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FINANCIAL SYSTEM ARCHITECTURE AND THE CO-EVOLUTION OF BANKS AND CAPITAL MARKETS*

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We examine financial system architecture evolution and show that banks and markets exhibit three forms of interaction: competition, complementarity and co-evolution. Co-evolution is generated by two elements missing in previous analyses: securitisation and bank equity capital. As banks evolve via improvements in credit screening, they securitise higher quality credits. This encourages greater investor participation and spurs capital market evolution. And, if capital market evolution is spurred by greater investor participation, banks find it cheaper to raise equity capital to satisfy endogenously arising risk-sensitive capital requirements. Bank evolution is thus stimulated as banks consequently serve previously unserved high-risk borrowers. Numerous additional results are obtained.

A fundamental question in comparative financial systems, with implications for aggregate credit extension and real-sector growth, concerns the most efficient way to transfer capital from savers to investors. Should the emphasis be on markets or on banks?[1] 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 financial system evolution 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 its impact on the real sector. There are many open questions. How do borrower credit attributes affect the borrower's financing source choice 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 banks or markets) always at the expense of the other? In particular, how does the development of each sector affect the development of the other? Our objective is to address these questions.

The key theoretical findings in the literature are as follows. First, market-based financial systems behave differently from bank-based systems. 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

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[1] Financial systems are typically classified as bank-based or market-based, based on the share of banks and other intermediaries in total financing. A common example of a bank-based system is Germany and typifying a market-based system is the US. 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.

are better at committing not to refinance unprofitable projects (Dewatripont and Maskin 1995) and markets may also provide managers valuable information through the feedback effect of prices (Boot and Thakor, 1997*a*; Subrahmanyam and Titman, 1999). Bilateral financing, common in bank-based systems, is better at protecting borrower proprietary information and at providing R&D incentives than the multilateral financing of market-based systems (Bhattacharya and Chiesa, 1995; Yosha, 1995). Market-based systems create stronger financial innovation incentives (Boot and Thakor, 1997*b*), and are better at funding projects subject to diversity of opinion (Allen and Gale, 1999) but bank-based systems resolve asset-substitution moral hazard more effectively (Boot and Thakor, 1997*a*). Second, with some exceptions, the dominant view is that banks and markets *compete*, implying that each develops at the expense of the other (Allen and Gale, 1997, 1999; Boot and Thakor, 1997*a*; Dewatripont and Maskin, 1995), an observation that seems buttressed by anecdotes such as the shrinkage of US depository institutions in the 1980s when (market-based) mutual funds emerged.[3]

The result that banks and markets compete has powerful policy implications but lacks strong empirical support.[4] Demirgüç-Kunt and Maksimovic (1996) find that stock market development engenders higher debt–equity ratios and thus generates more business for banks in developing countries. Sylla (1998) describes the complementarity between banks and capital markets in fostering the growth of the US economy from 1790 to 1840 and makes a strong case for studying banks–markets complementarity.

We study how banks and markets affect each other and thus how financial system architecture affects which borrowers are financed and by which source. In our model, the borrower chooses its financing source from the following menu:

(*i*) direct capital market financing;
(*ii*) securitisation in which the bank screens and certifies its creditworthiness first and then obtains capital market financing; and
(*iii*) a relationship loan from the bank.

Two frictions 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 means 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 finance, which include costs related to the fact that those seeking financing and those providing financing may value the project surplus differently, leading to a higher-than-first-best financing cost. We show that banks are

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

[4] In addition to the empirical studies, we can also see that the evolution of banks and capital markets in the US, UK, 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 *et al.*, 2000). In all four countries, one observes *Bank Credit*, *Stock Market Size* and *Bond Market Size* growing together in most periods.

better at diminishing the certification friction, whereas banks and markets differ in 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 in either bank or market finance lead to borrowers shifting towards one source of financing and away from the other. This is the standard result in the literature that banks and markets compete.

Two ingredients in our analysis enable us to go beyond this standard result and generate new results: securitisation and bank capital. With securitisation, the bank certifies and the capital market finances, so each sector of the financial system operates where it is best. Moreover, securitisation 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 help to reduce 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 complement each other.

Bank capital connects banks and markets in a different way. Capital market development reduces the bank's financing friction 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 the bank may have previously eschewed. Thus, it is through bank capital that capital market advances that diminish the financing friction end up being transmitted to banks, permitting banks to resolve the certification friction more effectively for some borrowers and expand their 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 banks–markets complementarity, our analysis also yields results that speak to the questions raised earlier. First, borrowers with high creditworthiness opt for direct capital market financing; borrowers with intermediate creditworthiness raise funds via bank securitisation; borrowers with low creditworthiness take relationship loans and borrowers with extremely low creditworthiness get no credit.[5] Second, bank evolution – due to an improvement in the bank's screening/certification technology – expands from below both the bank's relationship lending scope and its securitisation scope, in that the bank now lends to (previously unserved) riskier borrowers and also securitises riskier borrowers that were not securitised before. The expansion from below of the bank's securitisation scope leads to capital market evolution by enhancing investor participation. Third, capital market evolution expands the bank's lending scope from below 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.

We derive these results in a fairly general setting but take the cost of market financing, deposit insurance and capital requirements for banks as well as the costs associated with these requirements as exogenous. After deriving our main results, we endogenise these elements.

[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 securitisation.

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 article 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 one grows at the expense of the other (Allen and Gale, 1997, 1999; Bhattacharya and Chiesa, 1995; Boot and Thakor, 1997*a*; Dewatripont and Maskin, 1995). Our analysis clarifies that banks and markets have different comparative advantages and that they compete only when they are viewed in isolation – with no instruments that permit specialisation in their respective advantages – *not* when they interact. Securitisation is one interaction vehicle, creating a benefit flow from banks to markets. Bank capital is another, creating a benefit flow from markets to banks.

On the complementarity between banks and markets, two previous contributions are relevant, although neither examines co-evolution. Allen and Gale (2000) note that intermediaries may complement markets by providing individuals insurance against unforseen contingencies in 'obscure states', thereby eliminating the need for individuals to acquire costly state information and reducing their market participation costs. Unlike our analysis, however, bank equity capital and securitisation are absent and there is not a feedback loop from banks to markets and another from markets to banks such that both co-evolve. That is, their focus is entirely different. Holmstrom and Tirole (1997) develop a model 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. 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 changes in capital on investment, interest rates and forms of financing.

The rest is organised as follows. Section 1 describes the basic model. Section 2 analyses the borrower's choice of funding sources, highlighting the competition dimension of bank-market interaction. Section 3 generates our main results about the complementarity and co-evolution dimensions of bank-market interaction. In Section 4 we put additional structure on the model to endogenise the cost of capital market financing, deposit insurance and a regulatory capital requirement. The empirical predictions of the analysis are discussed in Section 5. Section 6 concludes. All proofs are in the Technical Appendix available on the Journal homepage at http://www.res.org.uk/economic/ta/tahome.asp or with the online of this article.

1. The Basic Model

1.1. *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 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 invests in the project. A crook who raises project financing 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 financier faces *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 ω as the cost the investor suffers because of the cash flow shortfall he experiences when he does not receive repayment from the borrower on the market security he has purchased.[7] We assume ω differs across investors and that for each investor it is a random variable (unknown to all at the outset) distributed uniformly on support $[0, \bar{\omega}]$.[8] All financing of borrowers involves debt contracts.[9]

Aggregate deposit supply exceeds maximum loan demand; the same is true for aggregate supply of capital market funding, through either securitisation or direct market financing. Each borrower can approach multiple *a priori* identical banks, although each bank transacts in equilibrium with only one borrower.

1.2. *Deposit Insurance and Regulatory Capital Requirement*

The regulator determines the bank's deposit insurance coverage and capital requirement at $t = 0$. The deposit insurance coverage is limited to be either zero or complete.[10] Suppose the capital requirement is $E \in [0, 1]$, so the bank needs to raise E in equity from the capital market at $t = 1$ and borrow the remaining $1 - E$ 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 to develop the project.

[7] This assumption is reminiscent of Diamond's (1984) non-pecuniary default penalty on the borrower that defaults, except that here this penalty is suffered by the investor who purchases a security from a crook. A simple interpretation is that investors have their own personal borrowing, with each investor's ability to repay personal debt dependent on the repayment he receives on the borrower's securities he purchases in the market. Borrower default can thus trigger investor default, 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 heterogeneous 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. Our main results remain qualitatively unchanged with partial deposit insurance.

depositors *afterwards* to lend \$1.[11] While both deposit insurance and bank capital are currently taken as exogenous, they will be endogenised in the complete model.

1.3. *The Borrower's Choice of Financing Source*

At $t = 0$, the borrower has three financing choices:

(*i*) borrow directly from the capital market;
(*ii*) let the bank screen and certify its type first and then borrow from the capital market via securitisation; or
(*iii*) take a relationship loan from the bank.

With *direct capital market access*, the borrower completely bypasses the bank, so there is no 'bank screening certification' provided to the borrower.

With *securitisation*, the bank screens the borrower first, and then decides whether to seek market financing 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 securitisation 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 if the loan defaults. This collateral is equal to a fraction, $\delta \in (0, 1)$, of the initial promised repayment of the securitised debt to investors. The bank incurs a fixed cost, $Z > 0$, to set up a trust for securitisation.

That is, the trust 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 securitisation counts as a loan under the rules of securitisation 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 precommits to a loan interest rate it will charge if it decides to lend. 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 is explained later. Deposit gathering is costly due to the cost of setting up branches, employing tellers etc., and the cost is $\tau > 0$ per dollar of deposit. Since the

[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. The term 'bank capital' refers to its equity capital.

[12] FAS 140 is the accounting rule in the US for whether a specific securitisation structure qualifies as a loan sale. See Greenbaum and Thakor (2007) for a discussion of securitisation. We will see later, when we endogenise capital requirements, that the securitisation structure we use will not require any capital to be posted.

borrower learns whether it is authentic or a crook before seeking financing, its financing choice may convey information about its type.

1.4. *The Bank's Screening and Its Private Signal about the Borrower's Type*

The bank specialises in noisy but informative pre-lending screening of the borrower's type at $t = 0$. This screening, unobservable to anyone but the bank, occurs if the borrower chooses a relationship loan or securitisation and 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

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

where $p \in [1/2, 1]$ is the precision of bank screening. If the bank lends only when the screening signal $s = s_a$, then p is the probability that an authentic borrower receives credit. We treat p as being common knowledge and exogenously given for now; it is endogenised later when we study the co-evolution of banks and markets. The bank's screening cost, given p, is $cp^2/2$, where $c > 0$ is a constant that is assumed to not be too large, in a sense made precise later. Each bank can screen only one borrower. Assuming that both the authentic borrower and the crook 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 securitisation) 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 literature that banks are specialists in credit screening (Allen, 1990; Boyd and Prescott, 1986; Coval and Thakor, 2005; Ramakrishnan and Thakor, 1984). In particular, the bank specialises in processing soft information (Stein, 2002) about the borrower's character, which is one of the 'five Cs of credit' and corresponds to the bank's screening permitting it to

[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 only 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.

distinguish crooks noisily 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]

1.5. *Market Structure and the Pricing of Securities*

When the bank raises equity capital E from the market to support the loan, the equity contract stipulates that the bank's initial shareholders and the new shareholders share the authentic borrower's loan repayment, L, to the bank, net of the bank's repayment to depositors.[16] The fraction of ownership in the bank sold to the new investors, $1 - \alpha$, is such that the bank is able to raise exactly E. The capital market is perfectly competitive for both debt and equity contracts, so $1 - \alpha$ is determined to yield the investors purchasing equity a competitive expected return of zero, the riskless rate. The bank's initial shareholders obtain a share α of the bank's terminal payoff. With multiple banks pursuing each borrower, banks are Bertrand competitors for borrowers, so L is endogenously determined such that the bank earns zero profit in equilibrium.[17] The deposit market is perfectly competitive too – depositors are promised a competitive expected return of zero, so the expected repayment on a \$1 deposit is \$1.

1.6. *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 whether it is authentic or a crook and then makes its choice of financing source. If the borrower chooses either a relationship loan or securitisation, it approaches a bank which conducts screening to determine the borrower's creditworthiness. The bank then makes its acceptance/rejection decision.

At $t = 1$, with direct market financing, investors must decide whether to finance the borrower, and they must do so without the benefit of bank screening. With securitisation, bank screening nosily sorts out crooks at $t = 0$, so funding is provided by investors if the bank screened the borrower affirmatively and accepted it 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 E in equity to satisfy the regulatory capital requirement and borrows $1 - E$ from depositors. With both securitisation and relationship lending, the bank can choose to screen or not to screen. So incentives to screen must be provided.

[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, 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 a negative reaction.

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

[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, $\tau(1 - E)$.

At $t = 2$, the authentic borrower's project payoff realisation is commonly observed, and financiers are paid off. If the borrower is a crook, financiers receive nothing. Figure 1 summarises these events.

2. 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, some elements of the model are taken as exogenous in order to simplify. These elements are endogenised later in the complete model.

Assumption 1. *Valuation Discount: For any borrower seeking financing from the capital market through either direct market borrowing or securitisation, the investors' valuation of the expected debt repayment is a fraction $\lambda(N) \in (0, 1)$ of the borrower's valuation, where N is*

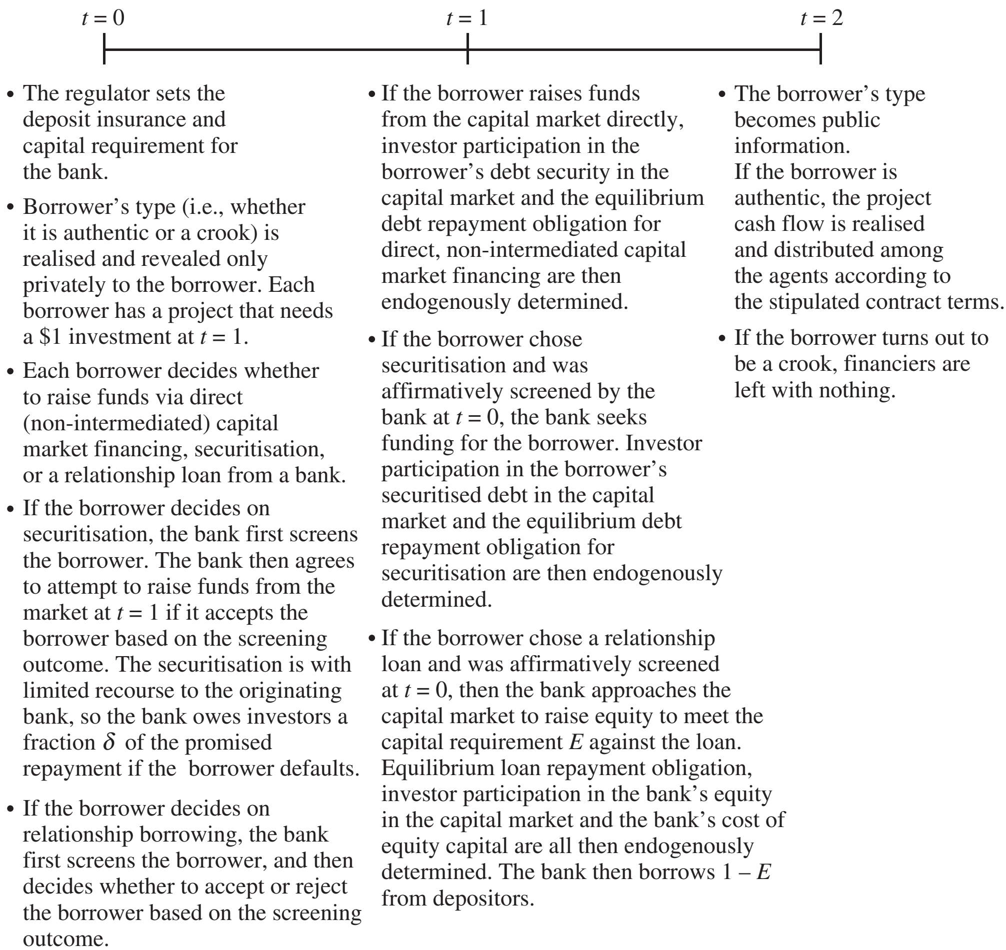

Fig. 1. *Sequence of Events*

investor participation in that security (non-intermediated debt or securitised 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 presence of crooks but also because those seeking financing (the borrower and the bank) and those providing financing (investors) value the surplus from the project being financed differently. While taken as an assumption for now, we endogenise this in Section 4 (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, securitised debt, or bank equity) in the market. The intuition is that a capital market with greater investor participation (larger N) in a given security permits investors with higher valuations to bid for the security. We endogenise 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.[18]

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 risk-sensitive and decreasing in borrower credit quality, i.e., $\partial E/\partial q < 0$.*

The intuition for $\partial E/\partial q < 0$ is as follows. Since the borrower is charged a lower rate when its credit quality is higher, 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 shown formally in the complete model), the regulatory capital

[18] 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 ρs are random *ex ante*, the highest ρ among N investors can be viewed *ex ante* as the Nth-order statistic of ρ. It is clear that the expected value of the Nth-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 $2\int_0^1 x^2 \mathrm{d}x = 2/3 > 1/2$.

requirement is also decreasing in borrower quality.[19] Both Assumptions 1 and 2 will be endogenised later.

2.1. *The Authentic Borrower's Payoffs from Various Funding Sources*

We begin with 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. We focus on authentic borrowers. We assume for now that a crook makes the same financing choice as an authentic borrower, and 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 maximise 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 characterise 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 is as follows. Yanelle (1997) studies Diamond's (1984) model, in which there are increasing returns to scale from intermediation; on the asset side increasing returns to scale arise because of the reduction of duplicated monitoring as the intermediary grows in size, and on the liability side it is 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, in our model, by assumption each bank deals with only one borrower – there is no advantage in dealing with multiple borrowers because there are *no* increasing returns to scale – and deposits are fully insured. With this setup, even two-sided Bertrand competition for loans and deposits yields zero profit for the bank in equilibrium.

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

[19] As we shall see later, it is interesting and perhaps surprising that the optimal capital requirement does *not directly* depend on the bank's cost of equity capital. If the capital market evolves so that the cost of bank equity declines, banks choose to lend to riskier borrowers and this exposes banks to higher (risk-sensitive) capital requirements. This is an indirect effect, however. Capital requirements have *no* direct dependence on the bank's cost of equity.

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

borrower will prefer at $t = 0$. These expected payoffs are computed prior to any bank screening of the borrower.

2.1.1. *Direct capital market access*

We first analyse the equilibrium investor participation, N_{dir}, for any borrower with prior credit quality q borrowing directly from the market. Note that since ω is uniformly distributed on $[0, \bar{\omega}]$, the highest disutility of financing a crook, ω, when N_{dir} out of $\bar{N}$ investors are participating is given by:

$$\omega = \bar{\omega}\ (N_{\text{dir}}/\bar{N}). \tag{4}$$

After the authentic borrower's choice of N_{dir} is made, each of the $\bar{N}$ investors receives a signal that informs him whether his disutility is above or below ω, defined in (4). Only investors with disutility less than or equal to ω will participate in lending, so in equilibrium there are indeed N_{dir} investors participating. However, all that each of the N_{dir} investors knows about his true disutility is that it is uniformly distributed on $[0, \omega]$, and thus each expects to incur a disutility of $\omega/2$ of financing a crook. The authentic borrower chooses the debt repayment obligation, R_{dir}, to maximise its expected payoff, denoted as π_{dir}:

$$\pi_{\text{dir}} = X - R_{\text{dir}}, \tag{5}$$

subject to those participating investors' individual rationality (IR) constraint:

$$\lambda(N_{\text{dir}})(qR_{\text{dir}}) - (1-q)(\omega/2) = 1. \tag{6}$$

In (5), $X - R_{\text{dir}}$ is the authentic borrower's net payoff. As for (6), note that the probability that a borrower receiving direct market financing is authentic is q, in which case 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 investors (see Assumption 1). The probability is $1 - q$ that a crook will be funded, in which case investors expect to suffer a disutility of $\omega/2$. The expected payoff across those two states must equal 1, the financing provided.

2.1.2. *Securitisation*

Next, consider a borrower with prior credit quality q whose bank loan is securitised. We now need to make sure that:

(*i*) the bank will indeed screen the borrower, and
(*ii*) it will securitise only a borrower for 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 securitisation, denoted as N_{sec}, can be analysed in the same way as N_{dir}.

The three choice variables, R_{sec} (the borrower's repayment obligation), $\hat{R}_{\text{sec}}$ (the repayment going to investors), and δ (fraction of the repayment promised to investors as recourse), are chosen to maximise the authentic borrower's expected payoff from securitisation, denoted as π_{sec}. Here, π_{sec} 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 repayment to the bank, R_{sec}, i.e.,

$$\pi_{\text{sec}} = p\ (X - R_{\text{sec}}). \tag{7}$$

The participating investors' IR constraint is:

$$\lambda(N_{\text{sec}})\big[(q^A \hat{R}_{\text{sec}}) + (1-q^A)(\delta\hat{R}_{\text{sec}})\big] - (1-q^A)(\omega/2) = 1, \tag{8}$$

where ω, given by $\omega/\bar{\omega} = N_{\text{sec}}/\bar{N}$, is the highest disutility of financing a crook among the N_{sec} investors who participate. The bank's IR constraint (prior to screening) is:

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

In (8), $\lambda(N_{\text{sec}})(1 - q^A)(\delta\hat{R}_{\text{sec}})$ is the investors' valuation of their recourse to 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 securitised credit has been screened and certified by the bank. To undersand (9), the bank's participation constraint, note that the bank only securitises 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., $\Pr(\text{authentic}) \times \Pr(s = s_a|\text{authentic}) = pq$, times the bank's net payoff, $R_{\text{sec}} - \hat{R}_{\text{sec}}$.[21] 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., $\Pr(\text{crook}) \times \Pr(s = s_a|\text{crook}) = (1-p)(1-q)$, 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 securitisation is $[qp + (1-q)(1-p)](Z)$. Finally, $cp^2/2$ is the bank's screening cost.[22]

We also need to check the screening incentive compatibility (IC) constraints in (*i*) and (*ii*) above. Consider (*i*). We need to ensure that the bank's net payoff from screening and securitising, given by (9), is no less than that from:

(*a*) not screening and not securitising, and
(*b*) securitising without screening.

Since the bank's payoff with (*a*) is zero, that constraint is obviously satisfied. As for (*b*), the IC constraint is that the bank's net payoff from securitising without screening is non-positive (recall q is the prior belief):

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

where we recognise that the bank will have to set up a securitisation trust in order to securitise, whether it screens or not prior to securitisation. Since (10) is binding in equilibrium, we solve it to obtain:[23]

[21] Note that the valuation discount, measured by $1 - \lambda(N_{\text{sec}})$, exists only between investors in the capital market and the borrower, but not between the bank and the borrower.
[22] Note that (9) is equivalent to: $q^A(R_{\text{sec}} - \hat{R}_{\text{sec}}) - (1-q^A)(\delta\hat{R}_{\text{sec}}) - Z - (cp^2/2)/[qp + (1-q)(1-p)] = 0$.
[23] Because recourse is costly to the bank, promising recourse greater than that needed for (10) to hold as an equality is inefficient.

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

Now consider (*ii*) – the bank should prefer to securitise only if $s = s_a$. Securitising 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 securitise when $s = s_c$, we need:

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

where the left-hand side is the bank's net payoff if it screens and securitises a borrower for which $s = s_c$, and the right-hand side is the bank's payoff if it screens and decides not to securitise. 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).

2.1.3. *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, maximises π_{loan} subject to the bank's own IR 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 participating investors' IR constraint in the capital market:

$$(1-\alpha)\lambda(N_{\text{loan}})(q^A)[L - (1-E)] - (1-q^A)(\omega/2) = E, \tag{16}$$

where N_{loan} is the equilibrium investor participation in the market providing equity capital to the bank, and ω is the highest disutility of financing a crook among the N_{loan} investors, 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, $cp^2/2$.[24] The bank raises equity E to make its relationship loan. The investors' IR constraint (16) equates the investors' expected payoff from providing capital to E, the amount of capital provided.[25] The investors' share of the bank's expected terminal payoff is $(1 - \alpha)$ and the expected terminal payoff itself is $\lambda(N_{\text{loan}})(q^A)[L - (1 - E)]$ as valued by investors, which is smaller than the bank's valuation, $(q^A)[L - (1 - E)]$.

Because of the satisfaction of the various IC constraints related to bank screening, our analysis in this Section has established the following result:

LEMMA 2. *In both securitisation 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, $s = s_c$.*

Since the bank makes its decision based on the screening outcome by accepting when $s = s_a$ and rejecting when $s = s_c$, it 'certifies' the borrower's creditworthiness to the market, so the borrower obtains better credit terms with securitisation than without the certification. Without such certification, securitisation is not viable.[26] Recall that investors who purchase the securitised debt have recourse to the bank for a fraction δ of the securitised debt if the borrower defaults. The key is that δ is set so high that in equilibrium the bank finds it unprofitable to securitise a borrower without screening it

[24] It is straightforward to check satisfaction of the IC constraints with relationship lending to ensure that the bank will indeed screen and lend only to a borrower when $s = s_a$. Note that (15) is equivalent to: $(\alpha q^A)[L - (1 - E)] - \tau(1 - E) = (cp^2/2)/[qp + (1 - q)(1 - p)]$. To ensure that the bank does not lend without screening, we need: $(\alpha q)[L - (1 - E)] - \tau(1 - E) \leq 0$, which is equivalent to: $c \leq [2\tau(1 - E)(2p - 1)(1 - q)]/p^2$. That is, as long as c is not too large, the equilibrium L (determined by the bank's IR constraint in (15)) will not be too large to induce the bank to lend without screening. It is easy to verify that this condition also ensures that the bank does not lend when $s = s_c$, i.e., $(\alpha q^C)[L - (1 - E)] - \tau(1 - E) - cp^2/2 \leq - cp^2/2$.

[25] 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:

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

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 participating investors' IR constraints become $\alpha(q^A)[L' - (1 - E)] - (1 - \varsigma)\tau(1 - E) - (cp^2/2) = 0$ and $(1 - \alpha)\lambda(N_{\text{loan}})(q^A)[L' - (1 - E)] - (1 - q^A)(\omega/2) - (\varsigma)\tau(1 - E) = E$, respectively, where L' is the loan repayment. Straightforward calculations show that:

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

which is larger than L, since $\lambda(N_{\text{loan}}) < 1$. That is, π_{loan} will *ceteris paribus* be smaller if the bank's equity contract asks investors to share the deposit-gathering cost. This is suboptimal. The case for screening-cost sharing is similar.

[26] If such certification is not provided with securitised debt, the credit terms that an authentic borrower obtains with securitisation are the same as those with direct market borrowing. But there is a securitisation cost, Z, that is fully absorbed by the borrower. Thus, direct market financing strictly dominates securitisation without bank certification.

first. Now, conditional on screening, if the bank were also to 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.[27] Thus, securitisation with recourse ensures that the bank's acceptance/rejection decision is signal-contingent and therefore the certification provided by securitisation is credible. The intuition for relationship borrowing is similar.

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

Next, solving the optimisation problems in (4) – (16), we have:

LEMMA 3. *The equilibrium investor participation and the expected payoffs to an authentic borrower from the three financing choices, non-intermediated debt, securitisation and relationship borrowing, are all increasing in borrower credit quality, q, and the number of investors in the capital market,* $\bar{N}$. *For securitisation and relationship borrowing, the equilibrium investor participation is also increasing in the precision of bank screening, p; for each of these two financing choices, a value of p exists that maximises 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 (larger N_{dir}) or securitisation (larger N_{sec}), and when the bank raises equity capital in relationship lending (larger N_{loan}). Second, for non-intermediated debt and securitisation, 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 securitisation (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 from the market.[28] Higher borrower quality increases investor participation and 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 securitisation 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 increases in p cause the authentic borrower's payoff to decrease. Thus,

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

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

there exists a payoff-maximising $p \in (1/2, 1)$ for securitisation and another for relationship borrowing.

2.2. *The Authentic Borrower's Choice of Funding Source*

In this Section, we prove a Proposition about the authentic borrower's funding-source choice. It is useful to see the intuition before the formal details. Consider first the lowest borrower credit quality. As the borrower's prior credit quality q declines, its loan repayment obligation L increases and its relationship borrowing payoff decreases (Lemma 3). Since L increases without bound as q decreases to 0, L becomes so high for a sufficiently low q that no bank wishes to finance a borrower who is almost certainly a crook. Thus, there is a quality cutoff, call it $q_l > 0$, below which borrowers cannot obtain financing. This cutoff defines the bank's lending scope, with a lower cutoff designating a broader scope.

Consider now the borrowers who can obtain financing ($q \geq q_l$). In equilibrium, these borrowers absorb the costs associated with the financing sources they choose. The relevant costs for a relationship loan are the capital market valuation discount related to the bank's capital requirement, E, and the deposit-gathering cost $\tau(1 - E)$. For securitisation, the relevant costs are the cost of the trust, Z, and the valuation discounts related to the loan and the bank's recourse. The capital market valuation discount decreases with borrower quality, q, and, thus, in the cases of both the relationship loan and securitisation, the valuation discount is lowered by the bank's screening (which increases the posterior belief about borrower quality for affirmatively-screened borrowers). For direct capital market access, the relevant cost is the valuation discount on the whole loan and there is no bank screening to diminish the discount.

For creditworthy borrowers with low values of q, the no-screening valuation discount associated with direct market access is very high. By comparison, bank screening with a relationship loan leads to a relatively low valuation discount associated with the bank's capital requirement, E. And because E is high when q is low, the deposit-gathering cost for a relationship loan, $\tau(1 - E)$, is relatively low. So borrowers with low q's prefer relationship loans to direct market access. As for securitisation, these borrowers face the fixed cost Z plus the valuation discount associated with market financing. Since there is screening with both relationship borrowing and securitisation, the borrower notes that the post-screening valuation discount with E (relationship loan) is less than the post-screening valuation discount with the entire loan \$1 (securitisation). Moreover, while Z is invariant to borrower quality, $\tau(1 - E)$ decreases as q becomes lower. Thus, borrowers with low q's find that the cost of a relationship loan is lower than that of securitisation.

As q increases, the bank's capital requirement E falls and the borrower faces higher values of $\tau(1 - E)$ with relationship borrowing, whereas the securitisation cost Z is unaffected.[29] Moreover, the spread between the post-screening valuation discount with capital market financing for the entire loan (securitisation) and the post-screening

[29] In equilibrium, the bank's capital requirement always binds. Because of complete deposit insurance, the marginal cost of equity for the bank always exceeds the marginal cost of deposits, so no bank keeps more capital than what is required.

valuation discount for the capital requirement E (relationship loan) gets smaller as q increases. So intermediate-quality borrowers prefer securitisation to relationship borrowing. They do not choose direct market finance because the lack of bank screening means the valuation discount with direct market finance exceeds the sum of Z and the post-screening valuation discount with securitisation.

When q is sufficiently high, the capital market valuation discount is so low anyway that screening matters little. For such borrowers, the cost of the valuation discount with direct market finance is less than the sum of Z and the post-screening valuation discount with securitisation. It is also lower than the sum of the post-screening valuation discount with E and the relatively high $\tau(1-E)$ associated with relationship borrowing. So the highest-quality borrowers choose direct market finance.

PROPOSITION 1. *Suppose the securitisation 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 Technical 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. 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.*
(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 securitisation. Moreover, q_m is decreasing in p.*

The unique universally divine sequential equilibrium (Banks and Sobel, 1987) is 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 that prior quality, $\pi_{\text{dir}}|_{q=q_h}$, is the same as the borrower's highest possible payoff from securitisation when the market believes it 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 securitisation and direct market finance, 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 prefer direct market finance to securitisation and yet they borrow via securitisation 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 finance over securitisation because the bank screening associated with securitisation 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 securitisation, investors would think that the borrower is more likely to be authentic 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 securitisation, 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 securitisation. It is clear that the precision of bank screening, p, has no effect on q_h.

As for the choice between securitisation and relationship borrowing, more precise bank screening invites greater investor participation in the market both for securitisation and for the bank's raising of equity to support its loan. This lowers the costs of both bank equity and securitised debt. But the effect on securitised debt exceeds that on bank equity. The reason is that more funding is raised from the market with securitised debt than by the bank when it raises equity capital ($E < 1$). Hence, securitisation 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; financiers learn nothing about a borrower's type by observing its financing choice.

Our analysis highlights two frictions that are complementary in that both impede the borrower's access to credit. One is due to a lack of information about borrower credit quality ('certification friction') and the other arises from the dissipative costs of external financing, including the valuation discount ('financing friction'). The certification friction leads to the rationing of creditworthy borrowers, whereas the financing friction engenders a higher cost of capital for the borrower. Banks are better at resolving the certification friction because of their screening technology. The financing friction is resolved in different ways by banks and markets. Banks resolve it by funding with insured deposits but incur a deposit-gathering cost. Markets resolve it by achieving a lower valuation discount via greater investor participation.[30] These different ways of resolving the financing friction generate benefits that differ across borrowers of different quality.

We comment now 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

[30] 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.

otherwise it has an *ex post* monopoly *after* screening the borrower affirmatively. Thus, if some banks make binding precommitments and others do not, borrowers will choose 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 loan rate if the bank agrees to lend. Similarly, borrowers need to precommit that if offered the loan at the posted price, they will take it. This is necessary because the bank earns an *ex post* rent when $s = s_a$ and it does lend; this rent covers the bank's *ex post* loss when $s = s_c$ and it does not recoup its screening cost because it does not lend.[31]

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

In this Section we analyse 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.

3.1. *Co-evolution of Banks and Capital Markets: Preliminary Remarks*

We now examine how bank evolution affects the market and how market evolution affects the bank. So we go back to $t = -1$ to determine the bank's choice of screening precision, p.

LEMMA 4. *At* $t = -1$, *the bank will choose a screening precision that maximises 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 maximise 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 maximise expected borrower surplus at $t = 0$ will be unable to attract a borrower away from a bank that chose the surplus-maximising p at $t = -1$.[32]

Consider now a borrower with prior credit quality q, which is drawn from a uniform distribution over support [0, 1].[33] The bank's problem at $t = -1$ is to choose p that maximises borrower surplus given below:

[31] 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 article.

[32] 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).

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

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

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 correspond to the traditional view of the functions of a financial system. A primary function is to acquire and process information. In our model, bank evolution means that the bank's screening investment becomes more efficient (lower c), possibly due to advances in information technology and credit screening models. Another function of a financial system is to mobilise savings by pooling capital from disparate 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.

3.2. *The Effects of Bank Evolution on Capital Market Evolution*

We now show that bank evolution has two effects. First, as shown in Lemma 3, it increases capital market investor participation with relationship borrowing, thereby lowering the bank's cost of meeting its capital requirement. Second, bank evolution also causes capital market investor participation with securitisation to increase, thereby powering capital market evolution. The following Proposition summarises these effects.

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 securitisation scope from below (q_m decreases).*
(*iii*) *It enhances investor participation in the capital market for both relationship borrowing and bank securitisation, 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 securitisation (q_m decreases) but also increases its volume by increasing investor participation in the capital market for securitisation. If we include both securitisation 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 securitisation 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 bank and market finance (Berlin and Mester, 1992; Boot and Thakor, 1997*a*; Rajan, 1992), what we add is securitisation. However, this does not merely add an element to the financing choice menu for descriptive completeness. Rather, securitisation generates an important interaction between the bank and the market that shapes financial system architecture. It propagates banking advances to the capital market, permitting market evolution to be driven by bank evolution. To see this clearly, consider what happens if we exclude securitisation.

COROLLARY 1. *Suppose there is no securitisation. 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 securitisation, the conduit through which bank evolution benefits the capital market, is excluded, we return to the standard result that banks and markets compete. As the bank's screening technology improves, its market share increases at the expense of the capital market.

Our analysis has ignored the role of non-bank financial intermediaries like credit rating agencies in this certification process. If such intermediaries were introduced, then improvements in the certification technologies of these intermediaries would enhance investor participation in the capital market independently of securitisation and what banks do. However, a key difference between banks and rating agencies 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 (Boot *et al.*, 1993) and rating agencies have only reputational capital at stake.[34]

3.3. *The Effects of Capital Market Evolution on Bank Evolution*

We now analyse 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

[34] 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.

to the bank.[35] 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.

In our model, creditworthy (authentic) borrowers with $q < q_l$ are rationed by banks.[36] Capital market evolution makes bank equity cheaper. The bank thus optimally raises more equity capital and serves *low-quality* borrowers that were previously unserved, thereby expanding its lending scope. The key role played by bank equity capital is to enable 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 as in previous research on financial system architecture. This connects market evolution to bank evolution and allows market advances to affect banks positively. This role of bank capital has not been previously examined.

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 of bank capital, in contrast to our article where it helps to propagate capital market advances to the banking sector. Of course, this propagation would not occur if we either excluded bank capital from the analysis or simply exogenously fixed the cost of bank capital.

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 to banks, we get the standard result that market evolution causes banks to lose business to the market.

3.4. *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 market evolution induces the bank to invest more in screening, and the improved precision spurs bank evolution. Moreover, the improved screening precision increases investor participation in the capital market (see Proposition 2), which helps market evolution. Thus, we have:

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.*

Proposition 4 shows that there is a virtuous cycle in which each sector benefits from the development of the other. This goes well beyond the one-way complementarity

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

[36] 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.

results in papers like Holmstrom and Tirole (1997) that bank monitoring can improve capital market access for borrowers.

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

4. The Complete Model

We now complete the model by endogenising:

(*i*) deposit insurance and bank equity capital; and
(*ii*) the valuation discount in market financing.

We maintain the same setting 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). A G project pays off $X > 1$ for sure at $t = 2$. A B 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: heterogeneous prior beliefs. This element helps us to endogenise Assumptions 1 and 2. That is, heterogeneous prior beliefs allow us *simultaneously* to endogenise the valuation fraction, $\lambda(N)$, which 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 endogenise. For example, heterogeneous transaction costs or risk aversion among investors may generate a valuation fraction but the important property that this fraction is endogenously increasing and concave in N would be lost. Moreover, transaction costs would not help us to endogenise complete deposit insurance.[37]

4.1. *Overview of the Intuition of the Complete Model*

Before examining the details, it will be useful to discuss the time line of events and the intuition behind the complete model briefly. The time line for the complete model is the same as that for the basic model, except that we add uncertainty about the quality of the authentic borrower's project. This uncertainty is *partially* resolved by a public noisy signal of project quality that is observed after capital market financing

[37] Risk aversion may also help endogenise deposit insurance. See, for example, Park (1996).

is raised (for any of the three financing choices) but before deposits are raised for relationship lending. Different agents may have different prior beliefs about the precision of this signal, leading to different posterior beliefs about project quality and hence possible *disagreement* about whether the project should be funded. This means that depositors may refuse to fund the relationship loan even if the bank wishes to make the loan. The regulator views this as a deadweight loss that can be eliminated by complete deposit insurance. But this creates moral hazard in that the bank now wishes to extend the loan even when its signal precision indicates that the project is not worth funding. A minimum capital requirement resolves this moral hazard. Note, however, that since the project-quality signal arises after capital market financing is raised, the project may be funded even though investors believe the signal precision is such that the project should be rejected. Investors compensate themselves for this *ex ante* by assigning a lower value to the project than the borrower does. This results in a valuation discount with direct capital market financing and securitisation as well as with bank equity capital in a relationship loan. When investors are heterogeneous in terms of their propensity to agree with the bank or the borrower, it will be the investors with the highest agreement who will invest in equilibrium because they assign the highest value to the borrower's project. As the number of participating investors increases, there are more investors to choose from and the likelihood of finding investors with higher agreement goes up. Consequently, the valuation discount declines with investor participation.

4.2. *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 signal values (φ_G or φ_B), they have different priors about the signal precision. The signal precision, denoted as υ, is precise (I) with probability $\mu \in [0, 1]$ and uninformative (U) with probability $1 - \mu$. A precise signal is viewed as perfect, and an uninformative signal has no incremental information content, so the posterior belief about the project's type stays at the prior belief.

To see this concretely, suppose the signal is φ_G. When the prior belief about the signal precision is $\upsilon = I$, the agent's belief about the project's type is $\Pr(G \mid \varphi = \varphi_G, \upsilon = I) = 1$; when $\upsilon = U$, the agent's belief about the project's type remains at its prior, i.e., $\Pr(G \mid \varphi = \varphi_G, \upsilon = U) = \theta$. If the signal is φ_B, 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 that the project NPV is negative. Thus, with $\varphi = \varphi_B$, all the agents agree 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 υ. We assume that the 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 signal precision, denoted as υ_b.[38] We also assume that the prior beliefs of depositors about signal precision, denoted as υ_d, are perfectly correlated, so that depositors act as a monolithic group.[39] We model potential divergence of prior beliefs between the borrower/bank/regulator on the one hand and depositors on the other hand regarding signal precision via the following conditional probabilities:

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

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 conditional probabilities:

$$\Pr(\upsilon_i = I \mid \upsilon_b = I) = \rho \in [0, 1], \Pr(\upsilon_i = U \mid \upsilon_b = I) = 1 - \rho. \tag{19}$$

Moreover, investors are heterogeneous in that ρ varies across investors (see Section 4.3).

From the standpoint of beliefs, we model depositors as homogeneous and investors as heterogeneous. The reason for assuming homogeneity with depositors is that (insured) deposits represent a single financial security that is likely to attract a homogeneous group of investors. By contrast, the 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.[40] See also Allen and Gale (1988) for a related argument in a state-preference framework.

Higher values of ρ_d (ρ) connote greater degrees of agreement between the borrower/bank/regulator and depositors (investors). The higher is ρ_d (ρ), the higher is the probability that the prior beliefs of the borrower/bank/regulator and depositors (investors) 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. If a project involves a radically new product or business design, there may be little hard historical data to gauge the success probability of the project. Project evaluation may thus be based largely on soft and inherently subjective

[38] Dropping the assumption of no disagreement between the bank and the borrower will not qualitatively change the analysis as long as 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.

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

[40] 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 heterogeneous.

information (Stein, 2002), possibly causing ρ_d (ρ) to be low. By contrast, for a more familiar project that is similar to projects having 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 all agents have 'rational beliefs' as defined by Kurz (1994*a,b*), who provides a theoretical foundation for heterogeneous priors, which says that agents with different priors can all be rational as long as none of the priors can be precluded by historical data. In our setting, distributions are non-stationary and historical data are lacking, so agents will *not* be able to derive the precision of the signal *uniquely* from historical data and many distributions of precision may be consistent with the data.[41]

4.3. *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 density function $f(\cdot)$ and support $[0, 1]\ \forall\ q$. The *equilibrium* ρ for any borrower is determined by investor participation in the market. The 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 *et al.* (2008), if there are N investors participating in the market in a given security, the market-clearing mechanism ensures that the security is purchased by investors with the highest ρ among the N investors, which is the Nth-order statistic of ρ, denoted as $\bar{\rho} \equiv \max_{\{1 \le i \le N\}} \rho_i$, where ρ_i is the agreement parameter between the ith investor and the borrowing agent. We call those investors 'maximal investors'.[42] Denote $\mathbf{E}(\bar{\rho}) \equiv \rho_M$, the equilibrium agreement parameter with market financing for the borrower when there are N investors participating in the market. Then we have:

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 Nth-order statistic of the agreement parameter is increasing in N, the number of investors participating in the market. We will explicitly characterise ρ_M when we analyse 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].

4.4. *Discussion of the Complete Model for the Borrower*

Each borrower is distinct in terms of its credit quality q, and the agreement parameter ρ, which represents the extent to which investors will agree with the borrower regarding

[41] Technically, what we are modelling is a setting in which the economic observables based on which agents form beliefs are 'stable' but not 'stationary' (Kurz, 1994*a,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.

[42] Since every participating investor has the same expected disutility, $\omega/2$, the investors with the highest ρ are willing to pay the highest price for the security.

project value. Credit quality reflects the usual post-lending borrower moral hazard, arising from the possibility that the borrower is a crook.[43] The investor-agreement parameter ρ, however, represents a departure from the usual common-priors assumption; priors differ not only between the borrower and the investors but also among investors.

Our choice of heterogeneous priors is motivated by the fact that assessments of technological innovations are typically associated with a diversity of opinions (Allen and Gale, 1999). When something is new and unfamiliar, it is natural for agents to have different beliefs about its value, and a paucity of historical data impedes convergence of these beliefs; see Schumpeter's (1934) observation that '…the new is only the figment of our imagination'. This stands in sharp contrast to investments in established industries with abundant historical data drawn from stationary distributions.

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, rather than invoking heterogeneous priors? The answer is no. Cash-flow risk is an inappropriate way to distinguish between innovative and established projects. For example, the US credit card business, which is well established, involves relatively high default risk. However, there is little disagreement over what these default rates are and how credit cards should be priced.

4.5. *Endogenising Market Valuation Discount, Deposit Insurance and Bank Capital*

We now use the additional model structure to endogenise Assumptions 1 and 2 in Section 2.

4.5.1. *Capital market valuation discount*

Consider an authentic borrower financing from the capital market via either direct borrowing or securitisation. Investors recognise that when $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_m = U\}$, the borrower will invest in a project they believe has negative NPV but the borrower believes has positive NPV. The investors' valuation of the expected repayment from the borrower is thus always lower than the borrower's valuation. The valuation fraction is determined by the level of agreement between the borrower and the 'maximal investor' in the market, which in turn is determined by investor participation in the market (see Lemma 5). The following Proposition endogenises Assumption 1.

PROPOSITION 5. *Suppose the equilibrium investor participation in the capital market is N for direct market financing, securitisation, 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:*

$$\lambda(N) = \frac{\theta + N}{1 + N} \in (0, 1). \tag{20}$$

[43] Although we do not model legal systems formally, we can think of an economy dominated by borrowers with lower q as an economy with weaker 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.

The intuition is that an increase in the number of investors raises the equilibrium agreement parameter (Lemma 5) and reduces borrower-investors disagreement, leading to a higher valuation by the investors.

4.5.2. *A rationale for deposit insurance*

We now rationalise deposit insurance. Suppose there is no deposit insurance and no capital requirement for the bank (i.e., $E = 0$). Consider a borrower with prior credit quality q to which the bank agrees to extend a relationship loan. 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, when $\{\varphi = \varphi_G, \upsilon_b = I, \upsilon_d = U\}$, the bank and the regulator believe the project is worth funding whereas depositors believe the project is a bad bet and withhold funding. 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.[44]

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 $t = 1$.[45] 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.[46] We thus have an endogenous justification for the full deposit insurance assumption stated in Assumption 2.

4.5.3. *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-

[44] 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 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.

[45] 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.

[46] Note that 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; 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.

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:[47]

$$[qp([1-q)(1-p)]\{(\alpha)[\theta\mu q^A(L-1)+(1-\theta\mu+\theta\mu q^A)(E)]-\theta\mu\tau(1-E)\}-cp^2/2. \tag{21}$$

In equilibrium, this expected profit is zero. Now consider the bank's investment decision with full deposit insurance and no capital requirement. The regulator would want the bank to reject negative-NPV projects. We will show, however, that this cannot be ensured without a capital requirement. Suppose the loan repayment obligation is $L > 1$ in a conjectured equilibrium with $E = 0$. In the state in which the signal is good but the bank's signal is uninformative, $\{\varphi = \varphi_G, \upsilon_b = U\}$, both the bank and the regulator believe the project has negative NPV and should be rejected. However, since deposits are fully insured, depositors are willing to provide funds with the deposit repayment being \$1. Thus, if the bank invests in this 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, deposit insurance creates moral hazard.

Capital Requirement with Relationship Loan. We now endogenise E, the capital requirement that resolves the moral hazard created by complete deposit insurance.[48] The time line is as follows. The bank first screens the borrower and then decides whether to accept the borrower for a loan. If the borrower is accepted, the bank raises E. After that, the bank receives the signal φ with precision υ_b, based on which it decides whether to accept the project. If the project is accepted and the borrower receives a loan, the bank raises deposits and the project surplus is shared between the bank and those investors who provided E. The bank accepts the project only when $\{\varphi = \varphi_G, \upsilon_b = I\}$. Otherwise, it rejects the project, and E is shared between the bank and those investors who provided E.[49]

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

[47] 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 (21) is the bank's *ex ante* expected payoff prior to screening.

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

[49] This setting is more complex than the one in the basic model. In Section 2.1.3 when we analyse relationship loans, there is no uncertainty about project quality with authentic borrowers. Thus, once the bank accepts the borrower after its screening, E is raised and always invested in the project, so it is never idle on the bank's balance sheet.

project, with a capital requirement $E > 0$. If the bank rejects the project, E remains on the bank's books and the bank retains a share of that capital. If the bank invests in the project and it 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 financing a negative-NPV project. A capital requirement of E 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 benefit of capital and introduces a tradeoff that determines the equilibrium bank capital requirement.[50] The following Proposition endogenises Assumption 2.

PROPOSITION 6. *The regulator provides full deposit insurance and sets the bank's capital requirement* $E \in (0,1)$,[51] *which is decreasing in the borrower's prior credit quality,* q.

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

This result provides a new rationale for deposit insurance and bank capital regulation with 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 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 reminiscent of the rationale in Morrison and White (2006) who show that, even without coordination failures, deposit insurance enhances welfare when adverse selection is severe.

Securitisation. The analysis now also clarifies why no capital requirement is needed with securitisation. 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 but the bank will be unable to securitise the loan because investors will not purchase any claims against it. Thus, there is no asset-substitution moral hazard.

[50] 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).

[51] Its mathematical expression is in the Technical Appendix.

5. Empirical Predictions

Our analysis generates the following empirical implications:

(1) Our analysis predicts that riskier firms prefer bank financing, while safer firms tap capital markets (see Proposition 1), consistent with Bolton and Freixas (2000) and Petersen and Rajan (1995).

(2) Recent empirical evidence indicates that economic performance across countries seems unaffected by financial system architecture (Beck and Levine, 2002; 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 matters. This view is consistent with our thesis that since banks and markets co-evolve, a financial system with strength in one sector will also display strength in the other (Propositions 2, 3 and 4).

(3) As the capital market develops, banking scope expands (Proposition 3). Hence, economies with better-developed capital markets should have banks that lend to riskier and smaller firms. We are not aware of existing empirical evidence on this prediction, but believe it is testable.

(4) Securitisation 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 securitisation, whereas complementarity describes this interaction more effectively now. Moreover, there are many countries in which securitisation is either virtually non-existent or in its infancy, so one should expect competition to dominate there.

(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 securitisation) should be weaker. This prediction awaits testing as well.

(6) The valuation fraction, λ, associated with asset values will rise as the capital market evolves (see Proposition 5). Co-evolution ensures that this benefit will also be experienced as banks evolve. Testing this prediction would require specifying, for benchmark purposes, a valuation model based on fundamentals and then performing an intermarket comparison of valuation discounts, possibly using international data. Such fundamental valuation models have been relied upon in the accounting literature (Frankel and Lee, 1998; Hess *et al.*, 2009) and elsewhere (Kaplan and Ruback, 1995).

6. 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 securitisation and bank capital requirements. Securitisation creates a vehicle by which bank evolution benefits markets since the improved bank screening that accompanies bank evolution enhances the credit quality of borrowers going to the market via securitisation, thereby increasing capital market investor participation. Bank capital generates a mechanism by which the evolution of markets benefits banks since it reduces the cost of bank equity capital, providing an incentive for banks to hold more capital, thereby diminishing the rationing of potentially creditworthy relationship borrowers. Besides providing a sharp departure from the existing notion of banks and markets as competitors for a *fixed* pool of borrowers, our analysis also generates numerous testable predictions. A key insight of our analysis is that when banks and markets evolve, the pool of borrowers is *not* static but evolves endogenously as well.

Further research could go in various directions. In particular, one direction is to explore further the dependence of optimal bank regulation on capital market evolution. Our analysis shows that the development of the market lowers the cost of bank equity and also leads banks to lend to riskier borrowers. This immediately suggests potential implications for how capital market evolution may affect prudential bank regulation but it may also have broader regulatory implications that are worth exploring formally.

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Additional Supporting Information may be found in the online version of this article:

Appendix S1. Proofs.

Please note: The RES and Wiley-Blackwell are not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the authors of the article.

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