct market financing})$ as the set of investors who must participate in the capital market with direct financing to make it strictly optimal for the authentic borrower to defect from securitization. Let $\mathbb{N}_d^o(a|\text{direct market financing})$ be the set of investors who must participate in the capital market with direct financing to leave the authentic borrower indifferent between direct market financing and securitization. Define N_{da}^o as:

$$\pi_{\text{sec}} = \pi_{\text{dir}}|_{N=N_{da}^o},$$

and hence

$$\mathbb{N}_d^o(a|\text{direct market financing}) = \{N_{da}^o\},$$

and

$$\mathbb{N}_d(a|\text{direct market financing}) = \{N | N > N_{da}^o\}.$$

Note that a crook's expected payoff from direct market financing is 1, which is strictly greater than $1-p$. A crook only cares about the likelihood that it will get funded but not the credit terms (since it knows it will never repay the loan). Hence, if we define $\mathbb{N}_d(c|\text{direct market financing})$ and $\mathbb{N}_d^o(c|\text{direct market financing})$ as the strict-defection and indifference sets for the crook, we have:

$$\mathbb{N}_d^o(c|\text{direct market financing}) = \phi,$$

and

$$\mathbb{N}_d(c|\text{direct market financing}) = \{N|N>0\}.$$

This means

$$\mathbb{N}_d^o(a|\text{direct market financing}) \cup \mathbb{N}_d(a|\text{direct market financing}) \subset \mathbb{N}_d(c|\text{direct market financing}).$$

Thus, by universal divinity, investors must believe that

$$\Pr(\text{defector is crook}|\text{defection from securitization to direct market financing}) = 1.$$

Given this belief, the authentic borrower nor the crook has an incentive to defect from securitization to direct market financing, and hence this equilibrium is universally divine.

Now, consider a defection from direct market financing to securitization for borrowers with $q \in [q_h, 1)$. Note that a crook is strictly worse off from that defection relative to not defecting since $1-p<1$. An authentic borrower is also strictly worse off by defecting since π_{dir} is greater than the highest possible payoff from securitization; note that $\pi_{\text{dir}} > \pi_{\text{sec}}|_{q^A=1} = X-1-Z, \forall q \in [q_h, 1)$. Thus, neither an authentic borrower nor a crook wants to defect. The other cases can be proved in a similar way. □

Proof of Lemma 4: First, note that for each given p, Bertrand competition at $t=0$ ensures that all surplus at $t=0$ goes to the borrower regardless of its financing choice. Thus, a borrower's expected payoff at $t=-1$ (before it knows q) for each given p is given by $\int_{q_l}^{q_m} \pi_{\text{loan}} dq + \int_{q_m}^{q_h} \pi_{\text{sec}} dq + \int_{q_h}^{1} \pi_{\text{dir}} dq$. Denote the value of p that maximizes that payoff as p^*. Second, if a bank does not choose $p=p^*$ at $t=-1$, then it cannot attract any borrower at that time. Thus, in equilibrium every bank will choose $p=p^*$. □

Proof of Proposition 2: We know from the proof of Lemma 3 (see (A6)) that $\partial L/\partial c > 0$. Hence, we have $\partial \pi_{\text{loan}}/\partial c < 0$, and consequently $\partial q_l/\partial c > 0$. That is, bank evolution (lower c) causes the bank to expand its lending scope from below (q_l decreases). This proves (i). To show (ii) and (iii), first note that the bank's optimal choice of p at $t=-1$ increases as c decreases. Then, the claim in (ii) follows directly from the result that $\partial q_m/\partial p < 0$ and $\partial q_h/\partial p = 0$ (see Proposition 1), and the claim in (iii) follows directly from the result in Lemma 3 that $\partial N_{\text{loan}}/\partial p > 0$ and $\partial N_{\text{sec}}/\partial p > 0$. □

Proof of Corollary 1: If there is no securitization, the claim that bank evolution causes the capital market to lose borrowers to the bank can be proved by observing that a lower c due to bank evolution increases the borrower's expected payoff from relationship borrowing π_{loan}, but not from direct capital financing π_{dir} (note that $\partial \pi_{\text{dir}}/\partial c = 0$). The claim that bank evolution expands the bank's lending scope from below can be established in the same way as in Proposition 2. □

Proof of Proposition 3: Denote $p^* \in \text{argmax} \left[\int_{q_l}^{q_m} \pi_{\text{loan}} dq + \int_{q_m}^{q_h} \pi_{\text{sec}} dq + \int_{q_h}^{1} \pi_{\text{dir}} dq \right]$. Note that: (i) when $\bar{N}$ increases, π_{loan} increases, and hence q_l decreases (see Proposition 1), (ii) $\partial \pi_{\text{loan}}/\partial p = [\partial \pi_{\text{loan}}/\partial q^A][\partial q^A/\partial p]$. Note that $\partial \pi_{\text{loan}}/\partial q^A$ and $\partial q^A/\partial p$ are decreasing in q. This implies that $\partial \pi_{\text{loan}}/\partial p$ is decreasing in q. Combining (i) and (ii) yields p^* being increasing in $\bar{N}$. □

Proof of Corollary 2: If the bank's equity capital and its cost are exogenously fixed, then capital market evolution (larger $\bar{N}$) has no effect on the bank's rasing of equity capital from the market. Thus, π_{loan}, and hence q_l, will not change with respect to capital market evolution. Also, note that $\partial \pi_{\text{sec}}/\partial \bar{N} > 0$ (see Lemma 3). This will lead to $\partial q_m/\partial \bar{N} < 0$, causing the bank to lose some borrowers to the market. □

Proof of Proposition 4: This comes from combining the results in Propositions 2 and 3. □

Proof of Lemma 5: It is clear that the distribution function of $\bar{\rho}$, denoted as $F(\bar{\rho}, N)$, can be written as $F(\bar{\rho}, N) = \Pr(\bar{\rho} \le \rho) = \Pr(\rho_1 \le \rho, \ldots, \rho_N \le \rho) = \prod_{i=1}^{N} \Pr(\rho_i \le \rho) = F(\rho)^N$. Since $F(\rho) \in [0,1]$, it is clear that for any two values of N, say N_1 and N_2 with $N_1 < N_2$, $F(\bar{\rho}, N_2)$ first-order stochastic dominates $F(\bar{\rho}, N_1)$. This implies that ρ_M is increasing in N, and hence proves the lemma. □

Proof of Proposition 5: Consider direct capital market financing. When the state $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = I\}$ occurs, i.e., both the borrower and investors perceive the project to be G, the debt repayment is R_{dir} as valued by both the borrower and investors. However, when the state $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = U\}$ occurs, the borrower perceives the project to be G whereas investors perceive it to be G with probability θ and B with probability $1-\theta$. In this state, the debt repayment is R_{dir} as valued by the borrower, but is only θR_{dir} as valued by investors. Thus,

$$\frac{\text{Investors' valuation of expected debt repayment}}{\text{Borrower's valuation of expected debt repayment}} = \frac{\{\rho_M + [1-\rho_M]\theta\}[R_{\text{dir}}]}{R_{\text{dir}}} = \rho_M + [1-\rho_M]\theta, \tag{A10}$$

where

$$\rho_M = N\int_0^1 F(x)^{N-1} f(x) x dx = N\int_0^1 x^{N-1} x dx = \frac{N}{1+N}. \tag{A11}$$

Thus,

$$\frac{\text{Investors' valuation of expected debt repayment}}{\text{Borrower's valuation of expected debt repayment}} \equiv \lambda(N) = \frac{\theta+N}{1+N} \in (0,1). \tag{A12}$$

The cases for securitization and bank equity can be proved in a similar way. It is clear that $\lambda'(\cdot) > 0$ and $\lambda''(\cdot) < 0$, which is consistent with Assumption 1. ☐

Proof of Proposition 6: Consider any borrower with prior quality q taking a relationship loan. Suppose the bank's asset-substitution moral hazard problem has been resolved, i.e., the bank only invests when $\{\varphi = \varphi_G, \upsilon_b = I\}$. From the bank's perspectives, conditional on screening yielding $s = s_a$, the net terminal payoff shared between the bank and investors is:[52]

$$\Pr(\varphi=\varphi_G, \upsilon_b = I)[q^A]\{L - [1-E]\} + [\Pr(\varphi=\varphi_B) + \Pr(\varphi=\varphi_G, \upsilon_b=U)][E] = \theta\mu q^A[L-1] + [1-\theta\mu+\theta\mu q^A][E].$$

The bank's share of the net terminal payoff, α, in equilibrium must be such that the bank's participation constraint is binding:[53]

$$\{qp+[1-q][1-p]\}[\alpha]\{\theta\mu q^A[L-1] + [1-\theta\mu+\theta\mu q^A][E]\} - \{qp+[1-q][1-p]\}\theta\mu\tau[1-E] - cp^2/2 = 0,$$

which yields:

$$\alpha = \frac{\theta\mu\tau[1-E] + \frac{cp^2/2}{qp+[1-q][1-p]}}{\theta\mu q^A[L-1] + [1-\theta\mu+\theta\mu q^A][E]}, \tag{A13}$$

$$L = 1 + \frac{\theta\mu\tau + \frac{cp^2/2}{qp+[1-q][1-p]} - [\theta\mu\tau + \alpha - \alpha\theta\mu + \alpha\theta\mu q^A][E]}{\alpha\theta\mu q^A}. \tag{A14}$$

If the bank invests in the negative-NPV project when the signal is good but uninformative, conditional on the borrower being authentic, with probability θ the authentic borrower is able to repay L and the net terminal payoff is $\{L-[1-E]\}$, and with probability $1-\theta$ the project turns out to be bad. Thus, the bank's expected payoff from investing in this negative-NPV project is $\alpha\theta q^A\{L-[1-E]\} = \frac{\theta\mu\tau + \frac{cp^2/2}{qp+[1-q][1-p]} - [\theta\mu\tau+\alpha-\alpha\theta\mu][E]}{\mu}$. To resolve the bank's asset-substitution moral hazard problem, the regulator needs to set the bank's capital requirement high enough so that its expected payoff from investing in the negative-NPV project is no more than its expected payoff from rejecting it, which is αE, i.e., $\frac{\theta\mu\tau + \frac{cp^2/2}{qp+[1-q][1-p]} - [\theta\mu\tau+\alpha-\alpha\theta\mu][E]}{\mu} \leq \alpha E$. This leads to:

$$E \geq \frac{\theta\mu\tau + \frac{cp^2/2}{qp+[1-q][1-p]}}{\theta\mu\tau + \alpha[1+\mu-\theta\mu]}. \tag{A15}$$

Substituting (A13) into (A15) and treating (A15) as an equality yields:[54]

$$E = \frac{[\theta q^A][L-1]}{1-\theta q^A}. \tag{A16}$$

[52]Note that: (i) $\{L-[1-E]\}$ is the terminal payoff when the bank perceives the project to be worth funding, i.e., $\{\varphi=\varphi_G, \upsilon_b = I\}$, and makes a deposit repayment of $1-E$ after receiving L from the authentic borrower; and (ii) when the bank does not invest, either because the signal is bad, i.e., $\{\varphi=\varphi_B\}$, or the signal is good but uninformative, i.e., $\{\varphi=\varphi_G, \upsilon_b=U\}$, the equity capital raised at $t=0$ is left intact and the terminal payoff is E.

[53]This is the bank's ex ante participation constraint before screening, where $\Pr(s=s_a) = qp+[1-q][1-p]$ is the probability that the bank accepts the borrower.

[54]The other solution is $E=1$, which is dominated by the solution in (A16) because of the cost of raising bank capital. Also, note that although the capital requirement in (A16) is designed to solve the bank's asset-substitution moral hazard problem in the state $\{\varphi=\varphi_G, \upsilon_b=U\}$, it automatically solves the bank's asset-substitution moral hazard problem in the state $\{\varphi=\varphi_B\}$ as well, since the bank perceives that $\Pr(G|\varphi=\varphi_B) \leq \Pr(G|\varphi=\varphi_G, \upsilon_b=U)$ and hence its project-investment distortion is less severe in the state $\{\varphi=\varphi_B\}$ than in the state $\{\varphi=\varphi_G, \upsilon_b=U\}$.

We shall now determine the equilibrium loan repayment obligation L. From the investors' perspective, the net terminal payoff to be shared with the bank is:[55]

$$
\begin{aligned}
& q^A \left[\begin{array}{l} \Pr(\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = I)\{L - [1-E]\} \\ + \Pr(\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = U)\theta\{L - [1-E]\} \end{array} \right] + [\Pr(\varphi = \varphi_B) + \Pr(\varphi = \varphi_G, \upsilon_b = U)][E], \\
& = \theta\mu q^A \{\rho_M + [1-\rho_M]\theta\}[L-1] + \{1 - \theta\mu + \theta\mu q^A\{\rho_M + [1-\rho_M]\theta\}\}[E].
\end{aligned}
$$

The ownership sharing, α, is determined such that the participation constraint for the marginal investor is binding in equilibrium, i.e.,

$$
[1-\alpha] \left[\begin{array}{l} \theta\mu q^A\{\rho_M + [1-\rho_M]\theta\}[L-1] \\ + \{1 - \theta\mu + \theta\mu q^A\{\rho_M + [1-\rho_M]\theta\}\}[E] \end{array} \right] - [1-q^A]\omega = E. \tag{A17}
$$

where $\omega = [\bar{\omega}/\bar{N}][N_{\text{loan}}]$. Combining (A13) and (A17), and substituting E with (A16), we have:

$$
L = 1 + \left[\frac{1-\theta q^A}{\theta q^A}\right] \left[\frac{\frac{\theta\mu\tau}{1+\mu-\theta\mu} + \frac{[1-q^A][\bar{\omega}/\bar{N}][N_{\text{loan}}]}{1+\rho_M[1-\theta]\mu}}{\frac{\theta\mu\tau}{1+\mu-\theta\mu} + \frac{\rho_M[1-\theta]\mu}{1+\rho_M[1-\theta]\mu}} \right]. \tag{A18}
$$

Substituting (A18) into (A16) yields the regulatory capital requirement:

$$
E = \frac{\frac{\theta\mu\tau}{1+\mu-\theta\mu} + \frac{[1-q^A][\bar{\omega}/\bar{N}][N_{\text{loan}}]}{1+\rho_M[1-\theta]\mu}}{\frac{\theta\mu\tau}{1+\mu-\theta\mu} + \frac{\rho_M[1-\theta]\mu}{1+\rho_M[1-\theta]\mu}}. \tag{A19}
$$

Note that the equilibrium capital market agreement parameter when there are N_{loan} investors participating in the capital market is given by (see the proof of Proposition 5):

$$
\rho_M = \frac{N_{\text{loan}}}{1+N_{\text{loan}}}. \tag{A20}
$$

Substituting (A20) into (A18) and (A19) yields:

$$
\begin{aligned}
L &= 1 + \left[\frac{1-\theta q^A}{\theta q^A}\right] \left[\frac{\Delta_3}{\Delta_1}\right] \left[\frac{N_{\text{loan}}^2 + \Delta_2 N_{\text{loan}} + \Delta_1}{N_{\text{loan}} + \Delta_3}\right], && \text{(A21)} \\
E &= \left[\frac{\Delta_3}{\Delta_1}\right] \left[\frac{N_{\text{loan}}^2 + \Delta_2 N_{\text{loan}} + \Delta_1}{N_{\text{loan}} + \Delta_3}\right], && \text{(A22)}
\end{aligned}
$$

where

$$
\begin{aligned}
\Delta_1 &\equiv \frac{\theta\mu\tau\bar{N}}{\bar{\omega}[1-q^A][1+\mu-\theta\mu]}, \\
\Delta_2 &\equiv 1 + \frac{\theta\mu\tau[1+[1-\theta]\mu]\bar{N}}{\bar{\omega}[1-q^A][1+\mu-\theta\mu]}, \\
\Delta_3 &\equiv \frac{\theta\tau}{[1+\mu-\theta\mu][1-\theta+\theta\tau]}.
\end{aligned}
$$

What remains to be determined is the equilibrium investor participation N_{loan} for relationship lending. The bank chooses L to maximize the authentic borrower's payoff from relationship borrowing, by minimizing L, given by (A21). It is easy to show that L is a convex function of N_{loan}. Thus, the first-order-condition (FOC) for optimality yields the solution for N_{loan} given by:

$$
N_{\text{loan}} = \sqrt{\Delta_1 - \Delta_2\Delta_3 + \Delta_3^2} - \Delta_3. \tag{A23}
$$

Substituting (A23) into (A22) gives E. The claim that $\partial E/\partial q < 0$ can be proved using the Envelope Theorem.[56] □

[55]First, investors perceive the net terminal payoff to be $\{L - [1-E]\}$ when they agree with the bank that the authentic borrower's project is worth funding, i.e., $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = I\}$. Second, when the bank thinks the project is worth funding but investors disagree, i.e., $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = U\}$, the investment decision rests entirely with the bank, so investors perceive that with probability θ the authentic borrower is able to repay L, and the net terminal payoff is $\{L - [1-E]\}$, and with probability $1-\theta$ the authentic borrower's project defaults and nothing is left to share. Third, when the bank does not invest, i.e., $\{\varphi = \varphi_B\}$ and $\{\varphi = \varphi_G, \upsilon_b = U\}$, the equity capital raised is left intact and the net terminal payoff is E.

[56]Note that the relationship between L and E is given by (A16) and hence the bank's problem of minimizing L is equivalent to minimizing E.

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Figure 1: **Sequence of Events**

$t=0$

- The regulator sets the deposit insurance and capital requirement for the bank.
- Borrower's type (i.e., whether it is authentic or a crook) is realized and revealed only privately to the borrower. Each borrower has a project that needs a \$1 investment at $t=1$.
- Each borrower decides whether to raise funds via direct (non-intermediated) capital market financing, securitization, or a relationship loan from a bank.
- If the borrower decides on securitization, the bank first screens the borrower. The bank then agrees to attempt to raise funds from the market at $t=1$ if it accepts the borrower based on the screening outcome. The securitization is with limited recourse to the originating bank, so the bank owes investors a fraction δ of the promised repayment if the borrower defaults.
- If the borrower decides on relationship borrowing, the bank first screens the borrower, and then decides whether to accept or reject the borrower based on the screening outcome.

$t=1$

- If the borrower raises funds from the capital market directly, investor participation in the borrower's debt security in the capital market and the equilibrium debt repayment obligation for direct, non-intermediated capital market financing are then endogenously determined.
- If the borrower chose securitization and was affirmatively screened by the bank at $t=0$, the bank seeks funding for the borrower. Investor participation in the borrower's securitized debt in the capital market and the equilibrium debt repayment obligation for securitization are then endogenously determined.
- If the borrower chose a relationship loan and was affirmatively screened at $t=0$, then the bank approaches the capital market to raise equity to meet the capital requirement E against the loan. Equilibrium loan repayment obligation, investor participation in the bank's equity in the capital market and the bank's cost of equity capital are all then endogenously determined. The bank then borrows $1-E$ from depositors.

$t=2$

- The borrower's type becomes public information. If the borrower is authentic, the project cash flow is realized and distributed among the agents according to the stipulated contract terms.
- If the borrower turns out to be a crook, financiers are left with nothing.

Figure 2: **A Graph of Financial System Architecture: Different Sources of Financing**
π_{loan}, π_{sec} and π_{dir} are the expected payoffs for the authentic borrower with prior credit quality q from relationship borrowing, securitization and non-intermediated, direct capital market financing, respectively. The cutoff q_l defines the bank's lending scope, q_m is the cutoff between relationship borrowing and securitization, and q_h is the cutoff between securitization and non-intermediated, direct capital market financing.