

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 2005

I thank Josef Zechner as well as Arnoud Boot, Cyprian Bruck, Gilles Chemla, Thomas Dangl, Giovanni Dell' Ariccia, Engelbert Dockner, Helmut Elsinger, Michael Fishman, Zsuzsanna Fluck, Ron Giammarino, Michel Habib, Michael Halling, Vojislav Maksimovic, Steven Ongena, Pegaret Pichler, Kristian Rydqvist, Jacob Sagi, Neal Stoughton, Martin Summer, Anjan Thakor, Andrew Winton and Youchang Wu for their helpful comments as well as seminar participants at Boston University, the Universities of Amsterdam, British Columbia, Maryland, Odense, Oxford, and Vienna, and the Western Finance Association Meetings, 2004.

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 analysis shows that industry expertise enables banks to extract rents proportional to their exposure to industry-specific credit risk. This exposure is in turn determined by the number of banks aiming to focus on lending to an industry. In equilibrium, the industry receives funding from a limited number of banks with industry expertise, as well as from a competitive fringe of financiers without such expertise. The equilibrium yields testable predictions about the concentration of bank lending to an industry, and about the correlation between this concentration and the recovery rates, default rates, and interest rates of bank loans.

JEL: G21, L13.

Keywords: bank lending, market power, industry expertise, credit risk.

1 Introduction

The effects of banking on industry structure have proved to be central to many reforms of bank regulation and competition policy. In a number of these reforms, it was in fact the main objective to spur industrial capital formation through more vigorous competition in banking. Recent empirical studies have shown that this objective was largely achieved: excessive concentration of banking market power proved to be a barrier to entry, and deregulation of banking led to a decrease in the concentration of various non-financial industries in many countries.¹

In this paper, I consider a limit of any policies to reduce the concentration of banking markets: the concentration that arises endogenously if banks need industry expertise to make lending decisions. My analysis shows that adopting an industry focus gives banks market power to an extent that depends on the credit risk they bear in lending to borrowers in a certain industry. Since the banks need such market power to recover the cost of industry expertise, bank lending to an industry will be concentrated to a certain degree. However, this concentration does not represent a barrier to entry into the industry. Moreover, it increases in the typical size of the firms in the industry, and, thus, in the industry's concentration. The correlation of the concentration levels of banking and non-financial industries should therefore persist even after deregulation.

The analysis in this paper is motivated by numerous stylized facts and empirical evidence suggesting 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.² 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 firms on whose boards the banks are represented. This suggests that board representation allows the banks to benefit from industry knowledge in their lending decisions.

To acquire industry expertise, banks frequently resort to in-house data collection and analysis.

¹For example, see Cetorelli and Strahan (2004), and Bertrand, Schoar, and Thesmar (2004). The empirical analysis of Bonaccorsi and Dell'Arriccia (2004) suggests that the effect of banking market competition on entry into a non-financial industry depends on the tangibility of the industry's assets.

²See http://www.csfb.com/investment_banking/industry/index.shtml.

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.³ 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' 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".⁴

This paper proposes a model that is sufficiently comprehensive to characterize the optimal industrial organization of bank lending to an industry. The model is based on the observations of the Basel Committee: banks acquire industry expertise by analyzing data obtained through monitoring many borrowers in an industry. Moreover, the model incorporates an immediate implication of the Basel Committee's findings: with a number of borrowers in the same industry, a bank's loan to one of them may affect its payoff from the other loans since the borrowers compete in the same market. These two aspects of bank lending to an industry will be jointly analyzed in order to show that banks derive market power from internalizing the effects of competition among their borrowers. The banks require such market power since they are exposed to a hold-up problem: they incur the cost of industry expertise before negotiating with their borrowers about loan rates.⁵ This hold-up problem is posed in the context of a model with two periods. In the first period, the banks can acquire costly industry expertise by monitoring their borrowers' entry into an industry. In the second period, the banks can benefit from their industry expertise when they decide whether to stop lending to the industry, or to refinance their borrowers.

³For 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.

⁴The 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."

⁵This hold-up problem could only be avoided through long-term loan contracts with loan rates that can be adjusted for changes in a bank's view of an industry's prospects. I will assume that such contracts cannot be written since it is not possible to verify the information that a bank has about an industry. This is in line with the Basel Committee's description of banks' industry analyses as their internal processing of confidential information.

The model is analyzed recursively. The first part of the analysis concerns the market power that banks exercise when they draw on their industry expertise in order to decide whether to refinance their borrowers in the second period of the model. The structure of bank lending to an industry is analyzed in the second part of the paper. The analysis shows how many banks acquire industry expertise, and how many borrowers receive loans from each bank.

To show that banks derive market power from lending with an industry focus, I consider an industry with an output market characterized by demand uncertainty. Banks with industry expertise receive signals about the level of demand, but remain exposed to credit risk since their signals are noisy. The banks' borrowers default when they cannot sell their output for a sufficiently high price; this may happen because of an over-supply of output, funded by financiers without industry expertise. In the event of borrowers defaulting, a bank's payoff depends on the borrowers' cash flows and, thus, on the price of their output. I assume that this price decreases in the total output produced. With sufficiently many borrowers in an industry, banks therefore have incentives to restrict industrial output production.⁶ To offset this restrictive lending policy, the banks must earn rents proportional to the volume of their lending to the industry. Such rent extraction takes place in the second period of the model, i.e. when the banks decide whether to refinance their borrowers. Each bank's borrowers must pay interest above the bank's cost of capital in order to receive loans in spite of using the loaned funds to compete with other borrowers of the same bank.⁷ The borrowers cannot obtain financing from other sources; lacking industry expertise, other financiers cannot profit from refinancing former borrowers of banks with such expertise.

In the first period of the model, the number of borrowers per bank is determined when the banks finance their borrowers' entry into the industry. For banks aiming to acquire industry expertise, each of their borrowers represents a source of data about the industry; the more such data the banks collect by monitoring borrowers, the more likely is it that the banks' signals

⁶This issue is the subject of a strand of literature going back to the work of Gerschenkron (1962) on the role of banks in the process of industrialization. Tilly (1989) cites a German banker who describes the role of the German banks as follows: "In the degree to which banks and bankers extend or restrict industrial credit, is industrial production either encouraged to accelerate or wisely retarded."

⁷Such 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 inventory of competing projects [...]." To fund competing projects, banks must thus charge developers for any reduction in the value of collateral of existing loans.

correctly indicate the demand for the borrowers' output. There exists an optimal number of borrowers per bank since the marginal benefit of additional data decreases in the volume of data already collected.

Overall, my analysis characterizes the optimal industrial organization of bank lending to an industry. In equilibrium, several banks decide to focus on lending to the same industry in order to acquire industry expertise. Each of these banks grants loans to many borrowers in the industry, and hires industry experts to perform industry analyses based on data obtained by monitoring the borrowers. In addition, the industry receives funding from a competitive fringe of financiers without industry expertise. These financiers save the cost of hiring industry experts but take substantial risks in financing industrial output production without information about the demand for the output. The value of such information is endogenously determined by the number of banks with industry expertise. The more such banks there are, the smaller the decrease in the expected price of industry output if demand is low since the informed banks tend to avoid funding output production in the low-demand state, thus reducing the expected supply of output. 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 is sufficiently beneficial, the number of banks with industry expertise must be limited.

The equilibrium provides a theoretical justification for the view of Acharya, Hasan, and Saunders (2002) that “the optimal industrial organization of the banking sector might be one with several focused banks”. Moreover, I show that the concentration of bank lending to an industry is positively related to the concentration of the industry. This prediction is consistent with findings in Cetorelli (2001). However, the present paper stresses that the structure of bank lending to an industry is determined by the structure of the industry. This focus distinguishes the paper from prior studies (cited in Cetorelli (2001)) which take the structure of the banking sector as given. I argue that banks can only profit from expertise in lending to an industry if they do so at a level sufficiently high relative to the typical funding requirements of borrowers in the industry. Since these funding requirements are higher for an industry with bigger firms, the concentration of bank lending to an industry increases in the concentration of the industry.

The structure of the equilibrium also yields insights concerning the optimal industrial diversi-

fication of banks, even though a full analysis of this issue would require a model of bank lending to borrowers in different industries. 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 insurance). The results of the present paper suggest that under-diversification is not necessarily inefficient, unless *all* banks remain under-diversified; focus is efficient for some banks. These banks may specialize to the detriment of the overall diversification of their loan portfolios. 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. This implies an interdependence between banks' optimal strategies which concerns not only their decisions whether to specialize in lending to a certain industry, but also the optimal extent of such specialization. In this respect, the paper belongs to the literature on "industry equilibria" (see, e.g. Maksimovic and Zechner (1991) and Adam, Dasgupta and Titman (2005)).

This paper offers a rationale for focus in bank lending that follows from banks' exposure to risk factors affecting the profitability of *all* firms in an industry. In addition, other credit risk factors may induce banks to focus on lending to an industry. For example, this may enable banks to screen loan applicants more effectively, or to resolve industry-specific moral hazard problems. However, most of these effects do not give rise to an interdependence between banks' optimal strategies as in the present paper. Besides in bank lending, adopting an industry focus is also common in other types of financing, such as venture capital finance. However, the nature of such specialization seems to be very different from that in bank lending. For example, it is rarely the case that two or more competing firms receive funding from the same venture capitalist. Owning equity, venture capitalists perhaps internalize too much of the effects of competition between firms sharing the same output market. In the light of the theory in the present paper, this could make it very costly for the firms to obtain financing from the same venture capitalist.

Besides the papers cited above, there are two other strands of related theoretical literature: the literature on relationship banking, 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.⁸ 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 if its other borrowers default.

In addition, 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.⁹ 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), Bhattacharya and Chiesa (1995), and Cestone and White (2003) also provide analyses of the financing of firms whose payoffs are directly interdependent. Of these papers, only that by Bhattacharya and Chiesa (1995) derives an equilibrium featuring an endogenous industrial organization of bank lending. However, Bhattacharya and Chiesa (1995) do not consider banks’ incentives to acquire industry expertise.

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). Section 4 presents extensions of the current analysis, and concludes the paper.

2 The Model

Players: There are several 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 θ 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 financiers with and without “industry expertise”, defined below. Financiers with industry expertise will be modeled as banks which finance industrial capacity formation by lending to the entrepreneurs. Financiers without industry expertise may be banks or equity investors. There are sufficiently

⁸For recent reviews of the literature on relationship banking, see Ongena and Smith (2000), Boot (2000), and Degryse and Ongena (2001). Moreover, see Berger and Udell (1998) for the role of banks in small business financing.

⁹Related to the paper by Boot and Thakor (2000), Yafeh and Yosha (2000) analyze the effect of competition between banks on the extent to which banks specialize in relationship lending. There is also a large empirical literature. See Degryse and Ongena (2003) for an extensive survey of the literature.

many entrepreneurs and (potential) financiers of entry into the industry that entrants realize an NPV of zero in equilibrium, conditional on any publicly available information about the industry.

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 . After date $t = 0$, no new production capacity can be set up. 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_τ and worthless otherwise. The value of q_τ depends on whether the entrepreneur is skilled or unskilled, $\tau \in \{s, u\}$, for $q_s > q_u > 0$. At date $t = 2$, marketable output can be sold for a per-unit price of p ,

$$p = A + \alpha - Q, \tag{1}$$

where Q denotes the aggregate marketable output of all entrepreneurs. The intercept of function (1) has a stochastic part with two equally likely realizations: $\alpha \in \{-a, +a\}$; $\alpha = +a$ ($-a$) denotes the high-demand (low-demand) state.

After an entrepreneur produces output, her fixed assets are worthless. Net of depreciation, output production thus either generates a profit of $k(p - c)$ (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 $k(q_\tau E[p] - c)$ (since her output is marketable with probability q_τ). If this NPV is negative, no output should be produced. Instead, the entrepreneur should exit the industry and sell her fixed assets. For simplicity, I assume that there is only infinitesimal asset depreciation before date $t = 1$, such that early liquidation yields a payoff of (almost) kc . This assumption is without loss of generality.

Technologies for assessing the profitability of entrepreneurs' investments: Financiers can use two technologies to assess the profitability of entrepreneurs' investments: T_0 and T_I . At

date $t = 0$, both technologies reveal an entrepreneur's true type with probability ξ . However, only technology T_I generates information about the industry, as described below. With technology T_0 , a financier incurs a cost of $\theta k x_0$ in order to observe an entrepreneur's type; this cost is smaller than the cost of using technology T_I , which equals $\theta k x_I$ (per entrepreneur), for $x_I > x_0$. I assume that technology T_I is available only to banks; any banks using this technology are referred to as banks with industry expertise. For now, I assume that such banks abstain from also using technology T_0 ; this assumption can be relaxed, as discussed in Section 4.

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." This happens *after* the banks extend loans to skilled entrepreneurs since monitoring the entrepreneurs yields data required for the banks' industry analyses.

Consider one of b banks using technology T_I , labeled bank $i \in \{1, \dots, b\}$. Suppose that this bank incurs a cost of $n_i x_I$ to identify n_i/k skilled entrepreneurs, and to have industry experts monitor the entrepreneurs after the bank finances their investments in fixed assets for a total production capacity of n_i .¹⁰ Then, bank i observes a noisy signal with two equally likely realizations, $\sigma_i \in \{0, 1\}$, where

$$\text{Prob}[\sigma_i = 1 | \alpha = +a, n_i] = \text{Prob}[\sigma_i = 0 | \alpha = -a, n_i]. \quad (2)$$

This probability depends on n_i as a proxy for the extent to which bank i 's industry experts receive data about the industry if they monitor the bank's n_i/k borrowers in the industry.

Given the realization of its signal σ_i , bank i 's expects that:

$$\text{Prob}[\alpha = +a | \sigma_i = 1, n_i] = \text{Prob}[\alpha = -a | \sigma_i = 0, n_i] = \rho[n_i], \quad (3)$$

where $\rho[n_i]$ is assumed to be a concave function: $\rho'[n_i] > 0$, $\rho''[n_i] < 0$, and $1 > \rho[n_i] \geq 0.5$.¹¹ I will refer to the value of this function as bank i 's level of industry expertise, even though this is not really appropriate since $\rho[n_i]$ is only an indirect measure of the probability with which bank

¹⁰To finance skilled entrepreneurs' investments for an aggregate production capacity of n_i , bank i must pick n_i/k such entrepreneurs from a group of $(n_i/k)/\theta$ entrepreneurs (a fraction θ of whom are skilled). With technology T_I , this implies that bank i incurs a total cost of $(n_i/k)/\theta \times (\theta k x_I) = n_i x_I$.

¹¹The function $\rho[\cdot]$ can be compared to a learning curve. The more borrowers of bank i are monitored by the bank's industry experts, the less can they learn from monitoring an additional borrower in order to obtain additional data about the industry.

i 's signal correctly indicates the state of demand.¹²

I assume that the signals of any two banks $i, j \in \{1, \dots, b\}$ are independently distributed conditional on the demand realization α . 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.¹³

Parameter restrictions: For the industry to be economically viable, the expected intercept of the inverse demand curve (1) must exceed the unit cost of capacity, $A > c$, and the output of skilled entrepreneurs must be marketable with a sufficiently high probability, $q_s > c/A$. In order to simplify the notation in the analysis below, I set $q_s = 1$.

For the technologies T_0 and T_I to be used by financiers of entrepreneurs' investments in production capacity, two sufficient conditions must be satisfied. First, it must be sufficiently likely that the technologies correctly reveal whether an entrepreneur is skilled, i.e. the probability ξ must be high enough. Second, the NPV of unskilled entrepreneurs' output production must be negative since it is too likely that their output is not marketable, $q_u < c/(A + a)$. For notational simplicity, I consider the case in which $\xi \rightarrow 1$ and $q_u \rightarrow 0$.

Informational assumptions and contractual incompleteness: For each bank with industry expertise, $i \in \{1, \dots, b\}$, the number and identity of its borrowers, its level of industry expertise $\rho[n_i]$, and the realization of its signal, σ_i , are private information. If such a bank decides to (re-)finance a borrower, no other player can observe this decision or any negotiations preceding it. Also, I assume that no financier of industrial capacity formation can take the aggregate demand for financing at date $t = 1$ as a source of information about the signals of banks with industry expertise. This may be the case since the aggregate demand contains a random component that swamps any demand for financing by former borrowers of banks with industry expertise which refused to refinance the borrowers.¹⁴

¹²The probability $\text{Prob}[\sigma_i|\alpha, n_i]$ is a direct measure of bank i 's industry expertise. I work with the probability $\text{Prob}[\alpha|\sigma_i, n_i]$ since this probability enters into the objective function of bank i .

¹³This assumption conforms with findings of Elsas and Krahen (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." Parlour and Rajan (2001) provide a rationale for why firms should in fact benefit from a commitment to borrow from no more than one bank.

¹⁴This assumption and its interpretation can be compared to an assumption commonly imposed in market microstructure models: in the presence of uncertainty about the (net) demand for securities, traders have incentives to acquire information about the value of the securities. See Hellwig (1980) and Diamond and Verrechia (1981). In

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 and what price p is being paid for it. All publicly observable events can be contracted upon.

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 assumed to be 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 $t = 1$. Financiers without industry expertise use long-term contracts to fund entrepreneurs' investments, such as equity or loans to be repaid at $t = 2$. This is optimal since these financiers obtain no private information about the industry.¹⁵

Time-line:

t=0 The financing of industrial capacity formation: If identified as being skilled, entrepreneurs receive funding in order to set up production capacity. Banks aiming to acquire industry expertise grant their borrowers short-term loans to be repaid at date $t = 1$, and hire industry experts to collect and analyze data about the borrowers. Financiers without industry expertise use long-term contracts to finance industrial capacity formation.

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

- (i) Each bank with industry expertise, $i \in \{1, \dots, b\}$, observes a noisy signal σ_i indicating the demand realization α and, hence, the expected price $E[p|\sigma_i]$.
- (ii) The borrowers of each bank $i \in \{1, \dots, b\}$ must repay their 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 loans to be repaid at date $t = 2$.

t=2 Entrepreneurs in possession of fixed assets produce and sell k units of output. The payoff is split between the entrepreneurs and their financiers as specified by the contracts between them.

my model, the assumption is imposed in order to guarantee that banks acquire industry expertise.

¹⁵Furthermore, short-term contracts cannot be used since this would expose financiers without industry expertise to a hold-up problem. See the discussion below Proposition 2.

Overview: I will analyze the model recursively, starting with date $t = 1$. In Section 3.1, I will show how banks with industry expertise can extract rents in refinancing borrowers at date $t = 1$. This analysis complements that by Von Thadden (1998) who considers rent extraction in bank lending if banks have some bargaining power. The present paper stresses that industry expertise gives banks market power, enabling them to extract rents even if they lack any bargaining power. In Section 3.1, I analyze banks' ability to extract such rents for the case of monopolistic competition: I assume that the borrowers of a bank with industry expertise cannot switch to borrowing from another bank date $t = 1$. This assumption is imposed for expositional reasons; an extended analysis (in Stomper (2004)) shows that banks (or other financiers) would face a winner's curse in refinancing former borrowers of a bank with industry expertise which refused to refinance the borrowers. In Section 3.2, I will analyze the expected profit of banks with industry expertise in an equilibrium with a number of such banks. The equilibrium will be characterized by two variables: (i) n^* denotes the aggregate production capacity of the borrowers of each bank with industry expertise, and (iii) N^* denotes the aggregate production capacity of entrepreneurs who receive funding from financiers without industry expertise. Section 3.3 presents closed form solutions for an equilibrium with an endogenous number of banks with industry expertise. For simplicity, I will focus on equilibria in which n^* is much higher than the production capacity of a single entrepreneur: $n^* \gg k$. This implies that, in equilibrium, borrowers of banks with industry expertise default with a probability that does not depend on a bank's decision whether to finance a *single* borrower's production of output.

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 $t = 1$. It suffices to consider a representative bank with industry expertise, $i \in \{1, \dots, b\}$. Suppose that at date $t = 0$, this bank grants loans to sufficiently many skilled entrepreneurs to finance and monitor their investments in fixed assets for a total of n_i units of production capacity. At date $t = 1$, the bank observes the signal σ_i and decides whether to refinance any of its borrowers; this decision is the subject of this section.

As it has been discussed above, I characterize the market power associated with an industry focus in bank lending. The analysis shows that bank i can extract rents even though it has no bargaining power since 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 the bank. This is due to the borrower anticipating that the bank receives such requests from several borrowers in the industry. In this situation, the bank may reject a borrower's request for refinancing since it is reluctant to lend to a competitor of its other borrowers. To see this, notice that bank i 's expected profit can be written as the sum of two components. The first is the bank's direct expected profit from a loan it grants to refinance a specific borrower. Taken on its own, such a loan yields an expected profit of

$$\bar{\pi}[\sigma_i, n_i, r] = kE[\min[p, c(1+r)]|\sigma_i, n_i] - kc, \quad (4)$$

where the first term is the bank's expected payoff while the second term is the borrower's refinancing need, kc . The expectation is taken over the price p at which the borrower sells her output at time $t = 2$. Bank i 's signal σ_i indicates whether demand and, thus, the price p is likely to be sufficiently high that the borrower can repay her loan: $p > c(1+r)$.

The second part of bank i 's profit function captures its expected profit from lending to other borrowers in the industry. This expected profit decreases if the bank refinances an additional borrower since this allows the borrower to produce output, contributing k units to the expected marketable output of the industry while reducing the expected price $E[p|\sigma_i, n_i]$ by a similar amount. To see that bank i internalizes some of this price decrease, suppose that the bank's other borrowers default at date $t = 2$ after producing $o[\sigma_i, n_i]$ units of marketable output. Then, a price drop of k reduces bank i 's default payoff by $o[\sigma_i, n_i]k$. For a probability of default of $\delta[\sigma_i, n_i]$, this leaves bank i with an expected profit reduction of $\delta[\sigma_i, n_i]o[\sigma_i, n_i]k$.¹⁶

To summarize the above discussion, I define bank i 's overall expected profit as of date $t = 1$. If the bank accepts a specific borrower's request for refinancing with probability λ , its overall expected profit is given by,

$$\Omega[\sigma_i, n_i, r] = \bar{\Pi}[\sigma_i, n_i] + \lambda(\bar{\pi}[\sigma_i, n_i, r] - \delta[\sigma_i, n_i]o[\sigma_i, n_i]k), \quad (5)$$

¹⁶If bank i refinances its borrowers while charging all of them the same interest rate r , then $\delta[\sigma_i, n_i] = \text{Prob}[p < c(1+r)|\sigma_i, n_i]$. If different borrowers were to pay different interest rates, then $\delta[\sigma_i, n_i]$ would have to be interpreted as an average across the borrowers.

where $\bar{\Pi}[\sigma_i, n_i]$ denotes the base level of bank i 's expected profit from refinancing other borrowers in the industry. Differentiating the above-stated expression with respect to λ yields bank i 's optimal decision:

$$\lambda[\sigma_i, n_i, r] = \begin{cases} 1 & \text{for } \bar{\pi}[\sigma_i, n_i, r] > \delta[\sigma_i, n_i]o[\sigma_i, n_i]k, \\ \lambda \in [0, 1] & \text{for } \bar{\pi}[\sigma_i, n_i, r] = \delta[\sigma_i, n_i]o[\sigma_i, n_i]k, \\ 0 & \text{otherwise.} \end{cases} \quad (6)$$

Lemma 1: *Suppose that at date $t = 0$, investors without industry expertise finance sufficiently many skilled entrepreneurs that the investors and the entrepreneurs expect to just break even on any costs they incur. Then, a bank $i \in \{1, \dots, b\}$ with industry expertise never refinances any of its borrowers at date $t = 1$ if its industry experts predict low demand for the borrowers' output: $\lambda[\sigma_i, n_i, r] = 0$ if $\sigma_i = 0$. This is optimal since the borrowers would realize a negative NPV by producing output.*

Proof: See the Appendix in the on-line supplement to this paper.

The first sentence of Lemma 1 states a condition that holds in any equilibrium of the overall game (which starts at date $t = 0$).¹⁷ In such an equilibrium, an endogenous number of entrepreneurs receive funding from financiers without industry expertise who fail to adapt their financing decisions to the state of demand. Knowing this, bank i should not refinance any of its borrowers if its industry experts predict demand to be low. This would not be profitable since it would be too likely that the borrowers' output adds to an expected over-supply of output in the low-demand state: $\bar{\pi}[\sigma_i, n_i, r] < 0$ if $\sigma_i = 0$ since bank i 's borrowers realize a negative NPV conditional on $\sigma_i = 0$.

Next, I can derive the interest rate r at which a borrower of bank i should request refinancing. Such a borrower anticipates that the bank may refuse to refinance her even if its industry experts predict high demand, $\sigma_i = 1$. As has been discussed above, the bank could thus raise its expected payoff from refinancing other borrowers. To offset bank i 's incentive to do this, the borrower must make it sufficiently profitable for the bank to refinance her if its signal indicates high demand, $\sigma_i = 1$. Hence, the borrower must request refinancing at an interest rate of $r \geq \underline{r}[n_i]$, where the hurdle rate $\underline{r}[n_i]$ solves the equation,

$$\bar{\pi}[\sigma_i, n_i, r] = \delta[\sigma_i, n_i]o[\sigma_i, n_i]k, \quad \text{for } \sigma_i = 1. \quad (7)$$

¹⁷This equilibrium is the subject of Sections 3.2 and 3.3. The condition stated in the first sentence of Lemma 1 corresponds to condition (10) stated in Section 3.2.1.

For any smaller interest rate, $r < \underline{r}[n_i]$, bank i 's optimal move probability (6) implies that it would never refinance the borrower: $\lambda[\sigma_i, n_i, r] = 0$ for any $\sigma_i \in \{0, 1\}$.

Proposition 1:

(a) At date $t = 1$, a borrower of bank i requests refinancing at the interest rate $\underline{r}[n_i]$ for which the bank can expect to profit from granting the borrower a second period loan, in spite of her using the loaned funds to compete with the bank's other borrowers.

(b) At date $t = 1$, bank i refinances a borrower if and only if (i) the bank observes the high-demand signal, $\sigma_i = 1$, and (ii) the borrower requests refinancing at the interest rate $\underline{r}[n_i]$ or a higher rate.

Hence, the bank refinances the borrower with probability $\lambda[\sigma_i, n_i, r]$:

$$\lambda[\sigma_i, n_i, r] = \begin{cases} 1 & \text{for (i) } \sigma_i = 1 \text{ and (ii) } r \geq \underline{r}[n_i], \\ 0 & \text{otherwise.} \end{cases} \quad (8)$$

In the remainder, I disregard σ_i as argument of the functions $\Omega[\cdot]$, $\bar{\pi}[\cdot]$, $\delta[\cdot]$, and $o[\cdot]$ since it only matters what values these functions take if bank i refinances its borrowers since its signal indicates high demand. For example, condition (7) will now be written as follows:

$$\bar{\pi}[n_i, r] = \delta[n_i]o[n_i]k. \quad (9)$$

3.2 The Financing of Industrial Capacity Formation

In this section, I analyze the financing of industrial capacity formation at date $t = 0$. I show that besides banks with industry expertise, also financiers without such expertise provide funding to entrants into the industry. I analyze these financiers' 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' expertise.

3.2.1 The Lending Decisions of Financiers without Industry Expertise

In this section, I analyze the financing of industrial capacity formation by financiers without industry expertise, i.e. banks or equity investors using technology T_0 in order to identify skilled entrepreneurs at a cost of kx_0 per entrepreneur.¹⁸ For the financiers to recover this cost, skilled entrepreneurs must realize an NPV higher than kx_0 by producing output. Whether this is possible

¹⁸This cost is the ratio of the cost θkx_0 of using technology T_0 to identify the type of one entrepreneur, and the rate of incidence of skilled entrepreneurs, θ , since one of those is among a group of $1/\theta$ entrepreneurs.

depends on the expected price $E[p]$, determined by the inverse demand function (1). Since this expected price decreases in the expected output produced, the financing of industrial capacity formation can only be profitable up to a certain extent.

In equilibrium, free entry into the industry eliminates any profit opportunities for financiers without industry expertise and the entrepreneurs who receive funding from such financiers. As will be discussed below, sufficient industrial capacity is set up that the following equation holds:

$$k(E[p] - c) = kx_0, \quad (10)$$

for $E[p] = A + E[\alpha - Q_b] - N^*$, where Q_b denotes the aggregate marketable output of all borrowers of banks with industry expertise, and N^* denotes the aggregate production capacity of all entrepreneurs who receive funding from financiers without such expertise. The left-hand side of the above-stated condition equals the NPV that skilled entrepreneurs realize by producing output. If $E[p] - c > x_0$, this NPV is sufficiently high to exceed the cost that financiers without industry expertise incur to identify additional skilled entrepreneurs by means of technology T_0 . However, as more skilled entrepreneurs receive funding, the expected total output of the industry increases, the expected price of the output decreases, and so does the NPV realized by the entrepreneurs. Once this NPV equals kx_0 (as in condition (10)), it is no longer profitable for financiers without industry expertise to finance further skilled entrepreneurs' entry into the industry since it is too costly to identify such entrepreneurs.

Proposition 2:

In equilibrium, financiers without industry expertise finance skilled entrepreneurs' investments in fixed assets for an expected aggregate production capacity of N^ units:*

$$N^* = A + E[\alpha - Q_b] - c - x_0. \quad (11)$$

Proof: For $E[p] = A + E[\alpha - Q_b] - N^*$, condition (10) implies expression (11) for N^* .

Proposition 2 implies that financiers without industry expertise must use long-term contracts to finance entrepreneurs' investments in capacity at date $t = 0$. With short-term contracts, the entrepreneurs would have to obtain re-financing at date $t = 1$. However, free entry implies that there is no surplus to be split between the entrepreneurs and their financiers if they were to negotiate at date $t = 1$ about the financing of the entrepreneurs' output production. With any

bargaining power, the entrepreneurs could extract rents, making it impossible for their financiers to recover the cost of using technology T_0 to identify skilled entrepreneurs at date $t = 0$.

3.2.2 The Lending Decisions of Banks with Industry Expertise

At date $t = 0$, banks can acquire industry expertise by financing skilled entrepreneurs' investments in production capacity, and hiring industry experts to assess the prospects of the industry based on data about the entrepreneurs' operations. 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 exogenous interest rate of r in refinancing borrowers at date $t = 1$. To this end, I derive the change in the expected profit of a bank with industry expertise, $i \in \{1, \dots, b\}$, due to the "marginal" loan that the bank grants to a skilled 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. This implies the following change in bank i 's expected profit from refinancing its borrowers (if $\sigma_i = 1$):

$$\begin{aligned} \Delta_{\Omega}[n_i, r] &= \Omega[n_i, r] - \Omega[n_i - k, r] \\ &= \lambda[r]\bar{\pi}[n_i, r] + (\delta[n_i - k] - \delta[n_i])\gamma[r]o[n_i] - \lambda[r]\delta[n_i]o[n_i]k, \end{aligned} \quad (12)$$

where the first line states the definition of $\Delta_{\Omega}[n_i, r]$ in terms of the profit function $\Omega[\cdot]$, and the second line shows that $\Delta_{\Omega}[n_i, r]$ is the sum of three terms. The first term is bank i 's expected profit from refinancing the marginal borrower, $\bar{\pi}[n_i, r]$, multiplied by the probability $\lambda[r]$ with which bank i refinances this borrower if $\sigma_i = 1$. The second term captures bank i 's benefit from data about the marginal borrower: with access to such data, the bank's industry experts can predict the state of demand more reliably, which raises bank i 's industry expertise from $\rho[n_i - k]$ to $\rho[n_i]$. As a consequence, it is less likely that bank i refinances its borrowers if demand is low, $\alpha = -a$, and that the borrowers default at date $t = 2$ since they cannot sell their output for a high enough price. Expression (12) captures that the default probability decreases from $\delta[n_i - k]$ to $\delta[n_i]$; this reduction in the default probability is weighted by the expected loss that bank i incurs if its borrowers default. Per unit of the borrowers' output, this expected loss is given by

$$\gamma[r] = c(1 + r) - \mathbb{E}[p|p < c(1 + r)], \quad (13)$$

bringing the overall expected loss (on the inframarginal borrowers' output) to $\gamma[r]o[n_i]$.¹⁹ The last term of expression (12) represents a cost that bank i expects to incur. This term captures

¹⁹Recall that $o[n_i]$ has been defined in Section 3.1 as the output of all but one of bank i 's borrowers.

that bank i 's lending to the marginal borrower reduces its expected profit from refinancing other borrowers. As discussed below expression (4), this expected profit decreases by $\delta[n_i]o[n_i]k$; in function (12), this profit reduction is weighted by the probability $\lambda[r]$ with which bank i refinances the marginal borrower if $\sigma_i = 1$.

Expression (12) captures how bank i 's marginal loan at date $t = 0$ affects the bank's expected profit from refinancing borrowers at date $t = 1$. As of date $t = 0$, the bank realizes this expected profit with a probability of $\text{Prob}[\sigma_i = 1] = 0.5$ (since it never refinances any borrowers unless $\sigma_i = 1$.) Moreover, the bank incurs a cost of kx_I per borrower which includes both the cost of identifying skilled entrepreneurs, and the cost of industry expertise.²⁰ Net of this cost, the bank earns an expected profit of $0.5\Delta_\Omega[n_i, r] - kx_I$ on its marginal borrower at date $t = 0$.

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

$$n_i^*[r] = \arg \max_{n_i \in \{0, k, 2k, \dots\}} 0.5 \Omega[n_i, r] - n_i x_I, \quad (14)$$

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 (12), and $\Omega[0, r] = 0$.

Proposition 3: *Suppose that bank $i \in \{1, \dots, b\}$ expects that it can earn an interest rate of r in refinancing borrowers at date $t = 1$. This implies that, at date $t = 0$, this bank optimally finances skilled entrepreneurs' investments in fixed assets for $n_i^*[r]$ units of production capacity. As a necessary condition, the following inequalities must be satisfied in the optimum:*

$$0.5\Delta_\Omega[n_i^*[r], r] \geq kx_I \text{ and } 0.5\Delta_\Omega[n_i^*[r] + k, r] < kx_I. \quad (15)$$

Proof: Condition (15) follows from the (recursive) definition of $\Omega[n_i, r]$ below condition (14).

3.2.3 The Equilibrium Value of Banks' Industry Expertise

This section states 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

²⁰By the law of large numbers, there is one skilled entrepreneur among a group of $1/\theta$ entrepreneurs. With technology T_I , bank i therefore incurs a cost of $(1/\theta)\theta kx_I = kx_I$ in order to identify one skilled borrower, and to have industry experts gather data about this borrower.

of their expertise. This sets the stage for Section 3.3 which presents an equilibrium with an endogenous number of banks with industry expertise.

Equilibrium: An equilibrium is characterized by the number of banks with industry expertise, b , the aggregate production capacity of the borrowers of each such bank at date $t = 0$, n^* , and the aggregate production capacity of entrepreneurs who receive funding from financiers 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 (10) and (14). 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 (14) must be positive. Hence, I obtain the following system of equilibrium conditions:

$$x_0 = E[p] - c, \tag{10'}$$

$$0 \leq 0.5 \Omega[n^*, r^*] - n^* x_I, \text{ for} \tag{16}$$

$$n^* = \arg \max_n 0.5 \Omega[n, r^*] - n x_I, \text{ for } n \in \{0, k, 2k, \dots\}, \tag{14'}$$

where condition (10') determines N^* , the aggregate production capacity of entrepreneurs who receive funding from financiers without industry expertise (as discussed in Section 3.2.1), and where r^* denotes the interest rate at which borrowers of banks with industry expertise request refinancing at date $t = 1$. In equilibrium, the banks' borrowers anticipate how many of them request refinancing from the same bank; this is determined by n^* , the level of industrial capacity formation financed by each bank with industry expertise at date $t = 0$. As a consequence, r^* must equal $\underline{r}[n^*]$ (defined by condition (9) for $n_i = n^*$), such that the equilibrium is at the intersection of the functions $\underline{r}[n]$ and $n_i^*[r]$,

$$r^* = \underline{r}[n^*] \text{ and } n^* = n_i^*[r^*], \tag{17}$$

where $n_i^*[r]$ is given by condition (14).

Next, I will derive the equilibrium value of banks' industry expertise. This value depends on the expected profit that a bank with such expertise earns by refinancing borrowers when its industry experts predict high demand; since this happens with probability 0.5, the value of industry expertise equals $0.5\Omega[n^*, r^*]$. Since $r^* = \underline{r}[n^*]$, I can drop r^* as argument of the function Ω , thus defining a function $\Omega^*[n^*]$ for the equilibrium value of industry expertise.

Proposition 4: *The equilibrium value of a bank's industry expertise equals $0.5\Omega^*[n^*]$, for*

$$\Omega^*[n^*] = \delta[n^*]o[n^*]n^*. \quad (18)$$

Proof: See the Appendix in the on-line supplement to this paper.

Proposition 4 presents an important feature of the model: a bank with industry expertise earns a strictly positive expected profit if it refinances its borrowers at date $t = 1$ – per unit of output of the borrowers, this expected profit equals $\Omega^*[n^*]/n^* = \delta[n^*]o[n^*]$, i.e. 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 their output sells for too small a price, $p < c(1 + r^*)$. The other credit risk factor measures the bank's exposure to the price p in the event of default: $o[n^*]$ equals the aggregate output of all (but one) of the borrowers of a bank with industry expertise. Jointly, these credit risk factors capture the equilibrium level of such a bank's exposure to changes in the price p . This result is obtained since a bank with industry expertise derives market power from the fact that it internalizes the price implications of its lending decisions. To receive refinancing, the bank's borrowers must pay an interest rate for which the bank earns a positive expected profit in lending to each of them, and a strictly positive expected profit on all but one of the loans.

The result in Proposition 4 follows from the assumption that banks consider the effects of their lending decisions on the business conditions in an industry, as measured by the price p . Industry-specific default rates can be used to judge the plausibility of this assumption. For example, consider an industry with an industry-specific default rate of 2% p.a. or slightly less than 10% over a period of five years, a common time to maturity of industrial loans. Suppose that the industry is structured as it is assumed in the model. Taking the 10% five-year default rate as a measure of $\delta[n^*]$, there must be 10 firms borrowing from each bank with industry expertise for such a bank to be affected to a similar extent as the owners of one firm by the price implications of the bank's lending decisions. Given this relatively small number of borrowers per bank, it seems reasonable that banks do not behave as price-takers in reality. However, this does not imply that they limit the product market competition between their borrowers. Instead, the presence of banks with industry expertise either expands or reduces output production, depending on the state of demand.

3.3 Equilibria with an Endogenous Number of Banks with Industry Expertise

This section presents specifications of the model that are suited for analyzing equilibria in which sufficiently many banks acquire industry expertise that no other banks can profit from doing likewise. The first part of the section shows how the structure of such equilibria depends on the structure of the industry, determined by the parameter k as a measure of firm size. In the second part, closed-form solutions of the equilibrium conditions are derived for the limit of $k \rightarrow 0$.

3.3.1 Industry Structure and the Structure of Bank Lending to an Industry

This section analyzes the relation between the structure of an industry, and that of bank lending to the industry. In this analysis, the industry structure is characterized by the parameter k which measures firm size in terms of the production capacity of one entrepreneur. The structure of bank lending to an industry is measured in a similar way, i.e. in terms of n^* , the total production capacity of all borrowers of one bank with industry expertise. The analysis shows how n^* depends on k for an equilibrium in which the break-even condition (16) holds as equation:²¹

$$0.5\Omega^*[n^*] = n^*x_I. \quad (19)$$

This break-even condition determines the relation between n^* and k since these two variables jointly determine the equilibrium value of a bank's industry expertise, stated on the left-hand side. One of these effects has already been described below Proposition 4: the value of n^* determines the market power of a bank with industry expertise via its exposure to any drop in the price p . However, this market power also depends on the parameter k , which enters into the expression (18) for $\Omega^*[n^*]$ via $o[n^*] = n^* - k$, the aggregate output of all but one of the borrowers of a bank with industry expertise. To analyze this effect, I substitute for $\Omega^*[n^*]$ in condition (19), and write this condition as follows:

$$\delta[n^*](n^* - k) = 2x_I, \quad (20)$$

where the term on the left-hand side is the product $\delta[n^*]o[n^*]$ which equals a bank's exposure to the output price p due to all but one of its loans at date $t = 1$. In the remainder, I assume

²¹Due to indivisibilities condition (19) holds only in approximation if banks are restricted to pure strategies. If banks adopt mixed strategies in the decision whether or not to acquire industry expertise, condition (19) determines the expected number of banks with industry expertise.

that this exposure increases in the level of a bank's lending to an industry. This assumption is intuitively appealing – it rules out unreasonable equilibria in which banks profit from industry expertise since it is optimal for each of them to choose a sufficiently *small* volume of lending to an industry.²² For the other equilibria, the assumption implies that n^* is positively related to k : the higher the production capacity per entrepreneur, the more entrepreneurs receive funding from each bank with industry expertise.

To see the economic rationale for this result, hold constant the level of a bank's funding of entrepreneurs' investments in production capacity and consider the effects of an increase in k . The higher the value of k , the smaller the number of entrepreneurs who receive loans from a bank seeking to finance borrowers with a certain aggregate production capacity. At date $t = 1$, this makes the bank less reluctant to refinance a borrower since fewer other borrowers are affected. As a consequence, the bank's borrowers obtain refinancing at more favorable terms, and the bank's expected profit decreases. To offset this profit reduction, the bank must finance additional borrowers' investment in production capacity at date $t = 0$: n^* must increase for condition (20) to be satisfied after an increase in k .

The positive relation between n^* and k implies a testable hypothesis: the higher the concentration of an industry, the higher that of bank lending to the industry. This hypothesis is consistent with the findings of empirical studies documenting a positive correlation between the concentration levels of the banking sectors and non-financial industries in many countries. The present paper provides a novel explanation for the empirical evidence. I show that banks can only recover the cost of industry expertise if they finance firms' investments in industrial capacity beyond a certain critical level which increases in the typical size of the firms in an industry.

3.3.2 Closed-Form Solutions

This section imposes restrictions on the structure of the model in order to derive closed-form solutions for the system of equilibrium conditions. The analysis reveals how many banks acquire industry expertise in an equilibrium in which the banks' borrowers default at date $t = 2$ if and only if demand is low: $\alpha = -a \Leftrightarrow p < c(1 + r^*)$. For such an equilibrium, I can derive closed-form

²²To see this, notice that the assumption implies that condition (16) holds as a strict inequality for values of n^* higher than that which satisfies condition (19), rather than for smaller values of n^* .

solutions since the default probability $\delta[n_i]$ equals the probability with which a bank $i \in \{1, \dots, b\}$ refinances its borrowers in the low-demand state since its industry experts falsely predict high demand: $\delta[n_i] = \text{Prob}[\alpha = -a | \sigma_i = 1, n_1] = 1 - \rho[n_i]$. This probability decreases in n_i according to the derivative $\delta'[n_i] = -\rho'[n_i]$ which captures the effect of a marginal increase in the volume of data available to bank i 's industry experts if this bank extends its financing of industrial capacity formation. To allow for marginal changes in n_i , I will consider the limit of $k \rightarrow 0$, i.e. the case in which the industry consists of infinitely many entrepreneurs with infinitesimal production capacity per entrepreneur. This implies that condition (15) can be replaced by a first order condition. As long as the objective function of problem (14) is globally concave, the results are an approximation of the equilibrium with a non-infinitesimal value of k ; a sufficient condition for concavity is stated in Proposition 5.

Consider a bank with industry expertise, $i \in \{1, \dots, b\}$. At date $t = 0$, this bank finances industrial capacity formation at an optimal level of $n_i^*[r]$, determined by the following first-order condition:

$$0.5\Delta_{\Omega}[n_i, r] = x_I, \quad (21)$$

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

$$\begin{aligned} \Delta_{\Omega}[n^*, r^*] &= (\delta[n^* - k] - \delta[n^*]) \quad \gamma[r^*] \quad o[n^*] \\ &= \rho'[n^*] \quad \gamma[r^*] \quad n^*, \end{aligned} \quad (22)$$

where the first equation follows from expression (12) for $r = r^*$ (since condition (9) implies that the first and the third term of expression (12) cancel each other out), while the second equation is obtained by taking the limit of $k \rightarrow 0$: $\delta[n^* - k] - \delta[n^*] \rightarrow \rho'[n^*]$ and $o[n^*] = n^* - k \rightarrow n^*$.¹⁹

Condition (21) 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 such that condition (16) is satisfied. Lemma 2 characterizes 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".

Lemma 2: *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 skilled entrepreneurs' investments in fixed assets for more than n_0 units of production capacity: $n^* \geq n_0$.*

Proof: See the Appendix in the on-line supplement to this paper.

The result in Lemma 2 implies that banks can only break even on the cost of industry expertise if they aim for a sufficiently high level of expertise. In equilibrium, it must be optimal for the banks to finance and monitor sufficiently many borrowers that $n^* \geq n_0$ and, thus, $\rho[n^*] \geq \rho[n_0]$. I will argue below that this requirement limits the number of banks with industry expertise.

I start with condition (21) which determines n^* , the level of industrial capacity formation financed by a single bank with industry expertise, $i \in \{1, \dots, b\}$. By virtue of expression (22), the left-hand side of condition (21) increases in $\gamma[r^*]$, bank i 's expected loss per unit of output of its borrowers if low demand forces them into 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 has sufficiently many borrowers in the industry, it will also have sufficient market power to break even since the borrowers demand refinancing at a high enough interest rate. This is true even if 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 industry expertise by facing the risk of a sufficiently high 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 incur in the low-demand state, the number of such banks, b , must be limited in equilibrium. This is necessary since each bank $i \in \{1, \dots, b\}$ benefits from the industry expertise of other banks if low demand forces its borrowers to default. By curtailing their financing of output production, the other banks effect a reduction in the expected supply of output in the low-demand state. As a consequence, the borrowers of bank i can sell their output for a higher expected price, allowing them to pay more to bank i even if low demand forces them into default.²³ From bank i 's perspective, this implies

²³By expression (13), a default of bank i 's borrowers leaves the bank with an expected loss that decreases in the expected price $E[p|p < c(1 + r^*)] = E[p|\alpha = -a]$ which in turn depends on the intercept of the residual demand for the borrowers' output: $E[p^{-i}|\alpha = -a] = E[p^{-i}] - a + (E[Q_b^{-i}] - E[Q_b^{-i}|\alpha = -a])$, where Q_b^{-i} denotes the expected total output of borrowers of other banks with industry expertise. The more such banks there are, the higher is the

that the bank has a weaker incentive to acquire industry expertise. For the bank to be committed to a profitable level of expertise, $\rho[n^*] \geq \rho[n_0]$, the number of other banks with industry expertise must therefore be limited.

Next, I derive the equilibrium with an endogenous number of banks with industry expertise, determined by the break even condition (19). To obtain closed-form solutions, I must specify a function $\rho[\cdot]$ for the banks' industry expertise. I assume that this function is from a two-parameter family for which the odds of borrowers defaulting decrease in n_i at a constant order:²⁴

$$\frac{\delta[n_i]}{1 - \delta[n_i]} = \frac{1 - \rho[n_i]}{\rho[n_i]} = \frac{\epsilon}{n_i^\nu - \epsilon}. \quad (23)$$

Thereby, ν equals the order at which the odds of default decrease in the level n_i at which some bank $i \in \{1, \dots, b\}$ finances industrial capacity formation. In Proposition 5, I restrict ν to be smaller than one: this restriction is (just) sufficient for a global maximum in the solution of the first order condition (21) since $\nu < 1$ implies that objective function of problem (14) is globally concave. While ν controls the shape of the function $\rho[\cdot]$, the parameter ϵ measures the level of banks' industry expertise via the "boundary condition" $\rho[1] = 1 - \epsilon$ (for $0.5 \geq \epsilon > 0$). The higher ϵ , the more can banks raise their expertise if they have industry experts gather data about additional borrowers. Hence, ϵ can be interpreted as a measure of banks' benefit from access to data about the industry.

Proposition 5: *Suppose that the function $\rho[\cdot]$ satisfies equation (23) for $\nu < 1$.*

In equilibrium, there are b^ banks with industry expertise:*

$$b^* = \frac{(a - x_0)\epsilon\nu - 2x_I((1 - \nu)(n^*)^\nu - \epsilon)}{\nu x_I((n^*)^\nu - 2\epsilon)}. \quad (24)$$

At date $t = 0$, each of these banks finances skilled entrepreneurs' investments in fixed assets for n^ units of capacity:*

$$n^* = n_0 = \left(\frac{2x_I}{\epsilon} \right)^{\frac{1}{1-\nu}}. \quad (25)$$

At date $t = 1$, the borrowers of banks with industry expertise request refinancing at an interest

expected output contraction in the low-demand state, $E[Q_b^{-i}] - E[Q_b^{-i}|\alpha = -a]$, and the smaller is $\gamma[r^]$.*

²⁴It would be more general to allow for ν to vary in n_i but this would render the model intractable. The qualitative results of the equilibrium should hold for any function $\rho[\cdot]$ for which the product $\delta[n]n = (1 - \rho[n])n$ increases in n . As discussed below condition (20), this is required in order to rule out that banks profit from industry expertise by lending to an industry to a sufficiently small extent.

rate of r^* :

$$r^* = \frac{2x_I}{c} \frac{1 + \nu}{\nu}. \quad (26)$$

Proof: See the Appendix in the on-line supplement to this paper.

Proposition 6 summarizes the comparative statics of the number of banks with industry expertise, b^* .

Proposition 6: *The number of banks with industry expertise decreases in the cost of industry experts, x_I , and increases in the size of the demand shock, a , as well as in the banks' benefit from access to data about the industry, ϵ .*

Proof: See the Appendix in the on-line supplement to this paper.

The results in Proposition 6 are intuitively appealing, though perhaps not very surprising if viewed in isolation. More interesting results follow from analyzing how the endogenous variables of the equilibrium co-vary in the parameters of the model. Since n^* increases in x_I and decreases in ϵ , there is a negative relation between the number of banks with industry expertise, b^* , and the equilibrium level of such a bank's financing of industrial capacity formation, n^* . A decrease in b^* is therefore associated with an increase in the concentration of bank lending to an industry, as proxy for the extent to which the industry relies on financing by banks with industry expertise. Based on this insight, I obtain testable predictions concerning the credit risk that the banks bear. Since the default probability $\delta[n^*] = 1 - \rho[n^*]$ decreases in n^* , the firms in an industry should default with a probability which depends negatively on the concentration of bank lending to the industry. In addition, the equilibrium level of this concentration is related to the expected recovery rate of the loans of the banks with industry expertise if low demand forces the banks' borrowers into default. The following result implies that this expected recovery rate will be the higher, the more concentrated the banks' lending to the industry:²⁵

Proposition 7: *If low demand forces their borrowers in an industry to default, banks with industry expertise recover an expected fraction $\gamma[r^*]/(c(1+r^*))$ of the face value of their loans. This expected recovery rate increases in the cost of industry expertise, x_I , and decreases in the banks' benefit from data about the industry, ϵ .*

Proof: See the Appendix in the on-line supplement to this paper.

²⁵Despite this result, the concentration of bank lending to an industry is positively related to the absolute expected loss that banks with industry expertise incur if low demand forces their borrowers to default.

The result in Proposition 7 implies that there is a negative relation between the probability $\delta[n^*] = 1 - \rho[n^*]$ with which low demand forces the borrowers of banks with industry expertise into default, and the expected recovery rate, $\gamma[r^*]/(c(1 + r^*))$. This result is consistent with the findings of a recent empirical study by Grunert and Weber (2005). Moreover, the result implies that credit risk models are mis-specified if default rates and recovery rates are assumed to be independently distributed, as it is normally done in the credit risk models that are currently used.²⁶

Besides predictions about the credit risk associated with the structure of bank lending to an industry, the equilibrium also yields predictions about the effect of such credit risk on the interest rate r^* that banks with industry expertise charge in refinancing their borrowers. In my model, this interest rate depends not only on borrower-specific risk factors, but also on the level of a bank's *aggregate* lending to an industry, n^* , as a proxy for the banks' exposure to exogenous changes in the price of industry output. This prediction can be tested in terms of two hypotheses, depending on the availability of data. On the industry-level, loan rates should be positively correlated with the concentration of bank lending to an industry. In bank-level data, a positive relation should be observed between the loan rates that banks charge to their borrowers, and the total volume of the banks' lending to the borrowers' industries.

4 Conclusion and Extensions

In this paper, I analyze banks' incentives to invest in expertise in order to assess the creditworthiness of borrowers in an industry. The analysis yields testable empirical predictions as well as insights of relevance for future theoretical research. The equilibrium reveals that “the optimal industrial organization of the banking sector is one with several focused banks”, as claimed by Acharya, Hasan, and Saunders (2002). Besides these banks, the industry also receives some funding from a competitive fringe of financiers without industry expertise. By contrast to these financiers, banks with such expertise derive market power from their exposure to industry-specific credit risk. The extent of such exposure increases in the concentration of the banks' lending to the industry. This concentration must therefore be sufficiently high that the banks can extract

²⁶For further discussion of this important point, see Hu and Perraudin (2002) and Grunert and Weber (2005).

enough rents to recover the cost of industry expertise.

The equilibrium yields a number of testable predictions. First, the concentration of bank lending to an industry depends on the industry structure and increases in the typical size of the firms in the industry. Second, the structure of bank lending determines the credit risk borne by banks with industry expertise due to the possibility of an exogenous deterioration of the business conditions in an industry. The more concentrated the banks' supply of loans to the industry, the smaller the probability with which adverse business conditions force the banks' borrowers to default on their loans, and the higher the expected recovery rate of the loans in the event of a default. The analysis thus suggests that default rates and recovery rates are negatively correlated. Finally, the model highlights that the interest rates of bank loans depend not only on borrower-specific credit risk factors, but also on the aggregate volume of a bank's lending to the industries of their borrowers.

There are several possible extensions of the current analysis, as well as questions for future research. Stomper (2004) shows that the results of the present paper hold also for two extensions of the model. Under the first extension, banks bear not only industry-specific but also borrower-specific default risk since even skilled entrepreneurs may fail to produce marketable output ($q_s < 1$). Extending the model in this way does not change any of the qualitative results. The second extension separates banks' collection of data about the industry from their search for and lending to skilled entrepreneurs at date $t = 0$. This shows that there does not exist a unique optimal level of industry expertise if the banks use a linear screening technology (like T_0) in order to assess borrower-specific credit risk factors.²⁷ However, the above-stated model explains differences in the structure of bank lending to different industries that remain after controlling for any differences across industries in banks' exposure to borrower-specific credit risk factors.

For future research, there remain several interesting topics. First, the analysis 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 de-

²⁷Instead, there are multiple equilibria. This result however depends on the assumption of a linear screening technology, with a constant cost of screening an additional borrower. With a U-shaped cost of screening borrowers, there exists only one equilibrium. It is reasonable to assume that the cost of screening borrowers is U-shaped, with initial cost reductions due to learning-by-doing, and an eventual cost increase due to the scarcity of able loan officers.

mand. As an alternative source of industry expertise, the bank could then use a mechanism to elicit information from prospective borrowers.

Second, this paper provides a foundation for future 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.

Finally, it would be interesting to analyze how banks' financial structures affect their choices 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.²⁸

References

- Acharya V. V., I. Hasan, and A. Saunders, 2002, "Should Banks be Diversified? Evidence from Individual Bank Loan Portfolios", working paper, London Business School.
- Allen, L. and A. Saunders, 2002, "A Survey of Cyclical Effects in Credit Risk Measurement Models", working paper, New York University.
- Anand, B. N. and A. Galetovic, 2000, "Information, Nonexcludability, and Financial Market Structure," *Journal of Business*, 73(3), 357-402.
- Basel Committee on Banking Supervision, 2001, "The New Basel Capital Accord," Bank for International Settlements, Basel.
- Berger, A. N. and G. F. Udell, 1998, "The Economics of Small Business Finance: the Roles of Private Equity and Debt Markets in the Financial Growth Cycle," *Journal of Banking and Finance*, 22(6-8), 613-673.
- Bertrand, M., A. S. Schoar, and D. Thesmar, 2004, "Banking Deregulation and Industry Structure: Evidence from the French Banking Reforms of 1985", working paper, Centre for Economic Policy Research.
- Bhattacharya, S. and G. Chiesa, 1995, "Proprietary Information, Financial Intermediation, and

²⁸Maksimovic 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.

Research Incentives”, *Journal of Financial Intermediation*, 4, 328-357.

Black, S. E. and P. E. Strahan, 2002, “Entrepreneurship and Bank Credit Availability,” *Journal of Finance*, 57, 2807-2833.

Bonaccorsi di Patti, E. and G. Dell’Ariccia, 2001, “Bank Competition and Firm Creation,” working paper, International Monetary Fund.

Boot, A. W. A., 2000, “Relationship Banking: What do We Know?,” *Journal of Financial Intermediation*, 9(1), 7-25.

Boot, A. W. A. and A.V. Thakor, 2000, “Can Relationship Banking Survive Competition?,” *Journal of Finance*, 55(2), 679-713.

Cerasi, V. and Daltung, S., 2000, “The Optimal Size of a Bank: Costs and Benefits of Diversification,” *European Economic Review*, 44(9), 1701-1726.

Cestone, G. and L. White, 2003, “Anti-Competitive Financial Contracting: The Design of Financial Claims,” *The Journal of Finance*, forthcoming.

Cetorelli, N., 2001, “Does Bank Concentration Lead to Concentration in Industrial Sectors?,” working paper, Federal Reserve Bank of Chicago.

Cetorelli, N. and M. Gambera, 2001, “Banking Market Structure, Financial Dependence and Growth: International Evidence from Industry Data,” *Journal of Finance*, 56(2), 617-648.

Cetorelli, N. and P. Peretto, 2000, ”“Oligopoly Banking and Capital Accumulation,” working paper, Federal Reserve Bank of Chicago.

Cetorelli, N. and P. E. Strahan, 2005, “Finance as a Barrier to Entry: Bank Competition and Industry Structure in Local U.S. Markets”, *The Journal of Finance*, forthcoming.

Degryse, H. and S. Ongena, 2001, “Bank-Firm Relationships and The Structure and Integration of International Banking Markets”, working paper, Tilburg University.

Degryse, H. and S. Ongena, 2003, “Distance, Lending Relationships and Competition”, *The Journal of Finance*, forthcoming.

Elsas R. and J. P. Krahenen, 1998, “Is Relationship-Lending Special? Evidence from Credit-File Data in Germany,” *Journal of Banking and Finance*, 22, 1283-1316.

Fischer, K., 1990, “Hausbankenbeziehungen als Instrument der Bindung zwischen Banken und Unternehmen,” Dissertation, University of Bonn.

- Freixas, X. and J. C. Rochet, 1997, *Microeconomics of Banking*, MIT Press.
- Gehrig, T., 1998, "Screening, Market Structure, and the Benefits from Integrating Loan Markets", in M. Bagella, I. Hasan and G. Szego, *Banking Concentration, Financial Markets and Interest Rates*, Elgar Publishing.
- Gerschenkron, A., 1962, "Economic Backwardness in Historical Perspective", Harvard University Press.
- Grunert, J. and M. Weber, 2005, "Recovery Rates of Bank Loans: Empirical Evidence for Germany", working paper, University of Mannheim.
- Hannan, T.H., 1991, "Bank Commercial Loan Markets and the Role of Market Structure: Evidence from Surveys of Commercial Lending," *Journal of Banking and Finance*, 15(1), 133-149.
- Hauswald, R. and R. Marquez, 2000, "Competition and Strategic Focus in Lending Relationships," working paper, University of Maryland.
- Hellwig, M., 1998, "Allowing for Risk Choices in Diamond's "Financial Intermediation as Delegated Monitoring," working paper, University of Mannheim.
- Hu, Y. and W. Perraudin, 2002, "The Dependence of Recoveries and Defaults", working paper, Bank of England and Birkbeck College.
- Leshchinskii, D., 2000, "Venture Capitalists as Benevolent Vultures: The Role of Network Externalities in Financing Choice", working paper, HEC.
- Maksimovic, V. and J. Zechner, 1991, "Debt, Agency Costs and Industry Equilibrium", *The Journal of Finance*, 1619-1645.
- Maksimovic, V., A. Stomper and J. Zechner, 1999, "Capital Structure, Information Acquisition and Investment Decisions in Industry Equilibrium", *European Finance Review* 2, 251-271.
- Manove, M., A.J. Padilla, and M. Pagano, 2001, "Collateral vs. Project Screening: A Model of Lazy Banks", *RAND Journal of Economics*, 32(4), 726-744.
- Mester, L. J., L. I. Nakamura, and M. Renault, 2001, "Checking Accounts and Bank Monitoring," working paper, Federal Reserve Bank of Philadelphia.
- Ongena, S. and D.C. Smith, 2000, "Bank Relationships: A Review," in P. Harker and S. A. Zenios (eds.), *The Performance of Financial Institutions: Efficiency, Innovation, Regulation*, Cambridge University Press.

- Parlour, C. A. and U. Rajan, 2001, "Competition in Loan Contracts", *American Economic Review*, 91(5), 1311-1328.
- Petersen, M.A. and R.G. Rajan, 1995, "The Effect of Credit Market Competition on Lending Relationships," *Quarterly Journal of Economics*, 407-443.
- Phelps, J.M.W., S.C. Hughes, W.B. Bowling, and P.R. Stallings, 1998, "Metropolitan Atlanta Construction and Development Lending Trends," FDIC Bank Trends.
- Sapienza, P., 2002, "The Effect of Banking Mergers on Loan Contracts," *Journal of Finance*, 57, 329-368.
- Sharpe, S.A., 1990, "Asymmetric Information, Bank Lending and Implicit Contracts: A Model of Customer Relationships," *Journal of Finance*, 45, 1069-1087.
- Stomper, A., 2004, "A Theory of Banks' Industry Expertise, Market Power, and Credit Risk", working paper, University of Vienna, <http://ssrn.com/abstract=295568>.
- Tilly, R., 1998, "Universal Banking in Historical Perspective", *Journal of Institutional and Theoretical Economics*, 154(1).
- Von Thadden, E.L., 1998, "Asymmetric Information, Bank Lending and Implicit Contracts: The Winner's Curse," working paper.
- Winton, A., 1997, "Competition among Financial Intermediaries when Diversification Matters", *Journal of Financial Intermediation*, 6, 307-346.
- Winton, A., 1999, "Don't Put All Your Eggs in One Basket? Diversification and Specialization in Lending," working paper, University of Minnesota.
- Yafeh, Y. and O. Yosha, 2001, "Industrial Organization of Financial Systems and Strategic Use of Relationship Banking", *European Finance Review*, 5(1-2), 63-78.
- Yanelle, M. O., 1989, "The Strategic Analysis of Intermediation", *European Economic Review*, 33(2/3), 294-301.
- Yosha, O., 1995, "Information Disclosure Costs and the Choice of Financing Source", *Journal of Financial Intermediation*, 4, 3-20.
- Yosha, O., 1997, "Diversification and Competition: Financial Intermediation in a large Cournot-Walras Economy", *Journal of Economic Theory*, 75, 64-88.

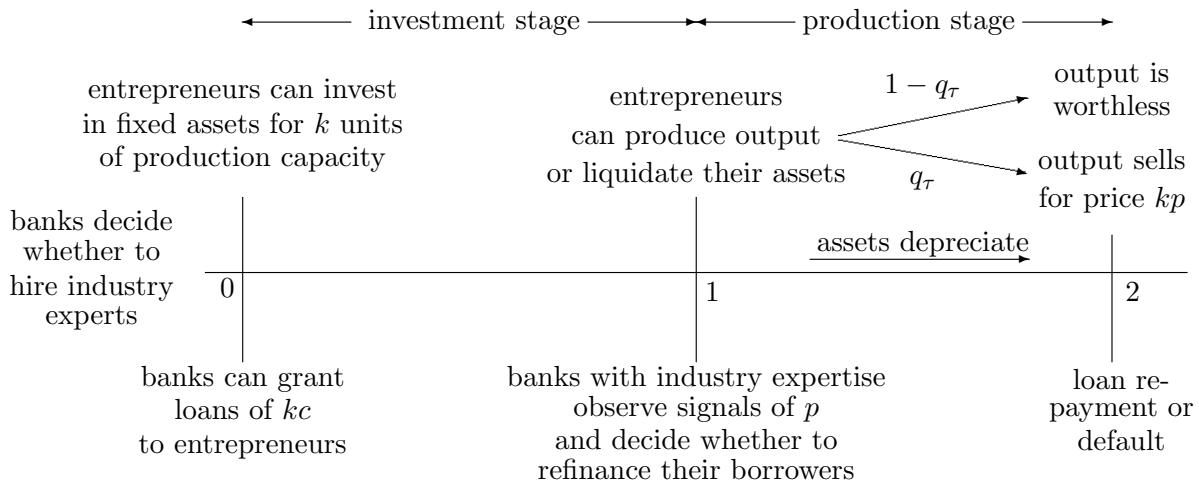


Figure 1: Timeline

A Theory of Banks' Industry Expertise, Market Power, and Credit Risk: Appendix

Alex Stomper

University of Vienna

Proof of Lemma 1: Given the realization of its signal, $\sigma_i \in \{0, 1\}$, bank i expects that a skilled entrepreneur realizes an NPV of $NPV_{\sigma_i} = k(\mathbb{E}[p|\sigma_i, n_i] - c)$ by producing k units of output. It must be the case that $NPV_{\sigma_i} \geq kx_I$ for (at least) one of the two possible values of σ_i : otherwise, bank i (as a representative bank with industry expertise) could never expect to break even on the cost of using technology T_I .

I will next show that $NPV_{\sigma_i} < 0$ if and only if $\sigma_i = 0$, and hence $NPV_{\sigma_i} \geq kx_I$ for $\sigma_i = 1$. To this end, I will first show that there exists some value of $\sigma_i \in \{0, 1\}$ for which $NPV_{\sigma_i} < 0$; then, I will show that this is the case for $\sigma_i = 0$. The first result follows from the condition in the first sentence of Lemma 1 which can be stated more formally as in condition (10) (that must hold in any equilibrium with free entry):

$$x_0 = (\mathbb{E}[p] - c) = 0.5(\mathbb{E}[p|\sigma_i = 0, n_i] - c) + 0.5(\mathbb{E}[p|\sigma_i = 1, n_i] - c). \quad (10')$$

In the above-stated equation, the two terms in brackets equal NPV_{σ_i}/k for $\sigma_i = 0$ and $\sigma_i = 1$, respectively. Since I have argued above that there must exist a value of $\sigma_i \in \{0, 1\}$ for which $NPV_{\sigma_i} \geq kx_I$, equation (10') and $x_I > x_0$ imply that $NPV_{\sigma_i} < 0$ for the other possible value of σ_i . Hence, there must exist a value of σ_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, $\sigma_i = 0$.

To obtain a contradiction, I assume that $NPV_0 > 0$ and $NPV_1 < 0$. This implies that bank i can only expect to profit from refinancing a borrower if it observes the low-demand signal, $\sigma_i = 0$. If $\sigma_i = 1$, the bank will reject any borrower's request for refinancing: $\lambda[\sigma_i = 1, n_i, r] = 0$, since $NPV_1 < 0$ implies that $\bar{\pi}[\sigma_i = 1, n_i, r] < 0$ for any r . If $\sigma_i = 0$, the bank refinances the borrower with probability $\lambda[\sigma_i = 0, n_i, r] \geq 0$ (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 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, $E[p|\alpha = -a] < E[p|\alpha = +a]$. (This inequality is strict since the intercept of the inverse demand function (1) is lower if $\alpha = -a$ than if $\alpha = +a$.) This inequality contradicts the assumption that $NPV_0 > 0 > NPV_1$ since it implies that $E[p|\sigma_i = 0, n_i] < E[p|\sigma_i = 1, n_i]$, and hence $NPV_0 = k(E[p|\sigma_i = 0, n_i] - c) \leq NPV_1 = k(E[p|\sigma_i = 1, n_i] - c)$.

Proof of Proposition 4: A bank with industry expertise refinances its 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, $\Omega^*[n^*]$. To derive the expression for $\Omega^*[n^*]$, I use condition (9). This condition implies that, per borrower, a bank earns the following expected profit in refinancing its borrowers if its industry experts predict high demand:

$$\bar{\pi}[n^*, r^*] = \delta[n^*]o[n^*]k. \quad (27)$$

Per unit of capacity, this implies an expected profit of $\bar{\pi}[n^*, r^*]/k = \delta[n^*]o[n^*]$, bringing the bank's overall expected profit to $\Omega^*[n^*] = n^*\pi[n^*]/k = \delta[n^*]o[n^*]n^*$.

Proof of Lemma 2: Given the result in Proposition 4, a bank with industry expertise can break even if the following condition holds:

$$0.5\Omega^*[n^*] = 0.5\delta[n^*]o[n^*]n^* = 0.5(1 - \rho[n^*])(n^*)^2 \geq n^*x_I, \quad (28)$$

where the first equation follows from expression (18), and the second equation is obtained since $\delta[n^*] = \text{Prob}[p < c(1 + r^*)|\sigma_i = 1, n_i = n^*] = \text{Prob}[\alpha = -a|\sigma_i = 1, n_i = n^*] = (1 - \rho[n^*])$ (by $\alpha = -a \Leftrightarrow p < c(1 + r^*)$), and $o[n^*] = n^* - k \rightarrow n^*$ for $k \rightarrow 0$. If $\rho[\cdot]$ satisfies the condition stated in Lemma 2, 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 equation:

$$0.5(1 - \rho[n_0])(n_0)^2 = n_0x_I. \quad (29)$$

Proof of Proposition 5: As stated in Section 3.2.3, the equilibrium is determined by condition (10') (as equivalent to the condition stated in Proposition 2), condition (21) (as equivalent to condition (14') for $k \rightarrow 0$), and condition (16) (as equation). Of relevance for the analysis below, condition (10') determines the expected price of marketable output, $E[p] = (c + x_0)$, and hence the conditional expected price of such output if demand is low, $\alpha = -a$ and bank i finances its borrowers' output production since $\sigma_i = 1$:

$$\begin{aligned} E[p|\alpha = -a] &= E[p] - a + (E[Q_b^{-i}] - E[Q_b^{-i}|\alpha = -a]) - 0.5n^* \\ &= c + x_0 - a + (b^* - 1)(\rho[n^*] - 0.5)n^* - 0.5n^*, \end{aligned} \quad (30)$$

where I have used that $E[Q_b^{-i}|\alpha = -a] = (b^* - 1)(1 - \rho[n^*])n^*$ and $E[Q_b^{-i}] = (b^* - 1)0.5n^*$ since n^* is the aggregate marketable output of the borrowers of one bank with industry expertise, if the bank refinances the borrowers.

Before deriving closed form solutions, I will rearrange the equilibrium conditions in order to state them more conveniently. Condition (21) determines the optimal level at which each of the banks with industry expertise finances industrial capacity formation. Upon using expression (22) to substitute for $\Delta_\Omega[n^*, r^*]$, I obtain the condition:

$$0.5\rho'[n^*]\gamma[r^*]n^* - x_I = 0, \quad (31)$$

where $\gamma[r^*] = c(1+r^*) - E[p|p < c(1+r^*)]$ (by expression (13)) for $E[p|p < c(1+r^*)] = E[p|\alpha = -a]$ given by the expression stated above. Under the assumption that $\rho[\cdot]$ satisfies equation (23), $\rho'[n^*]$ 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:

$$(1 - \rho[n^*])(c(1 + r^*) - E[p|\alpha = -a])n^* - \frac{2x_I n^*}{\nu} = 0. \quad (32)$$

Condition (16) holds as equation in an equilibrium with free entry. By the expression for $\Omega^*[n^*]$ stated in Proposition 4, this equation can be stated as follows:

$$0.5\delta[n^*]o[n^*]n^* - n^*x_I = 0, \quad (33)$$

where $\delta[n^*] = \text{Prob}[p < c(1 + r^*)|\sigma_i = 1, n_i = n^*] = \text{Prob}[\alpha = -a|\sigma_i = 1, n_i = n^*] = (1 - \rho[n^*])$ (by $\alpha = -a \Leftrightarrow p < c(1 + r^*)$), and $o[n^*] = n^* - k \rightarrow n^*$ for $k \rightarrow 0$.

In equilibrium, banks with industry expertise finance industrial capacity formation at the level of $n^* = n_0$ units, defined in the proof of Lemma 2 as the solution to condition (33). This implies

that the banks' skilled borrowers request refinancing at an interest rate of $r^* = \underline{r}[n^*]$, given by condition (27) for $\bar{\pi}[n^*, r^*] = k(\rho[n^*]c(1+r^*) + (1-\rho[n^*])E[p|\alpha = -a]) - kc$, $\delta[n^*] = (1-\rho[n^*])$, and $o[n^*] = n^*$:

$$\rho[n^*]c(1+r^*) + (1-\rho[n^*])(E[p|\alpha = -a]) - c = (1-\rho[n^*])n^*. \quad (27')$$

To summarize, I must solve the following system of equations for n^* , r^* and b^* :

$$(i) \quad 0 = \quad \rho[n^*]c(1+r^*) + (1-\rho[n^*])(E[p|\alpha = -a]) - n^* \quad -c, \quad (27')$$

$$(ii) \quad 0 = \quad ((1-\rho[n^*])c(1+r^*) - (1-\rho[n^*])E[p|\alpha = -a])n^* \quad -\frac{2x_I n^*}{\nu}, \quad (32')$$

$$(iii) \quad 0 = \quad (1-\rho[n^*])(n^*)^2 \quad -2x_I n^*, \quad (33')$$

where b^* enters the first two equations as a determinant of the expected price $E[p|\alpha = -a]$. Multiplying condition (i) by n^* and adding the result to condition (ii) yields the following equation:

$$c(1+r^*)n^* - (1-\rho[n^*])(n^*)^2 - cn^* - \frac{2x_I n^*}{\nu} = 0. \quad (34)$$

Condition (iii) implies that the second term of the above-stated condition equals $2x_I n^*$; upon substituting for this term, dividing the resulting expression by n^* and rearranging, I obtain result (26).

Condition (iii) can be written as follows:

$$(1-\rho[n^*])n^* - 2x_I = 0. \quad (35)$$

Under the assumption that $\rho[\cdot]$ satisfies equation (23), the first term of the above-stated equation equals $\epsilon(n^*)^{1-\nu}$. Hence, solving this equation for n^* yields result (25).

Finally, I derive the expression for b^* . To do this, I use results (26) and (25) to substitute for r^* and n^* in condition (i) and solve the resulting equation for b^* to obtain result (24).

It remains to show that condition (21) 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 6: Differentiating result (24) yields the expressions,

$$\begin{aligned} \frac{\partial b^*}{\partial x_I} &= -\frac{\epsilon((a-x_0)((n^*)^\nu - 2\epsilon(1-\nu)) + 2x_I(n^*)^\nu(2\nu-1))}{((n^*)^\nu - 2\epsilon)^2 x_I^2 (1-\nu)}, \\ \frac{\partial b^*}{\partial \epsilon} &= \frac{((a-x_0)\nu + 2x_I(2\nu-1))(n^*)^\nu}{((n^*)^\nu - 2\epsilon)^2 x_I \nu (1-\nu)}. \end{aligned} \quad (36)$$

Since banks with industry expertise observe informative signals (i.e. $\rho[n^*] > 0.5$, and, hence, $n^* > 2\epsilon$), the first of these expressions decreases in the size of the demand shock, a , while the second increases in a . Since the number of banks also increases in a , $b^* \geq 1$ is a sufficient condition for $\partial b^*/\partial x_I < 0$ ($\partial b^*/\partial \epsilon > 0$), if the first (second) 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,

$$\begin{aligned}\frac{\partial b^*}{\partial x_I}\Big|_{b^*=1} &= -\frac{(n^*)^\nu(2-\nu)-2\epsilon(1-\nu^2)}{((n^*)^\nu-2\epsilon)x_I\nu(1-\nu)} < 0, \\ \frac{\partial b^*}{\partial \epsilon}\Big|_{b^*=1} &= \frac{(n^*)^\nu(2-\nu)}{((n^*)^\nu-2\epsilon)\epsilon\nu(1-\nu)} > 0.\end{aligned}\tag{37}$$

Proof of Proposition 7: As discussed above Proposition 7, a bank with industry expertise incurs an expected loss of $\gamma[r^*]n^*$ if it refinances its skilled borrowers in the low-demand state. The recovery rate is given by $\gamma[r^*]n^*/(c(1+r^*)n^*) = \gamma[r^*]/(c(1+r^*))$. By expression (13) and $\mathbb{E}[p|p < c(1+r^*)] = \mathbb{E}[p|\alpha = -a]$, $\gamma[r^*]/(c(1+r^*))$ is given by,

$$\frac{\gamma[r^*]}{c(1+r^*)} = 1 - \frac{\mathbb{E}[p|\alpha = -a]}{c(1+r^*)} = \frac{cr^*}{c(1+r^*)} \frac{1}{1-\rho[n^*]} - \frac{n^*}{c(1+r^*)},\tag{38}$$

where the second equation follows from condition (27') (in the proof of Proposition 5) which implies the following expression for the expected price $\mathbb{E}[p|\alpha = -a]$:

$$\mathbb{E}[p|\alpha = -a] = c(1+r^*) - cr^* \frac{1}{1-\rho[n^*]} + n^*.\tag{39}$$

Notice that $\gamma[r^*]$ does not depend on the size of the demand shock, a . To obtain the results in Proposition 7, I use results (25) and (26) to substitute for n^* and r^* in expression (38), and differentiate the resulting expression with respect to x_I and ϵ :

$$\begin{aligned}\frac{\partial}{\partial x_I} \frac{\gamma[r^*]}{c(1+r^*)} &= \frac{1}{\nu} \frac{(2c/\epsilon)(2x_I/\epsilon)^{\nu/(1-\nu)}}{(c+2x_I(1+\nu)/\nu)^2} > 0, \\ \frac{\partial}{\partial \epsilon} \frac{\gamma[r^*]}{c(1+r^*)} &= -\frac{1}{\nu} \frac{(2x_I/\epsilon^2)(2x_I/\epsilon)^{\nu/(1-\nu)}}{c+2x_I(1+\nu)/\nu} < 0.\end{aligned}\tag{40}$$