A Theory of Banks’ Industry Expertise, Market Power, and Credit Risk

Alex Stomper

University of Vienna
Bruennerstrasse 72, 1210 Wien
Austria
Tel.: +43-1-4277-38075
Fax: +43-1-4277-38074
alexander.stomper@univie.ac.at

September 2003

This article is based on a chapter of my dissertation. I thank Josef Zechner as well as Arnoud Boot, Cyprian Bruck, Gilles Chemla, Thomas Dangl, Giovanni Dell’Ariccia, Engelbert Dockner, Helmut Elsinger, Zsuzsanna Fluck, Ron Giammarino, Michel Habib, Steven Ongena, Pegaret Pichler, Kristian Rydqvist, Jacob Sagi, Neal Stoughton, Martin Summer, Andrew Winton and Youchang Wu for their helpful comments as well as seminar participants at Boston University, the Universities of Amsterdam, British Columbia, Odense, Oxford, and Vienna, the Norwegian School of Economics and Business Administration, and the Norwegian School of Management.
A Theory of Banks’ Industry Expertise, Market Power, and Credit Risk

Abstract

I analyze banks’ incentives to acquire expertise in judging the credit-worthiness of borrowers in an industry with uncertain business conditions. The optimal industrial organization of bank lending features several banks with industry expertise, as well as a competitive fringe of banks without such expertise. The analysis provides a foundation for analyzing the relative merits of focus vs. diversification in bank lending. Furthermore, I analyze how banks’ industry expertise gives them market power, and how that affects the industry. Finally, I show that credit risk models should consider banks’ industry expertise as a determinant of correlation between credit risk factors.

JEL: G21, L13.

Keywords: bank lending, industry expertise, credit risk, diversification.
1 Introduction

Stylized facts and empirical evidence suggest that industry expertise is valuable for banks. Most visibly, many banks hire industry experts. Credit Suisse First Boston claims to have been one of the first banks to do this, in order to create “industry groups” dedicated to providing industry knowledge to the bank’s clients.\(^1\) Through industry experts, banks are also frequently represented on firms’ supervisory boards. Kroszner and Strahan (2001) analyze banks’ board representation and find that banks do a disproportionate amount of their lending to the industries of the firms in which their bankers are on boards. This suggests that board representation allows the banks to benefit from specialized industry knowledge in their lending decisions. Banks also acquire such knowledge through lending. In loans to borrowers in young industries, banks typically use loan covenants to have borrowers report on the attainment of certain cash flow or sales targets.\(^2\) To the extent that these reports capture industry-wide business conditions, the banks can assess industry-specific determinants of credit risk. Similar industry knowledge is essential for lending to borrowers in cyclical industries. In the case of construction lending, banks routinely base appraisals of borrowers’ real estate collateral on data about local market conditions.

A recent survey of banks’ internal credit-rating assignment processes by the Basel Committee for Banking Supervision illustrates the relevance of banks’ industry expertise. The Basel Committee finds that “formal industry analysis plays a significant role in assigning ratings” to banks’ borrowers, and that “such analysis is provided by internal economic analysis units [...] with the goal of [...] a common view of an industry’s outlook across all relevant borrowers”.\(^3\)

This paper analyzes banks’ industry expertise. This expertise is interpreted as a technology for assessing the credit-worthiness of borrowers in an industry the output of which is in uncertain demand. As input, such an assessment requires data that banks obtain through monitoring borrowers in the industry. Processing the data yields a noisy signal about the demand for industry output; each bank privately observes one such signal. Banks’ industry expertise is defined as the reliability of their signals.

I analyze the optimal industrial organization of bank lending to borrowers in an industry. In equilibrium, several banks decide to focus on lending to the industry; each of these banks hires industry experts and grants loans to several borrowers in the industry. Besides these

\(^1\)See http://www.csfb.com/investment_banking/industry/index.shtml.
\(^2\)For loans to mobile phone companies such covenants specify targets in terms of “subscription” numbers. I would like to thank Mike Elliff from JP Morgan, London, for this information.
\(^3\)The quotes are from a summary of the survey, titled “Range of Practice in Banks’ Internal Ratings Systems”, in the chapter “The Internal Ratings-Based Approach” of “The New Basel Capital Accord.”
banks, there is also a competitive fringe of banks without industry expertise. While these banks save the cost of hiring industry experts, they face substantial credit risk since they cannot base lending decisions on information about the demand for the industry’s output.

The number of banks with industry expertise determines how much these banks benefit from having industry experts assess the demand for industry output, in order to curtail their financing of output production if their experts predict low demand. The more such banks there are, the smaller the decrease in the expected price of industry output if demand is low since the banks effect a reduction in the supply of output in the low-demand state. However, the more the effect of low demand is offset by the supply reduction, the smaller the benefit that each bank derives from having industry experts assess demand. Since no banks would hire industry experts unless this benefit is sufficiently high, the number of banks with industry expertise must be limited.

With a certain number of banks focusing on lending to borrowers in an industry, the equilibrium deviates from traditional banking theory based on the delegated monitoring argument by Diamond (1984). According to traditional theory, the level of a bank’s lending to a particular industry depends mainly on its diversification opportunities. In this paper, that is not true; instead, the optimal level of a bank’s lending to the industry depends on (i) whether it employs industry experts, (ii) the industry expertise of other banks, and (iii) features of the industry. For a bank without industry experts, the optimal strategy is consistent with traditional theory: in equilibrium, such a bank lends to the industry at the smallest feasible level. For a bank with industry experts, the equilibrium specifies an interior optimal level of the bank’s lending to the industry, as a function of parameters characterizing the industry. In equilibrium, such a bank can recover the cost of its industry expertise. This is the case since the bank has market power in lending to borrowers who compete with each other on a common output market. The borrowers pay interest above the bank’s cost of funds in order to receive loans in spite of using the loaned funds to compete with other borrowers of the same bank. The mark-up offsets the bank’s incentive to deny a borrower credit in order not to decrease its expected payoff from lending to other borrowers (who would earn higher profits if they faced one competitor less). By

---

4While I don’t model diversification in bank lending, the smallest feasible level of bank lending to an industry can be thought of as determined by its diversification strategy.

5This argument has been presented in a simplified manner. While the details will be discussed below, I want to point out that such loan pricing may also be induced by bank regulation. In construction lending, a recommendation of the Fed (supervisory letter SR 95-16) on real estate appraisal states “The basis for determining whether an appraisal continues to be valid will vary depending upon the circumstances of the property and marketplace. Some of the factors that need to be taken into account include: the passage of time; the volatility of the local market; the inventory of competing projects; [...]” To fund competing projects, banks must thus charge developers for any reduction in the value of collateral of existing loans.
charging this mark-up to all of its borrowers in the industry, the bank actually earns a strictly positive expected profit that depends on the level of its lending to the industry. In equilibrium, this expected profit equals the cost of the bank’s industry expertise.

The equilibrium is consistent with findings of Acharya, Hasan, and Saunders (2002). I provide a theoretical foundation for these authors’ view that “the optimal industrial organization of the banking sector might be one with several focused banks”. In addition, the analysis characterizes the relation between the structure of bank lending to borrowers in an industry and the structure of the industry: the more concentrated the industry, the higher the concentration of bank lending to borrowers in the industry. This result is consistent with findings of Cetorelli (2001).

This paper is also of interest for the modelling of credit risk. Allen and Saunders (2002) point out that credit risk models tend to ignore the possibility of systematic correlation between credit risk factors such as default probabilities and banks’ expected loss rates in the event of default. The model in this paper characterizes the relation between several credit risk factors for banks’ lending to an industry, in equilibrium. The analysis highlights that not all banks are alike: a distinction must be drawn between banks with industry expertise and those without such expertise. Concerning the credit risk borne by the former banks, the analysis highlights a “peso-problem”: adverse industry-wide business conditions tend to leave these banks with high losses if they focus on lending to borrowers in an industry where they normally would incur such losses with only a small probability.

Related literature There are several strands of related theoretical literature: the literature on relationship banking, that on diversification in bank lending, and that on bank competition. Fischer (1990), Sharpe (1990), and Von Thadden (1998) analyze how banks can extract rents in lending to borrowers that are “informationally captured” since other lenders lack information about them.\(^6\) In contrast to these articles, the present paper focuses on banks’ incentives to abstain from lending to borrowers they know: by doing so, a bank can effect a reduction in the output of the industry, an increase in the price of the output, and hence an increase in its expected payoff in case its other borrowers default.

The paper also provides a foundation for analyzing diversification in bank lending.\(^7\) Hellwig (1998) shows that banks may have incentives to remain under-diversified since the downside risk of such a strategy is mainly borne by their depositors (or by deposit insur-

\(^6\)For recent reviews of the literature on relationship banking, see Ongena and Smith (2000), Boot (2000), and Degryse and Ongena (2001). Additionally, see Berger and Udell (1998) for the role of bank lending in small business financing.

\(^7\)A number of papers analyze diversification in bank lending while assuming that loan payoffs are uncorrelated. For example, see Cerasi and Daltung (2000), Winton (1997), Yosha (1997). In my paper, the correlation between loan payoffs is endogenous.
The results of the present paper suggest that under-diversification is not necessarily inefficient, unless all banks remain under-diversified; some focus is efficient for some banks. Winton (1999) shows that the benefit of diversification depends on the downside risk of bank loans and on the effect of diversification on banks’ incentives to monitor borrowers. I propose a model in which, for each bank, the downside risk of bank loans is endogenously determined by other banks’ choices of whether or not to focus on lending to an industry. As a result, banks’ optimal strategies are interdependent. With its focus on such interdependence, the present paper belongs to the literature on “industry equilibria” (see, e.g., Maksimovic and Zechner (1991)).

Finally, the paper is related to the literature on bank competition, where it complements contributions by Petersen and Rajan (1995), Boot and Thakor (2000), and Hauswald and Marquez (2000) on banks’ regional- or sector-specialization. In contrast to all of these authors, I model banks’ lending to borrowers whose payoffs are directly inter-dependent since they compete with each other on a common output market. Yosha (1995) and Cestone and White (2003) also provide analyses of the financing of firms whose payoffs are directly interdependent. In contrast to both papers, the present paper proposes an equilibrium featuring an endogenous industrial organization of bank lending.

The paper is structured as follows. In Section 2, I present the model. Section 3 contains a general analysis of the relation between banks’ industry expertise and their market power (in Sections 3.1 and 3.2), as well as the derivation of a specific equilibrium in closed form (in Section 3.3). In Section 4, extensions are presented. Section 5 concludes.

2 The Model

I present a model of banks’ financing of industrial capacity formation. The model captures to which extent banks acquire industry expertise in lending to borrowers in an industry subject to (i) borrower-specific and (ii) industry-wide risk factors.

Players and preferences: There are three groups of risk neutral players. The first group consists of entrepreneurs who may enter into one industry. There are two types of entrepreneurs: a fraction $\theta$ of them are “skilled” and the rest are “unskilled”, $\tau \in \{s,u\}$. All entrepreneurs want to invest in productive assets but they lack any monetary wealth. Thus, they rely on financing from two other groups of players, banks with and without “industry expertise”, defined below. There are sufficiently many banks and entrepreneurs that entry into the industry can drive to zero the net present value (NPV) realized by

---

entrants who borrow from banks without industry expertise. All banks seek to maximize their total value; entrepreneurs maximize their equity value.

**Entrepreneurs’ investment process:** Each entrepreneur has a two-staged investment project, depicted in Figure 1. The first stage is the investment stage. During this stage an entrepreneur makes preparations for the second stage by acquiring production capacity, manufacturing prototypes, test-marketing, etc. The second stage is the production stage during which the entrepreneur produces and markets her output.

The investment stage starts at date \( t = 0 \): each entrepreneur can invest in assets (like machines, etc.) for a fixed number of units of production capacity, \( k \). Per unit of capacity, this requires an investment of \( c \), bringing the overall investment to \( kc \). Date \( t = 1 \) is the start of the production stage. Each entrepreneur can use her production capacity to produce \( k \) units of output of one of two possible kinds: the output is marketable with probability \( q_\tau \) and worthless otherwise. The value of \( q_\tau \) depends on whether the entrepreneur is skilled or unskilled, \( \tau \in \{s, u\} \), for \( 1 \geq q_s > q_u > 0 \). At date \( t = 2 \), marketable output can be sold for a price of \( \tilde{p} \) per unit of such output,

\[
\tilde{p} = A + \tilde{\alpha} - \tilde{Q},
\]

where \( \tilde{Q} \) denotes the aggregate marketable output of all entrepreneurs. The intercept of function (1) has a stochastic part \( \tilde{\alpha} \) with two equally likely realizations: \( \alpha \in \{-a, +a\} \). \( \alpha = +a (-a) \) denotes the high-demand (low-demand) state. For the industry to be economically viable, the expected intercept must exceed the unit cost of capacity, \( A > c \), and the output of skilled entrepreneurs must be marketable with a sufficiently high probability, \( q_s > c/A \).

After an entrepreneur produces output, her fixed assets are worthless. Net of depreciation, output production thus either generates a profit of \( k(\tilde{p} - c) \) (if the entrepreneur’s output is marketable) or a loss of \( kc \) (if her output is worthless). An entrepreneur of type \( \tau \in \{s, u\} \) therefore realizes an NPV of \( k(q_\tau E[\tilde{p}] - c) \) (since her output is marketable with probability \( q_\tau \)). If this NPV is negative, no output should be produced. Instead, the entrepreneur should exit the industry and sell her fixed assets before depreciation takes place to realize a liquidation payoff of \( kc \) at date \( t = 1 \).

**Parameter restrictions:** The following parameter restrictions on \( q_u \) and \( \theta \) ensure that a bank benefits from knowing whether a borrower is skilled.

**Assumption 1:** I consider the case in which \( q_u \to 0 \): an unskilled entrepreneur’s output is marketable with a probability approaching zero.\(^9\) This implies that it is inefficient if such an entrepreneur produces output since the expected value of her output falls short of the

\(^9\)It would suffice to assume that \( q_u \) is so small that an unskilled entrepreneurs realizes a negative NPV by producing output: \( q_u < c/(A + a) \). However, less notation is required to analyze the limit \( q_u \to 0 \).
depreciation of her fixed assets during the production stage. In spite of that, an unskilled entrepreneur will want to produce output if her investment in assets is financed by a bank. While the cost of asset depreciation is borne by the bank, the entrepreneur takes the chance of a positive payoff if her output turns out marketable.

**Assumption 2:** Skilled entrepreneurs are rare: $\theta < (c/(A + a) - q_a)/(q_s - q_a)$. As a consequence, a bank will not lend to an entrepreneur of unknown type.$^{10}$

**Banks’ technologies for assessing the creditworthiness of borrowers:** To assess the creditworthiness of entrepreneurs, each bank can choose between two technologies, $T_0$ and $T_1$. While both technologies can be used to discover an entrepreneur’s type, only technology $T_1$ yields information about the industry. To obtain such information, a bank must have industry experts monitoring its borrowers throughout the investment stage. Such monitoring yields data that can be used to assess the state of demand, as will be described below. While technology $T_0$ yields no information about demand, it is less costly than technology $T_1$. With technology $T_0$, a bank incurs a cost of $kx_0$ that can be interpreted as the cost of screening an entrepreneur.$^{11}$ Such screening reveals whether an entrepreneur is unskilled; I assume that the probability of a type-II error is infinitesimal.$^{12}$ With technology $T_1$, a bank incurs a cost of $kx_I$ per borrower, for $x_I > x_0$ since the bank obtains information not only about the borrower’s type but also about the industry, as will be described below.$^{11}$ To simplify the analysis, I assume (without loss of generality) that $x_I \geq 2x_0$.$^{13}$

I refer to a bank choosing technology $T_1$ as a bank with industry expertise. For now, I assume that such a bank abstains from also using technology $T_0$ to screen entrepreneurs at date $t = 0$; this assumption will be relaxed in Section 4. Technology $T_0$ is used by banks without industry expertise. I assume that these banks can recover the cost of screening entrepreneurs since they can avoid post-screening competition with other banks in lending to entrepreneurs identified as being skilled.$^{14}$

---

$^{10}$To see this, note that by charging an interest rate of $\bar{R} = (A + a)/c - 1$, banks effectively claim their borrowers’ entire payoff of $kp \leq k(A + a) = (1 + \bar{R})kc$ if the borrowers’ output is marketable. For $c > (\theta q_s + (1 - \theta)q_u)(A + a)$, granting loans of $kc$ to borrowers of unknown type cannot be profitable even at the interest rate $\bar{R}$ since such borrowers’ output is marketable only with probability $\theta q_s + (1 - \theta)q_u$.

$^{11}$This cost is stated as a multiple of the parameter $k$ since I consider the limit of $k \rightarrow 0$ to derive closed-form solutions in Section 3.3. I abstract from the problem that fixed costs may keep banks from testing the creditworthiness of entrepreneurs.

$^{12}$Allowing for a non-infinitesimal probability of a type-II error would complicate the analysis without changing the qualitative results.

$^{13}$This assumption simplifies the analysis as will be shown in the proof of Proposition 1. It implies that in equilibrium, a bank would refuse to refinance any of its borrowers if its industry experts predict low demand. For $x_0 < x_I < 2x_0$, a bank’s information about demand would have a smaller effect on its financing of output production, but this changes none of the qualitative results of my analysis.

$^{14}$Gehrig (1998) shows how such competition can be avoided: each of the banks must commit to match any offers that its prospective borrowers receive from other banks. If all banks enter into such commitments,
Banks’ industry expertise: Corresponding to the Basel Committee’s statement cited in the Introduction, I model how banks form their “view of an industry’s outlook across all relevant borrowers.” The banks need industry experts and data. For each bank, the extent of its financing of industrial capacity formation at date \( t = 0 \) determines how much data is available to its industry experts, if they monitor the bank’s borrowers during the investment stage. Access to such data enables the industry experts to test hypotheses about the state of demand, \( \hat{\alpha} \), and hence about the price \( \hat{p} \).

Suppose that there are \( b \) banks with industry expertise, labelled 1, ..., \( b \). Consider bank \( i \in \{1, \ldots, b\} \). Suppose that, at date \( t = 0 \), this bank finances \( n_i/k \) borrowers’ investments in fixed assets for a total production capacity of \( n_i \) units of output. Then, the bank incurs a cost of \( n_i x_I \) when its industry experts monitor the borrowers during the investment stage. At date \( t = 1 \), the bank obtains two pieces of information. First, it observes the type of each of the borrowers: I assume that a fixed fraction \( \theta \) of the borrowers turn out to be skilled. Second, bank \( i \) observes a noisy signal \( \hat{\iota}_i \) with realization \( \iota_i \in \{0, 1\} \) that captures what state of demand is predicted by its industry experts. Bank \( i \)’s posterior is given by:

\[
\rho[n_i] = \text{Prob}[\alpha = + a | \iota_i = 1, n_i] = \text{Prob}[\alpha = - a | \iota_i = 0, n_i],
\]

where \( \rho[n_i] \) is a concave function: \( \rho'[n_i] > 0, \rho''[n_i] < 0, \) and \( 1 > \rho[n_i] \geq 0.5 \). This function captures the probability with which bank \( i \)’s industry experts correctly predict the state of demand. I refer to this probability as bank \( i \)’s level of industry expertise.

I assume that the signals \( \hat{\iota}_i \) and \( \hat{\iota}_j \) of any two banks \( i, j \in \{1, \ldots, b\} \) are independently distributed conditional on the demand realization \( \alpha \). In practical terms, this requires that there be no overlap between any two banks’ data about their borrowers since no two banks share one borrower. This assumption is maintained throughout the analysis.¹⁶

Informational assumptions and contractual incompleteness: For each bank with industry expertise, \( i \in \{1, \ldots, b\} \), the number and identity of its borrowers, its level of industry expertise \( \rho[n_i] \), and the realization of its signal, \( \iota_i \), are private information.¹⁷ If such a bank decides to (re-)finance a borrower, no other player observes this decision.

¹⁵Saying that a fixed fraction of the borrowers are skilled is a “law of large numbers” assumption.
¹⁶This assumption conforms with findings of Elsas and Krahnen (1998) who report that “information intensive” business relationships between banks and firms “crowd out” firms’ business with other banks. Further, Mester, Nakamura, and Renault (2001) find a “definite correlation between the completeness of [a bank’s] data [on a firm] and whether the bank serves as the firm’s exclusive bank.”
¹⁷While banks publicize that they employ industry experts, the level of banks’ expertise depends on their involvement in unobservable business relationships with borrowers in the industry.
Each entrepreneur’s investments and production of output can be observed only by her bank. However, it is publicly observable which entrepreneurs try to market their output, whether the output is marketable, and what price $\tilde{p}$ is being paid for it. All publicly observable events can be contracted upon. Since this paper is about bank lending, I focus on debt financing of entrepreneurs’ investments. To benefit from private information about demand, a bank with industry expertise must provide its borrowers with staged financing. As in Sharpe (1990), it is impossible at date $t = 0$ to write contracts specifying the interest rate at which entrepreneurs can borrow from a bank with industry expertise at date $t = 1$.

Banks’ financing of entrepreneurs’ investments:

$t=0$ The financing of industrial capacity formation: Borrowers of banks with industry expertise receive “first period loans” to be repaid at date $t = 1$; borrowers of banks without such expertise receive loans to be repaid at date $t = 2$.

$t=1$ The refinancing of borrowers of banks with industry expertise:

(i) Each bank with industry expertise, $i \in \{1, \ldots, b\}$, observes which of its borrowers are of the skilled type. Moreover, bank $i$ observes a noisy signal $\tilde{\iota}_i$ of the demand for and, hence, the expected price of borrowers’ marketable output, $E[\tilde{p}|\tilde{\iota}_i]$.

(ii) The borrowers of each bank $i \in \{1, \ldots, b\}$ must repay their first period loans. To this end, they must either liquidate their fixed assets or try to obtain refinancing. Bank $i$ negotiates with its borrowers about the terms of refinancing, i.e. the interest rate of “second period loans” to be repaid at date $t = 2$. If these negotiations fail, a borrower can only avoid liquidation if she receives financing from another bank. Each of bank $i$’s borrowers can contact one other bank in order to ask for financing.\textsuperscript{18} I assume that such a bank will not provide financing to the borrower without first screening her in order to observe her type $\tau \in \{s, u\}$\textsuperscript{19}. Thereby, the bank will also discover that it is dealing with a former borrower of another bank, and that this bank is one with industry expertise, namely bank $i$.

$t=2$ Entrepreneurs in possession of fixed assets produce $k$ units of output. If an entrepreneur’s output is marketable, she pays $k \min[\tilde{p}, c(1 + r)]$ to her bank, where $r$ denotes the interest rate charged by the bank. Net of this payment, the entrepreneur receives a payoff of $k \max[\tilde{p} - c(1 + r), 0]$. If the output is worthless, the entrepreneur and her bank both receive nothing.

Overview: I will analyze the model recursively, starting with date $t = 1$. In Section 3.1, I will show how banks with industry expertise benefit from an “informational capture” of their borrowers. This analysis complements that by Von Thadden (1998) of how banks’ rents depend on their bargaining power as well as their borrowers’ “outside option” in bargaining, i.e. to stop bargaining and to borrow from another bank. In the present paper, banks’ industry expertise is associated with market power, enabling them to extract rents

\textsuperscript{18}The results generalize to the case in which the borrower can contact more than one other bank if her negotiations with bank $i$ fail.

\textsuperscript{19}This is a consequence of Assumptions 1 and 2 and the assumption that banks cannot free-ride on each other’s screening efforts since no bank can freely observe the lending decisions of another bank.
even if they lack any bargaining power. This is the case since, at date \( t = 1 \), a number of borrowers rely on each of the banks \( 1, \ldots, b \) for refinancing. The borrowers anticipate that the bank takes into account how its decisions affect the price \( \hat{p} \). As more of the borrowers receive refinancing, more marketable output is produced, the price of such output decreases, and so does the bank’s expected payoff if the borrowers default. As will be shown in Section 3.1, this implies that the bank is reluctant to refinance borrowers unless this is sufficiently profitable. To overcome the bank’s reluctance, its borrowers request refinancing at a “hurdle rate” of interest that exceeds the bank’s cost of funds. As a result, the bank earns rents, even if it lacks any bargaining power.

I focus on market power as the only determinant of any rents that banks earn in refinancing borrowers at date \( t = 1 \). In Section 3.2, I analyze the expected profit of banks with industry expertise in an equilibrium in which some banks have industry expertise while other banks lack such expertise. The equilibrium will be defined below; it is characterized by three variables: (i) \( b \) denotes the number of banks with industry expertise, (ii) \( n^* \) denotes the aggregate production capacity of the borrowers of each such bank at date \( t = 0 \), and (iii) \( N^* \) denotes the aggregate production capacity of the borrowers of all banks without industry expertise. At date \( t = 1 \), each bank with industry expertise will refinance skilled borrowers if and only if its signal indicates high demand. Receiving such refinancing allows these borrowers to produce output. In exchange, they pay an interest rate of \( r^* \) if they can repay their loans since their output can be sold for a price of at least \( c(1 + r^*) \).

In equilibrium, the price of marketable output \( \hat{p} \) will take one of a finite number of realizations in a “price grid” \( \mathcal{P} \). This price grid is defined as the set of all possible realizations of \( \hat{p} \), given by the inverse demand function (1) for all possible combinations of realizations of \( \hat{\alpha} \) and the signals of banks with industry expertise (which determine the banks’ financing of output production). The “gaps” between adjacent prices in \( \mathcal{P} \) imply that, by producing output, an entrepreneur will typically not affect the probability \( \text{Prob}[\hat{p} < c(1 + r^*)] \) with which she and other entrepreneurs default since they receive too small a price for marketable output to repay their loans at date \( t = 2 \). While the prices in \( \mathcal{P} \) will decrease in proportion to the entrepreneur’s production capacity \( k \), this effect typically is small relative to the difference between adjacent prices in \( \mathcal{P} \) which is proportional to the aggregate production capacity of all skilled borrowers of a bank with industry expertise. Figure 2 depicts this: while the price grid \( \mathcal{P} \) shifts to \( \mathcal{P}' \), there is no change in the default probability, \( \text{Prob}[\hat{p} < c(1 + r^*)|\mathcal{P}] = \text{Prob}[\hat{p} < c(1 + r^*)|\mathcal{P}'] \). This case is the subject of the analysis below: I focus on equilibria in which the production of output by a single entrepreneur has no effect on the probability of default. Such equilibria exist for any parameterization of the model with \( k \) being sufficiently small; for \( k \to 0 \), there are no other equilibria.
3 Banks’ Industry Expertise and Market Power

3.1 The Refinancing of Borrowers of Banks with Industry Expertise

In this section, I focus on the continuation game starting at date \( t = 1 \): I define and characterize the equilibrium of this game. It suffices to consider a representative bank with industry expertise, \( i \in \{1, \ldots, b\} \). At date \( t = 0 \), this bank has financed borrowers’ investments in fixed assets for \( n \) units of production capacity. At date \( t = 1 \), the bank observes each borrower’s type as well as the signal \( \iota_i \), and decides whether to refinance its borrowers. I will show below that the borrowers cannot obtain financing from another bank. This is the case since banks face a winner’s curse in lending to former borrowers of a bank with industry expertise, like bank \( i \). Hence, any borrower of bank \( i \) relies on this bank refinancing her at date \( t = 1 \) and bank \( i \) does not grant loans to borrowers other than those who have been borrowing from this bank at date \( t = 0 \).

As discussed in Section 2, I assume that bank \( i \) has no bargaining power: it can merely decide whether to refinance a borrower at a certain interest rate \( r \) that is specified by the borrower in a request for refinancing she sends to bank \( i \).\(^{20}\) Figure 3 depicts the interaction between bank \( i \) and one of its borrowers in extensive form. If bank \( i \) refuses to refinance her, the borrower may try to obtain financing from another bank, labelled \( j \). For now, I focus on the case in which bank \( j \) has industry expertise at the same level (of \( \rho[\eta] \)) as bank \( i \) since both banks finance industrial capacity formation at the same level \( n \) at date \( t = 0 \).\(^{21}\) The borrower moves at nodes marked by a black circle; bank \( i \) and bank \( j \) move at nodes marked by a black square and a white square, respectively. Nodes of the same information set are connected by dashed lines. Each bank has private information about the realization of its signal. In contrast to bank \( j \), bank \( i \) knows the borrower’s type \( \tau \in \{s, u\} \).

Before I can define the equilibrium, I have to introduce some notation for the players’ beliefs and their payoffs. I start with bank \( j \). This bank may receive information about bank \( i \)’s signal \( \iota_i \) if one of bank \( i \)’s borrowers contacts bank \( j \) to obtain financing after bank \( i \) has refused to refinance her. To see this, suppose that bank \( j \) screens the borrower and discovers (i) that she is a former borrower of another bank with industry expertise, namely bank \( i \), and (ii) that this bank has refused to refinance the borrower even though she is skilled, \( \tau = s \). This suggests that bank \( i \)’s industry experts have recommended

\(^{20}\) Giving banks bargaining power would not change the comparative statics of the equilibrium derived below.

\(^{21}\) This case is the relevant one if there exists a unique optimal level of industry expertise for each bank which acquires such expertise. This is the case in the equilibrium of the overall game which starts at date \( t = 0 \) and includes the game in Figure 3 as a continuation game. (See Proposition 6.)
that the bank curtail the volume of its lending to the industry, perhaps since they expect low demand, \( \kappa_1 = 0 \). In Figure 3, bank \( i \)'s lending decision is denoted as \( L \in \{ R, A \} \), i.e. whether the bank Accepts the borrower’s request for refinancing, \( L = A \), or Rejects it, \( L = R \). To characterize the information content of this decision, suppose that bank \( i \) accepts the borrower’s request with the probability \( \lambda_i^r [r] = \text{Prob}[ L = A | r, \kappa_1, \tau] \). Based on this move probability, I can define bank \( j \)'s posterior belief about bank \( i \)'s signal \( \kappa_1 \) if bank \( j \) discovers (through screening) that bank \( i \) has refused to refinance the borrower even though she is skilled. This posterior is denoted as \( \mu_{j1}^i = \text{Prob}[ \kappa_1 = 1 | L = R, \kappa_j, \tau = s] \). The value of \( \mu_{j1}^i \) determines bank \( j \)'s expected profit from lending to the borrower, and hence whether it can recover the cost of screening. In Figure 3, bank \( j \)'s screening decision is denoted as \( Z \in \{ S, N \} \), characterized by the probability \( \varsigma_{js}^\hat{r} = \text{Prob}[ Z = S | \hat{r}, \kappa_j] \) with which the bank Screens the borrower, \( Z = S \). Thereby, \( \hat{r} \) denotes the interest rate that bank \( j \) would earn in lending to the borrower. This interest rate determines the bank’s expected profit from such a loan:

\[
\pi_{j1}^i [\hat{r}] = \mu_{j1}^i \pi_{s1}^{1,ij} [\hat{r}] + (1 - \mu_{j1}^i) \pi_{s0}^{0,ij} [\hat{r}],
\]

(3)

where \( \pi_{s1}^{1,ij} [\hat{r}] \) denotes the bank’s expected profit for \( \kappa_1 \in \{ 0, 1 \} \), given by the difference between the bank’s expected payoff and the borrower’s financing need, \( k \kappa_1^c \):

\[
\pi_{s1}^{1,ij} [\hat{r}] = q_s k \mathbb{E}[\min[\tilde{p}, c(1 + \hat{r})] | \kappa_1, \kappa_j] - k \kappa_1^c.
\]

(4)

In forming its posterior belief about bank \( i \)'s signal \( \kappa_1 \), bank \( j \) must take into account that a number of borrowers come to bank \( i \) to obtain refinancing. In this situation, the bank may reject a skilled borrower’s request for refinancing irrespective of the signal realization \( \kappa_1 \) since it is reluctant to lend to a competitor of its other borrowers. To see this, note that bank \( i \)'s expected profit function consists of two parts. The first is the bank’s direct expected profit from refinancing the specific borrower considered in Figure 3. Taken on its own, the bank’s second period loan to the borrower yields the expected profit

\[
\bar{\pi}_1^i [r] = \eta_1^{ij} \pi_{1}^{1,ij} [r] + (1 - \eta_1^{ij}) \pi_{0}^{0,ij} [r],
\]

(5)

for \( \eta_1^{ij} = \text{Prob}[ \kappa_j = 1 | \kappa_1] \) and \( \pi_{1}^{1,ij} [r] = q_s k \mathbb{E}[\min[\tilde{p}, c(1 + r)] | \kappa_1, \kappa_j] - k \kappa_1^c \).

The second component of bank \( i \)'s profit function captures its expected profit from any second period loans to borrowers other than the one considered in Figure 3. The bank’s decision to refinance this particular borrower indirectly affects its expected profit from these other loans. This happens since the bank effectively enables the borrower to produce output, contributing \( q_r k \) units to the expected marketable output of the industry while
reducing the expected price $E[\tilde{p}_i t_i]$ by a similar amount. Bank $i$ “internalizes” some of this price decrease if it refinances other borrowers. To see this, suppose that the other borrowers default at date $t = 2$ after producing $\delta^o[n]$ units of marketable output. Then, a price drop of $q_r k$ reduces bank $i$’s default payoff by $\delta^o[n]q_r k$ since this default payoff equals what is being paid for marketable output of the borrowers. For a probability of default denoted as $\delta_\tau \tau [n]$, this leaves bank $i$ with an expected profit reduction of $\delta_\tau \tau [n] \delta^o[n]q_r k$.\footnote{The function $\delta^o[n]$ will be defined below. It captures how the borrowers’ output depends on bank $i$’s financing of industrial capacity formation at date $t = 0$, and its refinancing of borrowers if it observes the signal $t_i$.}

Figure 3 captures this effect for the case in which the borrower is skilled, $\tau = s$. To see this, consider any combination of $t_i, t_j \in \{0, 1\}$. For $\tau = s$, the path of play reaches one of the terminal nodes $[A. t_i t_j] - [C. t_i t_j]$; Table 1 states bank $i$’s expected profit in each case. Suppose that bank $i$ rejects the borrower’s request for refinancing, $L = R$. If bank $j$ also refuses to lend to the borrower (node $[C. t_i t_j]$), then bank $i$’s expected profit differs by $\delta^o[n] \delta_\tau \tau [n] q_s k - \tilde{\pi}^o \tau [r]$ from the case in which it refinances the borrower (node $[A. t_i t_j]$). This is the case since bank $i$ earns a higher expected profit by refinancing other borrowers: this expected profit increases from some base-level, denoted as $\Pi^i \tau [n]$ to $\Pi^i \tau [n] + \delta^o[n] \delta_\tau \tau [n] q_s k$. Besides these two cases, there is also a third one in which bank $i$ rejects the borrower’s request for refinancing, $L = R$, while bank $j$ grants her a loan (node $[B. t_i t_j]$). In this case, bank $i$ earns just an expected profit of $\Pi^i \tau [n]$.

I can now define bank $i$’s overall expected profit as of date $t = 1$. If the bank refinances a borrower of type $\tau$ with probability $\lambda^i [r] = \lambda$, its overall expected profit is given by,\footnote{While bank $i$’s refinancing an unskilled borrower would also affect its expected payoff from refinancing other borrowers, this effect is infinitesimally small since an unskilled borrower’s output is marketable with probability $q_u \rightarrow 0$, as stated in Assumption 1. Hence, some of the expressions in Table 1 can be (and are) simplified by assuming that $q_u = 0$; the qualitative results of my analysis continue to hold as long as $q_u$ is sufficiently small that an unskilled borrower realizes a negative NPV by producing output: $q_u < c/(A + a)$.} \footnote{This expression follows from Figures 3 and 1. To obtain the expression in the first line, I have to compute a weighted average of bank $i$’s expected profit for $\tau = s$ across the cases of $t_j = 0$ and $t_j = 1$. Rows $[A. t_i t_j] - [C. t_i t_j]$ state expressions for this expected profit for each possible path of play and some combination of $t_i$ and $t_j$. These expressions must be weighted by (i) the probability of each path of play stated in column (2) of Table 1, and (ii) the probability of $t_j = 0$ and $t_j = 1$ given by $(1 - \eta^i)$ and $\eta^i = \text{Prob}[t_j = 1 | \eta^i]$, respectively. A similar derivation yields the expression for $\tau = u$, based on the expressions stated in rows $[D. t_i t_j] - [F. t_i t_j]$ of Table 1.}

$$\begin{align*}
\Omega^i[n, r] & = \begin{cases} 
\tilde{\Pi}^i [n] + \lambda \tilde{\pi}^o \tau [r] + (1 - \lambda) \tilde{\pi}^o \tau [n] & \text{for } \tau = s, \\
\tilde{\Pi}^i [n] + \lambda \tilde{\pi}^o \tau [r] & \text{for } \tau = u,
\end{cases}
\end{align*}$$

(6)

for $\tilde{\Pi}^i [n] = \eta^i \Pi^{i, 1}[n] + (1 - \eta^i) \Pi^{i, 0}[n]$, $\tilde{\pi}^o \tau [r]$ given by expression (5), and

$$\tilde{\pi}^o \tau [n] = (\eta^i(1 - \zeta^i [\tilde{r}]) \delta^o \tau \tau [n] + (1 - \eta^i) (1 - \zeta^0 [\tilde{r}]) \delta^o \tau \tau [n]) o^o \tau [n] q_s k.$$

(7)
The term $\tilde{\pi}_i^{[n]}$ captures bank $i$’s incentive to abstain from refinancing a skilled borrower in order to make her exit the industry. As it has been discussed above, such a borrower’s exit would raise bank $i$’s expected payoff from refinancing other borrowers. I will show below that bank $i$ will therefore only refinance the borrower if this is sufficiently profitable: the bank’s direct expected profit $\tilde{\pi}_i^{[r]}$ must exceed the hurdle level $\tilde{\pi}_i^{[n]}$ which equals the reduction in bank $i$’s expected profit from refinancing other borrowers.

Bank $j$’s expected profit can be derived in a similar way. Table 1 states the bank’s expected profit for any combination of $\tau \in \{s, u\}$ and $\iota_i, \iota_j \in \{0, 1\}$. Bank $j$ cannot observe the type $\tau$ of the borrower considered in Figure 3 unless the bank incurs the cost of screening the borrower, $kx_0$. In this case, bank $j$ also observes that it is dealing with a former borrower of bank $i$. Let $\vartheta^{j\iota}$ denote the probability with which bank $j$ can expect to find a skilled entrepreneur who has been denied refinancing by a bank with industry expertise, like bank $i$.\(^{26}\) Then, bank $j$’s expected profit equals:\(^{27}\)

$$
\hat{\Omega}^{j}[n, \hat{r}] = E[\hat{\Pi}^{[s\iota_j]}[n]|\iota_j] + \varsigma (\vartheta^{j\iota} \tilde{\pi}_i^{[\hat{r}]} - kx_0) + (1 - \varsigma) \vartheta^{j\iota} \tilde{\pi}_i^{[n]},
$$

where $\varsigma$ is some value of the move probability $\varsigma^{j\iota}[\hat{r}]$, $E[\hat{\Pi}^{[s\iota_j]}[n]|\iota_j]$ is bank $j$’s expected profit from lending to other borrowers in the industry, and $\tilde{\pi}_i^{[n]}$ denotes the reduction in this expected profit if these borrowers face an additional competitor. This expected payoff reduction comes about in a similar way as it has been described above for bank $i$. It is given by:

$$
\tilde{\pi}_i^{[n]} = (\mu^{j\iota} \delta^{1\iota_j}[n] + (1 - \mu^{j\iota}) \delta^{0\iota_j}[n]) \delta^{j\iota}[n] q_s k,
$$

where $\delta^{j\iota}[n]$ denotes the expected marketable output of bank $j$’s borrowers.

Before I can define the equilibrium, I also need to introduce notation for the expected payoff of the borrower considered in Figure 3 if she obtains (re-)financing and produces output. For any combination of the signals $\iota_i$ and $\iota_j$, this expected payoff is given by:

$$
u_\iota^{[s\iota_j]}[r] = q_r k E[\max[\hat{p} - c(1 + r), 0]|\iota_i, \iota_j],
$$

---

\(^{26}\)Any difference $\theta - \vartheta^{j\iota} > 0$ is due to adverse selection resulting from banks refusing to refinance unskilled borrowers. (Recall that $\theta$ denotes the fraction of entrepreneurs who are skilled, $\tau = s$.)

\(^{27}\)This expected profit function follows from Figure 3 and Table 1 as a weighted average of bank $j$’s expected profit across the four cases corresponding all possible combinations of $\tau \in \{s, u\}$ and $\iota_i \in \{0, 1\}$. Given $\iota_i \in \{0, 1\}$, bank $j$’s conditional expected profit is a weighted average of the expressions stated in rows $B_{\iota_i, \iota_j}$, $C_{\iota_i, \iota_j}$, $E_{\iota_i, \iota_j}$ and $F_{\iota_i, \iota_j}$ (since bank $j$ only gets to move for the paths of play corresponding to these rows). The expression in row $[B.]$ receives a weight equal to the product of the probability $\varsigma$ with which bank $j$ screens the borrower and the probability $\vartheta^{j\iota}$, the expression in row $[C._\iota_i, \iota_j]$ receives a weight of $(1 - \varsigma)\vartheta^{j\iota}$, the expression in row $[E_{\iota_i, \iota_j}]$ receives a weight of $\varsigma(1 - \vartheta^{j\iota})$, and the expression in row $[F_{\iota_i, \iota_j}]$ receives a weight of $(1 - \varsigma)(1 - \vartheta^{j\iota})$. This yields bank $j$’s conditional expected profit given $\iota_i \in \{0, 1\}$: $\hat{\Omega}^{j}[n, \hat{r}]_{\iota_i} = \hat{\Pi}^{[s\iota_j]}[n] + \varsigma (\vartheta^{j\iota} \tilde{\pi}_i^{[\hat{r}]} - kx_0) + (1 - \varsigma) \vartheta^{j\iota} \tilde{\pi}_i^{[n]} q_s k$. Expression (8) for bank $j$’s unconditional expected profit follows for $\tilde{\pi}_i^{[\hat{r}]}$ and $\tilde{\pi}_i^{[n]}$ as defined in (3) and (9), respectively.
where $r$ denotes the interest rate at which the borrower obtains (re-)financing at date $t = 1$.

**Equilibrium of the continuation game starting at date** $t = 1$: The equilibrium consists of (i) the strategy of a representative bank $i$ with industry expertise, $(\lambda^i_r[r], u_{i,s}), u_{i,u} \in \{0,1\}, r \in \{s,u\}$, (ii) the strategy of a representative rival bank $j$ with industry expertise, $(\hat{\rho}^{i j}, \mu^{i j})_{j \in \{0,1\}}$, (iii) the strategy of a representative borrower of bank $i$, $(r_\tau)_\tau \in \{s,u\}$, and (iv) consistent beliefs of the rival bank $j$, $(\hat{\vartheta}^{i j}, \mu^{i j})_{j \in \{0,1\}}, 28$ such that for any $t_i, t_j \in \{0,1\}$ and $\tau \in \{s,u\}$,

\[
\begin{align*}
  r_s & \in \arg \max_r \sum_{(t_i,t_j) \in \{0,1\} \times \{0,1\}} \text{Prob}[(t_i,t_j)](\lambda^{i s}_u[r]v^{i s}_{t_i t_j}[r] + (1 - \lambda^{i u}_s[r])\hat{\vartheta}^{i j} u_{i,s}[\hat{r}]) \quad (I.s) \\
  r_u & \in \arg \max_r \sum_{(t_i,t_j) \in \{0,1\} \times \{0,1\}} \text{Prob}[(t_i,t_j)](\lambda^{i u}_u[r]v^{i u}_{u t_j}[r]) \quad (I.u) \\
  \lambda^{i s}_u[r] & \in \arg \max \lambda \Omega^{i s}[n, r], \quad (II.\tau, \tau) \\
  \hat{\vartheta}^{i j}[\hat{r}] & \in \arg \max \hat{\vartheta} \tilde{\Omega}^{i j}[n, \hat{r}]. \quad (III.\tau_j)
\end{align*}
\]

Conditions (I.s) - (III.\tau_j) specify how the players move to maximize their expected profit. Conditions (II.\tau, \tau) and (III.\tau_j) follow directly from the discussion above and from the definitions (6) and (8) of $\Omega^{i s}[n, r]$ and $\tilde{\Omega}^{i j}[n, \hat{r}]$, respectively. Conditions (I.s) and (I.u) determine the interest rate specified by a borrower of bank $i$ in her request for refinancing if the borrower is skilled and unskilled, respectively. In each case, the borrower seeks to maximize her expected payoff. For $\tau = s$, this expected payoff equals the sum of (i) the borrower’s expected payoff if bank $i$ accepts her request for refinancing, $v^{i s}_{t_i t_j}[r]$, weighted by the acceptance probability $\lambda^{i s}_u[r]$, and (ii) her expected payoff if she receives a loan from bank $j$, $\hat{\vartheta}^{i j}[\hat{r}]$, weighted by the probability with which this happens.29 For $\tau = u$, the borrower’s expected payoff equals zero if bank $i$ reject’s her request for refinancing: the borrower never receives a loan from bank $j$ since the bank discovers that $\tau = u$ if it screens the borrower.

To derive the equilibrium, I start with condition (III.\tau_j). Differentiating expression (8) with respect to $\zeta$ shows that the following move probability is optimal for bank $j$:

\[
\zeta^{i j}[\hat{r}] = \begin{cases} 
1 & \text{if } \hat{\vartheta}^{i j}[\hat{r}] > \frac{\hat{k}^{i j}}{\hat{\mu}^{i j}} + \hat{\vartheta}^{i j}[n], \\
\zeta & \text{if } \hat{\vartheta}^{i j}[\hat{r}] = \frac{\hat{k}^{i j}}{\hat{\mu}^{i j}} + \hat{\vartheta}^{i j}[n], \\
0 & \text{otherwise}.
\end{cases}
\]

28These beliefs are consistent if they satisfy Bayes’s rule. I will show below that rejecting a borrower’s offer is never an out-of-equilibrium-move of bank $i$, irrespective of both the interest rate $r$ at which the borrower requests refinancing, and the borrower’s type $\tau$: since $L = R$ with a strictly positive probability, Bayes’s rule can always be used.

29This probability is the product of the probability $(1 - \lambda^{i s}_u[r])$ with which bank $i$ rejects the borrower’s request for refinancing, $L = R$, and the probability $\zeta^{i j}[\hat{r}]$ with which bank $j$ screens the borrower, and hence detects that she is skilled.
Intuitively speaking, bank \( j \) should not incur the cost of screening unless it can realize a sufficiently high expected profit by lending to a skilled entrepreneur whose request for refinancing has been rejected by another bank with industry expertise. Weighted by the probability \( \vartheta_{ij} \) with which bank \( j \) can expect to find such an entrepreneur, its expected profit \( \tilde{\pi}_{ij}^*[\hat{r}] \) must exceed the sum of (i) the cost of screening, \( kx_0 \), and (ii) the reduction in its expected payoff from lending to other borrowers in the industry.

Next, I consider bank \( i \)'s decision whether or not to grant a borrower’s request for a second-period loan at an interest rate of \( r \). The optimal decision is characterized by the move probability \( \lambda^i_\tau[r] \) which maximizes bank \( i \)'s expected profit \( \Omega^i_{\tau}|n,r \), given by expression (6). Differentiating this expression with respect to \( \lambda \) shows that rejecting the borrower’s request is optimal if she is unskilled, \( \tau = u \), since Assumption 1 implies that \( \bar{\pi}^i_u[r] < 0 \) for any \( r \) and \( \iota_i \in \{0,1\} \). If the borrower is skilled, \( \tau = s \), bank \( i \)'s decision whether to refinance her depends on its incentive to make the borrower exit the industry in order to prevent that its other borrowers face an additional competitor. Differentiating expression (6) shows that the bank should reject the borrower’s request for refinancing unless it would be sufficiently profitable to refinance her:

\[
\lambda^i_\tau[r] = \begin{cases} 
1 & \text{for } \tau = s \text{ and } \bar{\pi}^i_s[r] > \bar{\pi}^i_u[n], \\
\lambda \in [0,1] & \text{for } \tau = s \text{ and } \bar{\pi}^i_s[r] = \bar{\pi}^i_u[n], \\
0 & \text{otherwise.}
\end{cases}
\] (12)

In the remainder of this section, it suffices to consider the case in which banks \( i \) and \( j \) can only expect to profit from financing a borrower’s production of output if the banks have positive private information about the demand for (marketable) output of the industry. As will be shown in the proof of Proposition 1, this case is the relevant one in the equilibrium of the game which starts at date \( t = 0 \) and includes the game in Figure 3 as a continuation game.\(^{30}\) In this equilibrium, some banks finance borrowers’ production of output even though these banks lack industry expertise, and hence fail to adapt their financing of output production to the state of demand. As a consequence, bank \( i \) should not refinance its borrowers if its industry experts predict demand to be low: \( \lambda^i_\tau[r] = 0 \) for any \( r \) and \( \tau \in \{s,u\} \) if \( \iota_i = 0 \). This would not be profitable for the bank since it would be likely that its borrowers produce output in the low-demand state, adding to an over-supply of output by borrowers of banks without industry expertise.

A similar result can be obtained for bank \( j \). To see this, recall that bank \( j \) cannot recover the cost of screening, \( kx_0 \), unless it earns a sufficiently high expected profit \( \tilde{\pi}_{ij}^*[\hat{r}] \) by lending to a skilled entrepreneur whose request for refinancing has been rejected by

\(^{30}\)This equilibrium is the subject of Sections 3.2 and 3.3.
another bank with industry expertise, like bank $i$:

$$
\hat{\pi}^i_{s'}[\hat{r}] \geq \frac{kx_0}{\vartheta^i}.
$$

(13)

I will argue below that the above inequality can only hold (for some value of $\hat{r}$) if there is a strictly positive probability with which bank $j$ gets to move at its node for $\iota_i = \iota_j = 1$ and $\tau = s$ in Figure 3. Again, this is due to the game in Figure 3 being part of a larger game in which some entrepreneurs receive financing from banks without industry expertise. In equilibrium, these banks finance production of output by sufficiently many skilled entrepreneurs that such entrepreneurs realize an NPV of $kx_0/\vartheta$, given any information that is publicly available at $t = 0$.\(^{31}\) Unless bank $j$ has positive private information about demand, this NPV represents an upper bound on its expected profit from lending to a skilled entrepreneur at date $t = 1$. For condition (13) to hold, two conditions must therefore be satisfied:\(^{32}\) (i) bank $j$ must observe the high-demand signal, $\iota_j = 1$, and (ii) the positive information contained in this signal must not be fully “offset” by bank $j$’s belief about bank $i$’s signal $\iota_i$ if it discovers that bank $i$ has refused to refinance a skilled borrower: $\mu^i_s = \text{Prob}[\iota_i = 1 | L = R, \iota_j, \tau = s] > 0$. In short, there must be a positive probability that bank $j$ gets to move when $\iota_j = \iota_i = 1$ and $\tau = s$.

It remains to consider the optimal strategies of banks $i$ and $j$ if their industry experts predict high demand, i.e. $\iota_i = 1$ and $\iota_j = 1$, respectively. I will show that a borrower of bank $i$ never receives financing from bank $j$. This result is obtained since bank $j$ faces a winner’s curse in lending to a former borrower of a bank with industry expertise, like bank $i$. Bank $j$ expects that a skilled borrower of bank $i$ would not try to switch banks unless bank $i$ refuses to refinance her. This is the case since such an entrepreneur cannot expect that bank $j$ charges her a smaller interest rate than that for which she can obtain refinancing from bank $i$ if the bank’s industry experts predict high demand, $\iota_i = 1$. To see this, notice that the optimal strategies (12) and (11) of banks $i$ and $j$ resemble each other in that neither bank will lend to a borrower of bank $i$ unless this is sufficiently profitable. However, I will show in Proposition 1 that bank $i$’s expected profit must exceed a smaller hurdle than that of bank $j$: $\pi^i_{s'}[n] < \hat{\pi}^i_{s'}[n]$ for $\iota_i = \iota_j = 1$ since bank $j$ is more reluctant to lend to a borrower of bank $i$ than bank $i$ itself. For bank $j$, such a loan would come on top of any other loans it grants to refinance borrowers who have been borrowing from the bank at date $t = 0$. Under the assumption that banks $i$ and $j$ have the same number

\(^{31}\)See equilibrium condition (16) in Section 3.2.1.

\(^{32}\)Besides these conditions, inequality (13) could also be satisfied if $\vartheta^i$ were sufficiently higher than $\vartheta$, the parameter that captures the incidence of skilled entrepreneurs. This is impossible since bank $j$ faces adverse selection in screening entrepreneurs whose requests for refinancing may have been rejected by other banks because the entrepreneurs are unskilled: $\vartheta^j \leq \vartheta$.  

16
of borrowers at \( t = 0 \), bank \( j \) would end up with more borrowers than bank \( i \) if one of bank \( i \)'s borrowers switched banks at date \( t = 1 \). In the output market of the industry such a borrower would therefore compete against more other borrowers of bank \( j \) than of bank \( i \). As a consequence, bank \( j \) would not lend to a former of borrower of bank \( i \) unless its expected profit exceeds a hurdle level higher than the minimum profit that bank \( i \) must earn to refinance the borrower. All else equal, this is only possible if bank \( j \) earns an interest rate \( \hat{r} \) that is higher than the smallest interest rate for which bank \( i \) would refinance a skilled borrower if its industry experts predict high demand.

However, all else is not equal. Instead, banks \( i \) and \( j \) would hold different beliefs about the state of demand if bank \( j \) discovered that bank \( i \) has refused to refinance a skilled borrower. This is the case since bank \( j \) would receive negative information about bank \( i \)'s signal \( \iota_i \). As will be shown in the proof of Proposition 1, bank \( j \) would never assign a higher probability to the event that bank \( i \) has observed the high demand signal than vice versa: for \( \iota_j = 1 \), bank \( j \)'s posterior \( \mu_j \) = \text{Prob}[\iota_i = 1|L = R, \iota_j = 1, \tau = s] \) would always be smaller than \( \eta_i \) = \text{Prob}[\iota_j = 1|\iota_i = 1] \) which captures bank \( i \)'s belief about bank \( j \)'s signal if \( \iota_i = 1 \). Relative to bank \( i \), bank \( j \) would therefore be less optimistic about the demand for (marketable) output being high, and hence expect that its borrowers default with a higher probability. Like the argument in the last paragraph, this implies that bank \( i \)'s borrowers cannot obtain cheaper financing from bank \( j \) than from bank \( i \).

I can now specify the equilibrium, starting with the optimal strategy of a borrower of bank \( i \). Since the bank will never refinance an unskilled borrower, it suffices to consider the case of a skilled borrower, \( \tau = s \). Such a borrower knows that she can obtain cheaper financing from bank \( i \) than from bank \( j \). Hence, she requests refinancing at the smallest rate for which bank \( i \) accepts her request if its industry experts predict high demand, \( \iota_i = 1 \). Thereby, the borrower anticipates that the bank may deny her refinancing to induce her exit from the industry. As it has been discussed above, bank \( i \) could thus raise its expected payoff from refinancing other borrowers by \( \bar{\pi}^i[n] \) (\( = \bar{\pi}^i[n] \) for \( \iota_i = 1 \) since the bank would not refinance any borrowers if \( \iota_i = 0 \)). To offset the bank’s incentive to do this, the borrower must make it sufficiently profitable for the bank to refinance her. Hence, she must request refinancing at an interest rate of \( r \geq \bar{r}[n] \), where the hurdle rate \( \bar{r}[n] \) solves the equation,

\[
\bar{\pi}^i_s[r] = \bar{\pi}^i_i[n], \quad \text{for} \quad \iota_i = 1.
\]  

(14)

By bank \( i \)'s optimal strategy in (12), the bank will accept the borrower’s request for refinancing whenever its industry experts predict high demand: \( \lambda^i_s[r] = 1 \) for \( r \geq \bar{r}[n] \) and \( \iota_i = 1 \). This in turn determines bank \( j \)'s posterior belief about bank \( i \)'s signal if bank \( j \) discovered that bank \( i \) has refused to refinance a skilled borrower: \( \mu^j_s = \text{Prob}[\iota_i = 1|L = \)
$R, \tau_j, \tau = s] = 0$ since bank $i$ would not do so unless its industry experts predict low demand, $\iota_i = 0$. Hence, there exists no interest rate $\hat{r}$ for which condition (13) is satisfied, even if bank $j$’s industry experts predict high demand, $\iota_j = 1$. This is the case since this positive information would be fully “offset” by bank $j$’s posterior belief about bank $i$’s signal. As a consequence, bank $j$ cannot expect to recover the cost of screening entrepreneurs who contact the bank at date $t = 1$ in order to ask for financing: $\zeta^{i,j}[\hat{r}] = 0$ for any $\hat{r}$ and $\iota_j \in \{0, 1\}$. Therefore, none of these entrepreneurs will receive financing from bank $j$.

**Proposition 1:**

(a) If the borrower is of the skilled type, $\tau = s$, she requests refinancing at the interest rate $r[n]$ for which bank $i$ can profit from granting her a second period loan, in spite of her using the loaned funds to compete with the bank’s other borrowers.

(b) Bank $i$ refinances the borrower if and only if (i) the borrower is of the skilled type, $\tau = s$, (ii) the bank observes the high-demand signal, $\iota_i = 1$, and (iii) the borrower requests refinancing at the interest rate $r[n]$ or a higher rate. Hence, the bank refinances the borrower with probability $\lambda^i_s[r]$:

$$\lambda^i_s[r] = \begin{cases} 1 & \text{for (i) } \tau = s \text{ and (ii) } \iota_i = 1 \text{ and (iii) } r \geq r[n], \\ 0 & \text{otherwise.} \end{cases} \quad (15)$$

(c) If bank $i$ refuses to refinance the borrower, she cannot obtain financing from bank $j$.

*Proof:* See the Appendix.

In the analysis leading up to Proposition 1, I have assumed that bank $j$ is a bank with industry expertise. If bank $j$ had no such expertise, the above-stated results would be reinforced since the bank would face a more severe winner’s curse. Moreover, I have taken as given any loans that bank $j$ grants to finance production of output by borrowers who have been borrowing from this bank already at date $t = 0$. This is justified if bank $j$’s decision whether to refinance such borrowers depends only on its own signal $\iota_j$ since the bank cannot receive information about the signals of any other banks with industry expertise when such bank’s borrowers ask bank $j$ for financing. To obtain this result, I must slightly extend the model to allow for an opportunity cost $\omega > 0$ that skilled entrepreneurs incur if they stay in the industry beyond date $t = 1$ since they forego other investment opportunities. If banks cannot observe entrepreneurs’ investment opportunities without screening them, then the results in Proposition 1 continue to hold. However, skilled entrepreneurs will exit the industry if they are denied refinancing by a bank with industry expertise such as bank $i$. This is the case since any other bank would interpret the first bank’s refusal to refinance a skilled entrepreneur as negative information about the industry. Hence, such an entrepreneur could not obtain financing at a sufficiently small interest rate to recover the
opportunity cost $\omega$ of staying in the industry beyond date $t = 1$. As a consequence, only unskilled entrepreneurs will contact bank $j$ to ask for financing after other banks (like bank $i$) refuse to refinance them. This implies that bank $j$ cannot obtain information about any other banks’ signals since banks always refuse to refinance unskilled borrowers.

In the remainder, I drop the sub- and superscripts of the functions $\Omega^{\iota}_i[\cdot], \lambda^{\iota}_i[\cdot], \bar{\pi}^{\iota}_i[\cdot]$ and $\phi^{\iota}[\cdot]$. By the results stated above, these functions matter only for $\tau = s$ and $\iota_i = 1$. I will therefore use the functions $\Omega[\cdot] \equiv \Omega^{\iota_i=1}_{\tau=s}[\cdot], \lambda[\cdot] \equiv \lambda^{\iota_i=1}_{\tau=s}[\cdot]$, etc. Furthermore, $\delta[n]$ denotes the probability with which bank $i$’s skilled borrowers default if the bank refinances them since its industry experts predict high demand, $\iota_i = 1$: $\delta[n] = \eta^1 \delta^{1,1}[n] + (1 - \eta^1) \delta^{1,0}[n]$.

### 3.2 The Financing of Industrial Capacity Formation

In this section, I analyze banks’ financing of industrial capacity formation at date $t = 0$, for banks with and without industry expertise. I derive an equilibrium in which each of the banks with industry expertise finances entrepreneurs’ investments in fixed assets for an aggregate production capacity of $n^*$ units. At date $t = 1$, such a bank interacts with each of its skilled borrowers as characterized by Proposition 1: the borrower requests refinancing at an interest rate of $r^* = r[n^*]$ and the bank refinances the borrower if and only if it observes the high-demand signal. No borrower requests refinancing at a smaller interest rate, $r < r^*$: the bank would not consider such a request unless it also refinances all of its other skilled borrowers (who are willing to pay the rate $r^*$), in which case the bank could not profit from refinancing a further borrower at an interest rate of $r < r^* = r[n^*]$ (by Proposition 1).

Besides banks with industry expertise, also banks without such expertise finance industrial capacity formation. I analyze these banks’ lending decisions in Section 3.2.1; Section 3.2.2 contains an analysis of industrial capacity formation financed by banks with industry expertise, and Section 3.2.3 derives the value of the banks’ industry expertise.

---

33To see this, consider bank $j$ and suppose that the bank’s industry experts predict high demand, $\iota_j = 1$. Then, bank $j$ would behave like a bank without industry expertise if it discovered that bank $i$ has refused to refinance a borrower even though she is skilled: as discussed above Proposition 1, bank $j$’s own positive private information about demand would be fully offset by its posterior about bank $i$’s signal, putting bank $j$ on par with banks without industry expertise. Hence, bank $j$ could not profit from lending to the borrower unless it charged her an interest rate (weakly) higher than the rate that banks without industry expertise charge their borrowers. However, these banks finance sufficient entry into the industry that no more skilled entrepreneurs can recover the opportunity cost $\omega$ if they borrow from a bank without industry expertise. Since bank $j$ is effectively also such a bank, this is also true for a borrower of bank $i$ who borrows from bank $j$ after bank $i$ refuses to refinance her.
3.2.1 The Lending Decisions of Banks without Industry Expertise

In this section, I analyze banks’ financing of industrial capacity formation for banks which use technology $T_0$ to screen entrepreneurs in order to find skilled one at a cost of $kx_0/\theta$ per borrower.\textsuperscript{34} For the banks to recover this cost, their borrowers must realize an NPV higher than $kx_0/\theta$ by producing output. Whether this is possible depends on the expected price of the borrowers’ marketable output, $E[\hat{p}]$, determined by the inverse demand function (1). Since this expected price decreases in the total marketable output of the industry, banks’ financing of industrial capacity formation can only be profitable as long as there is no over-supply of output relative to expected demand.

In equilibrium, free entry into the industry eliminates any profit opportunities for banks without industry expertise and their borrowers. As will be discussed below, the banks finance sufficient industrial capacity formation that the following equation holds:

$$k(q_s E[\hat{p}] - c) = \frac{kx_0}{\theta}, \quad (16)$$

for $E[\hat{p}] = A + E[\hat{\alpha} - \hat{Q}_b] - q_s N^*$, where $\hat{Q}_b$ denotes the aggregate marketable output of borrowers of banks with industry expertise, while $N^*$ denotes the aggregate production capacity of borrowers of banks without such expertise, a fraction $q_s$ of which will produce marketable output. The left-hand side of the above-stated condition equals the NPV that skilled entrepreneurs realize by producing output. If $q_s E[\hat{p}] - c > x_0/\theta$, this NPV is sufficiently high to exceed the cost $kx_0/\theta$ that banks incur to find further skilled borrowers by means of technology $T_0$. However, the banks’ financing of further capacity formation will raise the expected total marketable output of the industry, while decreasing the expected price of said output, $E[\hat{p}]$, and hence the NPV realized by the banks’ borrowers. Once this NPV equals $kx_0/\theta$ (as in condition (16)), it is no longer profitable for banks to finance further borrowers’ investments in capacity since the banks could not recover the cost of screening further entrepreneurs in order to find skilled ones.

Of the banks without industry expertise, none grant loans to more than one borrower. This result follows from the fact that the banks earn zero expected profit net of the cost of screening entrepreneurs. Upon lending to one borrower, no bank would screen further entrepreneurs in order to find another skilled borrower. This is not profitable since, facing an additional competitor, the first borrower would turn into a worse credit risk for the bank. Hence, the bank would profit less from the first loan and this profit reduction could not be offset by its expected profit from lending to another borrower (since this expected profit just covers the cost of screening entrepreneurs in order to find another skilled borrower).

\textsuperscript{34}This cost is the ratio of the cost of screening an entrepreneur, $kx_0$, and the rate of incidence of skilled entrepreneurs, $\theta$. 
Proposition 2: In equilibrium, banks without industry expertise finance skilled entrepreneurs’ investments in fixed assets for an expected aggregate production capacity of $N^*$ units:

$$N^* = \frac{1}{q_s} \left( A + E^q_{\tilde{\alpha}} - \tilde{Q}_b - \frac{e + x_0/\theta}{q_s} \right).$$

(17)

Individually, each bank grants a first period loan to at most one borrower to finance her investment in fixed assets.

Proof: See the Appendix.

3.2.2 The Lending Decisions of Banks with Industry Expertise

At date $t = 0$, banks can acquire industry expertise by financing borrowers’ investments in production capacity and hiring industry experts to monitor the borrowers. In this section, I analyze the optimal level of a bank’s financing of industrial capacity formation at date $t = 0$, if the bank expects to earn an interest rate of $r$ in refinancing skilled borrowers at date $t = 1$. To this end, I derive the change in the expected profit of a bank with industry expertise, labelled $i \in \{1, ..., b\}$, due to the “marginal” loan that the bank grants to an entrepreneur at date $t = 0$. Suppose that this loan raises the overall level of bank $i$’s financing of industrial capacity formation from $n_i - k$ to $n_i$ units of capacity. In the event that bank $i$ decides to refinance skilled borrowers at date $t = 1$, this implies a change in its expected profit of $\Omega[n_i, r] - \Omega[n_i - k, r] = \Delta\Omega[n_i, r]$. As will be discussed below, $\Delta\Omega[n_i, r]$ is given by the sum of three terms:

$$\Delta\Omega[n_i, r] = \theta\lambda[r]\bar{\pi}[r] + (\delta[n_i - k] - \delta[n_i])\gamma[r]o[n_i] - \theta\lambda[r]\pi[n_i].$$

(18)

The first term captures bank $i$’s benefit from borrower-specific information about the marginal borrower. This is the product of (i) the probability $\theta$ with which the borrower turns out to be skilled, (ii) the probability $\lambda[r]$ with which bank $i$ refinances the borrower (if skilled), and bank $i$’s direct expected profit from refinancing the borrower, $\pi[r]$.36

The second term captures bank $i$’s benefit from industry-specific information it receives if its industry experts monitor the marginal borrower. Recall that the bank’s information about the industry is represented by the signal $\tilde{\iota}_i$ that indicates the intercept of the inverse demand function (1), $A + \tilde{\alpha}$. The reliability of this signal is given by bank $i$’s industry expertise, $\rho[n_i]$, a function of the level of the bank’s financing of industrial capacity formation at date $t = 0$. The higher $\rho[n_i]$, the smaller the probability with which bank $i$

35 As it has been described in Section 2, the level of a bank’s industry expertise depends on its experts’ access to data about the industry as measured by the aggregate production capacity of its borrowers at date $t = 0$.

36 As stated at the end of Section 3.1, $\bar{\pi}[r]$ equals $\bar{\pi}_{\tau}$ as defined in expression (5) for $\tau = s$ and $\iota_i = 1$. 21
refinances borrowers if demand is low, $\alpha = -a$. As a consequence, it is also less likely that the borrowers default at date $t = 2$ since the price of marketable output is smaller than required for them to repay their loans, $p < c(1 + r)$; the probability with which this happens decreases from $\delta[n_i - k]$ to $\delta[n_i]$. In expression (18), this reduction in the default probability is weighted by the loss that bank $i$ expects to incur if its borrowers default since they cannot sell marketable output at a high enough price. Per unit of marketable output, this expected loss is given by the difference,

$$\gamma[r] = c(1 + r) - E[\tilde{p} | p < c(1 + r)],$$

(19)

bringing the overall expected loss (on all of the inframarginal borrowers' marketable output) to $\gamma[r]\sigma[n_i]$. The last term of expression (18) represents a cost that bank $i$ expects to incur. This term captures that bank $i$'s lending to the marginal borrower reduces its expected profit from refinancing other borrowers. This expected profit decreases by $\pi[n_i]$, defined in expression (7); in function (18), this profit reduction is weighted by the probability $\theta\lambda[r]$ with which bank $i$ refinances the marginal borrower upon refinancing its other skilled borrowers. Expression (18) captures how bank $i$'s marginal loan at date $t = 0$ affects the bank's expected profit from refinancing skilled borrowers at date $t = 1$. As of date $t = 0$, the bank realizes this expected profit with a probability of $\text{Prob}[\iota_i = 1] = 0.5$ since it never refinances any borrowers unless $\iota_i = 1$. Moreover, the bank incurs a cost of $kx_I$ per borrower in order to have industry experts monitoring the borrower during the investment stage. Net of this cost, the bank earns an expected profit of $0.5\Omega[n_i, r] - kx_I$ by lending to the marginal borrower at date $t = 0$.

I can now define the optimal level of bank $i$'s lending to entrepreneurs at date $t = 0$. The bank optimally finances borrowers' investments in $n_i^*[r]$ units of production capacity, given by the following discrete optimization problem:

$$n_i^*[r] = \arg\max_{n_i \in \{0, k, 2k, \ldots\}} 0.5 \Omega[n_i, r] - n_i x_I,$$

(20)

where $\Omega[n_i, r]$ is defined recursively: $\Omega[n_i, r] = \Omega[n_i - k, r] + \Delta \Omega[n_i, r]$ for $\Delta \Omega[n_i, r]$ given by expression (18), $\Omega[0, r] = 0$, and $\Omega[k, r] = \bar{\pi}[r]$ given by expression (5) for $\iota_i = 1$ and $\tau = s$.

Proposition 3: Suppose that bank $i \in \{1, \ldots, b\}$ expects that it can earn an interest rate of $r$ in refinancing skilled borrowers at date $t = 1$. This implies that, at date $t = 0$, this

---

37Recall that there are two reasons for default: $1 - q_s$ denotes the probability with which each skilled borrower defaults since her output is not marketable, while $\delta[\cdot]$ denotes the conditional probability with which marketable output cannot be sold for a high enough price, $\delta[n_i] = \text{Prob}[\tilde{p} < c(1 + r) | \iota_i = 1, n_i]$. In terms of the notation of Section 3.1, $\delta[n_i] = \eta^1 \delta^1[n_i] + (1 - \eta^1) \delta^0 \delta[\cdot][n_i]$. 

22
bank optimally finances borrowers’ investments in fixed assets for \( n^*_i[r] \) units of production capacity in aggregate. As a necessary condition, the following inequalities must be satisfied in the optimum:

\[
0.5 \Delta[ n^*_i[r], r ] \geq k x_I \quad \text{and} \quad 0.5 \Delta[ n^*_i[r] + k, r ] < k x_I.
\]

(21)

**Proof:** Condition (21) follows from the (recursive) definition of \( \Omega[n_i, r] \) below condition (20).

### 3.2.3 The Equilibrium Value of Banks’ Industry Expertise

In this section, I will state conditions for an equilibrium with an exogenous number of banks with industry expertise, \( b \). Furthermore, I will derive these banks’ expected profit as a measure for the value of their expertise. This sets the stage for Section 3.3 where I consider an equilibrium with an endogenous number of banks with industry expertise.

**Equilibrium:** The equilibrium is characterized by (i) the number of banks with industry expertise, \( b \), (ii) the aggregate production capacity of the borrowers of each such bank at date \( t = 0 \), \( n^* \), and (iii) the aggregate production capacity of borrowers of banks without industry expertise, \( N^* \). For now, I take the number of banks with industry expertise as exogenous. The other two variables are determined by the equilibrium conditions (16) and (20). Aside from these conditions, there is a constraint that must be satisfied for banks with industry expertise to break even: in the optimum, the value of the objective function of problem (20) must be positive. Hence, I obtain the following system of equilibrium conditions:

\[
\frac{x_0}{\theta} = q_r E[\hat{p}] - c, \quad (16')
\]

\[
0 \leq 0.5 \Omega[n^*, r^*] - n^* x_I, \text{ for } n^* = \arg \max_n 0.5 \Omega[n, r^*] - n x_I, \text{ for } n \in \{0, k, 2k, \ldots\}, \quad (20')
\]

where condition (16') determines \( N^* \), the aggregate production capacity of the borrowers of banks without industry expertise (as discussed in Section 3.2.1), and where \( r^* \) denotes the interest rate at which skilled borrowers of banks with industry expertise request refinancing at date \( t = 1 \). The borrowers anticipate how many of them rely on the same bank for refinancing; this is determined by \( n^* \), the level of industrial capacity formation financed by each bank with industry expertise at date \( t = 0 \). By part (a) of Proposition 1, this implies that \( r^* \) must be given by the function \( \bar{r}[n] \) for \( n = n^* \), such that the equilibrium is at the intersection of the “reaction functions” \( \bar{r}[n] \) and \( n^*_i[r] \),

\[
r^* = \bar{r}[n^*] \quad \text{and} \quad n^* = n^*_i[r^*],
\]

(23)

38See Section 3.3.3 for a discussion of how the borrowers anticipate how many of them rely on the same bank for refinancing.
where \( n^*_i[r] \) is given by condition (20) (for \( i \in \{1, ..., b\} \) since each bank with industry expertise finances industrial capacity formation at the same optimal level, \( n^* \)).

Next, I will derive the equilibrium value of banks’ industry expertise. This value depends on the expected profit that banks with such expertise earn by refinancing skilled borrowers when their industry experts predict high demand: since this happens with probability 0.5, the value of industry expertise equals 0.5\( \Omega[n^*, r^*] \). Thereby, I can drop \( r^* \) as an argument of the function \( \Omega \): since \( r^* = r[n^*] \), I can define a function \( \Omega^*[n^*] \) for the equilibrium value of the banks’ expected profit from refinancing skilled borrowers.\(^{39}\) To derive an expression for \( \Omega^*[n^*] \), I use condition (14), the solution of which defines the interest rate \( r[n^*] \). This condition implies that a bank earns the following expected profit by refinancing a skilled borrower if the bank’s industry experts predict high demand:

\[
\bar{\pi}[r^*] = \bar{\pi}[n^*] \quad \text{for} \quad \bar{\pi}[n] = \delta[n]o[n]q_s k
\]

(24)

With only a fraction \( \theta \) of its borrowers being skilled, the bank refinances borrowers with a total production capacity of \( \theta n^* \) units of output. Per unit of capacity, this yields an expected profit of \( \bar{\pi}[n^*]/k = \delta[n^*]o[n^*]q_s \), bringing the bank’s overall expected profit to

\[
\Omega^*[n^*] = \delta[n^*]o[n^*]q_s \theta n^*.
\]

(25)

**Proposition 4:** The equilibrium value of a bank’s industry expertise equals 0.5\( \Omega^*[n^*] \). Since such a bank incurs a cost of \( n^*x_I \) to have industry experts monitor its borrowers, the following condition must hold in equilibrium for banks with industry expertise to break even:

\[
0.5\Omega^*[n^*] - n^*x_I \geq 0.
\]

(22’)

**Proof:** A bank with industry expertise refinances its skilled borrowers if its experts predict high demand. Since this happens with probability 0.5, the value of the bank’s expertise equals 0.5 times its expected profit from refinancing the borrowers, \( \Omega^*[n^*] \), given by expression (25). \( \square \)

The results above reveal a central feature of the equilibrium. By expression (25), a bank with industry expertise earns a strictly positive expected profit if it refinances its skilled borrowers at date \( t = 1 \). Per unit of marketable output of the borrowers, this expected profit equals \( \Omega^*[n^*]/(q_s \theta n^*) = \delta[n^*]o[n^*] \), the product of two credit risk factors. The first of these credit risk factors is \( \delta[n^*] \), the probability with which the borrowers default since marketable output may sell for a price smaller than required for the borrowers to be able to

\(^{39}\) Out of equilibrium, this expected profit has been defined recursively above Proposition 3.

\(^{40}\) To obtain the expression for \( \bar{\pi}[n] \) recall definition (7). For \( \iota_i = 1 \) (the relevant case), this definition implies the expression for \( \bar{\pi}[n] \) stated in (24) since \( \zeta^i_r[r] = 0 \) for any \( r \) and \( \iota_i \in \{0, 1\} \) (by part (c) of Proposition 1), \( \delta[n] = \eta^1 \delta_1^1[n] + (1 - \eta^1) \delta_1^0[n] \) and \( o[n] = o^1[n] \) (since I drop the superscript of \( o^i[n] \)).
to repay their loans, \( p < c(1 + r^*) \). The other risk factor measures the bank’s exposure to the price \( \tilde{p} \) in the event of default: \( \delta[n^*] \) equals the aggregate marketable output of all (but one) of the skilled borrowers of a bank with industry expertise. Both of these credit risk factors capture such a bank’s exposure to industry-specific credit risk (the risk associated with the random price \( \tilde{p} \)) rather than to borrower-specific credit risk (the risk that a skilled borrower’s output is not marketable). This result is obtained since a bank with industry expertise derives market power from the fact that it internalizes how its lending decisions affect the price of marketable output of its borrowers, as it has been described in Section 3.1. To receive refinancing despite this, each skilled borrower of such a bank requests refinancing at the interest rate \( r^* \). By condition (24), this implies that it is profitable for the bank to grant loans to all of its skilled borrowers if its industry experts predict high demand: taking as given all but one of these loans, the one loan yields zero expected profit, \( \bar{\pi}[r^*] - \delta[n^*]o[n^*]q.sk = 0 \). However, the bank earns an overall expected profit of \( \Omega^*[n^*] \) since all “inframarginal” loans are strictly profitable.

### 3.3 Banks’ Industry Expertise, Market Power, and Credit Risk: Closed Form Solutions

While Propositions 2, 3 and 4 characterize the equilibrium in general, closed-form solutions can be obtained by imposing additional assumptions. In this section, I will derive such solutions for an equilibrium with an endogenous number of banks with industry expertise in which the state of demand fully determines whether the banks’ skilled borrowers default at date \( t = 2 \), if they receive refinancing at date \( t = 1 \).\(^{41}\) While skilled borrowers’ output is assumed to be always marketable, \( q_s = 1 \), low demand implies that the price of such output is too small for the borrowers to repay their loans: \( \alpha = -a \leftrightarrow p < c(1 + r^*) \).\(^{42}\) Hence, the default probability \( \delta[n] \) equals the probability with which a bank refines borrowers in the low-demand state since its industry experts falsely predict high demand: \( \delta[n] = \text{Prob}[\alpha = -a|\iota_i = 1, n] = 1 - \rho[n] \).

I first derive a condition that characterizes the level of industrial capacity formation financed by banks with industry expertise at date \( t = 0 \). To obtain closed-form solutions, I consider the limit of \( k \to 0 \), i.e. the case in which the industry consists of infinitely many entrepreneurs with infinitesimal production capacity per entrepreneur. Then, condition (21) for an optimum of problem (20) can be replaced by a first order condition. As long as

\(^{41}\)That such an equilibrium exists is demonstrated through a numerical example below Proposition 6.

\(^{42}\)Setting \( q_s \) equal to one simplifies the analysis without loss of generality. This is the case since banks’ expected profit depends merely on their exposure to industry-specific credit risk. For \( q_s = 1 \), banks only bear industry-specific credit risk.
the objective function of problem (20) is globally concave, the results are an approximation of the general solution of this problem for any value of \( k \); a sufficient condition for concavity is stated in Proposition 6.

Consider a bank with industry expertise, \( i \in \{1, \ldots, b\} \). At date \( t = 0 \), this bank finances industrial capacity formation at an optimal level of \( n^*_i[r] \), where \( r \) denotes the bank’s conjecture for the interest rate at which its skilled borrowers request refinancing at date \( t = 1 \). \( n^*_i[r] \) is determined by the following first-order condition:

\[
0.5\Delta_\Omega[n_i, r] = x_I,
\]

(26)

where \( \Delta_\Omega[n_i, r] \) has been defined above as bank \( i \)'s marginal expected profit from refinancing skilled borrowers if the bank’s signal indicates high demand, \( i_i = 1 \). In equilibrium, this marginal expected profit is given by:

\[
\Delta_\Omega[n^*, r^*] = \frac{(\delta[n^* - k] - \delta[n^*])}{\rho'[n^*]} \gamma[r^*] \frac{o[n^*]}{\theta n^*},
\]

(27)

where the first equation follows from expression (18) (since the first and the third term of this expression cancel each other out by virtue of condition (24)), while the second equation is obtained by taking the limit of \( k \to 0 \).

Condition (26) determines the extent to which banks with industry expertise optimally finance industrial capacity formation at date \( t = 0 \). However, the banks will not do so unless they earn a sufficiently high expected profit in the optimum. In Proposition 5, I draw on the result in Proposition 4 to characterize for which values of \( n^* \) this will be the case: I derive a condition which implies that it must be optimal for the banks to finance industrial capacity formation beyond a certain “zero-profit level”, denoted by \( n_0: n^* \geq n_0 \). In this case, the banks’ skilled borrowers request refinancing at an interest rate \( r[n^*] \) that is sufficiently high that the banks can recover the cost of industry expertise, \( n^* x_I \).

**Proposition 5:** Suppose that the function for banks’ industry expertise, \( \rho[\cdot] \), satisfies the condition \( \rho'[n] < (1 - \rho[n]) / n \) for all \( n \geq 0 \). This implies that at date \( t = 0 \), banks with industry expertise can expect to break even in an equilibrium in which it is optimal for each of them to finance entrepreneurs’ investments in fixed assets for more than \( n_0 \) units of production capacity.

**Proof:** See the Appendix.

\(^{43}\)To see this, recall that \( \delta[n^*] = 1 - \rho[n^*] \), and hence \( \delta[n^* - k] - \delta[n^*] = \rho[n^*] - \rho[n^* - k] \to \rho'[n^*] \) for \( k \to 0 \). Furthermore, \( o[n^*] \) is defined as the marketable output of all but one of the borrowers of a bank with industry expertise. These borrowers have an aggregate production capacity of \( n^* - k \) units, a fraction \( \theta \) of which belongs to skilled borrowers. For \( q_s = 1 \), these skilled borrowers produce \( o[n^*] = \theta(n^* - k) \) units of marketable output. For \( k \to 0 \), \( o[n^*] \to \theta n^* \).
The result in Proposition 5 highlights that the market power of banks with industry expertise depends on the extent of their financing of industrial capacity formation, \( n^* \). This is the case since \( n^* \) determines how many skilled borrowers rely on the same bank in order to obtain refinancing at date \( t = 1 \). For \( n^* \) to exceed \( n_0 \) in equilibrium, it must be optimal for banks to maintain a high enough level of industry expertise: \( n^* \geq n_0 \Leftrightarrow \rho[n^*] \geq \rho[n_0] \) (since \( \rho[\cdot] \) is a monotonic function). I will argue below that this can only be true for a limited number of banks with industry expertise. This is the case since all of these banks tend to curtail their financing of output production if their industry experts predict low demand. Hence, the banks effect a reduction in the expected supply of output in the low-demand state. The more banks with industry expertise there are, the more this supply reduction offsets the effect of low demand on the price \( \tilde{p} \), and the smaller the expected loss that a bank would incur if it happened to refinance borrowers in the low-demand state. This implies that each bank derives a smaller benefit from having industry experts assess the demand for borrowers’ output. Since this benefit must be high enough for banks to hire industry experts, the number of banks with industry expertise must be limited.

I start with the requirement that, at date \( t = 0 \), each bank \( i \in \{1, \ldots, b^*\} \) optimally finances industrial capacity formation at a level of \( n^* \geq n_0 \), determined by condition (26). By virtue of expression (27), the left-hand side of condition (26) increases in \( \gamma[r^*] \), bank \( i \)'s expected loss per unit of marketable output of its borrowers if low demand forced them to default. If this expected loss is sufficiently high, bank \( i \) will have sufficiently strong incentives to try to avoid refinancing borrowers in the low-demand state that it aims for a level of industry expertise of \( \rho[n^*] \geq \rho[n_0] \). Since this requires that bank \( i \) finances industrial capacity formation beyond the zero-profit level, \( n^* \geq n_0 \), sufficiently many skilled borrowers rely on the bank for refinancing that the bank can break even even since its market power is high enough. This is true even though I assume that none of the bank’s borrowers can directly observe its level of industry expertise. Instead, bank \( i \) is effectively “committed” to a profitable level of expertise by facing the risk of a high enough expected loss if low demand forced its borrowers to default at date \( t = 2 \).

With a lower bound on the expected loss that banks with industry expertise would incur in the low-demand state, the number of these banks must be limited in equilibrium. This is the case since each such bank \( i \) would benefit from the industry expertise of other banks if low demand forced its borrowers to default. By making their borrowers exit the industry, the other banks tend to decrease the output of the industry in the low-demand state; conditional on demand being low, the borrowers of bank \( i \) can therefore sell their output for a higher expected price, allowing them to pay more to bank \( i \). To see this, consider the residual inverse demand function for the marketable output of bank \( i \)'s borrowers. For
\( \alpha = -a \), this function has an intercept given by:

\[
E[\tilde{p}^{-i} | \alpha = -a] = E[\tilde{p}^{-i}] - a + (E[\tilde{Q}_b^{-i}] - E[\tilde{Q}_b^{-i} | \alpha = -a]),
\]

(28)

where \( \tilde{Q}_b^{-i} \) denotes the aggregate marketable output of borrowers of other banks with industry expertise. The more such banks there are, the higher the expected output contraction in the low-demand state: \( E[\tilde{Q}_b^{-i}] - E[\tilde{Q}_b^{-i} | \alpha = -a] \) increases, and so does the expected price \( E[\tilde{p}^{-i} | \alpha = -a] \). By expression (19), bank \( i \) would therefore incur a smaller expected loss if it refinanced skilled borrowers in the low-demand state. As a consequence, bank \( i \) has a weaker incentive to acquire industry expertise, as a way to try to avoid this expected loss. For the bank to commit to a profitable level of expertise, \( \rho[n^*] \geq \rho[n_0] \), the number of other banks with industry expertise must therefore be limited, \( b \leq b^* \).

Proposition 6 states closed-form solutions for an equilibrium with free entry of banks with industry expertise. To derive closed-form solutions I treat the number of banks with industry expertise as a continuous variable, determined by the break even condition (22); in equilibrium, this condition holds as equation. Furthermore, I have to specify a function \( \rho[n] \) for the banks’ industry expertise. I assume that this function is from a two-parameter family for which the odds of borrowers’ default decrease in \( n \) at a constant order:

\[
\frac{\delta[n]}{1 - \delta[n]} = \frac{1 - \rho[n]}{\rho[n]} = \frac{\epsilon}{n^\nu - \epsilon}.
\]

(29)

Thereby, \( \nu \) equals the order at which the odds of default decrease in the level \( n \) at which some bank \( i \) finances industrial capacity formation. In Proposition 6, I restrict \( \nu \) to be smaller than one: this restriction is (just) sufficient for a global maximum in the solution of the first order condition (26) since \( \nu < 1 \) implies that objective function of problem (20) is globally concave. While \( \nu \) controls the shape of the function \( \rho[\cdot] \), the parameter \( \epsilon \) measures the level of banks’ industry expertise via the “boundary condition” \( \rho[1] = 1 - \epsilon \) (for \( 0.5 \geq \epsilon > 0 \)). The higher \( \epsilon \), the smaller the level of banks’ industry expertise, but the more can they raise their expertise by financing further industrial capacity formation in order to have industry experts monitoring additional borrowers. Hence, \( \epsilon \) can be interpreted as a measure of banks’ benefit from access to data about the industry.

**Proposition 6** Suppose that the function \( \rho[\cdot] \) satisfies equation (29) for \( \nu < 1 \).

In equilibrium, \( b^* \) banks hire industry experts, with \( b^* \) given by:

\[
b^* = \frac{(ab - x_0)\epsilon \nu - 2x_I((1 - \nu)(n^*)^\nu - \epsilon)}{\nu x_I((n^*)^\nu - 2\epsilon)}.
\]

(30)

44 For other recent papers about externalities in information production and competition, see Cetorelli and Peretto (2000) and Anand and Galetovic (2000).

45 See Figure 4 for a plot of the function \( \rho[n] = 1 - \epsilon/n^\nu \) implied by condition (29). While it would be more general to allow for \( \nu \) to vary in \( n \), this would render the model intractable.

28
At date $t = 0$, each of these banks finances borrowers’ investments in fixed assets for an aggregate of $n^*$ units of capacity, with $n^*$ given by:

$$n^* = n_0 = \left( \frac{2x_I}{c\theta^2} \right)^{\frac{1}{1-\nu}}. \quad (31)$$

At date $t = 1$, skilled borrowers of banks with industry expertise request refinancing at an interest rate of $r^* = r[n^*]$, given by:

$$r^* = \frac{2x_I}{c\theta} \frac{1 + \nu}{\nu}. \quad (32)$$

Each of the banks refinances its skilled borrowers if and only if it observes the high-demand signal.

**Proof:** See the Appendix.

Figure 5 illustrates the determination of the equilibrium for a numerical example with five banks with industry expertise. The figure plots the “reaction functions” $r[n]$ (defined above Proposition 1) and $n^*[r]$ (defined implicitly by condition (26)). If five banks acquire industry expertise, these functions are tangent to each other in the point $(n^*, r^*)$ which satisfies condition (23). In this equilibrium, borrowers of banks with industry expertise default at date $t = 2$ if and only if demand is low: $\alpha = -a \Leftrightarrow p < c(1 + r^*)$, as stated at the start of Section 3.3.46

Proposition 7 summarizes the comparative statics of the number of banks with industry expertise, $b^*$. I will briefly discuss these results. Firstly, consider the effect of an increase in the size of the demand shock, $a$: as stated in Proposition 7, $b^*$ increases in $a$. Inspection of expression (28) reveals the rationale for this result: all else equal, an increase in $a$ decreases the price $E[\tilde{p}^{-1}|\alpha = -a]$. By expression (19), this implies that a bank incurs a higher expected loss if it refinances borrowers in the low-demand state. As a precaution against incurring this loss, more banks acquire industry expertise in order to base their financing decisions on information about the state of demand.

Second, consider the effects of an increase in the cost of industry expertise, as measured by $x_I$. The higher this cost, the higher the market power of banks with industry expertise must be for them to break even. This implies that, in equilibrium, more borrowers must rely on the same bank for refinancing, and hence request refinancing at a higher interest

---

46 In the high-demand state, the smallest possible price of industry output is given by the inverse demand function (1) for the case in which all five banks with industry expertise refinance their skilled borrowers. In equilibrium, this price equals 11.3977. In the low-demand state, the borrowers of one such bank can sell their output for the highest possible price if the four other banks abstain from refinancing their borrowers. This price equals 8.6023. Since 11.3977 > $c(1 + r^*) = 10.6939 > 8.6023$, skilled borrowers of banks with industry expertise default if and only if demand is low.
rate $r^*$. For more borrowers per bank with industry expertise, the number of these banks must decrease. The effects of an increase in the cost of industry experts, $x_I$, are similar to those of a decrease in $\epsilon$, the parameter that measures the banks’ benefit from access to data about the industry. This is the case as both parameters determine the cost at which banks can attain a certain level of industry expertise: like an increase in $x_I$, a decrease in $\epsilon$ increases this cost.

**Proposition 7:** The number of banks with industry expertise decreases in the cost of industry experts, $x_I$, and increases in (i) the size of the demand shock, $a$, (ii) banks’ benefit from access to data on the industry, $\epsilon$, and (iii) the incidence of skilled entrepreneurs, $\theta$.

**Proof:** See the Appendix.

The results in Proposition 7 show that the number of banks with industry expertise is negatively related to $n^*$, the equilibrium level of such a bank’s financing of industrial capacity formation.\(^{47}\) Hence, a decrease in $b^*$ is associated with an increase in the concentration of bank lending to the industry. In the remainder of this section, I will present further predictions about effects associated with a change in the equilibrium number of banks with industry expertise, $b^*$. To test these hypotheses, they should be rephrased as effects associated with the extent of the concentration of bank lending to an industry.

**Proposition 8:** The expected aggregate output of borrowers of banks with industry expertise increases in the size of the demand shock, $a$, as well as in the cost of industry experts, $x_I$, and decreases in the banks’ benefit from data on the industry, $\epsilon$, as well as in the incidence of skilled entrepreneurs, $\theta$.

**Proof:** See the Appendix.

Table 2 shows the relation between the number of banks with industry expertise, $b^*$, and two other endogenous variables. Firstly, $b^*$ is negatively related to the interest rate $r^*$ at which the banks’ skilled borrowers request refinancing, given by expression (32). Since $b^*$ is negatively related also to the concentration of bank lending to the industry, $r^*$ is positively related to this concentration. This result is consistent with empirical evidence. For example, Hannan (1991) finds that commercial loan rates tend to be higher in more concentrated bank loan markets.

Furthermore, the number of banks with industry expertise is ambiguously related to the expected aggregate output of their borrowers. While this result conforms with the mixed evidence for the effect of loan market concentration on the availability of credit, empirical studies of this effect usually assume that the structure of the banking sector is

\(^{47}\)By the result in Proposition 6, $n^*$ increases in $x$ and decreases in $\epsilon$ and $\theta$. Hence, changes in the parameters of the model have opposite effects on $n^*$ and $b^*$. However, the relation between $n^*$ and $b^*$ is “weakly” negative since an increase in the demand uncertainty $a$ increases $b^*$ while leaving $n^*$ unchanged.
Since this assumption is clearly violated in the present paper, it is unclear whether the findings of these studies shed light on the results in the rightmost column of Table 2. Instead, these results suggest variables that could be used as instruments in future empirical research taking the structure of the banking sector as endogenous. Such variables are proxies for uncertainty about the demand for the output of an industry or the cost of industry expertise.

Aside from the results in Table 2, the analysis in this paper yields insights of relevance for the modelling of credit risk and bank regulation. As the most basic point, credit risk models should distinguish between banks with industry expertise and banks without such expertise. In modelling the credit risk borne by banks with industry expertise, it is essential to take into account the correlation between credit risk factors. Allen and Saunders (2002) point out that credit risk models tend to ignore such correlation. This paper characterizes the relation between three credit risk factors: (i) the probability with which the banks’ skilled borrowers default since they cannot sell their output for a high enough price to repay their loans, (ii) the banks’ credit exposure, measured by the aggregate output of their skilled borrowers, and (iii) the banks’ expected loss in the event of default. While the comparative statics of the first two credit risk factors follow directly from the results in Proposition 6, Proposition 9 derives the comparative statics of the third one, i.e. the loss that a bank incurs if its industry experts falsely predict high demand such that the bank refines borrowers even though demand is low. This expected loss is the product of the output of the bank’s skilled borrowers, $\theta n^*$, and the bank’s expected loss per unit of output, $\gamma[r^*]$, given by expression (19).

**Proposition 9:** If low demand forces their borrowers in an industry to default, banks with industry expertise incur an expected loss that increases in the cost of industry experts, $x$, and decreases in the banks’ benefit from analyzing data about entrepreneurs’ pilot projects, $\epsilon$, as well as in the incidence of skilled entrepreneurs, $\theta$.

**Proof:** See the Appendix.

Drawing on the results of Propositions 6, 7 and 9, Table 3 shows the relation between the number of banks with industry expertise, $b^*$, the interest rate $r^*$ at which skilled borrowers of such banks request refinancing, and the three credit risk factors mentioned above. Notice that the interest rate $r^*$ is positively related to two of these credit risk

---

48 This assumption is justified in the presence of regulatory constraints. For example, Black and Strahan (2002) examine firm creation in the wake of U.S. banking deregulation and find a negative effect of concentration in the bank industry. See Cetorelli and Gambra (2001), Bonnaccorsi di Patti and Dell’Ariccia (2001), and Cetorelli (2001) for other papers analyzing effects of bank concentration. The seminal paper by Petersen and Rajan (1995) provides evidence for a positive effect of loan market concentration on the availability of credit to small firms.
factors: these are (i) the aggregate credit exposure taken on by a bank with industry expertise in (re-) financing its skilled borrowers in the industry, and (ii) the expected loss of such a bank if low demand forces the borrowers to default. This suggests that the level of a bank’s aggregate lending to an industry is an important determinant of the interest it earns in lending to any single borrower in the industry. Moreover, the result shows that it is essential to consider several credit risk factors in order to understand the effect of credit risk on interest rates. To see this, consider the negative relation between the interest rate $r^*$ and the default probability $\delta[n^*]$: while counterintuitive if viewed in isolation, this relation results from negative correlation between the default probability and the two other credit risk factors.

Correlation between credit risk factors is also of relevance for bank regulation, especially for regulators’ concerns that banks may incur high losses if they focus on lending to borrowers in one industry.\(^{49}\) The results in Table 3 suggest that bank regulators may face a “peso-problem”. That is, adverse industry wide business conditions may leave banks with high losses if they focus on lending to borrowers in an industry where they normally would incur such losses with only a small probability. In terms of the model in the present paper, this may happen since a bank may fail to curb its financing of borrowers’ output production even though demand is low because its industry experts falsely predict high demand. Table 3 shows that this happens with a smaller probability the higher banks’ expected loss in the event of default.

### 4 Extensions

In this section, I will briefly present two extensions of the analysis in Section 3. For each extension, I will discuss how it affects the level of industrial capacity formation financed by banks with industry expertise at date $t = 0$, and hence the level of the banks’ expertise. Thereby, I will focus on an equilibrium like that in Proposition 6 in which all banks make zero expected profit. For banks with industry expertise, this is the case if they finance borrowers’ investments in fixed assets for an aggregate production capacity of $n^*$ units, given by the solution of the break-even condition (22):

$$0.5\Omega^*[n^*] = n^* x_I,$$  \hspace{1cm} (33)

To analyze the extensions of the model, I must specify how $\Omega^*[n^*]$ changes in $n^*$, for $\Omega^*[n^*]$ given by expression (25). As it has been discussed below Proposition 4, $\Omega^*[n^*]$ depends

\(^{49}\)Winton (1999) cites the cases of Continental Illinois and Bank of New England which incurred high losses in lending to the energy-sector and real estate lending, respectively.
on the extent to which a bank with industry expertise internalizes how it decreases the price \( \hat{p} \) by refinancing skilled borrowers at date \( t = 1 \). This is determined by such a bank’s expected exposure to \( \hat{p} \), which enters into expression (25) as the product of two credit risk factors, \( \delta[n^*]o[n^*] \). In the remainder, I assume that this product increases in \( n^* \). This assumption is reasonable since it implies that a bank is (in expectation) the more exposed to \( \hat{p} \) the higher the level of its financing of industrial capacity formation at date \( t = 0 \).

**Banks’ industry expertise and industry structure:** In Section 3.3, I have considered the limit of \( k \to 0 \); in this limit, the industry consists of infinitely many entrepreneurs with infinitesimal production capacity per entrepreneur. I will now return to the general case (analyzed in Section 3.2) with a non-infinitesimal value of \( k \) as a measure of entrepreneurs’ “size”. For this case, I will analyze how the value of \( k \) affects the level of industrial capacity formation financed by a bank with industry expertise, as determined by the break-even condition (33).\(^{50}\) The value of \( k \) enters into this condition as a determinant of the expected marketable output produced by all but one of such a bank’s skilled borrowers if they receive refinancing at date \( t = 1 \): \( o[n^*] = q_s \theta (n^* - k) \), the product of the probability \( q_s \) with which each borrower produces marketable output, and the borrowers’ aggregate output of \( \theta(n^* - k) \) units. Upon substituting for \( o[n^*] \) in expression (25) and using the result to substitute for \( \Omega^*[n^*] \) in condition (33), I obtain the following equation:

\[
0.5\delta[n^*] \underbrace{q_s \theta (n^* - k)}_{o[n^*]} q_s \theta n^* = n^* x_I. \tag{34}
\]

Under the assumption that the product \( \delta[n^*]o[n^*] \) increases in \( n^* \), the solution of the above-stated equation must increase in \( k \): the higher the production capacity of each entrepreneur, the higher \( n^* \), the level of industrial capacity formation financed by each bank with industry expertise. To see the rationale for this result, hold constant the level at which such a bank finances capacity formation, and consider the effects of an increase in \( k \). The higher \( k \), the smaller the number of entrepreneurs who must receive loans from the bank to set up a certain production capacity in aggregate. With the bank lending to fewer borrowers at date \( t = 0 \), each of the skilled ones knows that, by producing output, she affects the bank’s expected payoff from refinancing fewer other skilled borrowers. Hence, each skilled borrower anticipates that she can obtain refinancing at more favorable terms since the bank is less reluctant to refinance her. Per unit of output produced by an (inframarginal) borrower, the bank therefore earns only a smaller expected profit in refinancing the borrower if its

\(^{50}\)Due to indivisibilities, this is an approximation. More precisely, a bank with industry expertise will finance borrowers’ investments in \( n^* \geq n_0 \) units of capacity at date \( t = 0 \), where \( n^* \) is the smallest multiple of \( k \) which exceeds \( n_0 \).
industry experts predict high demand at date $t = 1$. As a consequence, also the bank’s overall expected profit decreases. To “undo” this profit reduction, the bank must finance industrial capacity formation at a higher level at date $t = 0$ in order to have more skilled borrowers requesting refinancing at date $t = 1$: $n^*$ must increase.

This result constitutes a testable hypothesis: the higher the concentration of an industry (as measured by $k$), the higher the concentration of bank lending to the industry. This hypothesis is consistent with findings by Cetorelli (2001), even though Cetorelli chooses to focus on the effect of bank concentration on industry concentration. My analysis suggests that there is also an effect in the other direction.\textsuperscript{51}

**Banks’ industry expertise and their monitoring technology:** In Section 3, I have assumed that banks with industry expertise use only technology $T_I$ to test the creditworthiness of prospective borrowers. I can relax this assumption to analyze to which extent the banks also use technology $T_0$ to screen entrepreneurs at date $t = 0$. Such an analysis reveals the reason for why the equilibrium in Proposition 6 features a unique optimal level of industry expertise of banks which acquire such expertise. The uniqueness of this equilibrium is due to the concavity of the function for banks’ industry expertise, $\rho^*$. This function captures that banks benefit the less from receiving data about an industry the more data they already have. This non-linearity limits the number of equilibria as long as the banks do not also use a linear technology like $T_0$ to test the creditworthiness of entrepreneurs. If so, there no longer exists a unique equilibrium. Instead, the optimal level of banks’ industry expertise depends on the extent to which they need such expertise to benefit from borrower-specific information obtained by means of the linear technology. This result matters for testing the hypotheses put forward above, even though these hypotheses remain valid. With multiple equilibria, my model explains differences in the industrial organization of bank lending to industries that remain after controlling for the extent to which banks bear credit risk that emanates from borrower-specific risk factors rather than from industry-wide shocks. Appropriate control variables may be the average age of firms in an industry, the volatility of the prices of key inputs, etc.

5 Conclusion

In this paper, I analyze banks’ incentives to invest in expertise to assess the creditworthiness of borrowers in an industry. The analysis yields testable empirical predictions (summarized

\textsuperscript{51}Cetorelli (2001) uses instrumental variables estimates to show that his findings are robust to endogeneity of the structure of the banking industry. The present paper provides a rationale for such endogeneity.
in Tables 2 and 3) as well as insights of relevance for future theoretical research. The paper also provides a foundation for analyses of diversification vs. focus in bank lending. While such analyses should incorporate bank lending to more than one industry, I show that banks can have different strategies in lending to the same industry. This result suggests that neither diversification nor focus should be optimal for all banks. Instead, several banks should focus on an industry by hiring industry experts and lending to several borrowers in the industry. However, such focus is not optimal for all banks; while banks without relevant industry expertise cannot (strictly) profit from lending to the industry, they may nevertheless do so in order to realize diversification opportunities.

There remain several interesting questions for future research. First, the model could be extended to allow for the possibility that a bank and its borrowers disagree about the demand for industry output even if these borrowers know that the bank’s industry experts expect high demand. As an alternative source of industry expertise, the bank could then try to design a mechanism to extract information from prospective borrowers. Second, the model could be extended to incorporate several related industries. In particular, it would be interesting to analyze two industries whereby the output of one industry serves as input for the other. Finally, it would be interesting to analyze how banks’ financial structure affects their choice of whether to acquire industry expertise. Such an analysis would characterize how the financing of banks with industry expertise must differ from that of banks without such expertise to preserve the banks’ incentives to play their respective optimal strategy.\textsuperscript{52}

6 Appendix

Proof of Proposition 1: The proof is structured as follows. Firstly, I consider the net present value (NPV) that an entrepreneur realizes by producing output. Second, I derive the move probabilities $\lambda^i_r$ and $\zeta^i_r$, stated in parts (b) and (c) of Proposition 1. Finally, I derive the result stated in part (a).

The NPV of output production: Given the realization of its signal $\tilde{\iota}$, $\iota \in \{0, 1\}$, bank $i$ expects that a borrower of type $\tau \in \{s, u\}$ realizes an NPV of $\text{NPV}^i_\tau = k(q_\tau E[p|\tilde{\iota}] - c)$ by producing $k$ units of output. For an unskilled borrower, $\text{NPV}^i_u < 0$ for any $\iota \in \{0, 1\}$ since the output of such a borrower is unlikely to be marketable: $q_u \to 0$ by Assumption 1. For a skilled borrower, it must be the case that $\text{NPV}^i_s \geq kx_1/\theta$ for (at least) one of the two possible values of $\iota$: otherwise, bank $i$ (as a representative bank with industry expertise) could never break even on the cost of using technology $T_I$, which cannot be true in an equilibrium in which some banks acquire industry expertise.

I will next show that $\text{NPV}^i_s < 0$ if and only if $\iota = 0$, and hence $\text{NPV}^i_s \geq kx_1/\theta$ for $\iota = 1$. To this end, I will first show that there exists some value of $\iota \in \{0, 1\}$ for which $\text{NPV}^i_s < 0$; then, I will show that this is the case for $\iota = 0$. The first result follows from

\textsuperscript{52}Maksimovic and Zechner (1991) and Maksimovic, Stomper and Zechner (1999) provide similar analyses in the context of firms choosing between more or less risky investment policies.
the equilibrium condition (16) which must hold in any equilibrium with free entry of banks without industry expertise. This condition can be written as follows:

\[
x_0 = \frac{q_s E[p] - c}{\theta} = 0.5(q_s E[p | \iota_i = 0] - c) + 0.5(q_s E[p | \iota_i = 1] - c).
\] (16')

In the above-stated equation, the two terms in brackets equal \( NPV^i_s / k \) for \( \iota_i = 0 \) and \( \iota_i = 1 \), respectively. Since I have argued above that there must exist a value of \( \iota_i \in \{0, 1\} \) for which \( NPV^i_s \geq k x_I / \theta \), equation (16') and the parameter restriction \( x_I > 2x_0 \) imply that \( NPV^i_s < 0 \) for the other possible value of \( \iota_i \). Hence, there must exist a value of \( \iota_i \) for which bank \( i \) cannot profit from refinancing borrowers if it observes this signal realization. Below, I will show that this the case for the signal realization which indicates low demand, \( \iota_i = 0 \).

To obtain a contradiction, I assume that \( NPV^0_s > 0 \) and \( NPV^1_s < 0 \). This implies that bank \( i \) can only expect to profit from refinancing a skilled borrower if it observes the low-demand signal, \( \iota_i = 0 \). If \( \iota_i = 1 \), the bank will reject the borrower’s offer to take a second period loan, \( \lambda^0_{i}[r] = 0 \), since \( NPV^0_s < 0 \) implies that such a loan cannot be profitable for the bank \( (\pi^0_{k}[r] < 0 \text{ for any } r) \); if \( \iota_i = 0 \), the bank accepts the borrower’s offer with probability \( \lambda^0_{i}[r] \geq 0 \) (with a strict inequality for high enough values of \( r \), or else bank \( i \) could never break even on the cost of its industry expertise). As a consequence, the expected marketable output of the industry increases if the bank observes the low-demand signal, since this makes it more likely that the borrower obtains refinancing, allowing her to stay in the industry and to produce output. Since the same must be true also for any other bank with industry expertise, the expected aggregate marketable output of the industry will be higher in the low-demand state than in the high-demand state. By the downward-sloping demand function (1), this implies that the expected price of such output is strictly smaller in the low-demand state than in the high-demand state, \( E[p | \alpha = -a] < E[p | \alpha = +a] \). (That this inequality is strict (rather than weak) is due to the fact that the intercept of the inverse demand function (1) is lower if \( \alpha = -a \) than if \( \alpha = +a \).) This inequality contradicts the assumption that \( NPV^0_s > 0 > NPV^1_s \) since it implies that \( E[p | \iota_i = 0] < E[p | \iota_i = 1] \), and hence \( NPV^0_s = k(q_s E[p | \iota_i = 0] - c) \leq NPV^1_s = k(q_s E[p | \iota_i = 1] - c) \). (To see why \( E[p | \iota_i = 0] < E[p | \iota_i = 1] \), note that each of these expected prices can be written as a weighted average of \( E[p | \alpha = -a] \) and \( E[p | \alpha = +a] \) with the weights \( \text{Prob}[\alpha = -a | \iota_i] \) and \( \text{Prob}[\alpha = +a | \iota_i] \), respectively. Since \( \text{Prob}[\alpha = -a | \iota_i = 0] > \text{Prob}[\alpha = -a | \iota_i = 1] \), \( E[p | \alpha = -a] \) receives a higher weight in the expression for \( E[p | \iota_i = 0] \) than in that for \( E[p | \iota_i = 1] \); the reverse is true for the weights of \( E[p | \alpha = +a] \): \( \text{Prob}[\alpha = +a | \iota_i = 0] < \text{Prob}[\alpha = +a | \iota_i = 1] \).

For \( E[p | \alpha = -a] < E[p | \alpha = +a] \), this implies that \( E[p | \iota_i = 0] < E[p | \iota_i = 1] \).

The move probabilities \( \lambda^j_{k}[r] \) and \( \lambda^j_{k}[\tilde{r}] \): I first show that \( \lambda^j_{k}[\tilde{r}] = 0 \) for any \( \tilde{r} \) and \( \iota_j \in \{0, 1\} \). As discussed below condition (13), condition (16) implies that condition (13) can only hold if \( \iota_j = 1 \) and \( \mu^j_{k,s} > 0 \). To obtain a contradiction, I assume that this is possible: \( \lambda^j_{k}[\tilde{r}] > 0 \) for \( \iota_j = 1 \) and some value of \( \tilde{r} \) since \( \mu^j_{k,s} > 0 \). To see what this implies for the move probabilities of the other players, I must consider a perturbed version of these

\footnote{If \( x_0 < x_I < 2x_0 \), banks with industry expertise would always refinance some (but not all) of their skilled borrowers, such that enough output is being produced for the NPV of output production to equal zero for \( \iota_i = 0 \): \( NPV^0_s = 0 \). This would not affect any of the results derived below since these results continue to hold as long as \( NPV^0_s < k x_0 / \theta \). As claimed in Section 2, it is therefore the case that assuming that \( x_I > 2x_0 \) causes no loss of generality of my results.}
players’ equilibrium strategies:

\[ r_s = \begin{cases} 
  r \geq \bar{r}[n] & \text{with probability } 1 - e, \\
  r < \bar{r}[n] & \text{with probability } e,
\end{cases} \quad \lambda_s^n[r] = \begin{cases} 
  1 & \text{if } \iota_i = 1 \text{ and } r \geq \bar{r}[n], \\
  l & \text{if } \iota_i = 1 \text{ and } r < \bar{r}[n], \\
  0 & \text{if } \iota_i = 0.
\end{cases} \tag{35}

Then, \( \mu_s^{ij} = \text{Prob}[\iota_i = 1|L = R, \iota_j, \tau = s] \) is given by:

\[
\mu_s^{ij} = \frac{(1 - l)e\mu_0^{ij}}{(1 - l)e\mu_0^{ij} + (1 - \mu_0^{ij})},
\tag{36}
\]

where \( \mu_0^{ij} \) denotes the probability that bank \( j \) assigns to the event that \( \iota_i = 1 \) prior to screening the borrower. For \( \mu_s^{ij} > 0 \), it must be the case that \( e > 0 \) and \( l < 1 \). This implies that a borrower of bank \( i \) must find it optimal to request refinancing at an interest rate \( r < \bar{r}[n] \) since she expects that bank \( j \) would charge her a smaller interest rate \( \hat{r} \) than that for which she can obtain refinancing from bank \( i \) if this bank’s industry experts predict high demand: \( \hat{r} < \bar{r}[n] \). (Otherwise, it would not be optimal for a skilled borrower to set \( r_s < \bar{r}[n] \) with a strictly possible probability \( e \).) Given the two banks’ optimal strategies (12) and (11), it must therefore be the case that \( \pi^{i}[n] > \hat{\pi}^{ij} [n] \) for \( \iota_i = \iota_j = 1 \), and hence,

\[
\begin{aligned}
(\eta^1 \delta^{1,1}[n] + (1 - \eta^1)\delta^{1,0}[n])o^1[n]k > & (\mu^1_0 \delta^{1,1}[n] + (1 - \mu^1_0)\delta^{0,1}[n])\delta^1[n]k, \\
\pi^{i} & \text{ for } \iota_i = 1 \\
\hat{\pi}^{ij} & \text{ for } \iota_j = 1
\end{aligned}
\tag{37}
\]

where \( o^1[n] \) and \( \delta^1[n] \) denote the aggregate marketable output of other borrowers of bank \( i \) and bank \( j \), respectively. Since banks \( i \) and \( j \) have the same number of borrowers at \( t = 0 \), bank \( j \) would end up with more borrowers than bank \( i \) if one of bank \( i \)’s borrowers switched banks at date \( t = 1 \). Hence, \( o^1[n] < \delta^1[n] \) such that the above-stated inequality can only hold if \( \eta^1 \delta^{1,1}[n] + (1 - \eta^1)\delta^{1,0}[n] > \mu^1_0 \delta^{1,1}[n] + (1 - \mu^1_0)\delta^{0,1}[n], \) and hence \( \eta^1 < \mu^1_s \) (since the default probability \( \delta^{1,1}[n] \) is smaller if both banks’ industry experts predict high demand, \( \iota_i = \iota_j = 1 \), than if they disagree, \( \iota_i \neq \iota_j; \delta^{1,1}[n] < \delta^{0,1}[n] = \delta^{0,1}[n] \)). Using the above-stated expression for \( \mu^1_s \), the inequality \( \eta^1 < \mu^1_s \) can be rearranged as follows:

\[
\frac{\mu^1_0}{\eta^1} (1 - l)e > \frac{1 - \mu^1_0}{1 - \eta^1}.
\tag{38}
\]

Since \( (1 - l)e < 1 \), this inequality implies that condition (37) can only hold for \( \mu^1_0 > \eta^1 \). Hence, bank \( j \) must receive positive information about bank \( i \)’s signal \( \iota_i \) if one of this bank’s borrowers contacts bank \( j \) in order to ask for financing since bank \( i \) has refused to refinance her, \( L = R \). This cannot be the case since bank \( i \) will never refinance a borrower if its industry experts predict low demand, \( \iota_i = 0 \), because the borrower would realize a negative NPV by producing output, \( NPV^0_s < 0 \). As a result, it must be the case that \( \mu^1_s = 0 \), and hence \( c^{ij}[\hat{r}] = 0 \) for any value of \( \hat{r} \) and \( \iota_j \in \{0, 1\} \).

Next, I derive result (15). As it has been discussed above expression (12), it remains to consider the case of \( \tau = s \). Thereby, \( \lambda^s_n[r] = 0 \) if bank \( i \) observes the low demand signal, \( \iota_i = 0 \), since this implies that a skilled borrower realizes a negative NPV by producing output. For \( \iota_i = 1 \), expression (12) implies that \( \lambda^s_i[r] = 1 \) if \( \hat{\pi}^{ij}[r] > \bar{r}[n] \).

**The interest rate at which a skilled borrower requests refinancing:** The result in part (a) of Proposition 1 follows from result (15) since (i) bank \( i \) will always reject the
borrower’s request for refinancing unless \( r \geq r[n] \), and (ii) the borrower should not offer to pay an interest rate \( r > r[n] \) since this would not increase the probability with which the bank refines her. (For \( r < r[n] \), this probability depends only on the value of \( \iota_i \in \{0, 1\} \). If \( \iota_i = 0 \), bank \( i \) will never refinance the borrower since \( NPV^0_s < 0 \); if \( \iota_i = 1 \), bank \( i \) will always refinance the borrower.)

**Proof of Proposition 2:** Solving condition (16) for \( N^* \) yields the result in expression (17). It remains to derive the result stated below this expression. Consider a bank without industry expertise. Suppose that this bank decides to finance skilled entrepreneurs’ investments in fixed assets for an aggregate production capacity of \( z \) units. As discussed above Proposition 2, the bank can earn an expected profit of at most zero net of the cost \( z \) investments in fixed assets for an aggregate production capacity of \( z \) units. To break even, the bank must charge a borrower the interest rate \( r \) that satisfies the following condition:

\[
\frac{kx_0}{\theta} = kq_s((1 - \text{Prob}[\tilde{p} < c(1 + r)])c(1 + r) + \text{Prob}[\tilde{p} < c(1 + r)]E[\tilde{p}|p < c(1 + r)]) - kc, \tag{39}
\]

where the left-hand side is the cost of screening that the bank incurs to find one skilled borrower, while the right-hand side is the bank’s expected profit from lending to the borrower.

The bank solves the following problem to maximize its expected profit:

\[
\max_z -zx_0 + z(q_s((1 - \text{Prob}[\tilde{p} < c(1 + r)])c(1 + r) + \text{Prob}[\tilde{p} < c(1 + r)]E[\tilde{p}|p < c(1 + r)]) - c), \tag{40}
\]

where \( zx_0/\theta \) is the cost of screening that the bank incurs to find skilled borrowers. Differentiating the objective function shows that it decreases in \( z \):

\[
-x_0/\theta + (q_s((1 - \text{Prob}[\tilde{p} < c(1 + r)])c(1 + r) + \text{Prob}[\tilde{p} < c(1 + r)]E[\tilde{p}|p < c(1 + r)]) - c)
\]

\[
\underbrace{0 \text{ by condition (39)}}_{\text{where the inequality follows from the fact that } \left( \frac{\partial}{\partial z} E[\tilde{p}|p < c(1 + r)] \right) = -q_s < 0 \text{ since the bank’s skilled borrowers contribute } q_s z \text{ units of output to the expected aggregate marketable output of the industry, and since the expected price of such output decreases in proportion to the quantity produced. Since the objective function of the above-stated problem decreases in } z, \text{ the bank finances skilled borrowers’ investments in production capacity at the smallest feasible level by lending to at most one borrower.}}
\]

**Proof of Proposition 5:**

Net of monitoring costs of \( n^*x_I \), the expected profit of bank \( i \in \{1, \ldots, b\} \) is given by \( 0.5\Omega^*[n^*] - n^*x_I \), since the bank refinances its borrowers with probability \( \text{Prob}[\iota_i = 1] = 0.5 \), in which case it earns an expected profit of \( \Omega^*[n^*] \). Hence, bank \( i \) can break even if the following condition holds:

\[
0.5\Omega^*[n^*] = 0.5\delta[n^*]o[n^*]\theta n^* = 0.5(1 - \rho[n^*])(\theta n^*)^2 \geq n^*x_I, \tag{42}
\]

where the first equation follows from expression (25) for \( q_s = 1 \), and the second equation is obtained since \( \delta[n^*] = \text{Prob}[\tilde{p} < c(1 + r^*)|\iota_i = 1, n_i = n^*] = \text{Prob}[\alpha = -a|\iota_i = 1, n_i = n^*] \).
\( n^* = (1 - \rho[n^*]) \) (by \( \alpha = -a \Leftrightarrow p < c(1 + r^*) \)), and \( o[n^*] \to \theta n^* \) for \( k \to 0 \) and \( q_s = 1 \) (as it has been discussed in footnote (43)). If \( \rho[\cdot] \) satisfies the condition stated in Proposition 5, the above-stated inequality is satisfied for \( n^* \geq n_0 \) since the left-hand side increases fast enough to eventually exceed the right-hand side, where \( n_0 \) satisfies the inequality stated above as an equation:

\[
0.5(1 - \rho[n_0])(\theta n_0)^2 = n_0 x_I.
\]  

**Proof of Proposition 6:** As stated in Section 3.2, the equilibrium is determined by condition (16') (as equivalent to the condition stated in Proposition 2), condition (26) (as equivalent to condition (20') for \( k \to 0 \)), and condition (22) (as equation). Of relevance for the analysis below, condition (16') determines the expected price of marketable output, \( E[\bar{p}] = (c + x_o/\theta)/q_s \) (for \( q_s \) assumed to be one), and hence the conditional expected price of such output if demand is low, \( E[\bar{p}|\alpha = -a] \):

\[
E[\bar{p}|\alpha = -a] = E[\bar{p}] = a + (E[\tilde{Q}_b] - E[\tilde{Q}_b|\alpha = -a]) - 0.5\theta n^* \]

where I have used that \( E[\tilde{Q}_b|\alpha = -a] = (b - 1)(1 - \rho[n^*])\theta n^* \) and \( E[\tilde{Q}_b] = b^*0.5\theta n^* \) since \( \theta n^* \) is the aggregate marketable output of the skilled borrowers of one bank with industry expertise.

Before deriving closed form solutions, I will rearrange the equilibrium conditions in order to state them more conveniently. Condition (26) determines the optimal level at which each of the banks with industry expertise finances industrial capacity formation. Upon using expression (27) to substitute for \( \Delta_n[n^*, r^*] \), I obtain the condition:

\[
0.5\rho'[n^*] \gamma[r^*] \theta n^* - x_I = 0,
\]  

where \( \gamma[r^*] = c(1 + r^*) - E[\bar{p}|p < c(1 + r^*)] \) (by expression (19)) for \( E[\bar{p}|p < c(1 + r^*)] = E[\bar{p}|\alpha = -a] \) given by the expression stated above. Under the assumption that \( \rho[\cdot] \) satisfies equation (29), \( \rho'[n^*] \) is given by \( \rho'[n^*] = \nu(1 - \rho[n^*])/(n^*) \). By substituting for \( \rho'[n^*] \) and \( \gamma[r^*] \) and rearranging, I obtain the following condition:

\[
(1 - \rho[n^*]) (c + x_o/\theta) - E[\bar{p}|\alpha = -a] \theta n^* - \frac{2x_I n^*}{\nu} = 0.
\]  

Condition (22) holds as equation in an equilibrium with free entry. By the expression for \( \Omega^*[n^*] \) stated above Proposition 4, this equation can be stated as follows:

\[
0.5\delta[n^*] o[n^*] \theta n^* - n^* x_I = 0,
\]  

where \( \delta[n^*] = Prob[\bar{p} < c(1 + r^*)|\nu = 1, n = n^*] = Prob[\alpha = -a|\nu = 1, n = n^*] = (1 - \rho[n^*]) \) (by \( \alpha = -a \Leftrightarrow p < c(1 + r^*) \)), and \( o[n^*] = \theta n^* \).

In equilibrium, banks with industry expertise request finance industrial capacity formation at the level of \( n^* = n_0 \) units, defined in the proof of Proposition 5 as the solution to condition (47). This implies that the banks’ skilled borrowers request refinancing at an interest rate of \( r^* = r[n^*] \), given by condition (24) for \( \pi[n^*] = k(\rho[n^*] c(1 + r^*) + (1 - \rho[n^*]) E[\bar{p}|\alpha = -a]) - k c \) and \( \pi[n^*] \) as defined in expression (24) for \( \delta[n^*] = (1 - \rho[n^*]) \), \( o[n^*] = \theta n^* \) and \( q_s = 1 \). For the limit of \( k \to 0 \), condition (24) can therefore be stated as follows:

\[
\rho[n^*] c(1 + r^*) + (1 - \rho[n^*]) (E[\bar{p}|\alpha = -a]) - c = (1 - \rho[n^*]) \theta n^*.
\]
To summarize, I must solve the following system of equations for \( n^* \), \( r^* \) and \( b^* \):

\[
\begin{align*}
(1) \quad 0 &= \rho[n^*]c(1 + r^*) + (1 - \rho[n^*])(E[\hat{p}\alpha = -a] - \theta n^*) - c, \\
(2) \quad 0 &= ((1 - \rho[n^*])c(1 + r^*) - (1 - \rho[n^*])E[\hat{p}\alpha = -a])\theta n^* - \frac{2x_1 n^*}{\nu}, \\
(3) \quad 0 &= (1 - \rho[n^*])(\theta n^*)^2 - \frac{2x_1 n^*}{\nu},
\end{align*}
\]

where \( b^* \) enters the first two equations as a determinant of the expected price \( E[\hat{p}\alpha = -a] \).

Multiplying condition (i) by \( \theta n^* \) and adding the result to condition (ii) yields the following equation:

\[
c(1 + r^*)\theta n^* - (1 - \rho[n^*])(\theta n^*)^2 - c\theta n^* - \frac{2x_1 n^*}{\nu} = 0. \tag{49}
\]

Condition (iii) implies that the second term of the above-stated condition equals \( 2x_1 n^* \); upon substituting for this term, dividing the resulting expression by \( n^* \) and rearranging, I obtain result (32).

Condition (iii) can be written as follows:

\[
(1 - \rho[n^*])n^* - \frac{2x_1}{\theta^2} = 0. \tag{50}
\]

Under the assumption that \( \rho[\cdot] \) satisfies equation (29), the first term of the above-stated equation equals \( \epsilon(n^*)^{1-\nu} \). Hence, solving this equation for \( n^* \) yields result (31).

Finally, I derive the expression for \( b^* \). To do this, I use results (32) and (31) to substitute for \( r^* \) and \( n^* \) in condition (i) and solve the resulting equation for \( b^* \) to obtain result (30).

It remains to show that condition (26) identifies a global maximum if \( \nu < 1 \). This result is derived in a note that is available from the author upon request.

**Proof of Proposition 7:** Note that differentiating result (30) yields the expressions,

\[
\begin{align*}
\frac{\partial b^*}{\partial x_1} &= -\frac{\epsilon((a\theta - x_0)((n^*)^{\nu} - 2e(1-\nu)) + 2x_1(n^*)^{\nu}(2\nu - 1))}{(n^*)^{\nu} - 2e(1-\nu) + 2x_1(1-\nu)}, \\
\frac{\partial b^*}{\partial \epsilon} &= \frac{((a\theta - x_0)\theta + 2x_1(1-\nu))(n^*)^{\nu}}{(n^*)^{\nu} - 2e(1-\nu) + 2x_1(1-\nu)}, \\
\frac{\partial b^*}{\partial \theta} &= -\frac{\epsilon((a\theta - x_0)((n^*)^{\nu} - 2e(1-\nu)) + 4x_1(n^*)^{\nu}(2\nu - 1))}{(n^*)^{\nu} - 2e(1-\nu) + 2x_1(1-\nu)}. \tag{51}
\end{align*}
\]

Note that since banks with industry expertise observe informative signals, i.e. \( \rho[n^*] > 0.5 \), and, hence, \( n^* > 2e \), the first of these expressions decreases in the size of the demand shock, \( a \), while the second and third increase in \( a \). Since the number of banks also increases in \( a \), \( b^* \geq 1 \) is a sufficient condition for \( \partial b^*/\partial x_1 < 0 \) (\( \partial b^*/\partial \epsilon > 0 \), \( \partial b^*/\partial \theta > 0 \)), if the first (second, third) derivative is negative (positive) for that critical value of \( a \) that implies \( b^* = 1 \). Indeed, solving this equation for this critical value of \( a \) and using the result to substitute for \( a \) in the above-stated derivatives yields,

\[
\begin{align*}
\frac{\partial b^*}{\partial x_1} \bigg|_{b^* = 1} &= -\frac{(n^*)^{\nu}(2-\nu) - 2e(1-\nu^2)}{(n^*)^{\nu} - 2e(1-\nu)} < 0, \\
\frac{\partial b^*}{\partial \epsilon} \bigg|_{b^* = 1} &= \frac{(n^*)^{\nu}(2-\nu)}{2e(1-\nu)(1+\nu)} > 0, \\
\frac{\partial b^*}{\partial \theta} \bigg|_{b^* = 1} &= -\frac{((n^*)^{\nu} - 2e(1-\nu))\theta(1-\nu)}{(n^*)^{\nu} - 2e(1-\nu)} > 0. \tag{52}
\end{align*}
\]

**Proof of Proposition 8:** Since \( E[\hat{Q}_b] = 0.5b^*\theta\alpha \) the comparative statics with respect to
a follow by inspection of the results in Proposition 6. Furthermore, differentiating yields,

\[\text{sgn}[\frac{\partial}{\partial x_f} 0.5b^* \theta n^*] = \text{sgn}[\frac{\partial b^*}{\partial x_f} n^* + b^* \frac{\partial n^*}{\partial x_f}] = \text{sgn}[\frac{\partial b^*}{\partial x_f} n^* + b^* \frac{1 - \nu}{\nu} + \frac{1 - \nu}{\nu}]\]

\[\text{sgn}[\frac{\partial}{\partial \nu} 0.5b^* \theta n^*] = \text{sgn}[\frac{\partial b^*}{\partial \nu} n^* + b^* \frac{\partial n^*}{\partial \nu}] = \text{sgn}[\frac{\partial b^*}{\partial \nu} n^* - b^* \frac{n^*}{(1 - \nu)}] = \text{sgn}[\frac{\partial b^*}{\partial \nu} n^* - \frac{1 + \nu}{\nu}]
\]

(53)

where \(\text{sgn}[\cdot]\) is the sign function. Substituting for the partial derivatives of \(b^*\) as well as for \(b^*\) in the expressions on the right-hand side shows that the first expression increases in \(a\) while the second and third decrease in \(a\), i.e. \((\partial^2 / (\partial x_f \partial a))0.5b^* \theta n^* > 0\), \((\partial^2 / (\partial \nu \partial a))0.5b^* \theta n^* < 0\), and \((\partial^2 / (\partial \theta \partial a))0.5b^* \theta n^* < 0\). Moreover, \(\partial b^* / \partial x_f x_f / b^* + 1/(1 - \nu)\) changes its sign at a value of \(a\) corresponding to \(b^* = -((n^*)^\nu - \epsilon)/(\epsilon \nu^2) < 0\), \(\partial b^* / \partial \epsilon \epsilon / b^* - 1/(1 - \nu)\) changes its sign at a value of \(a\) corresponding to \(b^* = -((n^*)^\nu(1 - \nu^2) - \epsilon(1 - \nu))/(2\nu^2) < 0\). As a consequence, \(b^* \geq 0\) is a sufficient condition for \(\partial E[\tilde{Q}_b] / \partial x_f > 0\), \(\partial E[\tilde{Q}_b] / \partial \epsilon < 0\), \(\partial E[\tilde{Q}_b] / \partial \theta < 0\).

**Proof of Proposition 9:** As discussed above Proposition 9, a bank with industry expertise incurs an expected loss of \(\gamma |r^*| \theta n^*\) if it refinances its skilled borrowers in the low-demand state. By expression (19) and \(E[\tilde{p}|p < c(1 + r^*)] = E[\tilde{p}|\alpha = -a]\), \(\gamma |r^*| \theta n^*\) is given by,

\[
\gamma |r^*| \theta n^* = (c(1 + r^*) - E[\tilde{p}|\alpha = -a]) \theta n^* = \left(\frac{r^*c}{1 - \rho[n^*]} - \theta n^*\right) \theta n^*,
\]

(54)

where the second equation follows from condition (48) (in the proof of Proposition 6) which implies the following expression for the expected price \(E[\tilde{p}|\alpha = -a]\):

\[
E[\tilde{p}|\alpha = -a] = c - \frac{\rho[n^*]}{1 - \rho[n^*]} r^* c + \theta n^*.
\]

(55)

Using results (31) and (32) to substitute for \(n^*\) and \(r^*\) in expression (54), differentiating the resulting expression, and simplifying yields,

\[
\frac{\partial}{\partial x_f} (\gamma |r^*| \theta n^*) = \frac{4(n^*)^{1 + \nu}}{e(1 - \nu)^\nu} > 0,
\]

\[
\frac{\partial}{\partial \nu} (\gamma |r^*| \theta n^*) = -\frac{4r^*(n^*)^{1 + \nu}}{e(1 - \nu)^\nu} < 0,
\]

\[
\frac{\partial}{\partial \theta} (\gamma |r^*| \theta n^*) = -\frac{4r^*(n^*)^{1 + \nu} + \nu}{e(1 - \nu)^\nu} < 0.
\]

(56)
References


gration of International Banking Markets”, working paper, Tilburg University.


Freixas, X. and J. C. Rochet, 1997, Microeconomics of Banking, MIT Press.


Leshchinskii, D., 2000, “Venture Capitalists as Benevolent Vultures: The Role of Network Externalities in Financing Choice”, working paper, HEC.


43
Table 1: Players’ Expected Profits at Terminal Nodes of the Game in Figure 3

<table>
<thead>
<tr>
<th>Node</th>
<th>Probability of [·]</th>
<th>Expected profit of bank i</th>
<th>Expected profit of bank j</th>
</tr>
</thead>
<tbody>
<tr>
<td>[A,τ₉₄₇₉]</td>
<td>λₙᵢ [r]</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n]</td>
</tr>
<tr>
<td>[B,τ₉₄₇₉]</td>
<td>(1 - λₙᵢ [r])ςᵢₗ [r]</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n] + δᵢₛ₄₇₉ [n]</td>
</tr>
<tr>
<td>[C,τ₉₄₇₉]</td>
<td>(1 - λₙᵢ [r])(1 - ςᵢₗ [r])</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n] + δᵢₛ₄₇₉ [n]</td>
</tr>
<tr>
<td>[D,τ₉₄₇₉]</td>
<td>λₙᵢ [r]</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n] + δᵢₛ₄₇₉ [n]</td>
</tr>
<tr>
<td>[E,τ₉₄₇₉]</td>
<td>(1 - λₙᵢ [r])ςᵢₗ [r]</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n]</td>
</tr>
<tr>
<td>[F,τ₉₄₇₉]</td>
<td>(1 - λₙᵢ [r])(1 - ςᵢₗ [r])</td>
<td>0</td>
<td>Πᵢₛ₄₇₉ [n]</td>
</tr>
</tbody>
</table>

Table 1 states the expected profit of each player of the game in Figure 3 for the terminal nodes [A,τ₉₄₇₉]-[F,τ₉₄₇₉], given the borrower’s type τ ∈ {s, u} as well as the realizations of the signals τᵢ and τⱼ of banks i and j, respectively. For each node [·], the respective row of Table 1 states the probability with which the game terminates at this node (given τᵢ, τⱼ and τ), followed by an expression for the expected profit of each player. If the borrower is skilled, τ = s, the game terminates at one of the nodes labelled [A,τ₉₄₇₉]-[C,τ₉₄₇₉]. By Figure 3, the path of play reaches node [A,τ₉₄₇₉] if bank i accepts the borrower’s request for refinancing, L = A, which happens with probability λₛᵢ [r] = Prob[L = A|r, τᵢ, τ = s]. If the bank rejects the borrower’s request, the game terminates at node [B,τ₉₄₇₉] or node [C,τ₉₄₇₉], depending on whether or not bank j screens the borrower, Z ∈ {N, S}. Given the move probability ςᵢₗ [r] = Prob[Z = S|r, τⱼ], the game terminates at node [B,τ₉₄₇₉] with probability (1 - λₛᵢ [r])ςᵢₗ [r]. Otherwise, the game terminates at node [C,τ₉₄₇₉]. If the borrower is unskilled, τ = u, the game terminates at one of the nodes labelled [D,τ₉₄₇₉]-[F,τ₉₄₇₉]. The row for node [D,τ₉₄₇₉] resembles that for node [A,τ₉₄₇₉], with u replacing s as a subscript. If bank i rejects the borrower’s request for refinancing, L = R, the game terminates at node [E,τ₉₄₇₉] or node [F,τ₉₄₇₉], depending on whether or not bank j screens the borrower. In both cases, bank j will not lend to the borrower, either because the bank screens her and discovers that she is unskilled (node [E,τ₉₄₇₉]), or because the bank cannot profit from lending to the borrower without screening her (node[F,τ₉₄₇₉]).
<table>
<thead>
<tr>
<th>Increase in the parameter:</th>
<th>Number of banks with ind. exp., ( b^* )</th>
<th>Interest rate, ( r^* )</th>
<th>Expected aggregate output of borrowers of banks with ind. exp., ( E[\tilde{Q}_b] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost of ind. exp., ( x_I )</td>
<td>decreases</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>benefit of data, ( \epsilon )</td>
<td>increases</td>
<td>no change</td>
<td>decreases</td>
</tr>
<tr>
<td>demand shock, ( a )</td>
<td>increases</td>
<td>no change</td>
<td>increases</td>
</tr>
<tr>
<td>incidence of skilled entrepreneurs, ( \theta )</td>
<td>increases</td>
<td>decreases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

Table 2: Banks’ Industry Expertise and their Financing of Output Production

Table 2 summarizes results from Propositions 6, 7 and 8. \( b^* \) denotes the number of banks with industry expertise, the comparative statics of which are stated in Proposition 7. \( r^* \) denotes the interest rate at which these banks’ borrowers request refinancing, the comparative statics of which follow directly from result (32) in Proposition 6. \( E[\tilde{Q}_b] \) denotes the expected aggregate output produced by all borrowers of all banks with industry expertise in equilibrium, the comparative statics of which are stated in Proposition 8.

<table>
<thead>
<tr>
<th>Increase in the parameter:</th>
<th>Number of banks with ind. exp., ( b^* )</th>
<th>Interest rate, ( r^* )</th>
<th>Default prob., ( \delta[n^*] )</th>
<th>Credit exposure, ( n^* )</th>
<th>Exp. loss in event of default, ( \gamma[r^<em>]\theta n^</em> )</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost of ind. exp., ( x_I )</td>
<td>decreases</td>
<td>increases</td>
<td>decreases</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>benefit of data, ( \epsilon )</td>
<td>increases</td>
<td>no change</td>
<td>increases</td>
<td>decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>demand shock, ( a )</td>
<td>increases</td>
<td>no change</td>
<td>no change</td>
<td>no change</td>
<td>no change</td>
</tr>
<tr>
<td>incidence of skilled entrepreneurs, ( \theta )</td>
<td>increases</td>
<td>decreases</td>
<td>increases</td>
<td>decreases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

Table 3: Banks’ Industry Expertise, Loan Rates, and Credit Risk Factors

Table 3 summarizes results from Propositions 6, 7 and 9. \( b^* \) denotes the number of banks with industry expertise, the comparative statics of which are stated in Proposition 7. \( r^* \) denotes the interest rate at which these banks’ borrowers request refinancing, the comparative statics of which follow directly from result (32) in Proposition 6. \( \delta[n^*] = 1 - \rho[n^*] \) denotes the probability with which these borrowers default, the comparative statics of which follow directly from result (31) in Proposition 6. \( n^* \) denotes the banks’ credit exposure, as measured by the aggregate output of the borrowers of a bank with industry expertise, the comparative statics of which follow directly from result (31). \( \gamma[r^*]\theta n^* \) equals the expected loss of such a bank if its borrowers default, the comparative statics of which are stated in Proposition 9.
entrepreneurs can invest in fixed assets for \( k \) units of production capacity

entrepreneurs try to obtain refinancing to produce output or liquidate their assets

banks decide whether to hire industry experts

banks can grant loans of \( kc \) to entrepreneurs

banks with industry expertise observe signals of \( \tilde{p} \) and decide whether to refinance their borrowers

output sells for price \( k \tilde{p} \)

output is worthless

assets depreciate

loan repayment or default

\[ \text{investment stage} \quad \text{production stage} \]

Figure 1: Timeline

The price of marketable output of the industry, \( \tilde{p} \), takes one of a finite number of realizations in a “price grid” denoted as \( \mathcal{P} \). Production of output by a single entrepreneur decreases the prices in the grid in proportion to the entrepreneur’s production capacity, \( k \), if her output is marketable. Hence, the price grid \( \mathcal{P} \) shifts to \( \mathcal{P}' \), as shown in Figure 2. Since \( k \) is small relative to the difference between adjacent prices, there is no change in the default probability, \( \text{Prob}[\tilde{p} < c(1 + r^*)|\mathcal{P}] = \text{Prob}[\tilde{p} < c(1 + r^*)|\mathcal{P}'] \).

Figure 2: The Price Grid
Figure 3: Extensive Form for the Continuation Game starting at Date $t = 1$

Figure 3 depicts the extensive form for the continuation game starting at date $t = 1$, for a representative bank $i$ with industry expertise, a borrower of this bank, and a rival bank $j$ with industry expertise. The borrower moves at nodes marked by a black circle, bank $i$ and bank $j$ move at nodes marked by a black square and a white square, respectively. Nodes of the same information set are connected by dashed lines. Each bank has private information about the realization of its signal, denoted as $\iota_i$ and $\iota_j$ for bank $i$ and bank $j$, respectively. Bank $i$ knows the borrower’s type $\tau \in \{s, u\}$. Table 1 states the expected profit of each player for each combination of $\iota_j \in \{0, 1\}$, $\iota_i \in \{0, 1\}$ and $\tau \in \{s, u\}$. 
Figure 4: A Specific Functional Form for Banks’ Industry Expertise

Figure 4 depicts how a bank’s industry expertise $\rho[n]$ increases in the level at which it finances industrial capacity formation at date $t = 0$, $n$: $\rho[n]$ depends on $n$ as a measure for availability of data on which the bank’s industry experts can base predictions about the demand for the output of the bank’s borrowers. $\rho[n]$ determines the odds of the borrowers’ defaulting, given by $(1 - \rho[n])/\rho[n]$. For the specific form of the function $\rho[\cdot]$ depicted in Figure 4, these odds decrease in $n$ at a constant order, $\nu$, as stated in expression (29). Furthermore, the form of $\rho[\cdot]$ depends on the parameter $\epsilon = 1 - \rho[1]$. Figure 4 depicts three functions from this $(\nu, \epsilon)$-family: starting from the top, these are the functions $(0.7, 0.2)$ (in bold), $(0.5, 0.2)$, and $(0.5, 0.5)$.

Figure 5: Equilibrium

Figure 5 illustrates the determination of the equilibrium in Proposition 6 for the parameterization with a cost of industrial capacity of $c = 10$, $x_0 = 0$, $x_I = 0.1$, a functional form of banks’ industry expertise $\rho[\cdot]$ from the $(\nu, \epsilon)$-family specified in expression (29) with $\nu = 0.7$ and $\epsilon = 0.2$, an incidence of skilled entrepreneurs of $\theta = 0.7$, and a size of the demand shock of $a = 20.27$ (chosen such that there are 5 banks with industry expertise in equilibrium). The bold line depicts the interest rate $r[n]$. The other line depicts the inverse of the function $n^*_i[r]$ that solves condition (26). The point of tangency marks the equilibrium where $b^* = 5$ and each bank with industry expertise finances industrial capacity formation at the level $n^*_i = n^*_i[r^*] = 10.78$. Upon observing the high-demand signal at date $t = 1$, such a bank $i \in \{1, \ldots, 5\}$ grants second period loans at an interest rate of $r^* = r[n^*] = 6.94\%$ to refinance its skilled borrowers. This interest rate contains a mark-up of $2.97\%$ above the risk-premium for the credit risk associated with these loans. At date 2, the bank’s borrowers default with probability of $1 - \rho[n^*] = 3.79\%$. 