INTERMEDIATION VARIETY: BANKS AND PRIVATE EQUITY*

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Abstract

Why do small intermediaries, such as private equity firms (PEs), exist mainly in competitive credit markets and why do they fund mainly risky, innovative investments? In this paper, we build a general equilibrium search-and-matching model of entrepreneurial finance with endogenous intermediary entry. We show that with only bank finance, entrepreneurs make inefficient project choices in competitive credit markets—they forgo innovative projects in favor of traditional ones. However, private equity firms emerge to mitigate this inefficiency. This is because a PE's own capital structure works as a commitment device not to fund traditional projects; it thereby disciplines entrepreneurs to invest efficiently in innovative projects. Despite making high returns, PEs never take over the entire market, and PEs and banks coexist in equilibrium. Overall, our findings underscore that intermediation variety and entrepreneurial investment must be examined jointly.

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1 Introduction

Motivation, research questions, and key results. Banks play a dominant role in the allocation of credit in every country, with significant consequences for corporate investment. One reason for the prevalence of bank credit may be that banks have access to subsidized funding due to deposit insurance and bailout guarantees. This gives banks an advantage over other intermediaries, which could prevent these non-banks from entering the market and providing credit. However, in the past few decades, non-bank providers of finance, such as private equity firms (PEs), have proliferated, as credit markets have become more competitive.[1] Whereas banks continue to provide much of the funding for traditional projects, such bank alternatives have provided an increasing proportion of funding for innovative projects. They often earn high returns, but, despite their profitability, they still provide a relatively small proportion of funding in the economy. This raises the two main questions we address in this paper, questions that the literature has left relatively unexplored. First, why do small, specialized intermediaries such as PEs exist mainly in competitive markets? Second, why do banks and non-banks coexist in equilibrium, with banks funding relatively safe, traditional projects and PEs funding relatively risky, innovative projects?

To address these questions, we construct a model in which entrepreneurs' project choices and the mix of intermediaries in the market are determined jointly in general equilibrium. Our main findings rely on an inefficiency of bank funding in competitive credit markets. We show that with only bank finance, entrepreneurs make inefficient project choices, forgoing innovative projects for traditional ones. However, private equity firms emerge to mitigate this inefficiency.[2] This is because a PE's own capital structure works as a commitment device not to fund traditional projects; it thereby disciplines entrepreneurs to invest efficiently in innovative projects. In equilibrium, PEs fund only innovative projects, make high returns on average, and fund an increasing proportion of projects as credit market competition increases. However, they remain scarce even in the perfect competition limit. Our results thus provide a rationalization for the coexistence of banks and PEs, even in an environment in which entrepreneurs *are ex ante identical.*

[1] Boyd and Gertler (1994) point out that "A number of shocks have...jolted the banking industry in recent years, including increased competition," leading to a decline in banks' share of intermediation. Specifically, "In 1974 bank assets amounted to 45 percent of total intermediated claims...falling to 34 percent in 1992, [while other] types of intermediaries...increased their market share dramatically." Shapiro and Pham (2008) highlight the rise in PE transactions in particular, saying "The number...of U.S. private buyout-related deals rose from 12 transactions in 1970...to 2,474 deals in 2007."

[2] The only formal difference between banks and PEs in our model is that banks' liabilities are guaranteed by the government. Thus, our model could cast light on a variety of non-bank intermediaries. However, our insights apply particularly well to real-world private equity firms, as we discuss below.

Our findings offer novel explanations of the following stylized facts. First, an increase in credit market competition causes entrepreneurs to innovate less.[3] Second, in contrast, the development of equity markets leads entrepreneurs to innovate more.[4] Third, small intermediaries, such as PEs, seem to exist only in competitive credit markets.[5] Fourth, PEs have high returns.[6] Fifth, despite these high returns, PEs continue to provide only a relatively small fraction of the funding in the economy.[7] Sixth, PEs are highly levered and have a relatively high cost of capital.[8] Finally, PEs fund relatively innovative projects compared to banks.[9]

Model preview. We consider a two-period setup in which penniless entrepreneurs look for funding from creditors. There are two types of creditors, banks and PEs. The only formal difference between banks and PEs is that PEs have a relatively high cost of capital compared to banks, whose liabilities are guaranteed by the government. In each period, entrepreneurs and creditors are matched in a decentralized market. The probability that an entrepreneur finds a creditor reflects credit market competition. After an entrepreneur and a creditor are matched in the first period, the creditor can make an entrepreneur-specific investment in a monitoring technology, which is necessary to fund the entrepreneur if he undertakes an innovative project.[10] Next, the entrepreneur makes an irreversible project choice; he chooses between a innovative project and a traditional project. The innovative project has higher NPV than the traditional project, and is therefore the efficient choice. However, the innovative project requires monitoring, which the creditor can provide only if it has invested in the relationship-specific monitoring technology.[11] The entrepreneur and his creditor then negotiate a funding contract, in which the division of the NPV is determined by Nash bargaining. If they fail to reach an agreement, the entrepreneur searches for a new creditor in the second

[3] Hombert and Matray (2013) show that firms invest less in R&D-intensive projects after banking competition increases. Cornaggia, Mao, Tian, and Wolfe (2015) find that innovation by public firms decreases following deregulations that allow for more intense banking competition.

[4] Hsu, Tian, and Xu (2014) show that the development of equity markets encourages innovation by high-tech firms, but the development of credit markets seems to discourage it.

[5] See footnote 1.

[6] Harris, Jenkinson, and Kaplan (2014) document that the returns delivered by the PE funds have consistently exceeded those of public equity markets.

[7] From 2000–2005, the value of US buyout deals was $100 billion a year on average and the total value of commercial and industrial loans originated exceeded $11 trillion a year on average (see the data provided by the Federal Reserve Bank of St Louis at <https://research.stlouisfed.org/fred2/series/BUSLOANS/downloaddata>).

[8] For example, private equity deals are typically financed with sixty to ninety percent debt (Kaplan and Strömberg (2009)); approximately three-quarters of all buy-out funds pay a hurdle rate of eight percent to their limited partners (Metrick and Yasuda (2010)).

[9] See Lerner, Sorensen, and Strömberg (2011).

[10] A creditor that has acquired the monitoring technology may represent a *relationship lender*. This interpretation is in line with Boot (2000) and Boot and Thakor (2000), for example.

[11] In the full model, we provide a micro-foundation for this assumption, establishing it as a consequence of the more primitive assumption that the innovative project's cash flow is non-verifiable.

period. If the entrepreneur finds a new creditor, they may negotiate a funding contract for the entrepreneur's project. However, it is too late for the creditor to invest in the monitoring technology. This reflects the fact that relationship building takes time.[12] Note that this implies that if an entrepreneur chooses the innovative project in the first period, only his incumbent creditor is able to monitor him; no other creditor is willing to fund his project and hence he is "captive" to his incumbent creditor.

Discussion of key results. We now describe our results. We first establish the inefficiency of bank finance that underlies the rest of the analysis: when credit markets are competitive, bank-funded entrepreneurs choose the traditional project inefficiently. The reason is as follows. When an entrepreneur chooses the innovative project, only his incumbent creditor can monitor him. As a result, he is captive and his outside option is zero, making his bargaining position weak when he negotiates funding terms with the bank. In contrast, the traditional project does not require monitoring. Hence, an entrepreneur who has chosen it has a positive outside option as long as he can find funding from another creditor. The higher the competition, the easier it is to find a new creditor to fund the traditional project, and thus the higher is the entrepreneur's outside option. As a result, high credit market competition induces the entrepreneur to undertake the low-NPV traditional project to improve his bargaining position with a bank.

Our first main result is that PE funding mitigates the inefficiency by which entrepreneurs over-invest in traditional projects. This follows from the fact that a PE never wishes to fund a traditional project. The reason is that, due to its relatively high cost of capital, it wishes only to fund projects with high potential upsides. (Banks, in contrast, apply a lower hurdle rate to their investments since they have access to cheap funding thanks to government guarantees.) Consequently, if the entrepreneur is matched with a PE, he must choose the higher-NPV innovative project in order to obtain funding, even though he will become captive to the PE. PEs thus *discipline* entrepreneurs, inducing them to undertake innovative projects to obtain funding and thereby undoing the inefficiency of over-investment in traditional projects highlighted above. Our theory that a PE's own cost of capital determines its hurdle rate for investments finds empirical support in Axelson, Jenkinson, Strömberg, and Weisbach (2013) who show that PEs' cost of capital is the best predictor of their returns on deals.

Our second main result is a characterization of the proportion of PEs in the credit market, for which we provide a closed-form expression. We show that PEs enter only competitive credit markets and that they perform an increasing proportion of lending as credit market competition increases. However, they may still remain scarce in perfectly

[12] This interpretation is in line with the view of relationship lending in Bolton, Freixas, Gambacorta, and Mistrulli (2013), Boot and Thakor (1994), Hachem (2011), Rajan (1992) and von Thadden (1995), for example.

competitive credit markets. To see why this is the case, recall that for low credit market competition, banks fund high-NPV innovative projects. Because banks have access to subsidized funding, they make high profits and there is no room for other intermediaries to enter. However, for higher levels of credit market competition, entrepreneurs innovate too little with bank funding. Banks fund low-NPV traditional projects and make little profit. This inefficiency makes room for PEs to enter and to profit, exploiting their high hurdle rate to induce entrepreneurs to invest in high-NPV innovative projects. However, even though PEs restore efficient project choice, they do not take over the credit market entirely. The reason is that a higher proportion of PEs in the credit market effectively decreases competition among banks, thereby allowing banks to capture a higher fraction of the surplus from their loans, leading to more bank entry. This generates a *feedback loop* in which high credit market competition leads to PE entry, which increases bank profits, which leads to more bank entry, which increases credit market competition, thereby closing the loop. The feedback loop prevents PEs from taking over the entire market.

Our findings highlight the interaction between the variety of intermediaries in the credit market and the types of projects that entrepreneurs undertake. For high credit market competition, entrepreneurs undertake a mix of different projects, even though all entrepreneurs are ex ante identical. An entrepreneur's project choice is determined by the kind of creditor he has access to—if he anticipates bank funding he chooses a traditional project, whereas if he anticipates PE funding he chooses an innovative project. Likewise, the intermediaries that exist in the market are determined by entrepreneurs' project choices—PEs have incentive to enter only because entrepreneurs are making inefficient project choices, which PEs are able to undo thanks to their own leverage. Our model thus suggests a rationale for the coexistence of a variety of intermediaries that does not require any ex ante heterogeneity of entrepreneurs. Overall, our findings underscore that intermediation variety and entrepreneurial investment must be examined jointly.

In Figure 1, we illustrate how entrepreneurs' project choices and the variety of intermediaries in the credit market vary as a function of credit market competition.

Financing Regimes as a Function of Credit Market Competition

Low competition	Intermediate competition	High competition
Banks invest in monitoring	Banks don't invest in monitoring	Banks don't invest in monitoring
Bank-funded entrepreneurs choose risky projects	Bank-funded entrepreneurs choose safe projects	Bank-funded entrepreneurs choose safe projects
PEs don't enter	PEs don't enter	PEs enter
		PE-funded entrepreneurs choose risky projects

Credit market competition →

Figure 1: This figure illustrates the financing regions that emerge in response to credit market competition.

Organization of the paper. The rest of the paper is organized as follows. The remainder of the Introduction discusses the related literature. Then, Section 2 presents the model. Section 3 contains the model solution and analysis. Section 4 concludes.

1.1 Related Literature

To the best of our knowledge, our paper is the first to study the coexistence of banks and PEs in a general equilibrium model. The most related paper is Ueda (2004), which explains why some firms find funding from VCs as an alternative to banks. That paper presents a corporate-finance-style model, in which an entrepreneur seeks funding from a VC if it fails to get a loan from a bank. Our model has several features that are not present in Ueda's, including the following: (i) all entrepreneurs are ex ante identical in our model—our results thus suggest that heterogeneity in creditors may cause heterogeneity in entrepreneurs' investments; (ii) the only exogenous distinction between banks and PEs in our model is that banks' liabilities are guaranteed by the government—the other realistic differences between banks and PEs that we outline in the introduction arise endogenously; (iii) banks and PEs coexist in general equilibrium—PEs compete with banks effectively despite banks' access to subsidized funding.

In our model, PEs' high cost of capital passes though to the hurdle rate PEs apply to their own investments (consistent with evidence in Axelson, Jenkinson, Strömberg, and Weisbach (2013)). This high hurle rate works to discipline entrepreneurs into choosing the efficient project. Another paper in which a PE's capital structure mitigates the agency problem between the PE and the entrepreneur it funds is Axelson, Strömberg, and Weisbach (2009). Their focus is on how a single PE's capital structure affects its investments, whereas ours is on how PEs' capital structure affects investments in general equilibrium. Moreover, the main focus of our paper is different in that we explain how this capital structure effect generates intermediation variety, leading PEs and banks to coexist.

Another literature studies the coexistence of bank credit and market credit. Relevant papers in this literature include Allen and Gale (2004), Besanko and Kanatas (1993), Bolton and Freixas (2000), Boot and Thakor (1997), Chemmanur and Fulghieri (1994), Gersbach and Uhlig (2007) Holmström and Tirole (1997), Hoshi, Kashyap, and Scharfstein (1993), Rajan (1992), Repullo and Suarez (2000), and von Thadden (1999). Our first incremental contribution relative to this literature is to explain the coexistence of banks and PEs rather than of banks and markets. Moreover, unlike these papers, we assume no heterogeneity among entrepreneurs and little heterogeneity among intermediaries—the only formal difference between banks and PEs is that banks' liabilities are guaranteed by the government. In our model, heterogeneity in project choice is an equilibrium outcome resulting from search frictions in the credit market, not exogenously different characteristics of entrepreneurs.

A large literature studies the effects of credit market competition on banking outcomes. Petersen and Rajan (1995) suggest credit market competition can undermine banks' willingness to engage in relationship lending. Boot and Thakor (2000) question this result in a richer model, which includes banks' decisions about the *nature* of relationship lending. In Rajan (1992), Sharpe (1990), and Dell'Ariccia and Marquez (2004), an informational advantage gives incumbent banks monopoly over borrowers, leading to inefficient outcomes. Cao and Shi (2000) and Dell'Ariccia (2000) study the effects of credit market competition on bank screening and Guzman (2000) studies its effects on credit rationing and growth (see Pagano (1993) for a survey of the literature on finance and growth). Hellmann, Murdock, and Stiglitz (2000), Matutes and Vives (2000), and Repullo (2004) study how credit market competition affects bank risk-taking and Boyd and De Nicoló (2005), in contrast, consider how it affects *borrowers'* risk-taking. Wagner (2009) extends this model, considering the interaction between bank risk-taking and borrower risk-taking. Whereas most of this literature focuses on the effects of credit market competition on either lenders' choices *or* borrowers' choices in isolation, like Boyd and De Nicoló (2005) and Wagner (2009), we examine the two-way bridge between them. Unlike these papers, however, we include different types of intermediaries in our analysis.

Our focus on the choices of both lenders and borrowers in general equilibrium leads to some new empirical predictions, some of which we have already touched on. Notably, our model suggests that very competitive banking systems will involve little risk. This sheds light on the country-level empirical evidence presented by Schaeck, Cihak, and Wolfe (2009), who find that more competitive banking systems are less prone to systemic crises. However, our theory suggests the caveat that this safety comes at the cost of too much investment in traditional projects. This result also finds empirical support, as firms invest less in R&D-intensive projects when credit competition is high. Thus, our model suggests novel explanations of the findings in Cornaggia, Mao, Tian, and Wolfe (2015), Hsu, Tian, and Xu (2014), and Hombert and Matray (2013).

Finally, other papers have studied credit market competition in general equilibrium within a search-and-matching set-up. These include Inderst and Mueller (2004), Jovanovic and Szentes (2013)), Nanda and Rhodes-Kropf (2012, forthcoming) and Wasmer and Weil (2004). None of these papers, however, includes different types of intermediaries.

2 Model Set-up

There are two periods, Period 1 and Period 2. There are three types of players: entrepreneurs and two types of creditors, banks and PEs. At the beginning of each period there is a decentralized market in which creditors and entrepreneurs are matched. In Period 1, each entrepreneur chooses a project that he will implement in Period 2 if he can obtain funding from a creditor. A creditor's willingness to fund an entrepreneur is limited due to imperfect enforcement. Specifically, a creditor can verify the cash flow of an entrepreneur's project only if it has invested in a relationship-specific monitoring technology in Period 1.

The following sections describe the model in detail.

2.1 Players: Projects and Monitoring

Entrepreneurs. There is a unit continuum of penniless risk-neutral entrepreneurs. Each entrepreneur is endowed with two projects, a traditional (safe) project called Project S and an innovative (risky) project called Project R. Each project requires capital investment I. Project S pays off Y_S for sure. Project R pays off Y_R with probability p and zero otherwise. We will sometimes use the following shorthands for the projects' net present values, $\text{NPV}_S := Y_S - I$ and $\text{NPV}_R := pY_R - I$. Further, we refer to the difference in NPVs as $\Delta := \text{NPV}_R - \text{NPV}_S$. Both projects have positive NPV. The NPV of project R is higher than the NPV of Project S, thus Project R is the *efficient* project choice.[13] The payoff of a project is verifiable to an outside creditor only if that creditor has an entrepreneur-specific monitoring technology. The entrepreneur can undertake at most one project. In order to do so, he must find a creditor from which to raise the required capital I. Funding terms are determined by Nash bargaining between entrepreneurs and their creditors; entrepreneurs have bargaining power $1 - \eta$.

We emphasize that whereas a project's cash flows are verifiable only by a creditor with the monitoring technology, the project choice (Project S or Project R) is always verifiable. Since Project S is riskless, its cash flows are completely determined by this project choice. It follows that the cash flow of Project S is effectively verifiable even absent the monitoring technology. These assumptions on verifiability provide one microfoundation for the fact that innovative projects require monitoring from expert creditors.

An entrepreneur commits to his project choice before he invests outside funds. This reflects the fact that, in reality, loans are typically granted for specific purposes that must be identified at the time of the loan application; typically some elements of the project must be visibly in place before bank funding can be obtained. Although the literature on irreversible investment is vast (see, e.g., Dixit and Pindyck (1994)), its importance in connection with credit market competition remains relatively unexplored.

Creditors. There are large continua of penniless, risk-neutral banks and PEs. Each of these creditors can pay a non-pecuniary entry cost e to enter the credit market. φ denotes the proportion of entering creditors that are PEs. Upon entry, each creditor raises capital I to fund an entrepreneur. Banks raise I at net rate zero, reflecting government guarantees, whereas PEs borrow I at net rate $r > 0$, reflecting a risk premium. This difference in the cost of capital is the only formal difference between banks and PEs. We take it as exogenous in the baseline analysis, but in Subsection 3.6, we close the model and derive r in equilibrium.

If a creditor is matched with an entrepreneur in Period 1, he may acquire the relationship-specific monitoring technology at a non-pecuniary cost k. Creditors must make the investment in the monitoring technology in Period 1, i.e. in the "early stage" of the entrepreneur's project; they cannot invest in it in Period 2. Thus, we view Period 1 as a period of *relationship building* between creditors and early-stage entrepreneurs.

[13]That the innovative project is alway efficient is not necessary for our main results. In a previous version, we included three projects, traditional projects as well as two innovative projects, one with high NPV and another with low NPV. We have omitted the low-NPV innovative project from this version because it added complexity to the model, but it did not affect our main results.

This interpretation is consistent with the idea that relationship building takes time and creditors often need to establish relationships with firms from an early stage in order to understand them properly and monitor them effectively. This is in line with the view of relationship lending in Bolton, Freixas, Gambacorta, and Mistrulli (2013), Hachem (2011), Rajan (1992), and von Thadden (1995), for example.

We make one technical assumption on creditor preferences. We assume that a creditor never invests in a project that causes it to default with probability one. This amounts to a tie-breaking rule among actions that give creditors a payoff of zero. We make this specific assumption for simplicity; other natural assumptions would generate the same behavior, for example including an arbitrarily small cost of lending for creditors. (We use this assumption only in the proof of Lemma 3.)

2.2 The Credit Market: Search and Matching and Competition

Creditors and entrepreneurs find one another by searching in a decentralized market. Call θ_t the ratio of the mass of searching creditors to the mass of searching entrepreneurs in Period t. Since there is a unit mass of entrepreneurs, θ_1 coincides with the mass of entering creditors. We use $q_t \equiv q(\theta_t)$ to denote the probability that a creditor is matched with an entrepreneur and we use $Q_t \equiv Q(\theta_t)$ to denote the probability that an entrepreneur is matched with a creditor. If an entrepreneur is matched with a creditor, he is matched with a PE or a bank with probabilities proportional to the number of PEs and banks in the market. Thus, the probability that an entrepreneur is matched with a bank is $(1-\varphi)Q$ and the probability he is matched with a PE is φQ.

We now define credit market competition formally.

Definition 1. *The ratio θ_t of creditors to entrepreneurs in Period t is the credit market competition in Period t.*

In Subsection 2.4, we restrict the functional forms of the matching probabilities so that q is a decreasing function of θ_t and Q is an increasing function of θ_t, so as credit market competition increases, it is harder for a creditor to find an entrepreneur and easier for an entrepreneur to find a creditor.

In the analysis, it is useful to have a measure of interbank competition, i.e. competition among only banks, rather than among all creditors. We define interbank competition as the probability that an entrepreneur finds a bank in the market.

Definition 2. *The probability $(1-\varphi)Q_t$ that an entrepreneur is matched with a bank in Period t is the interbank competition in Period t.*

Finally, we note that θ_t is endogenous. We solve for it in equilibrium based on the entry decisions of banks and PEs. In equilibrium, θ_1 and θ_2 are decreasing functions of the creditors' entry cost e, which is exogenous. Thus, a decrease in e can also be viewed as an increase in credit market competition.

2.3 Timing

This section describes the formal timing of the game. First, each creditor either enters or stays out. If it enters, it pays entry cost e and raises capital I. Banks raise I at rate zero and PEs raise it at rate r (which we endogenize in Subsection 3.6). Then Period 1 and Period 2 proceed as follows.

Period 1.

Creditors and entrepreneurs are matched in a decentralized market.

Each creditor invests in the monitoring technology at cost k or does not.

Each entrepreneur chooses Project S or Project R.

Matched creditors and entrepreneurs Nash bargain over funding terms.[14]

Period 2.

Unmatched creditors and entrepreneurs are matched in a decentralized market.

Newly matched creditors and entrepreneurs Nash bargain over funding terms.

Funded projects are implemented and pay off.

Entrepreneurs repay or default; PEs repay their debt $(1 + r)I$ or default.

2.4 Parameter Restrictions

In this section, we impose a number of restrictions on parameters.

We assume specific functional forms on the matching probabilities, which allow us to solve the model in closed form.

Parameter Restriction 1. *The matching probabilities Q and q have the following forms*

$$Q(\theta) = \frac{\theta}{1+\theta} \quad \textit{and} \quad q(\theta) = \frac{1}{1+\theta}. \tag{1}$$

We impose the following restriction on PEs' cost of capital r.

Parameter Restriction 2. *PEs' cost of capital r is neither too low nor too high,*

$$\text{NPV}_S < rI < \frac{\Delta + (1-p)I}{p}. \tag{2}$$

[14] Our results do not depend on the forms of funding contracts; in Subsection 3.7, we calculate the equilibrium funding contracts for banks and PEs under the assumption that banks fund via debt and PEs fund via equity.

Recall that for now we take r as given, giving banks an exogenous advantage in funding due to government guarantees. However, in Subsection 3.6, we derive an equilibrium expression for r.

We impose a restriction on the cost of the monitoring technology. This ensures it is always efficient for creditors to invest in it.

Parameter Restriction 3. *The monitoring cost k is neither too low nor too high,*

$$\eta\big(\Delta - [p(1+r)-1]I\big) < k < \min\Big\{\eta\big(\Delta + (1-p)I\big)\,,\, \eta p\big(Y_R - (1+r)I\big)\Big\}. \quad (3)$$

We relax this restriction in Subsection 3.8, where we analyze the model with higher monitoring costs.

In Subsection 3.5, we present a numerical example which suggests that our assumptions on exogenous parameters are not overly restrictive, as all of the parameter restrictions above are satisfied.

2.5 Equilibrium

The model is a finite-horizon extensive game of complete information. The solution concept we use is subgame perfect equilibrium. We solve for the entrepreneurs' project choices, the creditors' decisions whether to invest in the monitoring technology, and the creditors' entry decisions by backward induction. (Note that the funding contracts between entrepreneurs and creditors are not strategic decisions, but rather are determined by Nash bargaining.)

3 Results

In this section, we present the analysis of the model. We first establish some preliminary results that will allow us to write down the continuation values of players. These constitute the outside options for Nash bargaining in Period 1. We then solve for entrepreneurs' project choices and creditors' decisions whether to invest in the monitoring technology in terms of credit market competition. We show that if credit competition is high enough, entrepreneurs do not invest in innovation. Next, we show that PEs use their own high cost of capital as a commitment device to mitigate this inefficiency. We then solve for creditors' entry decisions and solve for the equilibrium mix of banks and PEs. Under an additional technical condition, we provide a characterization of the equilibrium for all levels of credit market competition. Finally, we extend the model to solve for PE's funding rate r and we also characterize the equilibrium funding contracts between entrepreneurs and their creditors.

3.1 Preliminaries and Continuation Values

In this section, we establish some preliminary results that allow us to write down players' continuation values.

First we solve for an entrepreneur's best response when his creditor does not invest in the monitoring technology.

LEMMA 1. *If a creditor does not invest in the monitoring technology, it never funds Project R.*

Hence, if an entrepreneur is either unmatched or matched with a creditor that does not invest in the monitoring technology in Period 1, then the entrepreneur chooses Project S.

The first statement in the lemma above follows from the observation that a creditor without a monitoring technology has no way to enforce repayment from an entrepreneur who has chosen Project R, so it will not fund him ex ante.

The second statement in the lemma above follows from the observation that even without having invested in the monitoring technology a creditor can still enforce repayment from an entrepreneur who has chosen Project S; this is because project choice is verifiable and Project S is riskless. Thus, a creditor without the monitoring technology will fund Project S. As a result, if his creditor has not invested in the monitoring technology, an entrepreneur knows that he can obtain funding for Project S but not for Project R. Hence, he chooses Project S.

We now state the continuation values of all players in terms of credit market competition θ_1 and the ratio φ of PEs to banks in the credit market.

LEMMA 2. *The Period-1 continuation values of banks, PEs, entrepreneurs with traditional projects, and entrepreneurs with innovative projects are as follows.*

- *A bank's Period-1 continuation value π_b is given by*

$$\pi_b = q_2 \eta \mathrm{NPV}_S. \tag{4}$$

- *A PE's Period-1 continuation value is zero, $\pi_{\mathrm{PE}} = 0$.*
- *If an entrepreneur has chosen Project S, his Period-1 continuation value is given by*

$$\pi_S = (1-\varphi) Q_2 \,(1-\eta)\, \mathrm{NPV}_S. \tag{5}$$

- *If an entrepreneur has chosen Project R, his Period-1 continuation value is zero, $\pi_R = 0$.*

Further, credit market competition in Period 2, θ_2 (i.e. the argument of $q_2 = q(\theta_2)$ and $Q_2 = Q(\theta_2)$ above) is given by

$$\theta_2 = \theta_1^2. \tag{6}$$

Observe that an entrepreneur who has chosen Project S has a higher outside option than an entrepreneur who has chosen Project R. The reason is that an entrepreneur who has chosen Project R is captive to his creditor, since his creditor is the only one with the monitoring technology necessary to fund the project. An entrepreneur who has chosen Project S, in contrast, has a positive continuation value, since traditional projects do not require monitoring. Intuitively, there is a market where an entrepreneur with a traditional project can find a "transaction loan" from an "arm's length" creditor.

3.2 Inefficiency of Bank Funding

In this section, we analyze the actions of entrepreneurs and banks in Period 1. We show the inefficiency of bank funding in competitive credit markets.

Proposition 1. (The Inefficiency of Competitive Credit Markets: Too Little Innovation.) *Whenever interbank competition in Period 2 is sufficiently high, entrepreneurs matched with banks undertake Project S inefficiently. Specifically, they undertake Project S if and only if*

$$(1-\varphi)Q_2 > \frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S}. \tag{7}$$

The intuition for this result is as follows. Suppose that credit market competition is high and consider an entrepreneur who is matched with a bank that has invested in the monitoring technology. Even though he could obtain funding for the high-NPV innovative project, he chooses to undertake the low-NPV traditional project to improve his bargaining position. This is because choosing the traditional project allows the entrepreneur to capture a large proportion of the surplus, since any creditor can fund Project S, which does not require the monitoring technology. In other words, the outside option of an entrepreneur with Project S is relatively high, since competition among banks willing to fund Project S is high. On the other hand, if the entrepreneur chooses Project R, his outside option is low, since he is captive to his incumbent creditor, which has a monopoly on the monitoring technology. Hence, when credit market competition is high, the entrepreneur has an incentive to choose Project S to improve his bargaining position and get more rent.

3.3 The Disciplining Role of PE Leverage

In this section, we examine PE funding and its effect on entrepreneurs' project choices.

Lemma 3. *A PE never funds Project S.*

This result follows from the fact that PEs have a relatively high cost of capital. Thus, in order to fund a project, a PE must receive a return greater than in its hurdle rate r. But, since $(1+r)I > Y_S$ by Parameter Restriction 2, it is impossible for an entrepreneur to promise a PE a high enough repayment if he chooses Project S. Thus, a PE never funds Project S.

Proposition 2. (PE Capital Structure Disciplines Entrepreneurs.) *If an entrepreneur is matched with a PE, he always chooses Project R.*

The intuition for this result is as follows. Since a PE never funds Project S (Lemma 3), an entrepreneur who is matched with a PE in Period 1 must either choose Project R and obtain funding from a PE today or choose Project S and not obtain funding today, but potentially obtain funding from a bank tomorrow. If he chooses Project R, he is captive to the PE, since he cannot find a creditor with the monitoring technology in Period 2. However, if he chooses Project S and finds a bank to fund it in Period 2, he is also captive, since it is the final period (with no alternative future funding sources). The entrepreneur therefore chooses to undertake Project R, because it is better to be captive in Period 1 with a high NPV project than be captive in Period 2 with a lower NPV project.

These results suggest a reason that intermediaries such as PEs, that do not benefit from funding subsidies generated by government guarantees, may be able to compete with banks that benefit from such subsidies. A PE's relatively high cost of capital acts as a commitment device for the PE *not* to fund traditional projects inefficiently. Thus, PEs induce entrepreneurs to undertake innovative projects.

3.4 Intermediation Variety

In this section, we discuss the variety of intermediaries that exist in equilibrium. We first describe the cross-sectional differences between the projects that banks fund and those that PEs fund. Then we turn to the equilibrium mix of banks and PEs in the market. The findings underscore that entrepreneurs' project choices and the variety of intermediaries in the market must be determined jointly.

In the preceding sections, we established that whenever interbank competition is high, banks fund Project S and PEs fund Project R (Proposition 1 and Proposition 2). The next lemma summarizes these cross-sectional differences between the projects that banks fund and those that PEs fund.

Lemma 4. *In competitive credit markets, PEs fund riskier, more profitable projects than banks do.*

We now turn to the equilibrium mix of intermediaries in the market.

PROPOSITION 3. (INTERMEDIATION VARIETY.) *Define the constant*

$$C := \frac{k/\eta + \big(p(1+r)-1\big)I - \Delta}{\mathrm{NPV}_S}. \tag{8}$$

Given a competitive interbank market, the proportion of PEs is given by

$$\varphi = 1 - \frac{1}{1-\eta}\left(C + \frac{1-\eta+C+\theta_1}{\theta_1^2}\right) \tag{9}$$

as long as the expression is between zero and one. If the expression is less than zero, there are no PEs. If the expression is greater than one, there are only PEs.

Thus we have the following:

(i) PEs are present only in sufficiently competitive credit markets.

(ii) The proportion of PEs is increasing in credit market competition.

(iii) PEs never take over the entire credit market market and may even remain scarce in the perfect competition limit, as $\theta_1 \to \infty$,

$$\varphi \to 1 - \frac{C}{1-\eta} < 1. \tag{10}$$

The proposition above addresses the variety of intermediaries in the market. Since an entrepreneur chooses Project S when matched with a bank and chooses Project R when matched with a PE (by Lemma 4), the equilibrium exhibits a variety of projects as well as a variety of intermediaries, even though all entrepreneurs are ex ante identical. Not only is there no ex ante heterogeneity among entrepreneurs, but the only ex ante heterogeneity among creditors is that banks have a relatively low cost of capital thanks to government guarantees—all differences in creditors' expertise (PEs have the specialized monitoring technology) and projects funded (PEs specialize in funding risky, innovative projects) are equilibrium results.

The Proportion of PEs in the Market as a Function of Credit Market Competition

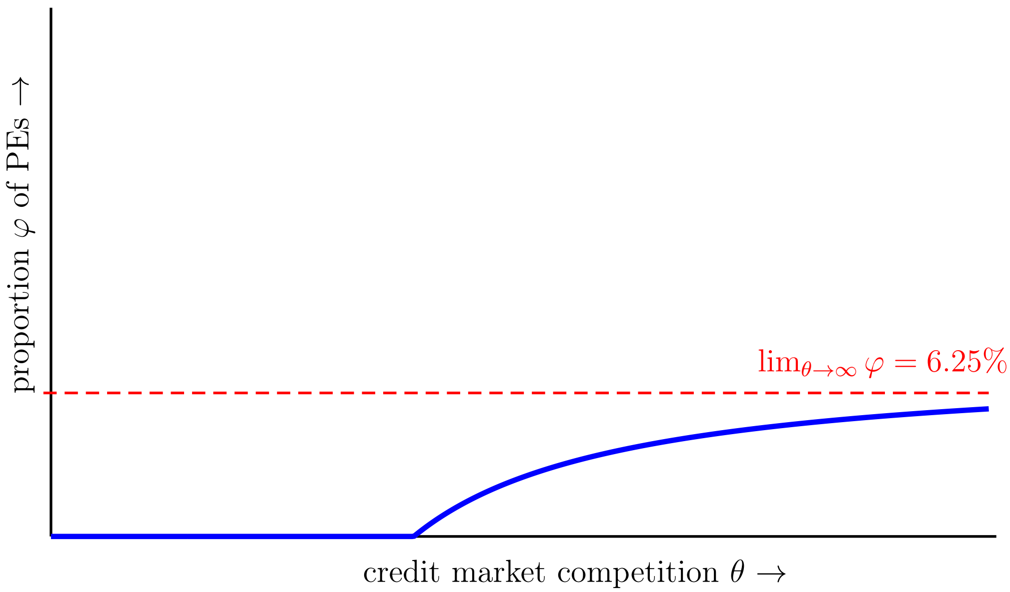


Figure 2: The graph depicts the proportion of PEs φ as given in Proposition 3. The parameters used to make the plot are given in Subsection 3.5.

The intuition for the results in Proposition 3 above relies on two key observations. The first is that PEs enter the market to mitigate the inefficiency of entrepreneurs choosing Project S in competitive credit markets. The second is that an increase in the proportion of PEs in the credit market has a *positive externality* on banks, by decreasing the competition to fund Project S in Period 2. We now explain how these observations lead to the results above in more detail.

The reason that PEs enter only competitive credit markets is that if banks are funding Project R, there is no room for PEs to enter, since their higher cost of capital is a disadvantage—they have the same technology but lower profit. However, when credit market competition is high, entrepreneurs choose Project S inefficiently when matched with banks. Since a PE's higher cost of capital acts as a disciplining device to induce entrepreneurs to undertake Project R (Proposition 2), it becomes an advantage, so there is room for PEs to enter and profit.

The reason that PEs do not take over the entire market, and in so doing restore efficiency entirely, is that an increase in the proportion of PEs makes banking relatively less competitive, i.e. PE entry has a positive externality on banks. This is because the higher the proportion of PEs, the less likely it is that an entrepreneur is matched with a bank in Period 2. This lowers the continuation value of an entrepreneur when he is matched with a bank in Period 1 and thereby strengthens the bank's bargaining position. In other words, when there are more PEs in the market, banks can capture more of the surplus from funding traditional projects in Period 1. This externality generates a *feedback loop* that works as follows. An increase in credit market competition weakens a bank's bargaining position, inducing more PEs to enter the market. But, when these PEs enter, they improve a bank's bargaining position, inducing more banks to enter as well. In equilibrium, these effects offset each other in such a way that the proportion of PEs increases at a decreasing rate and the proportion of PEs levels off to a constant as credit markets become perfectly competitive. The equilibrium proportion of PEs in the market is depicted in Figure 2.

3.5 Characterization of Financing Regimes and Numerical Example

In this section, we characterize funding regimes as a function of credit market competition θ_1. Specifically, in Proposition 4 below, we characterize the equilibrium mix of intermediaries in the market and entrepreneurs' associated project choices for all levels of credit market competition.

Proposition 4. (Characterization of Financing Regimes.) *Define the constants*

$$\theta^* := \sqrt{\frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S - \Delta - (1-p)I}}, \tag{11}$$

$$\theta^{**} := \frac{1 + \sqrt{1 + 4\big((1-\eta)^2 - C^2\big)}}{2(1-\eta-C)}, \tag{12}$$

where C is defined in Proposition 3.

As long as $\theta^* < \theta^{**}$ and $k + \eta prI > \Delta + (1-p)I$, we have the following characterization of financing regimes:

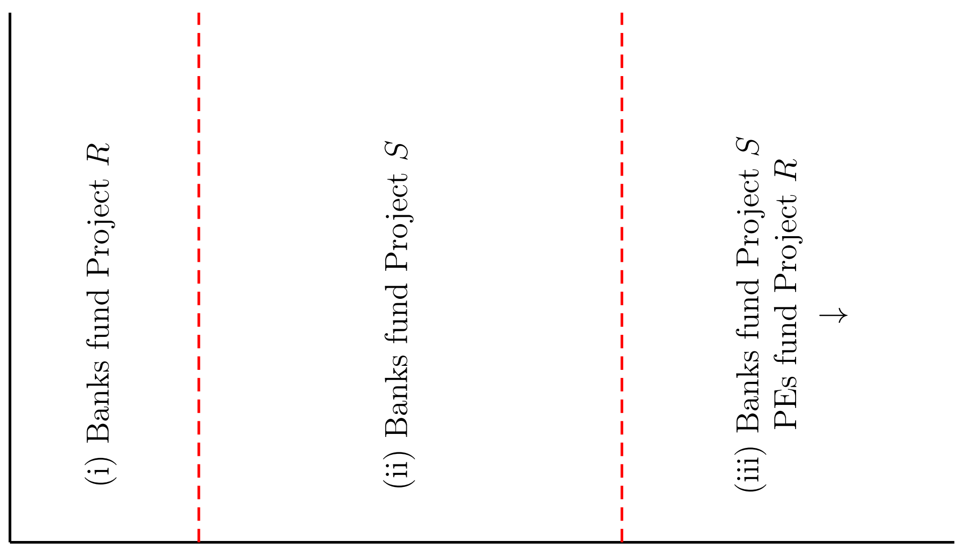
(i) For low levels of credit market competition, $\theta_1 < \theta^*$, banks invest in the monitoring technology and fund only Project R. There are no PEs.

(ii) For intermediate levels of credit market competition, $\theta^* \leq \theta_1 < \theta^{**}$, banks do not invest in the monitoring technology and fund only Project S. There are no PEs.

(iii) For high levels of credit market competition, $\theta_1 \geq \theta^{**}$, banks do not invest in the monitoring technology and fund only Project S. PEs enter, invest in the monitoring technology and fund only Project R.

To illustrate the regimes we find in Proposition 4, we provide a numerical example and plot the financing regimes. Figure 3.5 represents the financing regimes in Proposition 4 for the following parameterization: $k = 9, \eta = 0.8, \mathrm{NPV}_S = 60, \mathrm{NPV}_R = 67.5, p = 0.75, F = 210$, and $I = 150$. This also suggests that our assumptions on exogenous parameters are not overly restrictive, as all of the parameter restrictions in Subsection 2.4 and the hypotheses of Proposition 4 are satisfied. Given these parameters, the values for the regime thresholds are as follows: $\theta^* \approx 3.9$ and $\theta^{**} \approx 80$.

Financing Regimes as a Function of Credit Market Competition



logarithm of credit market competition $\log \theta_1 \rightarrow$

Figure 3: This figure illustrates the financing regions described Proposition 4. The numbers used to make the plot and the values for θ^* and θ^{**} are given in Subsection 3.5.

3.6 Intermediary Cost of Capital

In this section, we turn to intermediaries' cost of capital. So far, we have assumed that banks fund themselves at rate zero due to government guarantees and that PEs fund themselves at positive rate r. Below, we endogenize the rate at which PEs fund themselves. We assume that r is determined by bargaining between the PE's general partners (GPs), who are effectively equityholders, and the PE's limited partners (LPs), who are effectively debtholders, given the binary distribution of project cash flows in the model.[15] The main result of this section is that PEs' equilibrium funding rate is

[15]Formally, PEs are partnerships between GPs and LPs. However, the decision rights rest with GPs and GPs' cashflows strongly resemble those of levered equity holders. Typically, the division of surplus between GPs and LPs is as follows. For low profits, GPs get a management fee, and all profits go to LPs. For higher profits, the profit is divided, with GPs getting a twenty percent share. Thus, from the point of view of incentives, GPs effectively hold equity in a levered PE firm. See Axelson, Strömberg, and Weisbach (2009) for a detailed description and model of PE funding.

relatively high, as we assumed above.

When a PE is matched with an entrepreneur, the GPs and LPs negotiate r via Nash bargaining. This assumption that the terms of finance are negotiated between the GPs and LPs after the PE has found an investment project reflects the fact that much of PE financing is raised on a deal-by-deal basis (see Axelson, Strömberg, and Weisbach (2009)). Call the GPs' bargaining power $1-\beta$. The total ex post surplus that the PE captures is

$$\text{PE surplus } = \eta p\big(Y_R - (1+r)I\big). \tag{13}$$

By the Nash bargaining protocol, the LPs receive their outside option I plus a fraction β of this surplus. This must equal $p(1+r)I$, their expected payoff. Thus,

$$\beta\eta p\big(Y_R - (1+r)I\big) + I = p(1+r)I. \tag{14}$$

Solving for the PE's cost of capital r gives us the next lemma.

Lemma 5. *The PE's cost of capital r is given by*

$$1+r = \frac{\beta\eta p Y_R + I}{p(1+\beta\eta)I}. \tag{15}$$

The lemma implies that PEs do indeed have a high cost of capital in equilibrium. This is the case even if GPs have all the bargaining power—if $\beta = 0$, then $r = 1/p - 1$, which is higher than banks' cost of capital of zero.

This difference in the cost of capital, due to the government guarantees of bank liabilities, is the only exogenous difference between PEs and banks in our analysis. As we touched on in the Introduciton, this leads PEs in our model to share a number of features with real-world private equity firms in equilibrium; for example, PEs fund risky, innovative projects, they make high returns, they are relatively highly levered, they are expert monitors, and they are relatively scarce.

3.7 Equilibrium Funding Contracts

In this section, we write down the equilibrium funding contracts used by PEs and banks. So far, we have abstracted from the forms of these contracts by relying on the division of surplus given by the Nash bargaining solution. Here we show how our equilibrium can be implemented with debt and equity contracts. We assume that PEs fund entrepreneurs with equity and banks fund them with debt. Note, however, there is no substantive theoretical difference between debt and equity contracts in our setting.[16]

[16] Debt and equity are equivalent because Project R has a binary outcome and one outcome is zero and Project S is riskless.

To solve the equilibrium contracts, we start from the Nash bargaining solution and find the equity stake or face value of debt that implements that division of surplus, as we do to solve for the PEs cost of capital in Subsection 3.6 above. Note that we characterize the funding contracts only for the case in which competition is high so PEs and banks coexist, although we can use the same technique to solve for the face value of bank debt for any level of competition.

LEMMA 6. *In competitive credit markets, the equity stake that a PE takes in Project R is given by*

$$\text{PE equity stake} = \eta + (1-\eta)\frac{(1+r)I}{Y_S} \tag{16}$$

and the face value of the debt with which a bank funds Project S is given by

$$\text{face value of bank debt} = \eta\Big(1 + (1-\eta)\big[q_2 - (1-\varphi)Q_2\big]\Big)\text{NPV}_S. \tag{17}$$

Note that the equity stake that a PE take does not depend on credit market competition. This is because when an entrepreneur is matched with a PE, both parties always have the outside option of zero, independent of credit market competition. The face value of bank debt, in contrast, is decreasing in credit market competition, since the more competitive is the credit market, the higher is the outside option of an entrepreneur when he is matched with a bank.

3.8 Higher Costs of Monitoring

Above we have assumed that intermediaries' monitoring cost k is sufficiently low that intermediaries are always willing to investing in monitoring (Parameter Restriction 3). In this section we relax this assumption. We show that for sufficiently high k, banks may under-invest in the monitoring technology for low credit market competition. This is due to a hold-up problem: banks are unwilling to bear the private cost of investing in monitoring the innovative project because they share the benefits of the higher surplus with the entrepreneur. We state this result in the next lemma.

LEMMA 7. *If $k/\eta > \Delta + (1-p)I$, then banks do not invest in monitoring when Period-2 bank competition is low, leading entrepreneurs to undertake Project S inefficiently. Specifically, entrepreneurs matched with banks choose Project S if*

$$\frac{k/\eta - \Delta - (1-p)I}{(1-\eta)\text{NPV}_S} \leq (1-\varphi)Q_2. \tag{18}$$

The intuition for this result is as follows. If k is sufficiently large, low credit market competition distorts the bank's decision to invest in the monitoring technology. Specifically, banks inefficiently choose not to invest in the monitoring technology, which leads entrepreneurs to invest inefficiently in the traditional project in order to obtain funding. There is a hold-up problem because the bank pays the cost of investing in the monitoring technology before it bargains over the project NPV with the entrepreneur—the bank thus bears a *private* cost for a *shared* benefit. For low levels of credit market competition, the increased NPV of the innovative project may not justify bearing the private cost. Note that this hold-up is not present for high levels of credit market competition. This is because, in that case, the bank wants to induce the entrepreneur to choose the innovative project not only to increase the project NPV, but also to improve its own bargaining position—for high levels of credit market competition, the entrepreneur is captive to the bank only when he chooses the innovative project.

4 Conclusion

This paper has developed a theory of intermediation variety. The theory explains why banks and private equity firms co-exist, and how their emergence attenuates the inefficiencies associated with the investment choices of entrepreneurs. In particular, entrepreneurs make inefficient project choices with bank financing for high credit market competition, choosing safe, traditional projects at the expense of risky, innovative projects. At high levels of competition, private equity firms enter the market and induce the efficient project choice. They do this by using the absence of government guarantees to their advantage; their high cost of capital is a commitment device to fund only risky, innovative projects. The idea that the *intermediary's* capital structure can induce an efficient project choice by the *borrower* is one novel insight that distinguishes our paper from previous research. Another new feature of our model is that not only the variety of intermediaries in the market but also variety of entrepreneurial investments can result entirely from the heterogeneity in intermediaries' cost of funding that, in turn, results from heterogeneity in the extent to which they receive government guarantees.

A Proofs

A.1 Proof of Lemma 1

The first statement in the lemma is immediate: without the monitoring technology, a creditor can collect nothing from Project R, since Project R has minimum payoff zero. Thus, the creditor will not invest I in the project.

The second statement in the lemma follows from the first. If an entrepreneur is not matched with a creditor with the monitoring technology, he knows he will never find funding for Project R. He may, in contrast, find funding for Project S. Thus, he chooses Project S. □

A.2 Proof of Lemma 2

Before computing the continuation values, we first note that no match formed in Period 1 breaks down. This is because the Nash bargaining solution ensures that players reach agreement whenever there is surplus created by a match. In our model, there is always surplus created by creditors' funding entrepreneurs. This is important to note, because it implies that any player that is newly matched in the second period was unmatched in the first period. This implies that all entrepreneurs that are newly matched in the second period have chosen Project S, by Lemma 1.

A bank's Period-1 continuation value is given by

$$\pi_b = q_2\eta\,(Y_S - I) \tag{19}$$

$$= q_2\eta\mathrm{NPV}_S. \tag{20}$$

The expression follows from the following logic. With probably q_2 the bank is matched with an entrepreneur in Period 2. In this case, the bank and entrepreneur Nash bargain over the surplus. The surplus is given by $Y_S - I$, since the match creates output Y_S and the bank must repay I to its own creditors. The bank's bargaining power is η. With probability $1 - q_2$, the bank is unmatched and gets zero.

A PE's Period-1 continuation value is zero. The reason is as follows. First note that by Lemma 3 below a PE never funds Project S.[17] Further, if a PE is matched in Period 2, it is matched with an entrepreneur who has chosen Project S. This follows from Lemma 1 and from the comment at the beginning of this proof that no match formed in Period 1 breaks down. Thus, a PE searching in Period 2 never funds a project and its continuation value is zero.

[17] Note that Lemma 3 does not depend on this proof, so we can employ it freely here even though it comes later in the text.

An entrepreneur's Period-1 continuation value from choosing Project S is given by

$$\pi_S = (1-\varphi)Q_2(1-\eta)\left(Y_S - I\right) \tag{21}$$

$$= (1-\varphi)Q_2(1-\eta)\mathrm{NPV}_S. \tag{22}$$

This expression follows from the following logic. With probability $(1-\varphi)Q_2$ the entrepreneur is matched with a bank in Period 2. In this case, the entrepreneur and the bank Nash bargain over the surplus $Y_S - I$. The entrepreneur's bargaining power is $1-\eta$. With probability $1-(1-\varphi)Q_2$, the entrepreneur is either matched with a PE or is unmatched. In this case, his project goes unfunded and he gets zero.

An entrepreneur's Period-1 continuation value from choosing Project R is zero because he will not be able to obtain funding. This follows from Lemma 1.

We now turn to the computation of θ_2. The Period-2 credit market competition is determined by the unmatched entrepreneurs and creditors in Period 1 according to the following:

$$\theta_2 = \frac{|\#\text{ creditors }|(1-q_1)}{|\#\text{ entrepreneurs }|(1-Q_1)}. \tag{23}$$

Now note that

$$\frac{|\#\text{ creditors }|}{|\#\text{ entrepreneurs }|} \equiv \theta_1 \tag{24}$$

by definition and substitute in for the expressions for Q and q from Parameter Restriction 1 to recover that $\theta_2 = \theta_1^2$. □

A.3 Proof of Proposition 1

We first show that if interbank competition is high in Period 2, the entrepreneur chooses Project S even if the bank invests in the monitoring technology. Then we proceed to show that the entrepreneur chooses Project S only for high levels of interbank competition. That is, that for low levels of interbank competition, banks invest in monitoring and entrepreneurs choose Project R.

If matched with a bank that has invested in a monitoring technology, the entrepreneur chooses Project S if it gives a higher payoff than Project R, or

$$(1-\eta)\big(Y_S - I - \pi_b - \pi_S\big) + \pi_S > (1-\eta)\big(p(Y_R - I) - \pi_b - \pi_R\big) + \pi_R. \tag{25}$$

Substituting for the continuation values from Lemma 2, this inequality rewrites as

$$(1-\varphi)Q_2 > \frac{\Delta + (1-p)I}{\eta\mathrm{NPV}_S}, \tag{26}$$

which is the inequality in the statement of the proposition. So, for high levels of interbank competition the entrepreneur chooses to invest in Project S.

It follows that for low levels of interbank competition, the entrepreneur is willing to invest in Project R. However, for entrepreneur to invest in this the bank must be willing to fund it. The bank is willing to fund Project R as long as it is willing to bear the cost k of investing in the monitoring technology. This is the case whenever

$$\eta\big(p(Y_R - I) - \pi_R - \pi_b\big) + \pi_b - k \geq \eta\big(Y_S - I - \pi_S - \pi_b\big) + \pi_b. \tag{27}$$

Substituting for the continuation values from Lemma 2, this inequality rewrites as

$$(1-\varphi)Q_2 \geq \frac{k/\eta - \Delta - (1-p)I}{(1-\eta)\mathrm{NPV}_S}. \tag{28}$$

By Parameter Restriction 3 the right-hand-side of the inequality is negative, so it is always satisfied. This proves the proposition. □

A.4 Proof of Lemma 3

The result follows from Parameter Restriction 2, which says that $Y_S < (1+r)I$, or that the payoff of a traditional project is too low to cover a PE's debt. Thus, if a PE funds Project S, it necessarily receives payoff zero. Since the PE never funds projects that give it payoff zero (see the comment on the tie-breaking rule in Subsection 2.1), the PE never funds Project S. □

A.5 Proof of Proposition 2

In this proof, we note first that a PE always invests in the monitoring technology and, as a result, can always fund Project R. We then show that an entrepreneur who is matched with a PE always prefers to undertake Project R than to undertake Project S.

The reason that a PE always invests in the monitoring technology is that if it does not it can fund neither Project R (it cannot monitor to collect) nor Project S (by Lemma 3). Parameter Restriction 3 ensures that the payoff from investing in monitoring is positive.

We now show that an entrepreneur who is matched with a PE prefers Project R to Project S. Since the PE never funds Project S (Lemma 3), the entrepreneur must prefer investing in Project R in Period 1 to his continuation value π_S if he chooses Project S, or

$$(1-\eta)\big(p(Y_R - (1+r)I) - \pi_{\mathrm{PE}} - \pi_R\big) + \pi_R \geq \pi_S. \tag{29}$$

Substituting for the continuation values from Lemma 2, we can rewrite the inequality as

$$(1-\eta)p(Y_R-(1+r)I)-(1-\varphi)Q_2(1-\eta)\text{NPV}_S \geq 0. \tag{30}$$

This is always satisfied. To see see why, notice that it is minimized when $(1-\varphi)Q_2 = 1$. Substituting in for this and rearranging gives a positive lower bound:

$$(1-\eta)p(Y_R-(1+r)I)-(1-\varphi)Q_2(1-\eta)\text{NPV}_S \geq (1-\eta)\left(\Delta+(1-p)I-prI\right) \geq 0 \tag{31}$$

by Parameter Restriction 2. □

A.6 Proof of Lemma 4

The result follows immediately from Proposition 1 and Proposition 2. □

A.7 Proof of Proposition 3

Before proving the proposition, we prove two lemmata about creditor entry. These establish conditions for entry in terms of the entry cost e.

Lemma 8. *Given a competitive credit market, a bank enters if and only if*

$$\Big(\eta q_1\big[1-(1-\eta)(1-\varphi)Q_2\big]+\eta(1-\eta q_1)q_2\Big)\text{NPV}_S \geq e. \tag{32}$$

Proof. In a competitive credit market, an entrepreneur chooses Project S when he is matched with a bank. Thus, a bank anticipates funding Project S. A bank enters when its expected payoff from entering is greater than its entry cost e, or

$$q_1\big(\eta(Y_S-I-\pi_b-\pi_S)+\pi_b\big)+(1-q_1)\pi_b \geq e. \tag{33}$$

Substituting in for π_b and π_S from Lemma 2 and rearranging gives the expression in the statement of the lemma. □

Lemma 9. *A PE enters if and only if*

$$q_1\Big[\eta p\big(Y_R-(1+r)I\big)-k\Big] \geq e. \tag{34}$$

Proof. The payoff of a PE from investing is $\eta p\big(Y_R-(1+r)I\big)$, since it must repay its debt $(1+r)I$ out of its cash flow. In order to obtain this payoff it must be matched, which occurs with probability q_1, and pay k to invest in the monitoring technology. Note that if the PE does not find a match in Period 1, which occurs with probability $1-q_1$, it is too late for it to fund an innovative project and therefore it receives payoff zero. Thus, its expected payoff upon entry is $q_1\Big[\eta p\big(Y_R-(1+r)I\big)-k\Big]$. As stated in the lemma, a PE enters when this expected payoff exceeds its entry cost e. □

We now turn to the proof of the proposition, beginning with the expression for the equilibrium proportion of PEs in the market φ. For banks and PEs to coexist in equilibrium, both banks and PEs must be indifferent toward entering. Thus, in competitive credit markets, the inequalities in equations (32) and (34) must bind. We can eliminate the entry cost e, and observe the following condition for banks and PEs to coexist:

$$q_1\Big[\eta p\big(Y_R-(1+r)I\big)-k\Big]=\Big(\eta q_1\big[1-(1-\eta)(1-\varphi)Q_2\big]+\eta(1-\eta q_1)q_2\Big)\mathrm{NPV}_S. \quad (35)$$

Recall that $q(\theta)=1/(1+\theta)$ and $Q(\theta)=\theta/(1+\theta)$ from Parameter Restriction 1 and that $\theta_2=\theta_1^2$ from Lemma 2. We now substitute for q_1, q_2, and Q_2 as well as C from the statement of the proposition and rearrange to find

$$-\frac{C}{1+\theta_1}=\left(-(1-\eta)(1-\varphi)\frac{1}{1+\theta_1}\cdot\frac{\theta_1^2}{1+\theta_1^2}+\left(1-\frac{\eta}{1+\theta_1}\right)\frac{1}{1+\theta_1^2}\right). \quad (36)$$

Solving for φ gives

$$\varphi=1-\frac{1}{1-\eta}\left(C+\frac{1-\eta+C+\theta_1}{\theta_1^2}\right), \quad (37)$$

as stated in the proposition. This is the expression for φ when it is between zero and one.

We now prove the additional statements in the proposition. Throughout the proof below, we make use of the fact that $C>0$. This follows immediately from Parameter Restriction 3.

Statement (i). First, we prove statement (i) that PEs are present only in sufficiently competitive credit markets. Since the expression for φ above is continuous and approaches $-\infty$ as $\theta_1\to 0^+$, for low levels of competition, $\varphi=0$. In other words, PEs are not present when credit markets are not sufficiently competitive, as desired. (In the argument above, we have glossed over one subtlety: it remains to confirm that PEs never enter for low credit market competition when entrepreneurs choose Project R when matched with banks. We establish this formally in Lemma 10 below.)

Statement (ii). Second, we prove statement (ii) that the proportion of PEs is increasing in credit market competition. This follows from differentiating the expression for φ with respect to θ_1:

$$\varphi'=\frac{2(1-\eta+C)+\theta_1}{(1-\eta)\theta_1^3}>0. \quad (38)$$

Statement (iii). Third, we prove statement (iii) that PEs never take over the market. To do this, we take the limit of φ as $\theta_1\to\infty$:

$$\varphi=1-\frac{1}{1-\eta}\left(C+\frac{1-\eta+C+\theta_1}{\theta_1^2}\right)\to 1-\frac{C}{1-\eta} \quad (39)$$

as $\theta_1 \to \infty$. $\square$

A.8 Proof of Proposition 4

Here we prove statements (i) to (iii) in the proposition in reverse order. This is because it simplifies the proof to begin with the case in which competition is high and work toward the case in which competition is low.

As in the proof of Proposition 3 above, we make use of the fact that $C > 0$, which follows immediately from Parameter Restriction 3.

Statement (iii). Begin by recalling Proposition 3, which says that if interbank competition is high, PEs enter. Equation (9) gives the proportion φ of PEs that enter in equilibrium. When $\varphi = 0$ in the expression, PEs are indifferent between entering and not entering. For larger φ the proportion of PEs is positive. Thus, $\varphi = 0$ gives an equation for θ^{**}, the threshold above which PEs enter (conditional on entrepreneurs choosing Project S when matched with banks). This equation reads

$$(1-\eta-C)\theta_1^2 - \theta_1 - 1 + \eta - C = 0. \tag{40}$$

This is a quadratic equation with two roots. If the roots are real, the smaller root is negative, so we can restrict attention to the larger root, which is θ^{**} as stated in the proposition.

Note that here we have found the lowest level of credit market competition in which PEs enter conditional on entrepreneurs choosing Project S when matched with banks. It remains to show that for $\theta_1 > \theta^{**}$, entrepreneurs do indeed choose Project S. This comes from comparison with the bounds in Proposition 1. Specifically, as long as

$$(1-\varphi)Q_2 > \frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S}, \tag{41}$$

entrepreneurs choose Project S when matched with banks. We proceed show that this condition is always satisfied for $\theta_1 > \theta^{**}$. To do so, we argue that it is sufficient to show that it is satisfied for large θ_1 and then show that it holds in the limit as $\theta_1 \to \infty$.

The reason that it suffices to we show that the condition is satisfied for large θ_1 is that it is satisfied (it holds with equality) at $\theta_1 = \theta^*$ and for $\theta_1 > \theta^*$ it is either decreasing or increasing then decreasing. This implies that it is hardest to satisfy either at θ^* or in the limit as $\theta_1 \to \infty$. Since we already know that it is satisfied at θ^*, it suffices to show that it is satisfied in the limit.

First, we show that $(1-\varphi)Q_2$ is either decreasing or increasing then decreasing in

θ_1. We show this by direct computation:

$$\frac{\partial}{\partial \theta_1}(1-\varphi)Q_2 = \frac{\partial}{\partial \theta_1}\left(\frac{1}{1-\eta}\left(C + \frac{1-\eta+C+\theta_1}{\theta_1^2}\right)\frac{\theta_1^2}{1+\theta_1^2}\right) \tag{42}$$

$$= \frac{1-2(1-\eta)\theta_1-\theta_1^2}{(1-\eta)\left(1+\theta_1^2\right)^2}. \tag{43}$$

Thus, $(1-\varphi)Q_2$ is increasing whenever $1-2(1-\eta)\theta_1-\theta_1^2$ is positive. This is a negative quadratic with exactly one positive root, so for $\theta_1 > 0$ it is first positive and then negative. Thus $(1-\varphi)Q_2$ is either decreasing or increasing then decreasing for $\theta_1 > \theta^{**}$.

We now show that the condition is satisfied in the limit.

$$(1-\varphi)Q_2 = \frac{1}{1-\eta}\left(C + \frac{1-\eta+C+\theta_1}{\theta_1^2}\right)\frac{\theta_1^2}{1+\theta_1^2} \to \frac{C}{1-\eta} \tag{44}$$

as $\theta_1 \to \infty$. Now

$$\frac{C}{1-\eta} = \frac{k/\eta + p(1+r)I - I - \Delta}{(1-\eta)\mathrm{NPV}_S}. \tag{45}$$

Thus, entrepreneurs choose Project S whenever

$$\frac{k/\eta + p(1+r)I - I - \Delta}{(1-\eta)\mathrm{NPV}_S} > \frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S} \tag{46}$$

or,

$$k + \eta p r I > \Delta + (1-p)I, \tag{47}$$

which is satisfied by the hypothesis in the proposition.

Statement (ii). We now turn to statement (ii). Again, we exploit the result in Proposition 1 that entrepreneurs choose Project S whenever

$$(1-\varphi)Q_2 > \frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S}. \tag{48}$$

We show that there exists a region before PEs enter in which entrepreneurs are standardized when matched with banks. This follows from substituting for $Q_2 = \dfrac{\theta_1^2}{1+\theta_1^2}$ and $\varphi = 0$ in the inequality above, giving

$$\frac{\theta_1^2}{1+\theta_1^2} > \frac{\Delta + (1-p)I}{\eta \mathrm{NPV}_S}. \tag{49}$$

Solving for θ_1 in the equation above, we find that entrepreneurs choose Project S whenever $\theta_1 > \theta^*$ given in the proposition. Hence, since by the hypothesis that $\theta^{**} > \theta^*$, we have that $\varphi = 0$ for all $\theta^* < \theta_1 < \theta^{**}$.

Statement (i). Before proving statement (i), we state a lemma that says that if banks are funding Project R, PEs never enter.

LEMMA 10. *Given that banks are funding Project R, PEs do not enter.*

Proof. Given that banks are funding Project R, their entry condition implies that

$$q_1\left[\eta(p(Y_R - I) - \pi_b) + \pi_b - k\right] + (1 - q_1)\pi_b = e, \tag{50}$$

since the total surplus is $p(Y_R - I)$ due to government guarantees.

To show that no PEs enter, we show that a PE's expected profit is less than the entry cost e, or that

$$q_1\left[\eta p(Y_R - (1 + r)I) - k\right] < e. \tag{51}$$

Substituting in for e from the bank's entry condition gives the sufficient condition

$$q_1\left[\eta p(Y_R - (1 + r)I) - k\right] < q_1\left[\eta(p(Y_R - I) - \pi_b) + \pi_b - k\right] + (1 - q_1)\pi_b, \tag{52}$$

which simplifies to

$$(1 - q_1\eta)\pi_b > -q_1\eta prI. \tag{53}$$

This is always satisfied since the righthand side above is negative. □

We now prove statement (i) of the proposition. The proof of statement (ii) above, implies that for $\theta_1 < \theta^*$ banks invest in the monitoring technology and entrepreneurs choose Project R. The proof of Lemma 10 shows that PEs do not enter whenever $\theta_1 < \theta^*$. □

A.9 Proof of Lemma 6

To solve for the equilibrium contracts, we start from the Nash bargaining solution. Then we find the financial contract that implements the division of surplus.

We start with the PE's equity stake. For the proof, refer to it as α. In the event success, the PE gets αY_R and otherwise it gets zero. Thus, α solves

$$\eta p(Y_R - (1 + r)I) = p(\alpha Y_R - (1 + r)I), \tag{54}$$

which gives

$$\alpha = \eta + (1 - \eta)\frac{(1 + r)I}{Y_R} \tag{55}$$

as stated in the lemma.

We now solve for the bank's face value of debt. For the proof, refer to it as F_{bank}. Since there is no risk, the face value of debt is just the total surplus allocated to the bank in bargaining. Thus, F_{bank} is given by

$$F_{\text{bank}} = \eta\big(Y_S - I - \pi_S - \pi_b\big) + \pi_b \tag{56}$$

$$= \eta\Big(1 + (1-\eta)\big[q_2 - (1-\varphi)Q_2\big]\Big)\text{NPV}_S, \tag{57}$$

where we have substituted for π_b and π_S from Lemma 2. This is the expression given in the statement of the lemma. □

A.10 Proof of Lemma 7

The bank invests in the monitoring technology if

$$\eta\big(p(Y_R - I) - \pi_R - \pi_b\big) + \pi_b - k \geq \eta\big(Y_S - I - \pi_S - \pi_b\big) + \pi_b. \tag{58}$$

Substituting for the continuation values from Lemma 2, this inequality rewrites as

$$(1-\varphi)Q_2 \geq \frac{k/\eta - \Delta - (1-p)I}{(1-\eta)\text{NPV}_S}, \tag{59}$$

which is the left-hand side inequality in the statement of the proposition. □

A.11 Table of Notations

	Projects
I	required capital investment
Y_S	Project S payoff
NPV_S	NPV of Project S
Y_R	Project R success payoff
p	Project R success probability
NPV_R	NPV of Project R
Δ	difference in project NPVs, $\text{NPV}_R - \text{NPV}_S$
	Players
π_b	a bank's Period-1 continuation value
π_{PE}	a PE's Period-1 continuation value
π_S	a entrepreneur's continuation value if he has chosen Project S
π_R	a entrepreneur's continuation value if he has chosen Project R
	Credit Market
θ_t	credit market competition at Period t
$Q_t \equiv Q(\theta_t)$	probability an entrepreneur is matched with a creditor
$q_t \equiv q(\theta_t)$	probability a creditor is matched with an entrepreneur
φ	proportion of PEs
$(1-\varphi)Q_2$	Date-2 bank competition
	Parameters
k	cost of acquiring monitoring technology
e	creditors' entry cost
η	creditors bargaining power
β	LPs' bargaining power when funding PEs
r	PEs' cost of capital
C	constant defined in equation (8)

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