NBER WORKING PAPER SERIES

INTERMEDIATION VARIETY

Jason Roderick Donaldson
Giorgia Piacentino
Anjan Thakor

Working Paper 25946
http://www.nber.org/papers/w25946

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2019

We gratefully acknowledge helpful comments from Philp Bond (editor), two anonymous referees, Mike Burkart, Francesca Cornelli, Giovanni Dell'Ariccia, Philip Dybvig, Daniel Ferreira, Radha Gopalan, Vincent Glode, Denis Gromb, Ohad Kadan, Nataliya Klimenko, Mina Lee, Adrien Matray, Asaf Manela, Alan Morrison, Balazs Szentes, Basil Williams, Andy Winton, Vijay Yerramilli, Kostas Zachariadis, Jean-Pierre Zigrand and seminar participants at the 2015 EFA Summer Meetings, the 2015 FIRS Conference, the 2017 Five Star Conference, the London School of Economics, the 2018 SFS Cavalcade, and Washington University in St. Louis. Xiabo Yu provided outstanding research assistance. We alone are responsible for any remaining errors. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 25946
June 2019
JEL No. G21,G23,G24

ABSTRACT

We explain the emergence of a variety of intermediaries in a model based only on differences in their funding costs. Banks have a low cost of capital due to, say, safety nets or money-like liabilities. We show, however, that this can be a disadvantage, because it exacerbates soft-budget-constraint problems, making it costly to finance innovative projects. Non-banks emerge to finance them. Their high cost of capital is an advantage, because it works as a commitment device to withhold capital, solving soft-budget-constraint problems. Still, non-banks never take over the entire market, but coexist with banks in equilibrium.

Jason Roderick Donaldson
Olin Business School
Washington University in St. Louis
Simon Hall
1 Olympian Way
St Louis, MO 63130
j.r.donaldson@wustl.edu

Giorgia Piacentino
Columbia Business School
3022 Broadway
Uris Hall 813
New York, NY 10027
and NBER
gp2547@columbia.edu

Anjan Thakor
Washington University in St. Louis
Thakor@wustl.edu

1 Introduction

Depository financial institutions—"banks"—have a low cost of capital,[1] most likely because their liabilities benefit from a moneyness premium and government safety nets. Perhaps due to this funding-cost advantage, banks provided the bulk of finance until the 1970s. But as competition among banks increased, non-depository financial institutions—"non-banks"—proliferated. As Remolona and Wulfekuhler (1992) put it,

> During the 1980s, U.S. commercial banks faced increased competition in their lending activities from other financial intermediaries...[which] enjoyed their success despite carrying apparently heavier capital burdens and lacking the advantage of deposit insurance (p. 25).

It seemed like non-banks could even replace banks. Indeed, in 1994, Boyd and Gertler wrote a paper called "Are Banks Dead?" which begins

> It is widely believed that in the United States, commercial banking is a declining industry [because] nonbank credit alternatives have grown rapidly over the last 15 years (p. 2).

But banks remain alive and well today, with over $12.5 trillion in deposits in the US.[2] They still provide much of the finance for traditional projects—commercial and industrial loans to firms in established industries. However, non-banks, such as finance companies and venture capitalists, play an important role in financing innovative projects. Although these projects are often highly profitable, non-banks still provide only a minority of funding in the economy. Why do non-banks coexist with banks, even though they have a funding cost disadvantage? And why do they remain relatively scarce, even though they finance profitable projects?

Model preview. To address these questions, we develop a model in which financiers' choices to specialize in banking or non-banking and entrepreneurs' choices to do traditional or innovative projects are jointly determined in general equilibrium, and nd we characterize how these choices depend on competition among financiers.

In the model, ex ante identical entrepreneurs seek financing for two-stage projects from financiers. When each financier enters, it chooses whether to specialize in banking or non-banking. When each entrepreneur meets a financier, he chooses whether to seek financing for a traditional project or an innovative one. Both are plagued by the soft-budget-constraint problem inherent in staged financing (Dewatripont and Maskin (1995); Kornai (1979, 1980)). Namely, entrepreneurs can avoid the costs of failure by

[1]For example, Startz (1979) and Nagel (2016) (online Appendix B) estimate that deposit rates are one-third to one-half of the competitive rate. See, e.g., Diamond (2019), Donaldson and Piacentino (2019), and Merton and Thakor (2018) for theoretical foundations.

[2]See the FDIC Quarterly Banking Profile at https://www.fdic.gov/bank/statistical/stats/2018dec/industry.pdf.

refinancing their projects. Anticipating refinancing at the second stage, they are reluctant to work at the first stage. To incentivize them, financiers can threaten termination following initial failure, but the threat is not credible if either the incumbent financier or a competing rival is willing to provide new capital. It is especially hard for the incumbent to commit not to finance continuation, since preventing termination can help it to recoup its initial investment—it can be ex post optimal for the financier to throw good money after bad, even if it is ex ante optimal to commit not to.

The model is based on two key assumptions. (i) We assume that the innovative project is associated with high agency costs. This makes entrepreneurs prefer the innovative project, because they can get agency rents. But, given the soft-budget-constraint problem, these rents can make it prohibitively costly to finance innovative entrepreneurs. (ii) We assume that banks have a lower cost of capital than non-banks (and are otherwise identical). This high cost of capital could seem like a strict disadvantage of being a non-bank, but we find that it is not.

Results preview. In fact, our first main result is that non-banks' high cost of capital can be an advantage. Because it can make refinancing entrepreneurs unprofitable, it can work as a commitment device to not provide additional finance after the first stage, and thereby harden entrepreneurs' budget constraints. And, with a hard budget constraint, entrepreneurs face a credible termination threat, making them cheap to incentivize. As a result, financing innovative projects becomes viable. Banks' low cost of capital, on the other hand, makes refinancing entrepreneurs attractive, and thereby keeps entrepreneurs' budget constraints soft. As a result, financing innovative entrepreneurs, with their high agency costs, is not viable. However, financing traditional entrepreneurs, with lower agency costs, can be attractive, despite their soft budget constraints, since banks are subsidized by their own low cost of capital.

Our second main result is that non-banks' hard budget constraints allow them not only to incentivize entrepreneurs cheaply, but also to keep them captive. Indeed, a non-bank-financed entrepreneur is unable to get any financing from rivals at all. The reason is that, with no soft-budget-constraint problem, his incumbent non-bank can extract a high repayment at the first stage. As a result, rivals are unwilling to finance him at the second stage, given he already owes a high repayment to someone else. Conversely, a bank-financed entrepreneur preserves access to financing from rivals. The reason is that, given the soft-budget-constraint problem, his incumbent bank cannot extract a high repayment at the first stage. As a result, rivals are still willing to finance him at the second stage. Thus, when a bank finances a traditional entrepreneur, it has to leave rents to the entrepreneur both at the first stage, to incentivize him, and at the second stage, to prevent him from seeking finance from rivals. The more competition there is among rivals, the more rents the incumbent bank has to leave to an entrepreneur to keep him from seeking finance from them.

Our third main result is that entrepreneurs choose their projects based on the kind of finance they have access to. Entrepreneurs know that non-banks are willing to finance innovative projects (given they impose hard budget constraints) but banks are not (given they cannot). Thus, when entrepreneurs meet non-banks, they choose innovative projects which generate high agency rents. But, when they meet banks, they choose traditional projects which give them access to finance. Thus, unlike in the existing literature,[3] the mix of financiers in the market determines the mix of projects, not the other way around.

Our fourth main result is a characterization of this mix of financiers as a function of the level of competition among them. We find a closed-form expression for the equilibrium proportion of non-banks in the market. It reveals that non-banks become more important as competition increases: they enter only competitive markets and provide an increasing proportion of financing as competition increases. However, they do not take over the whole market, but co-exist with banks for all levels of competition.

To understand the result, first observe how increasing competition can exacerbate the soft-budget-constraint problem. Competition makes it easy for entrepreneurs to refinance and avoid the cost of failure, which makes them reluctant to work in the initial stage. But only bank-financed entrepreneurs are affected by this competition for continuation financing; non-bank financed entrepreneurs are captive to their incumbents no matter what. Thus, as competition increases, so does the relative benefit of being a non-bank, i.e. the relative benefit of keeping entrepreneurs captive. If competition is low, this benefit is not enough to outweigh the cost of non-banks' high cost of capital. In this case, all financiers specialize in traditional banking. If competition is higher, non-banking becomes attractive. In this case, some financiers specialize in non-banking to mitigate the effects of the soft-budget-constraint problem. Not all financiers do, however. Some still specialize in banking. The reason is that if everyone were to specialize in non-banking, then few banks would operate, as for low competition, and banking would become attractive again. Hence, banks co-exist with non-banks, even for very high competition.

Our fifth main result is that entrepreneurs may choose the traditional project not only when they cannot access finance for the innovative one, as per our third main result, but also in some circumstances when they can. To show this, we relax the assumption that financing innovation is prohibitively costly for banks. In this case, if competition is low, banks finance innovation and there is no room for non-banks to enter, given they finance the same projects with a higher cost of capital. We find, however, that if competition among financiers is high, entrepreneurs who meet banks may choose the

[3] See, e.g., Bhattacharya and Chiesa (1995), von Thadden (1995), and Yosha (1995).

traditional project *despite having access to finance for the innovative one.* The reason is that, by choosing the traditional project, they avoid being captive, and thus can use the threat of getting financing from rivals at the continuation stage to extract more rents from incumbents at the initial stage. This threat is valuable, however, only if competition among financiers is high enough to make it relatively easy to get financing from a rival—entrepreneurs still prefer the innovative project if competition is low, since they are always effectively captive in this case. This result is reminiscent of the hold-up problem (e.g., Grossman and Hart (1986)) in that the entrepreneur chooses one thing (the traditional project) at the initial stage to ensure it can extract more rent at the continuation stage, even if choosing something else (the innovative project) could generate higher total surplus.

In summary, for low competition, there are only banks, and entrepreneurs choose traditional projects (unless banks are willing to finance innovative projects, as in the last result). For higher competition, banks finance only traditional projects, even if innovative projects are efficient. Non-banks emerge to fund innovation, providing an increasing share of finance as competition increases, but possibly remaining scarce, even in the perfect competition limit. (See Figure 1.)

Figure 1: Financing Regimes as a Function of Competition among Financiers

For low competition	For higher competition	As competition increases
All financiers specialize in banking	Most financiers specialize in banking	Some financiers continue to specialize in banking
None specialize in non-banking	But a few specialize in non-banking	More and more, but never all, specialize in non-banking
All entrepreneurs are bank-financed and choose traditional projects[4]	Bank-financed entrepreneurs choose traditional projects	Bank-financed entrepreneurs still choose traditional projects
There are no non-bank-financed entrepreneurs	Non-bank-financed entrepreneurs choose innovative projects	Non-banked financed entrepreneurs still choose innovative projects

[4]This holds in our baseline set-up. Recall, however, that, in general, whether entrepreneurs choose traditional or innovative projects can depend on parameters. Under our baseline assumptions, banks are unwilling to finance innovation and entrepreneurs choose the traditional project, as per our third main result. When we relax this assumption, so banks are willing to finance innovation, entrepreneurs still choose the traditional project for high competition, as per our fifth main result, but may choose the innovative project for low competition.

Our model and results resonate with practice. Our assumption that banks have a lower cost of capital than non-banks (see footnote 1 and Section 4.2) generates realistic, first-order differences between how non-banks and banks behave. Non-banks' ability to harden soft-budget constraints is arguably their main disciplining tool. As Sahlman (1990) stresses for VCs,

> The credible threat to abandon a venture, even when the firm is economically viable, is the key to the relationship between the entrepreneur and the VC (p. 507).

And banks' inability to harden soft-budget constraints was a first-order concern for economists worried about the decline of banking. As Jensen (1989) put it, "banks' chief disciplinary tool, their power to withhold capital from...companies, has been vastly reduced." And, as we spell out in Section 4.1, our results correspond to empirical predictions, consistent with existing findings. (i) With increased banking competition, non-banks are now likely to finance innovative projects. Indeed, (ii) access to non-bank finance is an important driver of entrepreneurs' choice to innovate. But banks are alive and well, and (iii) provide the bulk of finance for traditional projects, although (iv) they charge lower interest rates than non-banks. Moreover, (v) the effect of banking competition on real-sector innovation is ambiguous. Our results also give new perspectives on some policies. For example, policies that could lower banks' cost of capital, such as deposit insurance, bailout guarantees, and subsidized access to central bank liquidity facilities, can have an unintended consequence. By making them unable to harden entrepreneurs' budget constraints, these policies prevent banks from funding innovation, which could lead entrepreneurs to choose traditional projects inefficiently (Section 5).

Further results. In our baseline specification, we define competitiveness among financiers as the ratio of financiers to entrepreneurs, which determines the probability of a bilateral meeting between an entrepreneur and a financier. This way of modeling competition has a number of advantages, the primary one being that, by restricting attention to bilateral meetings, we can embed the soft-budget-constraint problem in a market economy and still keep the analysis tractable. But it is important to ask whether our results are specific to this notion of competition. We analyze two extensions to show that the answer is no. We model competition, first, in the quantity of credit provided à la Cournot and, second, as the probability of getting a simultaneous competing offer à la Bertrand. In both cases, we show that our results on how intermediation variety depends on competition are robust; in equilibrium, the basic functional forms are even the same as in the baseline specification. However, we have to capture the outcome of the soft-budget-constraint problem in reduced form in the Cournot case and to rely on a linear approximation in the Bertrand case. Hence, neither alternative is a complete substitute for our baseline.

In our baseline model, the equilibrating force that leads to the coexistence of banks and non-banks—to intermediation variety—is the negative spillover of one bank's entry on others' profits. By increasing the number of rival banks, a bank's entry allows entrepreneurs to extract more rents from their incumbents. But we also augment the model to explore two other ways in which a financier's entry can spill over on others' profits. First, we suppose that there is a limited supply of truly innovative ideas. In this case, the more non-banks enter and fund innovative projects, the fewer innovative projects are left for other non-banks to fund. This makes non-banking less attractive; hence it decreases the proportion of non-banks that operate in equilibrium. However, it does not qualitatively change our results. Second, we suppose that there is congestion among similar financiers, e.g., because they look for similar entrepreneurs. In this case, the more non-banks enter, the harder it is for other non-banks to find entrepreneurs to finance, and likewise for banks.[5] Whether this makes non-banking or banking more attractive depends on which financiers are most affected by the congestion; hence it can either increase or decrease the proportion of non-banks that operate in equilibrium. Either way, however, it does not qualitatively change our results.

Related literature. Our paper contributes to the literature on how borrowers choose between competing sources of finance, most of which focuses on the the trade-off between bank and market finance.[6] In this literature, borrowers are typically endowed with heterogenous projects which determine whether it is advantageous for them to seek bank or market finance. Perhaps most often, banks have an informational advantage over markets by assumption, as in e.g., Diamond (1991), Holmström and Tirole (1997), or Rajan (1992). Information-sensitive borrowers thus choose banks to benefit from bank monitoring or flexibility, whereas borrowers less in need of monitoring choose markets to avoid compensating banks for monitoring or giving them information rents. In Boot and Thakor (1997), the trade-off is between the market's ability to aggregate information and banks' ability to resolve moral hazard. Thus, again, borrowers' exogenous characteristics determine their choice of financing source. Unlike this literature, we assume that borrowers are ex ante identical. Differences among them arise ex post

[5]Such congestion externalities can also be present in our baseline set-up (although they need not be). However, unlike in this extension, they affect all financiers the same way; i.e. when a non-bank enters, it imposes the same externalities on banks as on other non-banks.

[6]See Allen and Gale (2004), Besanko and Kanatas (1993), Bolton and Freixas (2000), Chemmanur and Fulghieri (1994), Gersbach and Uhlig (2007), Hoshi, Kashyap, and Scharfstein (1993), Rajan (1992), Repullo and Suarez (2000), Song and Thakor (2010), and von Thadden (1999). Many papers study competition among banks, rather than between banks and other sources of finance; see, e.g., Boot and Thakor (2000), Boyd and De Nicolò (2005), Cao and Shi (2000), Cetorelli (2004), Dell'Ariccia (2000), Dell'Ariccia and Marquez (2004), Guzman (2000), Hellmann, Murdock, and Stiglitz (2000), Keeley (1990), Marquez (2002), Martinez-Miera and Repullo (2017), Matutes and Vives (2000), Petersen and Rajan (1995), Repullo (2004), Sharpe (1990), and Wagner (2009).

based on their source of finance. And, also unlike this literature, we focus on the trade-off between bank and non-bank finance, rather than between bank and market finance. This is likely to be the most relevant trade-off for the kinds of innovative/entrepreneurial borrowers we model.

There are a few other papers in which banks coexist with other types of financiers. In Bond (2004), they coexist with less-diversified financiers, such as conglomerates, which can economize on the costs of information sharing in some circumstances. In Ueda (2004), they coexist with VCs, which can screen entrepreneurs' projects better, but cannot commit not to expropriate them.[7] In Begenau and Landvoigt (2017) and Chrétien and Lyonnet (2019), they coexist with shadow banks, which are less regulated, but do not benefit from cheap funding due to moneyness or deposit insurance. In Hanson, Shleifer, Stein, and Vishny (2015), they also coexist with shadow banks, which, in line with the other papers cited, are less regulated. However, in contrast with the other papers, these shadow banks also enjoy a low cost of capital from creating money-like liabilities. Thus, they do not resemble the non-banks in our model, but are closer to our banks, whose defining feature is their low cost of capital. Indeed, their non-banks are closest to money market mutual funds, which invest in marketable securities, whereas ours are closest to venture capitalists or finance companies, which finance early-stage entrepreneurs.

Our model is also related to models of the market for venture capital, which also stress staged financing. Like us, Inderst and Mueller (2004), Jovanovic and Szentes (2013), Khanna and Mathews (2017), and Nanda and Rhodes-Kropf (2013) use models of bilateral meetings to embed dynamic VC-entrepreneur relationships in a wider market.[8] Many of these papers include search-and-matching frictions, which are likely to be first order for early-stage entrepreneurs with hard-to-assess projects.[9] We can too, but we do not have to for our results. What matters is that we can capture scarcity, not search frictions. Namely, some entrepreneurs can go unfunded just because capital is scarce, even if matching is frictionless. This is certainly first order for potential entrepreneurs, who report that raising capital is their principal problem (Blanchflower and Oswald (1998)).

Layout. The rest of the paper is organized as follows. In Section 2, we set up the model. In Section 3, we solve the model and present the main analysis. In Section 4, we comment on our model's empirical implications, we discuss some of our key assumptions, and we explore some alternative ones. In Section 5, we conclude and

[7]See also Chan, Siegel, and Thakor (1990). In that paper, banks, VCs, and markets all coexist and a borrower's financing choice depends on his experience and reputation.

[8]Some other papers, e.g., Boualam (2018), Payne (2018), Donaldson, Piacentino, and Thakor (2019), Herkenhoff (2019), and Wasmer and Weil (2004), use related models to study the market for bank credit.

[9]Indeed, in one survey, 20% of aspiring entrepreneurs say that *where* to get finance is their *biggest* concern (Blanchflower and Oswald (1998)).

comment on policy. The Appendix contains all proofs.

2 Model

Time is discrete and the horizon is infinite. Overlapping generations of entrepreneurs seek financiers to provide capital to two-stage projects. The projects suffer from a soft-budget-constraint problem, requiring additional capital if they do not pay off at the initial stage. Incumbent financiers have a monitoring advantage, but still compete with the next generation of financiers to provide continuation capital. This competition is the only link between generations. (We omit time indices since we focus on stationary equilibria.)

2.1 Entrepreneurs and Projects

At each date, a unit continuum of identical, penniless risk-neutral entrepreneurs is born. Each has access to two projects $\pi \in \{I, T\}$, where I stands for "innovative," and T for "traditional." Each entrepreneur meets a financier with probability Q. In this case, he may raise capital to invest in one of the two projects. Otherwise, he gets a reservation payoff normalized to zero.

The projects resemble those in Crémer (1995): each lasts two stages with moral hazard at each stage and a soft budget constraint. Specifically, each project requires first-stage financing K_0 at the initial date and continuation financing K_1^π at the interim date if it does not succeed in the first stage. If the project succeeds (at either stage), it pays off y^π. Otherwise, it pays off nothing. The probability of success at each stage depends on the entrepreneur's effort: if he works, the project succeeds with probability p; if he shirks, it succeeds only with probability $p - \Delta$, which we assume is small enough that projects are viable only if the entrepreneur works in both stages.[10] Although working increases the expected payoff of the project, it is costly for the entrepreneur, because it entails forgoing (non-pecuniary) private benefits at each stage. These equal B^π unless the financier monitors the project, in which case they are reduced to b^π in the second stage, as discussed below. A project $\pi \in \{I, T\}$ is thus characterized by seven parameters K_0, K_1^π, y^π, p, Δ, B^π, and b^π. Observe, however, that only the output, second stage financing cost, and private benefits depend on its type π (although below we often omit the superscript π even from these parameters). Limiting the parameters that vary across the projects imposes discipline, limiting our free parameters, and also simplifies the equations. It also means we abstract from some important aspects of

[10] A sufficient condition to ensure that working always dominates shirking in equilibrium is $\Delta\big((1-p)y + K_1\big) > p\left(B/\Delta - \max\{Q_b B, b\}\right)$, where B and b are the entrepreneur's private benefits from shirking and Q_b is the probability he meets a bank, as defined below.

innovation, such as risk. But, as we discuss in Section 4.2, the model can easily be adapted to include many of them.

We assume that both projects are associated with potential soft-budget-constraint problems.

Assumption 1. *For both projects, the cost of continuation financing is not too high: for* $\pi \in \{I, T\}$,

$$K_1^\pi < p\left(y^\pi - \frac{b^\pi}{\Delta}\right). \tag{1}$$

We also make two assumptions on parameters to distinguish the projects from each other, reflecting two key real-world characteristics of innovation (as discussed further in Section 4.2).

Assumption 2. *The private benefits of the innovative project are large:*

$$B^I > 2B^T. \tag{2}$$

This says that the innovative project is associated with large agency frictions.

Assumption 3. *The initial investment cost is neither too small nor too large:*

$$(2-p)py^I - (1-p)K_1^I - p\frac{B^I + b^I}{\Delta} < K_0 < (2-p)py^T - (1-p)K_1^T - 2p\frac{B^T}{\Delta}. \tag{3}$$

This assumption says that the soft-budget-constraint problem is more costly for the innovative project than the traditional one, in that it can make first-stage financing unattractive for the innovative project but not for the traditional one. Basically, it says that K_1^I is high relative to K_1^T. This is an important driver of our results, and, as we argue in Section 4.2, a realistic distinction between innovative and traditional projects. There, we also give a numerical example of "reasonable" parameters satisfying all of our assumptions.

2.2 Financiers

At each date, a continuum of mass F of identical risk-neutral financiers is born. Each chooses to become either a bank or a non-bank and meets an entrepreneur with probability q. We let φ denote the proportion of non-banks, so there are $(1-\varphi)F$ banks and φF non-banks in the market at each date.

The only difference between a bank and a non-bank is that banks have a low cost of capital, which we normalize to zero, relative to non-banks, which have a cost of capital $r > 0$, assumed to be sufficiently large (but not too large):

Assumption 4. *Non-banks' cost of capital is neither too small nor too large:*[11]

$$\frac{p\left(y^I - B^I/\Delta\right)}{K_0^I} > 1 + r > \max\left\{ \frac{p\left(y^I - b^I/\Delta\right)}{K_1^I}, \frac{p^2 B^T}{\Delta K_1^T} \right\}. \tag{4}$$

Both types of financiers want to invest in entrepreneurs' projects. If a financier meets an entrepreneur, it can make the entrepreneur a (take-it-or-leave-it) offer of initial financing K_0 in exchange for the repayment R_1 in the event that the project succeeds in the first stage. If the entrepreneur does not succeed in the first stage, the financier can make a (take-it-or-leave-it) offer of continuation financing K_1 in exchange for the additional repayment R_2 in the event that the project succeeds in the second stage.[12] If the entrepreneur rejects this offer, he can try to find continuation financing from another financier in the market at the interim date. This market is populated by the next generation of financiers. If he does not get financing, the project is scrapped, paying off zero.

We assume that incumbent financiers have an advantage in monitoring entrepreneurs, due to, say, proprietary information they acquire about the entrepreneur, as in Rajan (1992).[13] Following Holmström and Tirole (1997), we assume that if an entrepreneur gets continuation financing from his incumbent financier, his second-stage private benefits are reduced from B to b, but if he gets it from a rival his private benefits are still B. Formally, this can modeled by assuming incumbent financiers have a lower cost of monitoring than rivals. Indeed, it is equivalent to the extreme assumption in Crémer (1995), that the monitoring cost is zero if the incumbent finances the second stage, but infinite if a new financier does. Realistically, both incumbents and rivals are likely to monitor entrepreneurs. This is just a simple way to capture the idea that incumbents can monitor more cheaply, and hence are likely to monitor more. (See Section 4.2 for a discussion.)

Finally, financiers that do not meet entrepreneurs exit, getting a reservation payoff normalized to zero.

[11]The condition on the left ensures that non-banks are willing to finance the innovative entrepreneurs at the initial stage. The first condition on the right ensures that they do not provide continuation financing to innovative entrepreneurs whom they financed in the first stage, and the second condition on the right ensures that they do not provide continuation financing to traditional entrepreneurs whom someone else financed in the first stage.

[12]Note whether R_1 or R_2 is prioritized does not matter for the results. The reason is that repayments are determined by the entrepreneur's IC, which depends on only the total stock of debt. See equation (5) below.

[13]Botsch and Vanasco (2019) find empirical evidence of "learning by lending," by which incumbent financiers obtain such an informational advantage over competitors.

2.3 Timeline

At each date, each financier chooses to be a bank or a non-bank and meets an entrepreneur with probability q, where q is a decreasing function of the number of financiers F. Symmetrically, each entrepreneur meets a financier with probability $Q(F)$, where Q is a function of the number of financiers F, continuously increasing from $Q(0) = 0$ to $Q(\infty) = 1$. He meets a bank or a non-bank with probabilities proportional to their numbers, i.e. with $Q_b = (1 - \varphi)Q$ and $Q_{\text{nb}} = \varphi Q$, respectively. After meeting a financier, he chooses a project to seek financing for. Then, the financier offers the entrepreneur financing terms. After this, the entrepreneur works or shirks, and the project either succeeds, in which case the entrepreneur makes the agreed repayment, or does not, in which case the sequence repeats: the financier makes an offer to fund the continuation of the project; the entrepreneur works or shirks; and the project succeeds or fails. If it succeeds, the entrepreneur makes the agreed repayment; otherwise, he repays nothing. Entrepreneurs and financiers that do not meet anyone exit.[14]

Importantly, if the financier offers continuation financing, it takes into account that if the entrepreneur rejects it he can try to find financing elsewhere, receiving an offer from a next-generation financier with probability Q. Recall that private benefits are lower with the incumbent financier, given its monitoring advantage.

3 Results

In this section, we solve for the stationary subgame perfect equilibrium of the model. We first study the two-stage agency problem between financiers and entrepreneurs, showing how it depends on whether the entrepreneur has a hard or a soft budget constraint and on whether he is captive to his incumbent financier. Next, we show how an entrepreneur's project choice depends on the type of financier he has access to and on how the types of financiers in the market depend on the level of competition among them. Finally, we explore equilibrium project choices for some different parameters.

3.1 Entrepreneurs' Incentive Constraints

The model is built around the soft-budget-constraint problem inherent in staged financing. It must be incentive compatible for an entrepreneur to work at each stage.

[14]This assumption that everyone gets only one chance to match keeps the model stationary, so that competition is the same at each period. We intentionally abstract from dynamics, using the OLG set-up just to capture the effect of competition on multi-stage financing in a simple way. (See Biais and Landier (2015) for a model in which a similar link between overlapping generations of entrepreneurs does matter for aggregate dynamics.)

However, he has little incentive to work at the first stage if he knows that if he fails he can still get refinanced and continue at the second stage.

We begin with the first stage, and show how the entrepreneur's continuation value, denoted by u, affects his IC:

$$p\big(y - R_1\big) + (1 - p)u \geq (p - \Delta)\big(y - R_1\big) + (1 - p + \Delta)u + B, \tag{5}$$

where the LHS is his expected payoff if he works (his success probability is p), and the RHS is his expected payoff if he shirks (his success probability is only $p - \Delta$, but he gets private benefits B). The IC can be rewritten as an upper bound on his repayment R_1:

$$R_1 \leq y - u - \frac{B}{\Delta}. \tag{6}$$

The higher is the continuation value u, the lower is the repayment the financier can extract because it must leave the entrepreneur a lot of rent to incentivize him to work.

Following failure, the entrepreneur's project is terminated unless he gets refinanced. He could get refinancing from his incumbent or from a rival. In the case that he gets it from his incumbent, he is monitored, and his private benefits are reduced from B to b. His second-stage IC is

$$p\big(y - R_1 - R_2\big) \geq (p - \Delta)\big(y - R_1 - R_2\big) + b. \tag{7}$$

This IC is the analog of the first-stage IC (equation (5)). But the additional repayment R_2 the entrepreneur can commit to repay is limited because he already has R_1 to repay from his first stage financing. This gives a lower bound on the entrepreneur's continuation value, which is his expected payoff net of repayments:

$$u = p\left(y - R_1 - R_2\right) \geq p\frac{b}{\Delta}. \tag{8}$$

But he might also be able to get financing from a rival. In this case, he is not monitored, his private benefits remain B, and he can get more agency rent. Hence, if he can get outside finance—i.e. if he is not captive to his incumbent—his continuation value could be even higher. We explore whether an entrepreneur can get continuation financing from either his incumbent or a rival in the next section.

3.2 Soft vs. Hard Budget Constraints and Captivity

Here we ask whether entrepreneurs can access finance from rivals or are captive to incumbents. We solve backwards, showing that access to continuation financing creates a soft-budget-constraint problem which can undermine access to initial financing.

We consider entrepreneurs with each of the two types of projects separately, starting with the innovative project, which is costly to refinance, and then moving on to the traditional project, which is cheaper to refinance.

Innovative entrepreneurs. It is hard for an incumbent financier, which has provided initial capital to an entrepreneur, to commit not to finance his continuation, since doing so makes it more likely to recoup its initial investment. This can make financing innovative entrepreneurs, for whom refinancing is expensive, especially costly (cf. Assumption 3). But a non-bank's high cost of capital works as a commitment device not to refinance an innovative entrepreneur. In contrast, with its low cost of capital, a bank has no way to make such a commitment.[15] In other words, if an innovative entrepreneur gets non-bank financing, his budget constraint is hard, whereas if he gets bank financing, it is soft:

Lemma 1. (Innovative entrepreneurs' budget constraints.) *An incumbent bank provides continuation financing to an innovative entrepreneur; an incumbent non-bank does not.*

A non-bank not only imposes a hard budget constraint on the innovative entrepreneur, it also keeps him captive:

Lemma 2. (Innovative entrepreneurs are captive to non-banks.) *An innovative entrepreneur is captive to an incumbent non-bank.*

This result says that an innovative entrepreneur is endogenously captive to an incumbent non-bank. To see why, the first step is to observe that if the incumbent financier can credibly require a high initial repayment, then he can keep the entrepreneur captive. The reason is that if he owes a lot to his incumbent from the first stage, then he can promise little to a rival at the second stage. Hence, the rival is unwilling to finance him. The second step is to observe that, given a non-bank imposes a hard budget constraint, it can credibly require a high initial repayment. The reason is that then the entrepreneur faces a credible termination threat, since he cannot get continuation from his incumbent (given its high cost of capital) or from a rival (given he already owes too much to the incumbent). Thus, the entrepreneur has incentive to work even if a lot of his output goes to his financier when his project succeeds—he wants to avoid termination when it does not. Hence, the non-bank can extract enough rent to make financing an innovative entrepreneur at the first stage profitable:

[15]This result complements the intuition that financiers use their own leverage as a commitment device to prevent borrower opportunism. E.g., in Diamond and Rajan (2001) the risk of runs by bank creditors prevents renegotiation by their borrowers, and in Axelson, Strömberg, and Weisbach (2009) intermediary leverage mitigates the conflict of interest between a private equity fund and its investors.

Corollary 1. (Non-banks finance innovation.) *A non-bank will finance an innovative entrepreneur.*

Unlike non-banks, banks cannot commit not to refinance the entrepreneur (Lemma 1). Given he will always be able to refinance his project, the entrepreneur has a high continuation value u. This tightens his first-stage IC (equation (5)), making him costly to incentivize, especially if he has an innovative project, which comes with high agency costs by definition (Assumption 2). Indeed, this can be so costly that a bank will not fund an innovative entrepreneur at all (even if he is captive):

Corollary 2. (Banks do not finance innovation.) *A bank does not fund an innovative project.*

In summary, banks' funding-cost advantage becomes a disadvantage in that it prevents them from committing to take (or not to take) certain actions: with bank financing, innovative entrepreneurs' budget constraints remain soft. This prevents banks from financing them profitably.

Traditional entrepreneurs. We now turn to an entrepreneur with a traditional project, focusing on the case in which he gets financing from a bank (which turns out to be the the relevant case (Proposition 2)). Given its low cost of capital, the incumbent bank is always willing to refinance a traditional entrepreneur:

Lemma 3. (Traditional entrepreneurs' budget constraints.) *An incumbent bank provides continuation financing to a traditional entrepreneur.*

A bank not only cannot impose a hard budget constraint on the traditional entrepreneur, it also cannot keep him captive:

Lemma 4. (Traditional entrepreneurs are not captive to banks.) *Suppose that*

$$K_1^T \leq p^2 Q_b \frac{B^T}{\Delta}. \tag{9}$$

A traditional entrepreneur is not captive to an incumbent bank: he has access to finance from rival banks (but not from rival non-banks).

The reason a bank cannot keep a traditional entrepreneur captive is that it cannot harden his budget constraint. This means it must leave the entrepreneur substantial agency rent in the first stage to satisfy his IC (cf. equation (6)). This can make rival banks[16] willing to finance him, given that he owes little to his incumbent.

When an incumbent bank makes an offer for continuation financing, it takes into account that the entrepreneur can reject it and try to find finance from a rival. This is

[16] We show in the proof that, given its high cost of capital, a rival non-bank is never willing to finance him.

attractive for the entrepreneur, who gets higher private benefits $B > b$ when financed by a non-monitoring rival. In this case, his agency rent is pB/Δ (cf. equation (8)). But he meets a rival bank only with probability Q_b. Hence, he stays with his incumbent only if

$$p(y - R_1 - R_2) \geq Q_b p \frac{B}{\Delta}, \tag{10}$$

where the LHS is just his expected payoff from the incumbent, and the RHS is the probability Q_b he meets a rival bank times the expected payoff from the rival, as just described. Hence, with a soft budget constraint, the incumbent financier sets R_2 to make the tighter of the constraints in equations (7) and (10) bind:

$$R_2^{\text{not captive}} = y - R_1 - \max\left\{ \frac{b}{\Delta}, Q_b \frac{B}{\Delta} \right\}. \tag{11}$$

However, given Assumption 3, the soft-budget-constraint problem is not so severe that a traditional project is no longer viable. Indeed, the bank is still willing to finance it:

Corollary 3. (Banks finance traditional.) *A bank will finance a traditional entrepreneur.*

The results above stress that a hard budget constraint not only makes it easier to incentivize an entrepreneur, but also makes it easier to keep him captive. The reason is that the financier can demand a high initial repayment, so that if the entrepreneur does not succeed, he already owes so much to the incumbent financier that no one else will finance him. In contrast, a financier with a soft budget constraint has to leave surplus on the table in the initial stage, and thus must compete with other financiers for any remaining surplus at the continuation stage. In this sense, a financier suffers from the soft budget constraint twice, once when it must incentivize the entrepreneur, and again when it must compete with new financiers. High competition Q_b makes this second effect worse, because, roughly, the entrepreneur can easily pit a rival financier against his incumbent. In contrast, high competition has no effect on a financier with a hard budget constraint, given it has monopoly power over its captive entrepreneur no matter what. This fact that competition matters more with soft budget constraints will drive our comparative statics results below (Section 3.4), which we derive after describing the equilibrium project choices in the next section.

3.3 Access to Finance and Entrepreneurs' Project Choice

We now turn to entrepreneurs' project choices. Entrepreneurs are all identical, but could meet different types of financiers, banks and non-banks, which are themselves identical except for their different costs of capital. We have shown, however, that this matters for financiers, since a high cost of capital allows non-banks to solve the soft-budget-constraint problem. Now we show that it matters for entrepreneurs too. Because innovative projects are associated with costly soft budget constraints, entrepreneurs do not undertake them unless they have access to non-banks that can resolve the problem. The next result says that entrepreneurs who meet banks choose traditional projects. The reason is that they do not have access to finance for innovative ones.

Proposition 1. (No innovation with banks.) *Suppose that the condition in equation (9) holds. Entrepreneurs who meet banks choose traditional projects.*

Whereas banks are not willing to finance innovative projects, non-banks are. The reason is that non-banks' hard budget constraints discipline entrepreneurs, forcing them to work in the first stage. Entrepreneurs welcome this discipline, because it allows them to get innovative projects financed, which yield them higher payoffs. This is not due to a high payoff y^I associated with the innovative project itself—that would benefit the financier, given it offers the contract. Rather, it is due to the high private benefits B^I associated with it—this benefits the entrepreneur, given he gets agency rent. This leads to the next result:

Proposition 2. (Non-banks discipline.) *Entrepreneurs who meet non-banks choose innovative projects.*

These results stress that the kind of finance entrepreneurs have access to can determine their project choices—entrepreneurs choose traditional projects unless they have access to non-bank finance, in which case they choose innovative projects. In this sense, real innovation follows financial innovation.

In the next section, we turn to how entrepreneurs' access to finance is endogenously determined by financiers' choices to become banks or non-banks. First, though, we summarize how these different projects look in equilibrium.

Corollary 4. (Non-bank vs. bank finance.) *Suppose that the condition in equation (9) holds and y^I is sufficiently large relative to y^T; specifically,*

$$y^I > y^T + \max\left\{\frac{1-p}{p}\big(py^T - K_1^T\big), \frac{B^I - B^T - b^T}{\Delta}\right\}. \tag{12}$$

In equilibrium, non-banks finance high-return (innovative) projects, and banks finance low-return (traditional) projects. Moreover, non-banks charge higher repayments (R_1) than banks do.

This result could shed light on why some non-banks, like PEs, seem to earn high returns relative to the market (Harris, Jenkinson, and Kaplan (2014)). The results in the next section can explain why PE financing remains relatively scarce despite these high returns.

3.4 Intermediation Variety

We have established that entrepreneurs with access to non-banks choose innovative projects and that those with access to banks choose traditional ones. But will there be a *mix* of banks and non-bank financiers in equilibrium? Or will financiers all prefer to be banks, benefiting from the their low cost of capital? Alternatively, will they all prefer to be non-banks, benefiting from their hard budget constraints? Moreover, does the mix of financiers in the market depend on the level of competition among them?

To address these questions, we start by comparing the expected payoffs of banks and non-banks. Since financiers offer the contracts, they get the total surplus from a project less the agency rents they must leave on the table to incentivize entrepreneurs. In a meeting between an entrepreneur and a non-bank, the total surplus is the value of the innovative project, which can succeed in its first stage or not at all (given the hard budget constraint). We define this as Σ^I, noting that we need to multiply K_0 by the non-bank's cost of capital $(1 + r)$:

$$\Sigma^I := py^I - (1 + r)K_0. \tag{13}$$

Hence, since it meets an entrepreneur with probability q, the non-bank's expected payoff is

$$\text{non-bank's payoff } = q\left(\Sigma^I - p\frac{B^I}{\Delta}\right), \tag{14}$$

where the second term is the entrepreneur's expected rent $p(y - R_1)$. In a meeting between an entrepreneur and a bank, the total surplus is the value of the traditional project, which could succeed in its first or second stage (given the soft budget constraint). We define this as Σ^T:

$$\Sigma^T := py^T - K_0 + (1 - p)\big(py^T - K_1^T\big). \tag{15}$$

Hence, since it meets an entrepreneur with probability q, a bank's expected payoff is

$$\text{bank's payoff } = q\left(\Sigma^T - \frac{p}{\Delta}\big(B^T + \max\left\{\, Q_b\, B^T, b^T \,\right\}\big)\right), \tag{16}$$

where the second term is the entrepreneur's expected rent $p(y - R_1) + (1 - p)p(y - R_1 - R_2)$.

Different types of financiers coexist if and only if their payoffs are equal in equilibrium, so a financier is indifferent between becoming a non-bank and a bank, or

$$q\left(\Sigma^I - p\frac{B^I}{\Delta}\right) = q\left(\Sigma^T - \frac{p}{\Delta}\big(B^T + \max\left\{\, Q_b\, B^T, b^T \,\right\}\big)\right). \tag{17}$$

Each financier's choice can depend on the choices of others, since the probabilities q and Q_b depend on the proportion φ of non-banks in the market. These probabilities in turn depend on the number of financiers F, our measure of financing competition.

To explain how the variety of financiers operating depends on competition, we suppose for illustration that b^T is small, so $\max\left\{Q_b B^T, b^T\right\} = Q_b B^T$. Thus, the financiers' indifference condition in equation (17) becomes

$$\Sigma^I - p\frac{B^I}{\Delta} = \Sigma^T - p\frac{B^T}{\Delta}\big(1 + Q_b\big). \tag{18}$$

This expression captures a key trade-off in our model: an increase in banking competition, captured by the probability an entrepreneur meets a bank, Q_b, exacerbates the soft-budget-constraint problem, reducing the bank's profit on the RHS. The reason is that if Q_b is high, then the entrepreneur's continuation utility at the second stage is high too; as a result, the bank must leave him more agency rent in the first stage (see the IC in equation (5)). Thus, the more competitive the market is, the more financiers benefit from keeping entrepreneurs captive.

Now, since Q_b is increasing in the number of banks in the market, financiers become banks if not too many others do, and become non-banks otherwise. Rearranging equation (18), we see that this leads to an interior mix of banks and non-banks in equilibrium for

$$Q_b = Q_b^* := \frac{1}{B^T}\left(B^I - B^T + \frac{\Delta}{p}\left(\Sigma^T - \Sigma^I\right)\right), \tag{19}$$

as long as this is a well-defined probability. Thus, given $Q_b = (1-\varphi)Q(F)$, we have that

$$\varphi = \max\left\{0, 1 - \frac{Q_b^*}{Q(F)}\right\}. \tag{20}$$

Given $Q' > 0$, the expression for φ (equation (20)) implies that φ is an increasing function of F. If competition among financiers is very low, φ is zero, indicating that no non-bank operates. If competition is higher, some financiers become non-banks, and the proportion that does increases as competition increases, so as to keep the problems caused by the soft budget constraint at bay. But φ never reaches 1. Non-banks never take over the whole market, and banks provide some finance for all levels of competition F, with the proportion of non-banks approaching $1 - Q_b^*$ in the perfect competition limit $(F \to \infty)$, as depicted in Figure 2, and formalized in the next proposition.

Proposition 3. (Intermediation variety.) *Suppose that*

$$\max\left\{\frac{b^T}{B^T},\frac{\Delta K_1^T}{p^2B^T}\right\}<Q_b^*<1 \tag{21}$$

(where Q_b^* is as defined in equation (19)).

1. *Non-banks are present only if competition among financiers F is sufficiently high.*
2. *The proportion of non-banks is increasing in competition F.*
3. *Non-banks never take over the entire market; rather, banks provide a positive fraction of finance for all F.*

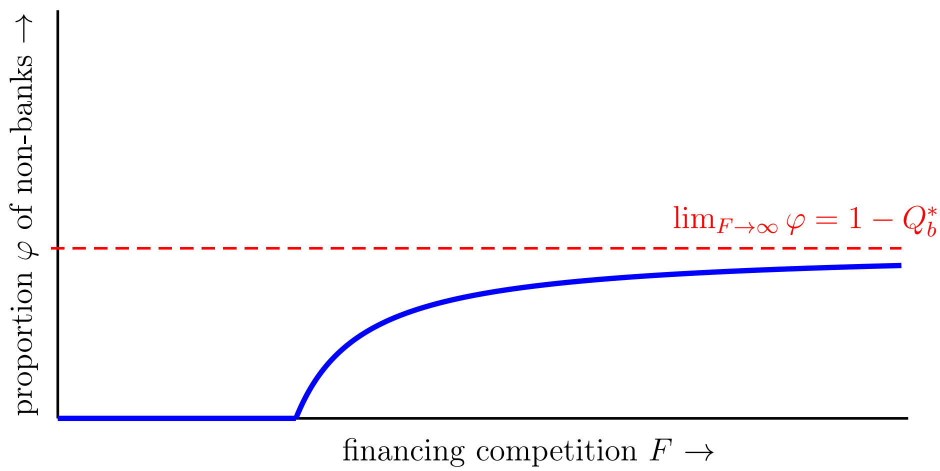

Figure 2: The proportion φ of non-banks in the market as a function of competition F. (For the plot, we used the "telephone" matching function (Stevens (2007)), which implies that $Q(F)$ has the form $\frac{F}{1+F}$.)

For low competition F, all financiers become banks to take advantage of their funding cost advantage. But as competition increases, and there are more banks in the market, it becomes easier for entrepreneurs to find banks to finance their second-stage investments, i.e. Q_b goes up. As a result, entrepreneurs can extract more rent from their incumbent banks. Hence, non-banks emerge to solve this problem. They keep entrepreneurs captive, and hence are always effectively monopolists, unaffected by competition. Still, non-banks do not provide all the finance for high competition.

The reason that banks provide a positive fraction of finance even for high F is that non-bank entry attenuates the effect of competition on banks, in the sense that it makes Q_b less sensitive to F. There are two effects behind this. (i) There is the direct effect that when many new financiers become non-banks, an increase in the number of financiers leads to a relatively small increase in the number of banks—i.e. the higher φ is, the less sensitive $Q_b = (1-\varphi)F$ is to F. (ii) There is the indirect effect that when many new financiers become non-banks, an increase in the number of financiers can induce congestion, decreasing the likelihood an entrepreneur meets a bank.

These congestion externalities are a hallmark of models of markets in which trading/search frictions can make it hard to find a counterparty, e.g., the Mortensen and Pissarides (1994) model of labor markets, the Duffie, Gârleanu, and Pedersen (2005) model of OTC financial markets, and the Inderst and Mueller (2004) model of venture capital markets. Their practical importance notwithstanding, congestion externalities only amplify our result; they are not strictly necessary for it. To see this, observe that they matter only if $Q(F)$ is non-linear, but that our results hold even if it is linear: if $Q(F) = \mu F$, Q_b is proportional to the mass of banks in the market:[17]

$$Q_b = (1-\varphi)Q(F) = \mu(1-\varphi)F = \mu \times |\text{banks}|, \tag{22}$$

and it is unaffected by the number of non-banks in the market—there are no congestion externalities. Nonetheless, we can use our expression for the proportion of non-banks in equation (20) to get $\varphi = \max\left\{0, 1 - \frac{Q^*}{\mu F}\right\}$, which is positive only for sufficiently high competition F; it is increasing, but at a decreasing rate; and it is never one (cf. 3). Moreover, the argument is even more general. From equation (19), we can see that it applies whenever Q_b is a function of only the number of banks in the market, $Q_b = f\big((1-\varphi)F\big)$.

3.5 Entrepreneurs Choose Not to Innovate

So far, entrepreneurs who met banks chose traditional projects because they knew they could not get funding for innovative projects. We now turn to another reason that they might choose not to do innovative projects—anticipating being captive with innovative projects, they choose traditional projects to extract more rent. This can happen if parameters are such that banks are willing to finance innovative entrepreneurs (despite the soft-budget-constraint problem) but that if they do, these innovative entrepreneurs are captive:[18]

Proposition 4. (Entrepreneurs choose not to innovate.) *Suppose that the condition in equation (9) holds. But now suppose that the first inequality in Assumption 3*

[17] Where we must restrict attention to $F \leq 1/\mu$ to ensure that this is a well-defined probability.

[18] Although many theory papers study banking competition (see footnote 6), to our knowledge only two of them study how it affects entrepreneurs' choices. These are Boyd and De Nicolò (2005), which shows that increasing competition can increase entrepreneurs' risk-shifting, and Martinez-Miera and Repullo (2010), which shows that diversification can offset the risk-shifting effect in Boyd and De Nicolò (2005). Goetz (2018) finds empirical evidence that an increase in banking competition reduces the risk of bank failures.

does not hold, or

$$K_0^I \leq py^I + (1-p)\Big(py^I - K_1^I\Big) - \frac{p\,B^I}{\Delta} - \frac{p}{\Delta}\max\left\{Q_b\,B^I, b^I\right\} \tag{23}$$

(which implies that banks fund an innovative project) and that

$$K_1^I > p^2 Q_b \frac{B^I}{\Delta} \tag{24}$$

(which implies that the innovative entrepreneur is captive to the bank).

Entrepreneurs matched with banks choose the traditional project (possibly inefficiently) if and only if interbank competition is sufficiently high, i.e.

$$Q_b \geq \left(\frac{b^I + B^I}{B^T}\right) - 1. \tag{25}$$

Intuitively, when entrepreneurs choose projects, entrepreneurs face a trade-off. With the innovative project, they get high private benefits, but are captive; with the traditional project, they get low private benefits, but are not. Thus, they may choose the traditional project, even if the innovative project is efficient, in the sense that the payoff y^I is sufficiently high relative to y^T.[19] This points to another way that non-banks' high cost of capital can discipline entrepreneurs: it not only allows non-banks to commit to deny second-stage financing, which hardens entrepreneurs' soft budget constraints, but also allows them to commit to deny financing to traditional projects, which forces entrepreneurs to innovate:

Lemma 5. (Non-banks force innovation.) *Suppose that the conditions in Proposition 4 are satisfied. Entrepreneurs with access to banks choose traditional projects, and those with access to non-banks choose innovative projects.*

[19] We refrain from giving a formal definition of efficiency mainly for two reasons. (i) With imperfect markets (bilateral matching) and heterogeneous agents (different costs of capital), there is not a clear way to define the discount rate that determines whether one project is better than another in an NPV sense. (ii) With financiers' funding cost difference taken in reduced form, there is not a clear way to define aggregate welfare. To do so, we would have to take a stand on where the difference comes from, and close the model in more general equilibrium. We choose not to do this, given the cost of capital difference could reflect a variety things (Section 4.2). Just for example, banks' low cost of capital could reflect a social purpose played by safe deposits, and these deposits could be safe in part because they are backed by low-risk traditional projects. In this case, investing in traditional projects need not be inefficient. In contrast, the low cost of capital could reflect fiscal backing by the government. In this case, investing in traditional projects most likely would be inefficient.

4 Empirical Content, Discussion, Robustness, and Extensions

In this section, we relate our findings to empirical evidence in the literature. Then we discuss some of our modeling assumptions, and show that our results are robust to alternative specifications and extensions.

4.1 Empirical content

Banks in our model represent institutions that take deposits, and have a low cost of capital as a result. Non-banks could represent a variety of institutions that do not take deposits, but still compete with traditional banks to finance entrepreneurs. Salient examples are finance companies and venture capital firms. Others are private equity firms, [20] insurance companies, and commercial mortgage banks.

Our analysis of how entrepreneurs' and financiers' choices are jointly determined in general equilibrium sheds light on a number of stylized facts. The empirical findings in Chernenko, Erel, and Prilmeier (2018) are particularly relevant to our results. After presenting evidence of the importance of non-bank finance, which accounts for 32% of loans in their data, they show that firms are more likely to borrow from non-banks if they are more R&D-intensive and if the banking market is less concentrated. They also find that non-bank borrowers pay higher interest rates. These findings support three of our main predictions:

1. *Non-banks finance innovative projects (Proposition 2).* For further support for this result, see, e.g., Kortum and Lerner (2000) on VCs, Lerner, Sorensen, and Strömberg (2011) on PEs, and (under the assumption that innovation is relatively risky[21]) Carey, Post, and Sharpe (1998) and Denis and Mihov (2003) for finance companies.
2. *The proportion of non-banks is increasing in competition (Proposition 3).* For further support for this prediction, see, e.g., Boyd and Gertler (1994), IMF (2016), Remolona and Wulfekuhler (1992), and Shapiro and Pham (2008).
3. *Non-banks require higher repayments per unit of capital invested than banks do (Corollary 4).*

[20] Our model might not apply to LBOs, in which PEs often target low-risk firms. But it could apply to other branches of the PE business. Indeed, anecdotally, it seems PEs are increasingly competing with banks in the lending market. See, e.g., "The New Business Banker: A Private Equity Firm," *Wall Street Journal*, August 12, 2018 and "How the Biggest Private Equity Firms Became the New Banks," *Financial Times*, September 19, 2018.

[21] In our baseline model, we assume that innovative and traditional projects have the same success probability. But, as discussed in Section 4.2, this is only to discipline the parameters and keep the equations simple. In reality, the types of projects we call "innovative" are likely to be risky too.

Another prediction is that non-banks discipline entrepreneurs by imposing a hard-budget constraint.

4. *Non-banks' termination threat disciplines entrepreneurs (Lemma 1 and Proposition 2).* For support for this prediction, see Gompers and Lerner (2001), who say "Staged capital infusion may be the most potent control mechanism a VC can employ (p. 155)."

This could also shed light on why non-bank loans tend to have fewer covenants than bank loans (Chernenko, Erel, and Prilmeier (2018)): the termination threat could substitute for covenants as a disciplining device.

The evidence on how competition among financiers affects innovation is mixed. So are our predictions. Thus, our analysis offers a potential reconciliation of the existing empirical findings:

5. *Real-sector innovation may be increasing banking competition (because more non-banks enter, as in Proposition 3) or decreasing in banking competition (because fewer entrepreneurs innovate, as in Proposition 4).* Chava et al. (2013) and Mao and Wang (2018) provide evidence consistent with the prediction that real-sector innovation increases with banking competition.[22] Hombert and Matray (2016), Cornaggia et al. (2015), and (under the assumption that innovation is relatively risky) Kaviani and Maleki (2018) provide evidence that real-sector innovation declines with banking competition.

Finally, our results stress the importance of access to finance for entrepreneurs' decisions.

6. *Access to (non-bank) finance leads to innovation (Proposition 2).* For support for this prediction, see, e.g., Blanchflower and Oswald (1998), who find that one of the main reasons people choose not to pursue entrepreneurship is that they have limited access to financing, and Samila and Sorenson (2011), who find that an increase in the supply of venture capital makes people more likely to engage in entrepreneurship. Anecdotally, access not only to financing, but to the right *type* of financing, is a first-order consideration for entrepreneurs. For example, access to VC financing is among the most-cited reasons why entrepreneurs decide to headquarter in the Bay Area (e.g., Cohan (2013) and Wessel (2013)). Indeed, Chen et al. (2010) find that location is related to VC outcomes.

[22] Under the assumption that, as is common in practice, banks finance with debt and non-banks with equity, this prediction also sheds light on Hsu, Tian, and Xu's (2014) finding that firms innovate more when equity markets are more developed, but the development of debt markets seems to discourage it. (Note, however, that debt and equity are theoretically equivalent in our set-up.)

4.2 Discussion

Banks' and non-banks' cost of capital. Underlying all of our results is the assumption that banks have a lower cost of capital than non-banks. It generates the high hurdle rate that non-banks apply to investments,[23] which in turn disciplines entrepreneurs, hardening their budget constraints.[24]

We stress above that banks' low cost of capital is likely due to their government guarantees and money-like deposits. But non-banks may have a higher cost of funding for other reasons as well. For example, unlike banks, non-banks such as VCs and PEs take on relatively few investments, and exposure to idiosyncratic risk could drive up their cost of capital.[25] Moreover, non-banks are likely to care more about upside payoffs, given that leverage and incentive distortions make their payoffs convex.[26] As a result, they may finance only entrepreneurs that still have high upside potential, which would also have the effect of hardening a soft budget constraint.[27] Finally, they are also likely to finance riskier investments and hence have higher probability of default themselves. This would drive up the rate they have to pay on their own financing to compensate their investors endogenously.

Innovative and traditional projects. For our results, the key distinction between the two types of projects is the severity of the soft-budget-constraint problem: compared to entrepreneurs with traditional projects, those with innovative projects are costly to incentivize and expensive to refinance. We capture these important features of innovation by assuming that innovative projects have higher private benefits at each stage (B and b) and higher costs of continuation financing (K_1). We assume, however, that all projects have the same start-up costs (K_0), the same payoff given failure (zero), and the same success probabilities (p if entrepreneurs work and $p - \Delta$ otherwise). This simplifies the exposition, but means we have to rely entirely on a few parameters to

[23] A few other papers show that VCs may impose high hurdle rates because the opportunity cost of their capital is high, even if their cost of capital is not; see Inderst, Mueller, and Münnich (2006), Jovanovic and Szentes (2013), and Khanna and Mathews (2017).

[24] Our model thus explains why some finance must be intermediated: non-banks' high cost of capital on the right-hand side of their balance sheets gives them the commitment power they need to make profitable investments on the left-hand side. See, e.g., Kashyap, Rajan, and Stein (2002) and Donaldson, Piacentino, and Thakor (2018) for other theories connecting intermediary assets and liabilities.

[25] E.g., Metrick and Yasuda (2010) find that the median VC fund expects to make only 20 investments over its lifetime and argue that "the expected number of investments plays an important role in driving the overall volatility of the fund portfolio, which in turn has a significant effect on the expected present value of revenue" (p. 2309).

[26] For example, finance companies lever their investments with bank debt limiting their downside risk (Chernenko, Erel, and Prilmeier (2018)), VCs want high upside payoffs to attract investor capital (Piacentino (2019)), and the general partners in PEs have contracts that reward them more on the upside (Axelson, Strömberg, and Weisbach (2009)).

[27] To capture this within our model, we need only to make the (reasonable) assumption that entrepreneurs' upside potential is higher at the first stage than the second. We abstract from this in the baseline only for simplicity; although it would amplify our results, it is not necessary for them.

generate meaningful differences across projects.

In particular, the assumptions in equations (4) and (9) suggest that K_1^T should be "a lot" smaller than K_1^I. This may be reasonable, even taken literally. For example, refinancing innovative projects could amount to starting over, whereas refinancing traditional projects could be closer to minor upkeep. But it can also be taken as a stand-in for differences in other parameters. Most notably, innovative projects actually do pay off zero in the event of failure (Hall and Woodward (2010)), whereas traditional projects are likely to have positive recovery value. Thus, the cost of continuation K_1^T should be interpreted as only the new capital needed for an entrepreneur to continue a traditional project, which, net of the first period payoff, is likely to be much smaller for traditional than innovative projects.

In reality, innovative projects are likely to be riskier in the sense of having a lower success probability too. Our framework can accommodate such heterogeneity without becoming intractable (although the equations do look significantly more complicated). We omit it only to present our results as clearly as we can.

Parametric assumptions (numerical example). To focus on our main results, we have made a number of assumptions on parameters. To show that they are not overly restrictive, we give an example of "reasonable" parameters that satisfy all of the them, i.e. Assumption 1, Assumption 2, Assumption 3, and Assumption 4 as well as the hypothesis of Proposition 3 (equation (21)) and the condition in footnote 10: $p = 3/4$, $\Delta = 1/2$, $r = 20\%$, $y^I = 200$, $y^T = 100$, $K_1^I = 110$, $K_1^T = 9.5$, $B^I = 50$, $B^T = 10$, $b^I = 20$, and $b^T = 4$.

Bilateral matching/Competition. We use a model of random bilateral meetings to embed a staged financing problem in market equilibrium. As touched on in the Introduction, this is a useful set-up with precedent in the literature. It also allows us to do comparative statics on the level of competition, which is captured by the number of financiers F. Still, in the following sections, we show that this way of modeling competition is not critical for our results.

We should say that one thing that is critical for our results is that project choices happen after entrepreneurs and financiers meet. This allows use to capture the idea that access to finance is a driver of innovation (see, e.g., Hellmann and Puri (2000), Kerr, Lerner, and Schoar (2011), and Lerner et al. (2015)). We could also model this in other ways though. For example, we could assume that markets are somewhat segmented, and some entrepreneurs have easier access to non-bank finance than others, e.g., entrepreneurs located in Silicon Valley may have more access to VC finance than those elsewhere. In this case, entrepreneurs would only innovate if they they were in a market segment with enough non-banks. Indeed, we use this kind of reduced-form market segmentation when we model Cournot competition in Section 4.3 below.

Incumbent's monitoring advantage. In our baseline model, we rely on the assumption that if an entrepreneur is refinanced by his incumbent financier, his private benefits are reduced from B to b, whereas if he is refinanced by a rival, they are not. This helps us to model imperfect competition. Even though financiers offer the contracts, the option to seek financing from a rival financier helps the entrepreneur to extract more surplus from his incumbent, because he can get higher private benefits/agency rents with the rival. (It is not strictly necessary, however; see Section 4.4.)

The assumption is intended to capture incumbent financiers' monitoring advantage, due, for example, to any propriety informational advantages they obtain in the course of their relationship with the entrepreneur (see, e.g., Rajan (1992)). We should stress, however, that when the entrepreneur gets financing from a rival at the second stage, his private benefits are not reduced, even if he has repayments to make to his incumbent from the first stage. This could be because information acquired during second-stage financing is complementary to that acquired during the first-stage relationship. Alternatively, it could be because the financier itself must have incentive to monitor, and does so only if it has a sufficiently large stake in the entrepreneur, as in Holmström and Tirole (1997).[28] In particular, a financier must prefer to monitor at cost c, ensuring the entrepreneur works, and get its total repayment R_{tot} with probability p, than not to monitor, inducing the entrepreneur to shirk, and get R_{tot} with probability $p - \Delta$:

$$pR_{\text{tot}} - c \geq (p - \Delta)R_{\text{tot}} \tag{26}$$

or $R_{\text{tot}} \geq c/\Delta$ (which is (IC_m) on p. 672 of Holmström and Tirole (1997)). Thus, as long as $\max\{R_1, R_2\} < c/\Delta < R_1 + R_2$, a financier monitors if and only if it has provided finance at both the first and second stages (i.e. only if $R_{\text{tot}} = R_1 + R_2$).

4.3 Cournot Competition

So far, we have captured competition among financiers as the probability that they find entrepreneurs in bilateral meetings. This way of modeling competition has the advantage of allowing us to study competition among financiers and multi-stage contracting in one framework. But it has the disadvantage of abstracting from the price and quantity choices that are central to more classical models. Hence, we now explore what happens if we replace our model of competition with a Cournot game in which financiers compete in the quantity of capital they supply.

We find that our results are robust. Indeed, the equilibrium proportion of non-banks φ takes the same functional form as in the baseline model (equation (20)). However,

[28] Using data on credit lines, Acharya et al. (2014) find empirical support for the predictions of this model of monitoring.

with competition limited to quantities (rather than multi-stage contracts), we have to make some reduced-form assumptions to capture the outcomes of our contracting analysis above. In particular, we assume that markets are segmented, with banks supplying capital to traditional entrepreneurs, non-banks to innovative ones. Then, as above, we allow financiers to choose whether to be banks or non-banks, and characterize the proportion of non-banks φ as a function of the total number of financiers F.

Before turning to supply-side competition, we model how each type of entrepreneurs' aggregate demand for capital K depends on the price/interest rate R. (For now, we suppress the index $\pi \in \{T, I\}$, which indicates whether variables correspond to the traditional or innovative market segment.) We assume that there is a representative entrepreneur of each type who uses the aggregate amount capital K to produce aggregate output yK. As in the baseline model, we assume that entrepreneurs must exert costly effort to generate output. Here, we assume that the cost is a quadratic function of the project scale, equal to $BK^2/2$. This generates a linear aggregate demand in each market: given entrepreneurs

$$\text{maximize } (y - R)K - \frac{B}{2}K^2, \tag{27}$$

the first-order approach implies

$$K = \frac{y - R}{B}. \tag{28}$$

Financiers thus supply the capital K, and the price R clears the market in each segment given each financier f supplies the quantity of capital k_f. Thus, the market clearing condition reads

$$K = \sum k_f, \tag{29}$$

where the sum is taken over all the financiers operating in the market segment. Given the demand K in equation (28), we can write the market price as a function of k_f:

$$R = y - B \sum k_f. \tag{30}$$

This says that R depends on k_f, and hence that financier f must take its effect on R into account when it chooses k_f to

$$\text{maximize } \big(R - 1 - r_f\big)k_f, \tag{31}$$

where r_f is its cost of capital, equal to zero for a bank and $r > 0$ for a non-bank. From here, we have the standard solution of a Cournot game with linear demand:

Lemma 6. (Cournot solution.) *Let N denote the number of financiers in a market segment. In the unique symmetric Nash equilibrium, a financier with cost of capital r_f*

supplies capital

$$k = \frac{y - 1 - r_f}{B(1+N)} \tag{32}$$

at price

$$R = y - \frac{N}{1+N}\left(y - 1 - r_f\right) \tag{33}$$

and makes profit

$$\Pi = \frac{1}{B}\left(\frac{y - 1 - r_f}{1+N}\right)^2. \tag{34}$$

From here, we can write financiers' indifference condition. If F is the total number of financiers and we abstract from indivisibility, we can let the number of banks be $(1-\varphi)F$ and of non-banks be φF, as in the baseline model. Hence, we can equate bank and non-bank profits from equation (34):

$$\frac{1}{B^T}\left(\frac{y^T - 1}{1 + (1-\varphi)F}\right)^2 = \frac{1}{B^I}\left(\frac{y^I - 1 - r}{1 + \varphi F}\right)^2, \tag{35}$$

having used the fact that banks fund only traditional entrepreneurs and non-banks only innovative. Solving for the proportion of non-banks φ gives the next proposition.

Proposition 5. (Cournot intermediation variety.) *The proportion of non-banks is given by*

$$\varphi = \max\left\{0\,,\, a_0 - \frac{a_1}{F}\right\} \tag{36}$$

where

$$a_0 = \frac{\sqrt{\frac{B^T}{B^I}}\left(y^I - 1 - r\right)}{y^T - 1 + \sqrt{\frac{B^T}{B^I}}\left(y^I - 1 - r\right)}, \tag{37}$$

$$a_1 = \frac{y^T - 1 - \sqrt{\frac{B^T}{B^I}}\left(y^I - 1 - r\right)}{y^T - 1 + \sqrt{\frac{B^T}{B^I}}\left(y^I - 1 - r\right)}. \tag{38}$$

The functional form of the proportion of non-banks φ in equation (36) is the same as in the baseline model with linear matching probability, $Q(F) = \mu F$ (cf. equation (20)). Hence, the mix of bank and non-bank finance depends on competition F in the same way:

Corollary 5. *Suppose that*

$$\frac{1}{B^T}\left(y^T - 1\right)^2 > \frac{1}{B^I}\left(y^I - 1 - r\right)^2. \tag{39}$$

There are no non-banks for low financing competition F. For higher competition, the *proportion of non-banks is positive and increasing. However, the fraction of banks remains positive for all F.*

The condition in equation (39) ensures that banks have a sufficient funding cost advantage that it is better to be a monopolist bank financing traditional entrepreneurs than a monopolist non-bank financing innovative entrepreneurs.[29] The analogous condition in the baseline model is $Q_b^* > 0$ in equation (19).

The analysis above affirms that our results about the mix of banks and non-banks in the market are not sensitive to how we model competition among them. With Cournot competition, as in the baseline model with random matching, banks and non-banks co-exist; non-banks enter only sufficiently competitive markets, and provide a greater proportion of financing as competition increase, but do not take over the market for any level of competition.

4.4 Probabilistic Bertrand Competition

Another way to model competition among financiers is to assume that incumbent financiers are Bertrand competing with rivals with probability Q and are monopolists with probability $1 - Q$. Hence, Q is a measure of competition: with $Q = 1$, there is perfect competition among financiers and, with $Q = 0$, there is none. We find that Q plays a nearly identical role to the probability that an entrepreneur meets a rival in the baseline model, which implies our results are not sensitive to how we model competition (cf. Section 3.4). Like our baseline model, this set-up has the advantage of embedding our contracting model. But, unlike our baseline model, it has the disadvantage of delivering complicated expressions, which we rely on approximations to simplify.

Given innovative entrepreneurs are captive to their incumbent non-banks (Lemma 2), getting a competing offer affects only bank-financed traditional entrepreneurs. Here, an entrepreneur's first-stage repayment is given by the same IC as in the baseline model (equation (6)),

$$R_1 = y - u - \frac{B}{\Delta}, \tag{40}$$

but the entrepreneur's continuation value u is now the average over his continuation value in two cases, (i) when he does not get a competing offer and (ii) when he does.

When the entrepreneur does not get a competing offer, his second-stage IC binds,

[29] To compare these monopoly profits, compare the payoffs in the indifference condition in equation (35) given there is just a single financier in each market (i.e. given there is one non-bank, $\varphi F = 1$, or one bank, $(1 - \varphi)F = 1$).

and we have the same condition as in equation (7) above:

$$R_1 + R_2^{\text{no comp}} = y - \frac{b}{\Delta}. \tag{41}$$

When the entrepreneur does get a competing offer, on the other hand, the competing bank's break-even condition binds (assuming parameters are such that working is still IC), and we have that

$$R_2^{\text{comp}} = \frac{K_1}{p}. \tag{42}$$

The entrepreneur's continuation value is thus

$$u = (1-Q)p\Big(y - R_1 - R_2^{\text{no comp}}\Big) + Qp\Big(y - R_1 - R_2^{\text{comp}}\Big) \tag{43}$$

$$= (1-Q)p\frac{b}{\Delta} + Q\Big(p(y - R_1) - K_1\Big). \tag{44}$$

Substituting back into the entrepreneur's IC in equation (40) allows us to solve for R_1,

$$R_1 = \frac{y - \Big(p\left(y - \frac{b}{\Delta}\right) - K_1\Big)Q - \frac{B+pb}{\Delta}}{1 - pQ}, \tag{45}$$

and, given a bank meets an entrepreneur, its payoff is as follows:

$$\begin{aligned} \text{incumbent bank's payoff } &= pR_1 - K_0 + \\ &+ (1-p)(1-Q)\left(p\big(R_1 + R_2^{\text{no comp}}\big) - K_1\right) + \\ &+ (1-p)Q\left(p\big(R_1 + R_2^{\text{comp}}\big) - K_1\right). \end{aligned} \tag{46}$$

Substituting for $R_2^{\text{no comp}}$, R_2^{comp}, and R_1 from equations (41), (42), and (45) and doing a first-order approximation gives the next result:

Proposition 6. (Probabilistic Bertrand competition.) *When incumbent banks Bertrand compete with rivals with probability Q, if a bank meets an entrepreneur, its payoff is*

$$\textit{incumbent bank's payoff } \approx \Sigma^T - p\frac{b+B}{\Delta} - aQ, \tag{47}$$

where $a > 0$ is a constant. A non-bank's payoff is as in the baseline model.

Given the expression for the incumbent bank's payoff in equation (47), financiers' indifference condition has the same form as in the baseline model (equation (18)), and hence will deliver the same results. This affirms that our results are not sensitive to how we model competition.

4.5 Scarcity of Innovative Projects

Here we show that our results are robust to, and indeed amplified by, the possibility that there could be relatively few truly innovative ideas available. To capture this, we suppose that the total supply of innovate projects is at most $S^I < 1$. We maintain the assumption that entrepreneurs are ex ante identical, but we suppose that if there are $E^I > S^I$ innovative entrepreneurs, each gets a viable project with probability S^I/E^I, and otherwise gets zero. If $E^I \leq S^I$, they all get viable projects, as in the baseline set-up. Thus, for low F, our assumption here that innovative projects are limited does not affect our analysis above, since we found that for low competition F, few, if any, innovative projects are funded. For high F, however, it can make becoming a non-bank less attractive, leading fewer financiers to become non-banks, and thereby amplifying our result.

To see why, observe that financiers' indifference condition now reads

$$\min\left\{1, \frac{S^I}{E^I}\right\}\left(\Sigma^I - p\frac{B^I}{\Delta}\right) = \Sigma^T - p\frac{B^T}{\Delta}(1 + Q_b), \tag{48}$$

which is just the baseline indifference condition in equation (18) with non-banks' payoff multiplied by the probability of successful innovation, i.e. by $\min\{1, S^I/E^I\}$.[30] Following the analysis in Section 3.4, we can rearrange equation (48) and see that this leads to an interior mix of banks and non-banks in equilibrium for

$$Q_b = \frac{1}{B^T}\left(B^I - B^T + \frac{\Delta}{p}\left(\Sigma^T - \Sigma^I\right)\right) + \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right)\left(1 - \min\left\{1, \frac{S^I}{E^I}\right\}\right) \tag{49}$$

$$= Q_b^* + \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right)\left(1 - \min\left\{1, \frac{S^I}{E^I}\right\}\right), \tag{50}$$

where Q_b^* is defined in equation (19). The next result follows immediately from solving for the proportion of non-banks φ.

Proposition 7. (Intermediation variety with scarce innovative projects.) *Suppose that the conditions of Proposition 3 hold and that there is a limited supply S^I of innovative projects, assumed not to be too small. The proportion of non-banks φ, given by the solution of equation (48), is smaller than it is in the baseline model with elastic supply.*

Intuitively, with a scarce supply of innovative projects, being a non-bank becomes relatively less attractive, since they may end up with an entrepreneur who has no viable idea at all. Hence, fewer financiers become non-banks.

[30] The number of innovative entrepreneurs, E^I, is itself endogenous. In fact, it is just equal to the probability an entrepreneur meets a non-bank, $E^I = \varphi Q(F)$, given entrepreneurs innovate if and only if they meet non-banks. We do not use this here, however, because it is not necessary for our result below.

4.6 Congestion

Here we show that our results are robust to, and sometimes amplified by, the possibility that similar financiers compete for the same entrepreneurs. To capture this, we allow for congestion within banks and non-banks. We do this by assuming that the probability that a bank meets an entrepreneur is decreasing in the number of other banks that operate, and likewise the probability that a non-bank does is decreasing in the number of other non-banks. In particular, we suppose they meet entrepreneurs with the "telephone" probabilities (Stevens (2007)):

$$q_b := \frac{1}{1+(1-\varphi)F} \quad \text{and} \quad q_{\text{nb}} := \frac{1}{1+\varphi F}. \tag{51}$$

Now, financiers' indifference condition reads

$$q_{\text{nb}}\left(\Sigma^I - p\frac{B^I}{\Delta}\right) = q_b\left(\Sigma^T - p\frac{B^T}{\Delta}(1+Q_b)\right), \tag{52}$$

which is just equation (17) with banks' and non-banks' matching probability q replaced by q_b and q_{nb}. Following the analysis in Section 3.4, we can rearrange equation (52) and see that this leads to an interior mix of banks and non-banks in equilibrium for

$$Q_b = \frac{1}{B^T}\left(B^I - B^T + \frac{\Delta}{p}\left(\Sigma^T - \Sigma^I\right)\right) + \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right)\left(1 - \frac{q_{\text{nb}}}{q_b}\right) \tag{53}$$

$$= Q_b^* + \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right)\left(1 - \frac{q_{\text{nb}}}{q_b}\right), \tag{54}$$

where Q_b^* is defined in equation (19). Solving for φ gives the next result.

Proposition 8. (Intermediation variety with congestion.) *Suppose that the conditions of Proposition 3 hold and that there is congestion within banks and non-banks, as specified in equation (51). In the perfect competition limit, the proportion of non-banks is given by*

$$\varphi \to \frac{1}{2}\left(1 - Q_b^* - 2\beta + \sqrt{\left(1 - Q_b^* - 2\beta\right)^2 + 4\beta}\right), \tag{55}$$

where

$$\beta := \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right) \tag{56}$$

(and the expression in equation (55) is well defined between zero and one).

The limiting proportion of non-banks is higher than in the baseline model if and only if $Q_b^* > 1/2$.

Since the limiting proportion of non-banks in the baseline model is $1 - Q_b^*$, the result says that congestion in each market works as an additional equilibrating force, bringing the limiting proportion of non-banks closer to a half. The reason is that congestion pulls against the thin market, be it the market of banks or of non-banks.

5 Conclusion

We have developed a theory of intermediation variety in which non-banks co-exist with banks, despite having a strictly higher cost of capital. The reason is that non-banks use this high cost of capital to their advantage to commit not to provide continuation financing to innovative entrepreneurs, and thereby harden their soft budget constraints. In equilibrium, not only the variety of intermediaries in the market but also the variety of entrepreneurial investments they finance endogenously emerges entirely from the heterogeneity in financiers' cost of capital. Increasing competition among financiers leads to an increased proportion of non-banks, which in turn leads entrepreneurs to innovate more.

Our analysis could give a new perspective on some policies. For example, within the context of our model, government safety nets that lower the cost of deposits for banks, such as bailout guarantees and deposit insurance, may make it harder for banks to commit not to provide refinancing, exacerbating the soft-budget-constraint problem for bank-financed entrepreneurs. Similarly, in contrast to the common view,[31] subsidies to financing innovation, such as venture capital "incubators," may have a downside in the model. They may make it harder for non-banks to commit not to provide refinancing, creating a soft-budget-constraint problem for non-bank-financed entrepreneurs. In our model, it is the *lack* of such subsidies that distinguishes non-banks from banks and equips them to fund innovation.

[31] See, e.g., Bronzini and Piselli (2014).

6 Appendix

6.1 Proof of Lemma 1

Given the entrepreneur's second-stage IC (equation (7)), his incumbent financier is willing to provide continuation financing if and only if the present value of its expected repayment $p(R_1 + R_2) = p(y - b/\Delta)$ is larger than its capital outlay K_1. Given a non-bank has cost of capital r it denies continuation financing if

$$p\left(y - \frac{b}{\Delta}\right) < (1+r)K_1, \tag{57}$$

which holds by Assumption 4. Given a bank has cost of capital zero, it provides continuation financing as long as

$$p\left(y - \frac{b}{\Delta}\right) > K_1, \tag{58}$$

which holds by Assumption 1. □

6.2 Proof of Lemma 2

We start by assuming that an entrepreneur with an innovative project is captive to the incumbent non-bank; then we show that indeed he is captive, in the sense that no other financier is willing to lend to him.

Recall that, by Lemma 1, a non-bank does not provide continuation financing to an innovative entrepreneur. Since, by assumption, entrepreneurs are captive to non-banks, we determine the first-stage repayment via the entrepreneur's binding IC as

$$R_1 = y - \frac{B}{\Delta}. \tag{59}$$

Now, we verify that the entrepreneur is indeed captive, i.e. that no other non-bank would be willing to provide continuation financing. Observe that if another financier provides continuation financing, it must set a repayment $\hat{R}_2$ such that working is still incentive compatible, i.e. such that

$$R_1 + \hat{R}_2 \leq y - \frac{B}{\Delta}. \tag{60}$$

This implies that

$$\hat{R}_2 \leq \frac{B}{\Delta} - \frac{B}{\Delta} = 0 \tag{61}$$

Hence, no new financier will fund an innovative project—it gets repayment at most zero. □

6.3 Proof of Corollary 1

Entrepreneurs with innovative projects are captive of their incumbent non-banks (Lemma 2) and have a HBC (Lemma 1). Thus, a non-bank's payoff is

$$pR_1 - (1+r)K_0 = p\left(y^I - \frac{B}{\Delta}\right) - (1+r)K_0, \tag{62}$$

having substituted from R_1 from equation (59). A non bank funds an innovative entrepreneur whenever this payoff is positive, which holds by Assumption 4. □

6.4 Proof of Corollary 2

First, recall that, by Lemma 1, the bank has a soft budget constraint with an innovative entrepreneur. After failing, the entrepreneur can get continuation financing from the incumbent, or possibly elsewhere. The incumbent financier offers the contract, and hence offers the entrepreneur the highest repayment subject to two constraints: (i) the entrepreneur's incentive compatibility constraint, which ensures he prefers to work than to shirk, and (ii) the entrepreneur's participation constraint, which ensures he prefers to stay with the incumbent than to look for finance elsewhere. One will be binding in equilibrium. Hence, there are two cases: Case 1, in which the entrepreneur's IC is binding with his incumbent, and Case 2, in which it is slack. We consider them in turn.

Case 1: IC binding with incumbent. If the entrepreneur gets continuation financing from the incumbent bank, his (binding) second-stage IC (equation (7)) implies

$$R_1 + R_2 = y - \frac{b}{\Delta}, \tag{63}$$

which gives the entrepreneur the continuation value $u = pb/\Delta$ (equation 8). Hence, his incentive compatibility constraint in the first stage (equation (5)) gives

$$R_1 = y - \frac{B + p\,b}{\Delta}. \tag{64}$$

Thus, a bank's profit is

$$pR_1 - K_0 + \big(1-p\big)\big(p\,(R_1+R_2) - K_1\big) = py - K_0 + (1-p)\big(py - K_1\big) - p\frac{B+b}{\Delta}. \tag{65}$$

Case 2: IC slack with incumbent. If the entrepreneur goes to the market and gets finance from a new financier, his repayment, denoted $\hat{R}_2$, is limited by his IC

$$p(y - R_1 - \hat{R}_2) \geq (p-\Delta)(y - R_1 - \hat{R}_2) + B, \tag{66}$$

or

$$R_1 + \hat{R}_2 \leq y - \frac{B}{\Delta}. \tag{67}$$

Given the new bank has offered the contract, this IC binds, and the entrepreneur gets

$$p\left(y - R_1 - \hat{R}_2\right) = p\,\frac{B}{\Delta} \tag{68}$$

conditional on meeting a new financier willing to provide finance. We will see below that non-banks are never willing to provide continuation financing,[32] so he can get continuation financing from a rival financier only if (but not necessarily if) he mets a bank, which happens probability Q_b.

The incumbent financier has to make the entrepreneur a TIOLI offer R_2 that makes the entrepreneur indifferent between staying with him or going to the market. That is

$$p(y - R_1 - R_2) = Q_b\, p\,\frac{B}{\Delta} \tag{69}$$

or

$$R_1 + R_2 = y - Q_b\,\frac{B}{\Delta}. \tag{70}$$

The entrepreneur's (binding) first-stage IC (equation (5) with $u = p(y - R_1 - R_2)$) says

$$\Delta\Big(y - R_1 - p(y - R_1 - R_2)\Big) = B. \tag{71}$$

Hence,

$$R_1 = y - (1 + p\,Q_b)\frac{B}{\Delta}, \tag{72}$$

and a bank's profit is

$$pR_1 - K_0 + (1-p)\big(p\,(R_1 + R_2) - K_1\big) = py - K_0 + (1-p)\Big(py - K_1\Big) - p\frac{(1 + Q_b)B}{\Delta}. \tag{73}$$

Combining the two cases above, we have that the bank does not finance an innovative entrepreneur if

$$py^I - K_0 + (1-p)\Big(py^I - K_1^I\Big) - p\frac{B^I + \max\left\{Q_b\,B^I, b^I\right\}}{\Delta} < 0, \tag{74}$$

which is implied by Assumption 3.

[32] Specifically, in Lemma 4, we show that non-banks never provide second-stage finance to traditional entrepreneurs financed by someone else at the first stage. This follows from Assumption 4. It actually turns out that this does not affect this result, however, since it holds for all Q_b.

6.5 Proof of Lemma 3

The proof is analogous to that of Lemma 1 for innovative entrepreneurs and the result (that incumbent banks do refinance traditional entrepreneurs) follows directly from Assumption 1.

6.6 Proof of Lemma 4

Hence we can focus on the statement that the traditional entrepreneur is not captive to an incumbent bank. To prove it, we assume that an entrepreneur with a traditional project is not captive to the incumbent bank, and proceed to show that indeed he is not, in the sense that a rival bank is willing to finance him. We also show a rival non-bank is not willing to finance him.

Denote the entrepreneur's repayment to a rival bank by $\hat{R}_2$. It is willing to finance the entrepreneur if

$$p\hat{R}_2 \geq K_1. \tag{75}$$

We have an expression for $\hat{R}_2$ in (67):

$$\hat{R}_2 = y - \frac{B}{\Delta} - R_1, \tag{76}$$

where R_1 denotes the entrepreneur's repayment to his incumbent, given by equation (72). Thus, substituting in inequality (75), the rival bank will finance continuation if

$$p^2 Q_b \frac{B}{\Delta} \geq K_1, \tag{77}$$

as stated in the lemma. Likewise, a rival non-bank will finance continuation if the LHS exceeds $(1+r)K_1$, which is never satisfied by Assumption 4. □

6.7 Proof of Corollary 3

Here we find the conditions under which it is profitable for the bank to finance a traditional entrepreneur in the first stage (even though he has a soft budget constraint and is not captive to an incumbent bank (Lemma 4)).

From equation (11), we know that the incumbent financier sets R_2 such that

$$R_2 = y - R_1 - \max\left\{ \frac{b}{\Delta}, Q_b \frac{B}{\Delta} \right\}. \tag{78}$$

And we know that working must be IC at the first stage, or

$$\Delta\Big(y - R_1 - p(y - R_1 - R_2)\Big) \geq B, \tag{79}$$

which holds with equality given the financier offers the contract. Substituting R_2 from above, we find that

$$R_1 = y - \frac{p}{\Delta} \max\{\, Q_b B \,,\, b\,\} - \frac{B}{\Delta}. \tag{80}$$

Now, we can write the bank's payoff, which must be positive for it to provide first-stage financing:

$$pR_1 - K_0 + (1-p)\Big(p(R_1 + R_2) - K_1\Big) \geq 0, \tag{81}$$

or

$$py - K_0 + \big(1-p\big)\Big(py - K_1\Big) - \frac{p}{\Delta}\Big(B + \max\{Q_b\, B, b\}\Big) \geq 0 \tag{82}$$

which is implied by Assumption 3 given $\max\{Q_b\, B, b\} \leq B$. □

6.8 Proof of Proposition 1

The result follows from those in Section 3.2. We know that a bank will not finance an innovative entrepreneur (Lemma 2); hence, an entrepreneur with access only to banks gets payoff of zero if he chooses the innovative project. And we know, in contrast, that a bank will finance a traditional entrepreneur (Lemma 3); hence, an entrepreneur gets positive payoff (due to his expected agency rent) if he chooses a traditional project. The result follows. □

6.9 Proof of Proposition 2

Here we show that an entrepreneur who is matched with a non-bank prefers to invest in an innovative project. (In this proof, unlike others, it is useful to keep the superscripts $\pi \in \{I, T\}$ to index project parameters, and also add them to their associated repayments.)

Recall that, by Lemma 1, the innovative entrepreneur has a HBC with a non-bank. His profit is

$$p\left(y^I - R_1^I\right) = p\frac{B^I}{\Delta}, \tag{83}$$

having substituted for R_1^I from equation (59).

An entrepreneur could have a hard or a soft budget constraint with a non-bank. If he has a HBC, he chooses the innovative project, given $B^I > B^T$ (equation (2)). If he has a SBC he gets

$$p(y^T - R_1^T) + \big(1-p\big)p\left(y^T - R_1^T - R_2^T\right), \tag{84}$$

where R_1^T and R_2^T are given in the proof of Corollary 2.[33] Substituting this into the

[33] That result actually pertains to a traditional entrepreneur's repayments to a bank, rather than to a non-

entrepreneur's payoff above, we find that if he chooses a traditional project he gets

$$p\frac{B^T}{\Delta} + p\max\left\{Q_b\frac{B^T}{\Delta}, \frac{b^T}{\Delta}\right\}. \tag{85}$$

Hence, he prefers the innovative project if

$$p\frac{B^I}{\Delta} > p\frac{B^T}{\Delta} + p\max\left\{Q_b\frac{B^T}{\Delta}, \frac{b^T}{\Delta}\right\} \tag{86}$$

or

$$B^I > \max\left\{Q_b\, B^T, b^T\right\} + B^T, \tag{87}$$

which is satisfied by Assumption 2.

6.10 Proof of Corollary 4

The result follows from those above: an entrepreneur who is matched with a non-bank chooses an innovative project (Proposition 2), whereas an entrepreneur who is matched with a bank chooses a traditional project (Proposition 1). The condition in the proposition says that the innovative project is more profitable.

From the proof of Corollary 3, we have that a non-bank sets the repayment

$$R_1^{\text{non-bank}} = y^I - \frac{B^I}{\Delta} \tag{88}$$

and a bank sets the repayment

$$R_1^{\text{bank}} = y^T - p\max\left\{\frac{b}{\Delta}, Q_b\frac{B}{\Delta}\right\} - \frac{B^T}{\Delta}. \tag{89}$$

Given the condition in the proposition, $R_1^{\text{non-bank}} > R_1^{\text{bank}}$. □

6.11 Proof of Proposition 3

The basic analysis is in the text. But it relies on some assumptions, which we verify now: the condition in the proposition (equation 21) ensures that the following conditions hold if $Q_b = Q_b^*$ equilibrium:

1. $\max\left\{Q_b\, B^T, b^T\right\} = Q_b B^T$. This implies that the indifference condition is indeed as in equation (18).
2. The condition in equation (9) is satisfied. This implies that entrepreneurs' project choices are as described in Section 3.3.

bank. However, that does not affect the expressions, which are determined just by incentive compatibility.

3. Q_b^* is well-defined (less than one). This implies that the indifference condition holds with equality for all F sufficiently high, as described in equation (19).

Given these conditions are satisfied, the analysis in the text implies the proportion of non-banks φ takes the form described in equation (20), i.e. $\varphi = \max\{0, 1 - Q_b^*/Q(F)\}$. That Q is continuously increasing and $Q(F) \to 1$ as $F \to \infty$ implies the statements in the proposition (as illustrated in Figure 2). $\square$

6.12 Proof of Proposition 4

First, recall that, by Lemma 1, the bank has a soft budget constraint with an innovative entrepreneur; it follows from the hypothesis in equation (23), banks finance innovative entrepreneurs despite this soft-budget-constraint problem. Now we show that entrepreneurs choose traditional projects.

Indeed, if the entrepreneur does the innovative project with a bank, he has a soft-budget constraint (Lemma 1) but, given the hypothesis in equation (24), he is captive (Lemma 2). His payoff is thus

$$\text{payoff with innovative } = p\left(\frac{B^I}{\Delta} + \frac{b^I}{\Delta}\right). \tag{90}$$

Instead, if the entrepreneur does a traditional project with a bank, he still has a soft-budget constraint but he is not captive (Lemma 4). His payoff is thus

$$\text{payoff with traditional } = p\left(\frac{B^T}{\Delta} + \frac{\max\{Q_b B^T, b^T\}}{\Delta}\right). \tag{91}$$

Hence, the entrepreneur prefers the traditional project over the innovative project if

$$p\left(\frac{B^T}{\Delta} + \frac{\max\{Q_b B^T, b^T\}}{\Delta}\right) > p\left(\frac{B^I}{\Delta} + \frac{b^I}{\Delta}\right). \tag{92}$$

Or, since $B^I > B^T$ and $b^I > b^T$, if

$$Q_b \geq \left(\frac{b^I + B^I}{B^T}\right) - 1, \tag{93}$$

which is the condition in the proposition. $\square$

6.13 Proof of Lemma 5

The result follows from the results in Proposition 2 and Proposition 4. By Proposition 2, entrepreneurs prefer to invest in innovative projects when matched with non-banks. And, by Proposition 4, entrepreneurs prefer to invest in traditional projects when matched with banks. □

6.14 Proof of Lemma 6

The result is a standard characterization of the equilibrium of a Cournot game with linear demand. Here, we derive it here in four steps:

1. We find each financier's supply from the FOC of the maximization problem in equation (31):
$$y - B\sum k_f - 1 - r_f - Bk_f = 0. \tag{94}$$
2. We impose symmetry, so $K = \sum_{f=1}^{N} k_f = Nk_f$. Now, equation (94) gives
$$k_f = \frac{y - 1 - r_f}{B(N+1)}. \tag{95}$$
3. We find R from the entrepreneurs' demand in equation (30):
$$R = y - BNk_f = y - \frac{N}{N+1}\big(y - 1 - r_f\big). \tag{96}$$
4. We substitute k_f and R back into the objective function in equation (31) to find the equilibrium profits:

$$\Pi = (R - 1 - r_f)k_f \tag{97}$$
$$= \left(y - \frac{N}{N+1}\big(y - 1 - r_f\big) - 1 - r_f\right)\frac{y - 1 - r_f}{B(N+1)} \tag{98}$$
$$= \frac{1}{B}\left(\frac{y - 1 - r_f}{1 + N}\right)^2. \tag{99}$$

□

6.15 Proof of Proposition 5

The result follows from the indifference condition in equation (35). □

6.16 Proof of Corollary 5

The result follows from the expression in equation (36). □

6.17 Proof of Proposition 6

Substituting for $R_1 + R_2^{\text{no comp}}$ and R_2^{comp} from equations (41), (42) and then for R_1 from equation (45) into the expression for the incumbent bank's payoff in equation 46 gives

$$\begin{aligned}\text{incumbent bank's payoff} &= -K_0 + p\Big(1+(1-p)Q\Big)R_1 + \\ &+ (1-p)(1-Q)\left(p\left(y-\frac{b}{\Delta}\right)-K_1\right) \qquad (100)\\ &= -K_0 + p\Big(1+(1-p)Q\Big)\frac{y-\left(py-K_1-p\frac{b}{\Delta}\right)Q-\frac{B+pb}{\Delta}}{1-pQ}+ \\ &+ (1-p)(1-Q)\left(p\left(y-\frac{b}{\Delta}\right)-K_1\right). \qquad (101)\end{aligned}$$

Now we use the geometric series,

$$\frac{1}{1-pQ} = \sum_{k=0}^{\infty}(pQ)^k \qquad (102)$$

and do a first-order approximation in about zero in Q to write

$$\begin{aligned}\text{incumbent bank's payoff} &\approx py - K_0 + (1-p)\big(py-K_1\big) - p\frac{b+B}{\Delta} + \\ &- \left(p\frac{B-(1-p)b}{\Delta}-K_1\right)Q \qquad (103)\\ &\equiv \Sigma - p\frac{b+B}{\Delta} - \left(p\frac{B-(1-p)b}{\Delta}-K_1\right)Q \qquad (104)\end{aligned}$$

from the definition of the surplus $\Sigma = \Sigma^T$ created with a bank (equation (15)). This is decreasing in Q as long as

$$p\frac{B-(1-p)b}{\Delta} - K_1 > 0. \qquad (105)$$

This last condition (equation (105)) is satisfied since we assumed that working was IC when the competing bank broke even, or when $R_2 = R_2^{\text{comp}}$. To see why, substitute for R_1 and R_2^{comp} from equations (42) and (45) into the condition that the IC is slack and evaluate at $Q = 0$:

$$y - \frac{b}{\Delta} > R_1 + R_2^{\text{comp}} \Big|_{Q=0} \tag{106}$$

$$= \frac{y - \left(py - K_1 - p\frac{b}{\Delta}\right)Q - \frac{B+pb}{\Delta}}{1 - pQ} + \frac{K_1}{p}\Big|_{Q=0} \tag{107}$$

$$= y - \frac{B + pb}{\Delta} + \frac{K_1}{p}. \tag{108}$$

Rearranging gives exactly the condition in equation (105). □

6.18 Proof of Proposition 7

Solving for φ from equation (50) gives

$$\varphi = \max\left\{0, 1 - \frac{Q_b^* + \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right)\left(1 - \min\left\{1, \frac{S^I}{E^I}\right\}\right)}{Q(F)}\right\} \tag{109}$$

$$\leq \max\left\{0, 1 - \frac{Q_b^*}{Q(F)}\right\}, \tag{110}$$

which is the expression for φ in the baseline model (equation (20)).

It remains only to check that entrepreneurs still choose innovative projects when they meet non-banks, despite the risk that the projects are not viable. Given that entrepreneurs strictly prefer innovative projects in the baseline model by Proposition 2, this is the case as long as the probability of getting a viable project S^I/E^I is high enough, which it is given our assumption that S^I is not too small. □

6.19 Proof of Proposition 8

The argument follows from taking the limit as $F \to \infty$ in financiers' indifference condition. We have that $Q_b(F) = (1 - \varphi)Q(F) \to 1 - \varphi$ since $Q(F) \to 1$ by assumption and that

$$\lim_{F\to\infty} \frac{q_{\text{nb}}}{q_b} = \lim_{F\to\infty} \frac{\frac{1}{1+\varphi F}}{\frac{1}{1+(1-\varphi)F}} \tag{111}$$

$$= \frac{1 - \varphi}{\varphi}. \tag{112}$$

Letting

$$\beta := \frac{\Delta}{pB^T}\left(\Sigma^I - p\frac{B^I}{\Delta}\right) \tag{113}$$

and substituting into the indifference condition in equation (54), we have

$$1 - \varphi = Q_b^* + \beta \left(1 - \frac{1 - \varphi}{\varphi} \right), \tag{114}$$

which is a quadratic equation. The unique positive root is given by the expression in the proposition (equation (55)).

The result that the proportion of non-banks is higher than it is in the baseline model if and only if $Q_b^* > 1/2$ follows from direct comparison of this expression with the limiting proportion of non-banks in the baseline model $1 - Q_b^*$ (equation (20)). □

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