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Asymmetric information in credit markets and entrepreneurial risk taking

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Asymmetric information in credit markets and entrepreneurial risk taking

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Abstract

The paper constructs a search-theoretic model of credit markets with a bilateral trading mechanism that enables the manageable introduction of asymmetric information. Borrowers' success probabilities are unobservable to financiers, but the degree of risk in observable projects can be used as a sorting device. We find that the efficiency of a perfect Bayesian equilibrium depends negatively/ positively on the credit market 'tightness'/liquidity. In general equilibrium, where the underlying market conditions are endogenously determined, steady states with greater credit market tightness are always associated with increasingly excessive investment in risky projects. Since tighter market conditions also imply less intense competition among financiers, the commonly asserted trade-off between competition and efficiency does not emerge. Tighter monetary policy is shown to worsen the adverse effect of informational frictions on efficiency.

Key words: credit market, asymmetric information, search, risk taking

JEL classification numbers: D82, D83, G14, G21, G24

Yrittäjän riskinotto luottomarkkinoiden informaation ollessa epäsymmetristä

Suomen Pankin keskustelualoitteita 14/2004

Timo Vesala
Tutkimusosasto

Tiivistelmä

Tutkimuksessa tarkastellaan luottomarkkinoiden tasapainoa etsintäteoreettisessa viitekehyksessä. Lainanhakijan ja rahoittajan kahdenvälisiä neuvotteluja mallinnetaan yksinkertaisella kaupankäyntimekanismilla, jossa on mahdollista käsitellä epäsymmetristä informaatiota. Riskialttiin investoinnin onnistumistodennäköisyys on luotonhakijan yksityistä informaatiota. Rahoittaja kuitenkin havaitsee investoinnin luonteen, joka siten voi toimia signaalina luotonhakijan tyypistä. Täydellisen bayesilaisen tasapainon tehokkuus riippuu negatiivisesti (positiivisesti) luottomarkkinoiden tiukkuudesta (likvidiydestä). Mallin yleisessä tasapainossa, jossa luottomarkkinoiden tiukkuus määräytyy endogeenisesti, epälikvideihin markkinatasapainoihin liittyy aina liiallista riskinottoa. Koska markkinoiden tiukkuus voidaan tulkita myös osoitukseksi vähäisestä kilpailusta rahoittajien välillä, tutkimus ei tue yleisesti esitettyä teoreettista väittämää, jonka mukaan rahoitussektorin kilpailu saattaa heikentää resurssien allokoitumisen tehokkuutta. Tutkimuksessa tarkastellaan myös, miten rahapolitiikan tiukentaminen lisäää epäsymmetrisen informaation aiheuttamaa tehottomuutta luottomarkkinoilla.

Avainsanat: luottomarkkinat, epäsymmetrinen informaatio, etsintä, riskinotto

JEL-luokittelu: D82, D83, G14, G21, G24

Contents

1 Introduction

The paper considers trading between financiers and entrepreneurs in a credit market with asymmetric information. The market's microstructure is characterized by search frictions and decentralized (pairwise) trading: loan prices are determined and transactions concluded in private meetings between entrepreneurs and financiers.

Entrepreneurs have access to either a 'risky' or a 'safe' investment. The characteristic of the project is observable to the financier, but the success probability of a risky project depends on entrepreneur's unobservable ability (type). The sequence of moves is as follows: Entrepreneurs with hidden types first choose either a 'risky' or a 'safe' project and then, after writing up the business plan, start seeking finance for the chosen project. Upon a meeting between an entrepreneur and a financier, the lender candidate proposes a loan contract offer based on the project's characteristics and his beliefs on the type of the entrepreneur. Since the observable project characteristic may serve as a signal of the unobservable success probability of the entrepreneur, the setting resembles the models where collateral can be used as a sorting device (eg Wette 1983 and Bester 1985, 1987).

Our construction differs from the conventional models of credit market with asymmetric information (eg Stiglitz and Weiss 1981 and de Meza and Webb 1987) by assuming decentralized price formation and by introducing a variety of available projects. In our model, the efficiency of trading is driven by entrepreneurs' self-selection among the business opportunities.[1] The upcoming analysis demonstrates that these extensions are non-trivial. They also seem meaningful extensions, since pairwise trading is a common mode of interaction in credit markets and its unlikely that entrepreneurs would be bound to uniform investment opportunities.

The aim of the paper is twofold. The first contribution is theoretical and stems from the way the pairwise trading under asymmetric information is treated.[2] The well-known complexities related to asymmetric information in Rubinstein's (1982) strategic bargaining game[3] are avoided by assuming that only the uninformed party, ie financiers, are allowed to make offers in a take-it-or-leave-it manner. However, in order to retain some market power also to the entrepreneurs, borrowers are assumed to have an option to *continue search* meanwhile negotiating with the financier. Our second objective is to

[1] Kanniainen and Leppämäki (2002) address the question how people with different talents get allocated to various projects under different financial institutions. Takalo and Toivanen (2003) also discuss adverse selection problem in financial markets via occupational choice between startting as an entrepreneur or a financier

[2] Inderst (2001) provides an interesting analysis on bargaining with asymmetric information in a bilateral matching model. However, his model is simplified by the assumption that principal's payoff is independent of the agent's type. Also Bester (1988) studies bargaining in a search model, where differences between sellers' types create price dispersions, but he does not consider adverse selection.

[3] See for example Muthoo (1999, ch. 9.8) and Fudenberg and Tirole (1991, ch. 10.4)

consider functioning of the credit market in a search theoretic context[4] and offer insights in the ongoing discussions about how changes in financial sector competitiveness/liquidity or in monetary policy may affect the efficiency of trading in the credit market.

Our main finding is that entrepreneurs have the stronger incentives to choose projects efficiently the larger is their share of the surplus generated by the financial match. Entrepreneurs' share of the surplus increases as the market 'tightness' eases off; ie as the credit market becomes more liquid in a sense that finance is more readily available. Correspondingly, financiers' market power increases along with credit market tightness. The negative relationship between efficiency and market tightness is due to the fact that the gains available for 'low ability' entrepreneurs from safe investments decrease more rapidly along with financiers' market power than the gains available from risky investments. This is because entrepreneurs with high success probability in risky projects 'cross-subsidize' the borrowers with low success rate.

In a general equilibrium of the model, we learn that steady states with greater credit market tightness are always associated with increasingly excessive investment in risky projects, and thereby with greater default risk. Since greater market tightness can also be interpreted as less intense competition on scarce financing projects, our result contradicts with the commonly held view that financial sector competition is likely to induce inefficient resource allocation and thereby financial fragility. In this view, the emphasis has typically been set on the financiers' active role in operating the selection of profitable investments. Cetorelli and Peretto (2000) state that banking competition hinders efficiency because competitive banks may have less incentives to exert costly project evaluation due potential free-riding problem. Petersen and Rajan (1995), in turn, argue that financiers operating in a competitive market cannot count on their ability to retain successful customers, which reduces their willingness to start new lending relationships. Hence, increasing competition could lead to worsening credit rationing. According to Broecker (1990), increased financial sector competition is likely worsen adverse selection problem since borrowers whose applications have been rejected at one bank can stay in the market and apply for loans at competing banks. As a result, the average quality of loan applicants decrease as the number of banks increases. Matutes and Vives (2000) have shown that intensified competition on deposits and introduction of deposit insurance may together lead to excessive risk taking by banks.[5]

In our model instead, the emphasis is shifted on the entrepreneurs' active role in project selection. Koskela and Stenbacka (2000) provide a somewhat similar approach and they also conclude in a model without informational asymmetries that lower lending rates (ie increased competition)

[4] Pairwise financial matching has been previously studied by Becsi, Li and Wang (2000) and Wasmer and Weil (2000), but they do not incorporate informational frictions in their analysis. Diamond (1990), in turn, focuses on comparing lumpy and smooth credit supply in a search equilibrium.

[5] There is some empirical evidence supporting the potentially negative relationship between competition and stability (eg Keeley 1990 and Beck, Demirguc-Kunt and Levine 2003), but Carletti and Hartmann (2003) and Allen and Gale (2003) conclude in their extensive surveys on the literature that the trade-off is unlikely to hold generally.

'unambiguously decrease the probability of default'. Moreover, since we postulate that entrepreneurs need not only to decide whether to invest or not but also what sort of project to choose, our setting avoids the feature of the model by de Meza and Webb (1987), where competition among financiers drives the equilibrium interest rate too low encouraging inefficiently low quality entrepreneurs to start projects with uniform characteristics.

Finally, we find that monetary tightening may hurt efficiency in two ways: Firstly, financiers' higher opportunity cost increases the external finance premia disproportionately, making risky investments more attractive for entrepreneurs with low success probability. This is because of the cross-subsidization by the 'high-ability' entrepreneurs. Secondly, tighter money discourages market entry by financiers leading to reduced liquidity, which in turn reinforces the adverse effect on the allocational efficiency.

The paper is organized as follows: Section 2 develops the basic model under exogenously given search frictions, describes the trading mechanism and defines the solution concept (perfect Bayesian equilibrium). In Section 3, the model is closed into general equilibrium by allowing free-entry by financiers and assuming an exogenous 'matching technology' that governs the decentralized meeting process. Section 4 concludes our discussion.

2 The basic model

2.1 Economic agents

There are two types of risk-neutral agents operating in the credit market: entrepreneurs and financiers. Entrepreneurs have access to investment opportunities whose implementation requires external finance. Financiers, in turn, possess access to financial resources. Without loss of generality, it is assumed that it takes exactly one entrepreneur and one financier to form a financial relationship.

Financiers are homogenous and generic: a financier can be interpreted as an individual investor or a financial institution such as bank. Entrepreneurs differ in their type θ, which is unobservable to the financier. It is common knowledge that entrepreneur can be either 'high-type' (θ_H) or 'low-type' (θ_L) with respective probabilities $\lambda(\theta_H) = \bar{\lambda}$ and $\lambda(\theta_L) = 1 - \bar{\lambda}$.

Each entrepreneur has access to either 'risky' (ω_σ) or 'safe' (ω_s)[6] project. Before meeting with a financier, entrepreneurs must commit to the business plan for which they are seeking finance. It is assumed that financiers can observe whether the chosen project is 'safe' or 'risky', and that they are able to monitor the implementation of the chosen project; ie there is no moral hazard in the model like for example in Holmstöm and Tirole (1997).

Regardless of the type of the entrepreneur, safe projects produce a constant and perpetual stream of output, the present value of which is denoted by W_s;

[6] The 'less risky' project is treated as 'safe' investment for simplicity.

ie

$$W_s = \int_{\tau}^{\infty} e^{-(t-\tau)r} w_s dt = \frac{w_s}{r},$$

where w_s is the return on safe investment at every instant and r is the risk-free interest rate, which also serves as the common discount rate of the economy.

When successful, a risky project generates a perpetual flow of output w_σ normalized to one; ie $W_\sigma = 1/r$. However, if a risky investment fails, it produces no output. In that case, due limited liability, the financier takes the credit loss and becomes 'idle' while the entrepreneur leaves the credit market forever. Whether the risky project succeeds or fails is revealed immediately after the investment.

If a high-type (low-type) entrepreneur chooses ω_σ, she will succeed with probability p_H (p_L) and fail with the complementary probability $1-p_H$ ($1-p_L$). Thus, the present value of the expected output from a risky project reads as p_i/r, $i = H, L$. The success probabilities p_i are common knowledge.

Any new start-up requires financial resources equal to a constant amount, K. If K units of capital were invested elsewhere in the financial markets, financiers could obtain a flow of rental earnings b, the discounted value of which is b/r.

* *Assumption 1*

(i) $p_H > p_L$,

(ii) $p_H > w_s > p_L$, $w_s > b$.

Hence, type-θ_H is a 'better' manager for a risky project than type-θ_L in a first-order stochastic dominance sense. Assumption 1 implies that, in a social optimum, type-θ_H should choose a risky project while type-θ_L should stick to a safe project.

Reminiscent of the models where collateral is used as a sorting device, eg Wette (1983) and Bester (1985, 1987), the riskiness of the chosen project can be thought to give a signal of the entrepreneur's innate type. Due to the sequential structure of the model (as depicted in Figure 1) a perfect Bayesian equilibrium (PBE) will be used as a solution concept.

2.2 Utilities from financial contracting

The general form of the financial contract is standard debt, because debt finance can be shown to be the equilibrium method of finance under Assumption 1[7]. Therefore, the present value of the expected utility that an

[7] The formal proof can be found in de Meza and Webb (1987). The intuition behind this result is that entrepreneurs with higher success probability than the average success rate, $\hat{p}$, prefer to issues debt while entrepreneurs with lower than average success probability would prefer equity. Therefore, financiers cannot gain by offering to buy equity.

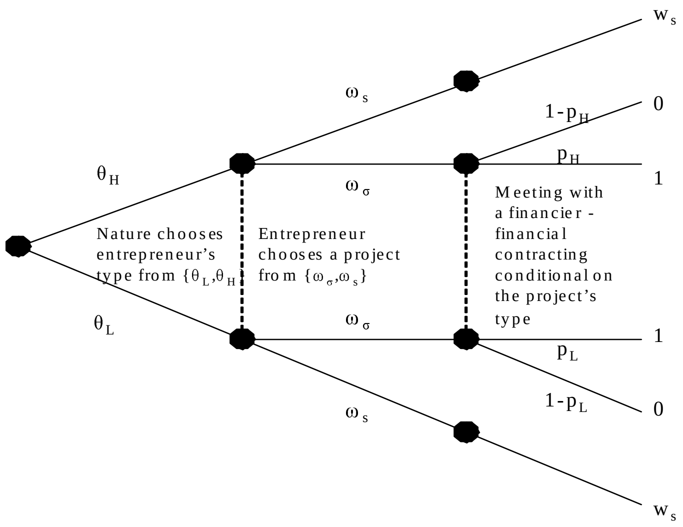

Figure 1: Sequence of events

entrepreneur of type-θ_i gets from a risky project is given by

$$U_\sigma^i = \frac{p_i\left(1 - R_\sigma\right)}{r}, \tag{2.1}$$

where R_σ is the interest rate charged by the financier in the case of a risky investment. Similarly, the discounted value of the utility from starting a safe project is given by

$$U_s = \frac{w_s - R_s}{r}, \tag{2.2}$$

where R_s is the interest rate charged in the case of a safe project.

Correspondingly, the present value of a financier's payoff from financing a safe project yields

$$V_s = \frac{R_s - b}{r}. \tag{2.3}$$

However, since entrepreneurs' types are their private information, the expected present value of the profits available from financing a risky project is given by

$$V_\sigma = \frac{\xi R_\sigma - b}{r}, \tag{2.4}$$

where the 'average' success probability ξ, $p_L \leq \xi \leq p_H$, reflects the fact that the risky project may be managed by either a type-θ_H or a type-θ_L. Let us denote by $\mu\left(\omega_\sigma\right)$ the financier's *posterior belief* on probability that the risky project is carried out by a high-type entrepreneur. Then we have

$$\xi = \mu\left(\omega_\sigma\right) p_H + \left(1 - \mu\left(\omega_\sigma\right)\right) p_L. \tag{2.5}$$

As in the model by de Meza and Webb (1987), there is cross-subsidization between the types. Since financiers make loan price offers for risky investments based on their posterior beliefs, type-θ_H with 'higher-than-average' success rate suffers while the type-θ_L with 'lower-than-average' success rate gains.

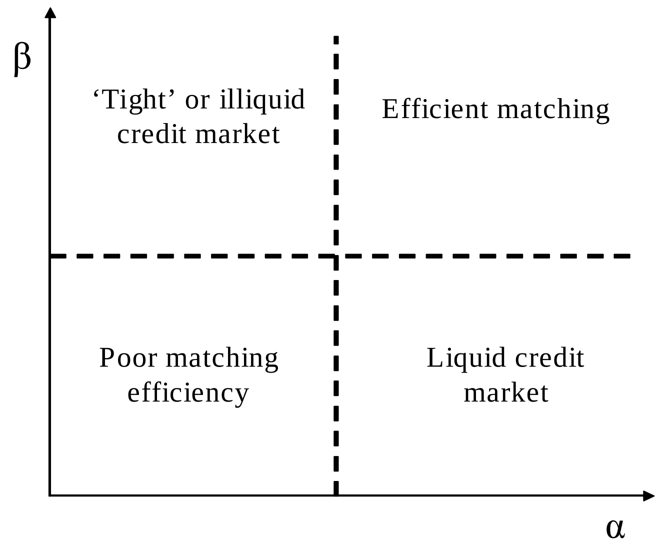

Figure 2: Taxonomy of market conditions

2.3 Search and matching

Unlike in the conventional Walrasian analysis, trading in the credit market is decentralized and carried out in an uncoordinated manner. Search for a trading partner is costless but time-consuming, which creates a friction in the functioning of the market[8]. Moreover, the matching process is random in a sense that each individual has an equal chance of locating a trading partner.

Since we utilize continuous-time framework, matching rates can be represented by Poisson flow probabilities. The contact rate of an unmatched entrepreneur with a financier is denoted by α while financiers locate entrepreneurs at rate β. For the time being, α and β are treated as exogenous parameters, even though they will be endogenously determined in general equilibrium in Section 3.

The number of entrepreneurs seeking finance is denoted by E and the number of financiers by F. The pairwise matching condition, $\alpha E = \beta F$, manifests the fact that exactly one entrepreneur and one financier is needed to establish a successful match.

The ratio $\varphi = E/F$ $(= \beta/\alpha)$ measures credit market tightness. If φ is high, credit market is 'tight' since there is a large number of entrepreneurs seeking finance per each 'vacant lot' of loan capital. Equivalently, $1/\varphi$ is an index of the liquidity of the credit market[9]: If φ is low, there is relatively large supply of credit compared to the demand and thereby finance is more readily available. If both α and β are low, the matching efficiency of the credit market is poor, while in the opposite case, search frictions are moderate and matching is relatively efficient. Figure 2 illustrates the interpretation of the $\alpha\beta$-plane in credit market context.

[8] Having direct search costs would introduce just another friction to the matching process.
[9] We follow here Wasmer and Weil (2000).

2.4 Pairwise trading

Upon meeting, the financier makes a loan contract offer in a take-it-or-leave-it manner. However, before accepting or rejecting the offer, the entrepreneur has an option to continue search for another financier. If another financier shows up, the two lender candidates must engage in a Bertrand-type price competition. As a result, the competing financiers lower their credit rate offers until driven to their reservation utility levels, V_0[10].

Thus, when there are two financiers at the meeting, the competitive loan prices are set on a level that, given the equilibrium beliefs $\mu^*(\omega_\sigma)$, produces the entrepreneur expected utility[11] equal to

$$\hat{U}_\sigma^{comp} = \frac{\xi(\mu^*) - b}{r} - V_0(R_s, R_\sigma), \tag{2.6}$$

if the underlying project is risky, and

$$U_s^{comp} = \frac{w_s - b}{r} - V_0(R_s, R_\sigma), \tag{2.7}$$

when a safe project has been chosen.

Note that $\xi - b$ $(w_s - b)$ represents the expected total surplus available from a risky (safe) investment. Thus, equations (2.6) and (2.7) simply state that the expected gain from trade for an entrepreneur facing two competing financiers equals the net of the expected total surplus and lenders' reservation utility, V_0.

In order to derive the formula describing V_0, let us denote by τ $(1-\tau)$ the probability that the 'next' project to be met is risky (safe). As financiers locate entrepreneurs at rate, V_0 can be determined by the following asset pricing formula:

$$rV_0(R_s, R_\sigma) = \beta\left\{(\tau V_\sigma(R_\sigma) + (1-\tau)V_s(R_s)) - V_0(R_s, R_\sigma)\right\},$$

which directly implies that

$$V_0(R_s, R_\sigma) = \frac{\beta}{\beta + r}(\tau V_\sigma(R_\sigma) + (1-\tau)V_s(R_s)). \tag{2.8}$$

Upon every meeting, the entrepreneur – with either a safe or a risky investment opportunity – faces an *option to continue search.* Let us denote the respective values of those options by $\hat{P}_\sigma$ and P_s. Since entrepreneurs locate financiers at rate α, the asset values of the continuation options yield respectively

$$\hat{P}_\sigma = \frac{\alpha}{\alpha + r}\hat{U}_\sigma^{comp}, \text{ and } P_s = \frac{\alpha}{\alpha + r}U_s^{comp}. \tag{2.9}$$

Since financiers can make take-it-or-leave-it offers, a profit maximizing lender proposes an offer that just prevents the entrepreneur from exercising her

[10] A more general treatment of this type of negotiation procedure can be found in Kultti and Virrankoski (2003).

[11] Again in present value terms.

continuation option[12]. Thus, the financier sets the loan prices in a manner that guarantees the entrepreneur with a risky project an average utility equal to

$$\hat{U}_\sigma(R_s, R_\sigma) = \hat{P}_\sigma(R_s, R_\sigma) = \frac{\alpha}{\alpha + r}\left(\frac{\xi(\mu^*) - b}{r} - V_0(R_s, R_\sigma)\right), \quad (2.10)$$

while the utility available for entrepreneurs with safe projects reads as

$$U_s(R_s, R_\sigma) = P_s(R_s, R_\sigma) = \frac{\alpha}{\alpha + r}\left(\frac{w_s - b}{r} - V_0(R_s, R_\sigma)\right). \quad (2.11)$$

In the trading process characterized by equations (2.6)–(2.11) entrepreneurs possess an option to continue search while financiers do not. This asymmetry facilitates our wish to let only the uninformed party to propose offers and, at the same time, provide some market power to the informed party as well. The assumptions needed to justify such an asymmetric structure are: 1) In order to maintain the contact with the entrepreneur, financier must propose an offer upon the meeting, 2) Once the entrepreneur has received the offer, it remains valid until she has either accepted or rejected it, and 3) All loan contract offers are enforceable; ie they obligate banks to provide finance at the proposed interest rate. Fortunately, these assumptions are somewhat weak and plausible.

Equations (2.10) and (2.11) implicitly define the loan prices R_σ and R_s respectively. Lemma 2.1 gives the explicit expressions for the pricing rule, $\{R_s, R_\sigma\}$ and the utility levels $\hat{U}_\sigma$ and U_s.

Lemma 2.1

$$R_s = \frac{(\alpha + r)(\beta + r)w_s + \alpha(\alpha + r)b + \tau\alpha\beta(\xi - w_s)}{(\alpha + r)(\alpha + \beta + r)},$$

$$R_\sigma = \frac{(\alpha + r)(\beta + r)\xi + \alpha(\alpha + r)b - \tau\alpha\beta(\xi - w_s)}{\xi(\alpha + r)(\alpha + \beta + r)},$$

while

$$U_s = \frac{\alpha((\alpha + r)(w_s - b) - \tau\beta(\xi - w_s))}{(\alpha + r)(\alpha + \beta + r)r},$$

$$\hat{U}_\sigma = \frac{\alpha((\alpha + r)(\xi - b) + \tau\beta(\xi - w_s))}{(\alpha + r)(\alpha + \beta + r)r}.$$

Proof. Follows directly from (2.11) and (2.10). ■

Corollary 2.2 $U_\sigma^H = \frac{p_H}{\xi}\hat{U}_\sigma > \hat{U}_\sigma$ *and* $U_\sigma^L = \frac{p_L}{\xi}\hat{U}_\sigma < \hat{U}_\sigma$.

Proof. Follows after few steps from (2.11) and (2.10), and Lemma 2.1. ■ The contact rates α and β affect the share of the surplus available to each trading partner. In general equilibrium, α and β are interlinked and

[12] Kultti and Virrankoski (2003) provide a rigorous proof for the fact that no continuation options are exercised in equilibrium.

endogenously determined, but it is instructive to first examine the behavior of the pricing rule as if the contact rates were exogenous parameters. If α is increased, entrepreneurs locate financiers more frequently – a fact that improves entrepreneurs' bargaining power. Therefore, an increase in α tend to have an adverse effect on loan prices. Obviously, the opposite is true, if there is an increase, *ceteris paribus*, in β – the rate at which financiers locate new entrepreneurs. Thus, tightening market conditions tend to increase equilibrium loan prices.

In Figure 2, matching efficiency increases as one moves to north-eastern direction in $\alpha\beta$-plane. In order to elaborate the effect of a 'symmetric' increase in matching efficiency on equilibrium loan prices, ie what happens if one moves along the 45°-line in Figure 2, let us set $\alpha = \beta \equiv m$. The expected utility equations derived in Lemma 2.1 can now be written as

$$\begin{aligned} U_s &= \frac{1}{r}\left[\frac{w_s - b}{2 + r/m} - \frac{\tau(\xi - w_s)}{(1 + r/m)^2 + (1 + r/m)}\right], \text{ and} \\ \hat{U}_\sigma &= \frac{1}{r}\left[\frac{\xi - b}{2 + r/m} + \frac{\tau(\xi - w_s)}{(1 + r/m)^2 + (1 + r/m)}\right]. \end{aligned}$$

Basically, better matching improves entrepreneurs' share from the surplus (the first two terms inside the brackets). This is because financiers' 'first-mover advantage'[13] dilutes along with more frequent financial matching. However, provided that $\xi > w_s$, the 'average' utility available from risky projects increases disproportionately, the disparity being the greater the more common it is to implement risky projects (the larger is τ). Since the 'high-types' cross-subsidize the 'low-types' in risky investments, financiers prefer launching risky projects, as long as $\xi > w_s$.

2.5 Definition of a perfect Bayesian equilibrium

A strategy for an entrepreneur of type-θ_i prescribes a probability distribution $\{1 - \eta, \eta\}$, over actions in the set $\Omega = \{\omega_s, \omega_\sigma\}$, given that financiers make loan contract offers according to the pricing rule expressed in Lemma 2.1. Thus, the strategy profile of type-θ_i gives the probability η $(1 - \eta)$ with which a risky (safe) project, ω_σ (ω_s), is chosen. Financiers, who observe the entrepreneur's choice from the set Ω, use Bayes' rule to update their beliefs and to obtain the posterior distribution $\mu(\omega)$ over the set Θ. Formally,

Definition 2.3 *An perfect Bayesian equilibrium (PBE) is an entrepreneur's strategy profile* $\{1 - \eta_i^*, \eta_i^*\}$, $i, j = H, L$ *and financier's posterior beliefs* $\mu^*(\omega)$ *such that*

$$(i)\ \eta_i^* \in \arg\max_{\eta_i \in [0,1]} \left\{(1 - \eta_i) U_s(R_\sigma(\eta_i, \eta_j^*)) + \eta_i U_\sigma^i(R_s(\eta_i, \eta_j^*))\right\},$$

and (ii) financiers propose offers, $R_s(\eta_i^*, \eta_j^*)$ *and* $R_\sigma(\eta_i^*, \eta_j^*)$, *according to*

[13] The fact that financiers unilaterally make offers upon meeting.

Lemma 2.1, and

$$(iii)\ \mu^*(\omega) = \frac{\lambda(\theta_H)\,\eta_i^*(\omega)}{\sum_{\theta_j\in\Theta}\lambda(\theta_j)\,\eta_j^*(\omega)},\ \omega\in\Omega$$

if

$$\sum_{\theta_j\in\Theta}\lambda(\theta_j)\,\eta_j^*(\omega) > 0.$$

If

$$\sum_{\theta_j\in\Theta}\lambda(\theta_j)\,\eta_j^*(\omega) = 0,$$

then $\mu^*(\omega)$ *is any probability distribution on* Θ*.*

By condition (i) in Definition 2.3, the equilibrium strategies yield

$$\begin{aligned}\{1-\eta_i^*,\eta_i^*\} &= \{0,1\} \ \Leftrightarrow\ \forall\eta_j^*\colon\ U_\sigma^i(R_s(\eta_i^*,\eta_j^*)) > U_s(R_s(\eta_i^*,\eta_j^*)) \text{ and}\\ \{1-\eta_i^*,\eta_i^*\} &= \{1,0\} \ \Leftrightarrow\ \forall\eta_j^*\colon\ U_\sigma^i(R_s(\eta_i^*,\eta_j^*)) < U_s(R_s(\eta_i^*,\eta_j^*)).\end{aligned}$$

On the other hand, a regime where type-θ_i randomizes her choice over the set Ω, ie $\{1-\eta_i^*,\eta_i^*\}$ s.t. $\eta_i^*\in(0,1)$, is an equilibrium only if

$$U_\sigma^i(R_s(\eta_i^*,\eta_j^*)) = U_s(R_s(\eta_i^*,\eta_j^*)),\ \forall\eta_j^*. \tag{2.12}$$

Condition (ii) states that the price formation is carried through the procedure described in Sections 2.4, and that financiers are actually willing to propose offers according to that pricing rule. Since any loan contract will produce the financier a payoff that at least equals his reservation value, and since this reservation value (in expected terms) can be shown to be positive under any credit market equilibria, the latter condition is automatically satisfied.

The Bayes' rule expressed in condition (iii) equals

$$\mu(\omega_\sigma) = \frac{\bar\lambda\eta_H^*}{\bar\lambda\eta_H^* + \left(1-\bar\lambda\right)\eta_L^*},\ \text{ and } \mu(\omega_s) = \frac{\bar\lambda\,(1-\eta_H^*)}{\bar\lambda\,(1-\eta_H^*) + \left(1-\bar\lambda\right)(1-\eta_L^*)}$$

Moreover,

$$\tau = \bar\lambda\eta_H^* + \left(1-\bar\lambda\right)\eta_L^*,$$

It is easy to check that under symmetric information, when the loan contracts can be conditioned directly upon entrepreneurs' types, the model produces a pricing rule that induces each type to choose efficiently from the set Ω. The next section discusses possible credit market equilibria under asymmetric information.

Lemma 2.4 *(i) Type-θ_H plays pure strategies by choosing either a safe project or a risky investment with probability* 1*; ie either* $\eta_H^* = 0$ *or* $\eta_H^* = 1$*. (ii) Type-θ_H chooses a risky project with probability* 1 *if type-θ_L either chooses a risky project with probability* 1 *or randomizes her choice; ie* $\eta_H^* = 1$ *iff* $\eta_L^* \in (0, 1]$.

Proof. (i) Assume the contrary, ie $\eta_H^* \in (0, 1)$, which implies $U_\sigma^H = U_s$. Since $U_\sigma^H > U_\sigma^L$, we must have $U_\sigma^L < U_s$, which in turn implies $\eta_L^* = 0$ so that $\tau = \bar{\lambda}\eta_H^*$ and $\xi = p_H$. But then by Lemma 2.1, the indifference condition $U_\sigma^H = U_s$ is satisfied only if $p_H = w_s$, which contradicts with assumption $p_H > w_s$.

(ii) If $\eta_L^* \in (0, 1]$, then $U_\sigma^L \geq U_s$ and $U_\sigma^H > U_s$, which implies $\eta_H^* = 1$. ■

Hence, up to four different type of equilibria are possible.

- *Separating equilibrium (SE) (first-best),* where entrepreneurs of type-θ_H choose risky projects with probability 1, and entrepreneurs of type-θ_L choose safe projects with probability 1,
- *Pooling equilibrium I (PE_I)*, where both types choose risky projects with probability 1,
- *Semi-separating equilibrium (SSE)*, where type-θ_H chooses a risky project with probability 1 while type-θ_L randomizes between risky and safe projects, and
- *Pooling equilibrium II (PE_{II})*, where both types stick to safe projects with probability 1.

The analysis in the main text will concentrate on SSE, because SE and PE_I are special cases of that equilibrium. The problem with PE_{II} is that its stability depends on the 'zero-probability' event where an entrepreneur chooses a risky investment and the equilibrium beliefs can be any distribution on Θ[14]. In fact, there is a continuum of stable PE_{II}s. Since PE_{II} is of some interest, the case will be analyzed in Appendix A3.

In a SSE, we have $\eta_H^* = 1$ and $\eta_L^* \in (0, 1)$, and

$$\begin{aligned} \mu^*(\omega_\sigma) &= \frac{\bar{\lambda}}{\bar{\lambda} + \left(1 - \bar{\lambda}\right)\eta_L^*}, \quad \tau = \bar{\lambda} + \left(1 - \bar{\lambda}\right)\eta_L^*, \text{ and} \\ \xi^{SSE} &= \frac{\bar{\lambda}p_H + \left(1 - \bar{\lambda}\right)\eta_L^* p_L}{\bar{\lambda} + \left(1 - \bar{\lambda}\right)\eta_L^*}. \end{aligned} \tag{2.13}$$

In any stable SSE, eq (2.12) hold for type-θ_L. Using (2.13) in (2.12) and solving for η_L yields

$$\eta_L = \frac{\bar{\lambda}}{1 - \bar{\lambda}} \frac{(p_H - w_s)\psi\beta - (\alpha + r)\left[p_H(w_s - p_L) - (p_H - p_L)b\right]}{(w_s - p_L)\psi\beta + (\alpha + r)p_L(w_s - p_L)}, \tag{2.14}$$

[14] In fact, the same is true in the case of PE_I where the 'zero-probability' event is the case where an entrepreneur chooses a safe project. However, since entrepreneur's type do not affect the outcome of safe projects, the stability of PE_I is not sensitive to the beliefs $\mu(\omega_s)$.

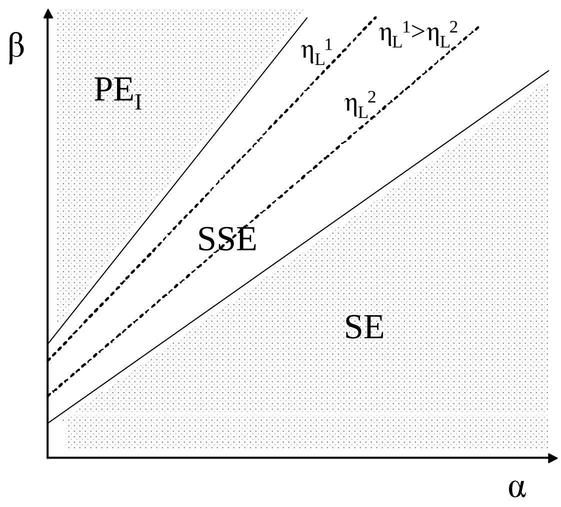

Figure 3: Location of different regimes on $\alpha\beta$-plane

where $\psi = \bar{\lambda} p_H + \left(1 - \bar{\lambda}\right) p_L$.

Proposition 2.5 *(i) Separating equilibrium (SE), ie* $\eta_H^* = 1$ *and* $\eta_L^* = 0$, *is stable, if* η_L *derived in* (2.14) *is non-positive.* $\eta_L \leq 0$ *if*

$$\beta \leq \frac{p_H (w_s - p_L) - (p_H - p_L) b}{(p_H - w_s) \psi} (\alpha + r) \equiv \hat{\beta}^{SE} (\alpha) .$$

(ii) Pooling equilibrium I (PE$_I$), ie $\eta_H^* = 1$ *and* $\eta_L^* = 1$, *is stable, if* $\eta_L \geq 1$, *which is the case if*

$$\beta \geq \frac{\psi (w_s - b) - p_L (\psi - b)}{\psi (\psi - w_s)} (\alpha + r) \equiv \hat{\beta}^{PE_I} (\alpha) .$$

(iii) The credit market is in a semi-separating equilibrium (SSE), $\eta_H^* = 1$ *and* $\eta_L^* \in (0, 1)$, *if*

$$\hat{\beta}^{SE} (\alpha) < \beta < \hat{\beta}^{PE_I} (\alpha) .$$

Proof. Appendix A1 ■

Figure 3 illustrates the information provided by Proposition 1; ie the prevalence of different regimes in $\alpha\beta$-plane. The 'iso-strategy' lines, ie the locuses that depict the combinations of α and β which support the same equilibrium strategies, are linear and increasing. Credit market tightness, φ, increases as one moves counter-clockwise in Figure 3. Obviously, an increase in φ – which strenghtens financiers' 'bargaining power' – tends to induce inefficiency by encouraging the 'low-types' to choose risky projects. Correspondingly, entrepreneurs have the incentives to act according to efficient SE-regime only if their share of the surplus generated by the match is sufficiently large, which happens if the credit market is liquid enough. The reason is that the gains available from safe investments for type-θ_L entrepreneurs decrease more rapidly along with financiers' market power than the gains from risky projects. This is because the 'low-types' benefit from the cross-subsidization by the entrepreneurs with high success probability.

The following comparative static results are also of some interest:

$$\frac{\partial \eta_L^*}{\partial m} > 0 \text{ and } \frac{\partial \eta_L^*}{\partial \bar{\lambda}} > 0,$$

ie an increase either in the matching efficiency (st $\alpha = \beta \equiv m$) or in the fraction of type-θ_H entrepreneurs leads to less efficient allocation on financial resources. As already noted in Section 2.4, more efficient matching increases the 'average' utility available from risky projects disproportionately. As a result, risky investment becomes an increasingly popular choice among entrepreneurs with low success probability. Note that as m approaches infinity, search frictions become infinitesimal. Therefore, a Walrasian competitive equilibrium, where each market participant has frictionless access to any trading opportunity, can be thought as a limiting case of the current model. In the limit, there will be 'overinvestment' in risky projects – a result that arises also in the model by de Meza and Webb (1987).

Moreover, entrepreneurs of type-θ_L are the more likely to choose risky projects the larger is the fraction $\bar{\lambda}$. This is because with higher $\bar{\lambda}$ the cross-subsidization effect by the 'high-types' is larger, which induces the 'low-types' to deviate in favor of less efficient project selection.

Lemma 2.6 *Under any stable credit market equilibrium, either $\xi^* > b$ or each type's optimal strategy obtains $\{1 - \eta_i^*, \eta_i^*\} = \{1, 0\}$ implying $\tau = 0$ (ie risky investments are never implemented).*

Proof. See Appendix A2. ■

Lemma 3 confirms that, under any stable equilibrium, entrepreneurs choose risky projects only if the expected output from those investments exceeds financier's opportunity cost. This fact directly implies that financiers' reservation values are non-negative making their participation always beneficial.

3 General equilibrium analysis

In this section, we construct a steady state equilibrium where E and F, and thereby the meeting rates α and β, are endogenously determined. We assume that, at each point of time, a constant measure δ of new entrepreneurs are born in the economy. Immediately after their birth, entrepreneurs make the irreversible project choice and enter credit market as loan applicants. On the financiers' side of the market, we assume free-entry; i.e. new financiers enter until the discounted value of being unmatched financier, V_0, equals a constant 'resource cost' ϕ. The resource cost captures all possible fixed costs related to starting a business as a financier. Immediately after trading, both entrepreneurs and financiers exit the market.

3.1 Definition of a steady state equilibrium[15]

Definition 3.1 *A steady state equilibrium is characterized by a loan price schedule,*

$$\{R_s(\eta_L^*, \eta_H^*), R_\sigma(\eta_L^*, \eta_H^*)\},$$

and a vector

$$(\eta_L^*, \eta_H^*, \alpha^*, \beta^*, E^*, F^*)$$

s.t.

$$\begin{aligned} (i)\ \alpha^* E^* &= \beta^* F^* = \tilde{m} M(E^*, F^*),\ \textit{(pairwise matching)} \\ (ii)\ \alpha^* E^* &= \delta\ \textit{(constant birth-rate)} \\ (iii)\ V_0 &= \phi\ \textit{(free-entry)} \end{aligned}$$

The system consists of six endogenous unknowns, η_L^*, η_H^*, α^*, β^*, E^* and F^*, which are determined by the loan pricing rule derived in Section 2.4 and the four equations in conditions (i)–(iii). The first equation in condition (i) is the pairwise matching condition, while the latter equation states that the total number of pairwise matches is determined by an exogenous 'matching technology' as a function of two inputs, E and F. For the matching function, $\tilde{m}M(E, F)$, we assume

* *Assumption 2:* Matching function $M : \mathbb{R}_+^2 \rightarrow \mathbb{R}_+$ is strictly increasing and strictly concave, satisfies the Inada-conditions, and exhibits constant returns to scale (CRS).

Parameter $\tilde{m}$[16] describes the efficiency of the matching technology and can be viewed to represent the institutional sophistication of the credit market.

Condition (ii) equates the number of exiting entrepreneurs with the mass of entering entrepreneurs. Conditions (i) and (ii) together establish a steady state. Condition (iii) captures unrestricted entry into financing business.

Utilizing (2.3), (2.4) and the loan prices derived in Lemma 2.1, the discounted value of entering credit market as a financier obtains

$$V_0 = \frac{\beta}{(\alpha + \beta + r) r} \left(\bar{\lambda} p_H + \left(1 - \bar{\lambda}\right) w_s - \left(1 - \bar{\lambda}\right) \eta_L (w_s - p_L) - b\right). \quad (3.1)$$

Note that the terms inside the brackets represent the social return from financial matchmaking: the first two terms capture the expected outcome of an average investment project when entrepreneurs choose projects efficiently, the third term reflects the social loss incurred by 'adverse selection' while b denotes the opportunity cost of implementing the investment. Hence, eq (3.1) gives the fraction of the social surplus generated by a successful match that the financier is able to capture.

[15] Our characterization is close to the model by Laing, Palivos and Wang (1995).

[16] Note that $\tilde{m}$ is different from the parameter m used previously in partial equilibrium.

In a steady state, condition (i) and the CRS-property of the matching function imply that

$$\alpha = \frac{mM(E,F)}{E} = mM(1,\frac{1}{\varphi}) \equiv mq(\varphi), \tag{3.2}$$

$$\beta = \frac{mM(E,F)}{F} = mM(\varphi,1) \equiv m\varphi q(\varphi), \tag{3.3}$$

where $q'(\varphi) < 0$. Therefore, the free-entry condition (FE), $V_0 = \phi$, can be expressed as an implicit equation,

$$G^{FE}(\eta_L, \varphi) = 0, \tag{3.4}$$

where the only endogenous variables are the investment strategy of the 'low-type', η_L, and credit market tightness, φ. Correspondingly, plugging (3.2) and (3.3) into (2.14), we have

$$\eta_L = g(\varphi; \cdot) \text{ or } G^{SL}(\eta_L, \varphi) = 0, \tag{3.5}$$

which gives us the equilibrium strategies played by the low-types (SL).

Now, equations (3.4) and (3.5) gives us the steady state values φ^* and η_L^*. In any of the allocational regimes that we consider here, we have $\eta_H^* = 1$. Moreover, the equilibrium contact rates $\alpha^* = mq(\varphi^*)$ and $\beta^* = m\varphi^* q(\varphi^*)$ directly imply that $E^* = \delta/mq(\varphi^*)$ and $F^* = \delta/m\varphi^* q(\varphi^*)$. Thus, the two equations (3.4) and (3.5), completely characterize the steady state general equilibrium.

The following two lemmas enable us to sketch the locuses of the FE- and the SL-curves in $\varphi\eta_L$-plane. A potential steady state equilibrium can be found at the intersection of the two curves.

Lemma 3.2 *Both the FE-curve and the SL-curve are upward-sloping in $\varphi\eta_L$-plane; ie*

$$-\frac{dG^{FE}/d\varphi}{dG^{FE}/d\eta_L} > 0 \text{ and } -\frac{dG^{SL}/d\varphi}{dG^{SL}/d\eta_L} > 0.$$

Proof. Follows directly from totally differentiating (3.4) and (3.5) w.r.t. η_L and φ. ■

Lemma 3.3 *A steady state equilibrium where entrepreneurs play pure strategies, ie $\eta_i^* \in \{0,1\}$, is unique.*

Proof. See Appendix A4. ■

As already noted in Section 2.6, increasing credit market tightness reduces the gains available from risky projects for the type-θ_L less than from safe investments due to the cross-subsidization by the type-θ_H entrepreneurs. As a result, the locus of the SL-curve is upward-sloping in $\varphi\eta_L$-plane. The upward-sloping property of the FE-curve, in turn, arises from the fact that financiers are the more reluctant to enter the less efficient is the allocational

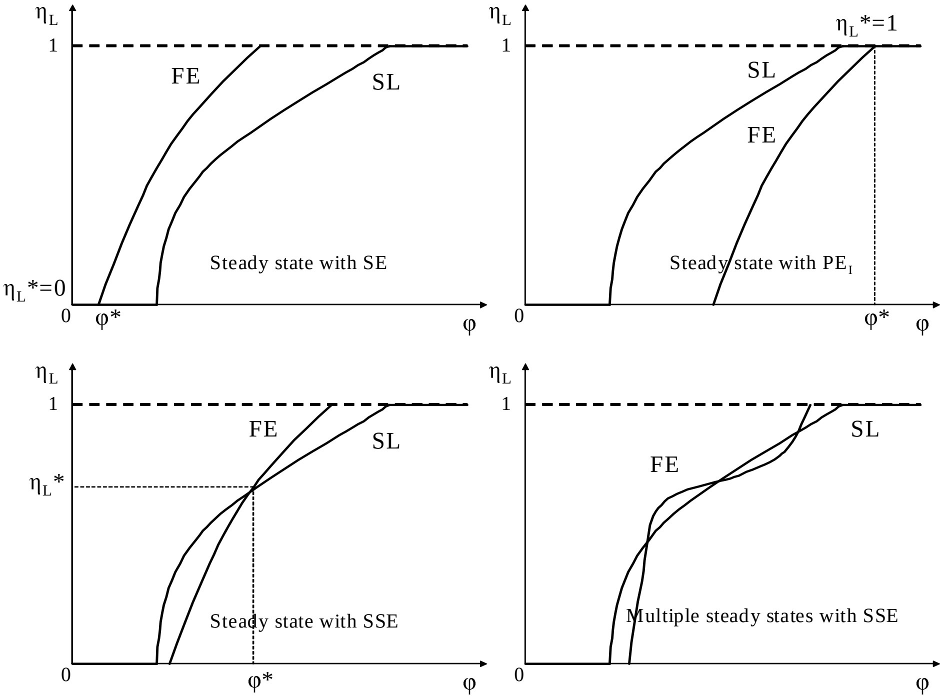

Figure 4: Possible steady states

regime prevailing in the market. Therefore, higher levels of η_L must be associated with greater credit market tightness, φ.

Figure 4 illustrates the possible outcomes. If the steady state equilibrium is to take place under either of the two pure-strategy regimes, SE or PE_I, then the credit market equilibrium is unique (see the graphs on the upper part of the figure). The possibility of multiple equilibria under semi-separating regime (SSE) cannot be ruled out, however (the graph on the south-eastern corner of the figure).

3.2 Macroeconomic implications of the general equilibrium

3.2.1 Market tightness vs default risk

According to Figure 4, steady states with greater credit market tightness, φ, are associated with increasingly excessive investment in risky projects. Since an increase in market tightness also means that the fierceness of the competition between financiers is reduced, our model predicts that the allocational efficiency is poorer and the probability of credit loss more prominent under less competitive ('tight') rather than more competitive ('liquid') market conditions.

This result contradicts with the rather popular view (eg Broecker 1990, Petersen and Rajan 1995, Cetorelli and Peretto 2000 and Matutes and Vives 2000) that financial sector competition is likely to induce inefficient resource allocation and thereby financial fragility. In this view, the emphasis has

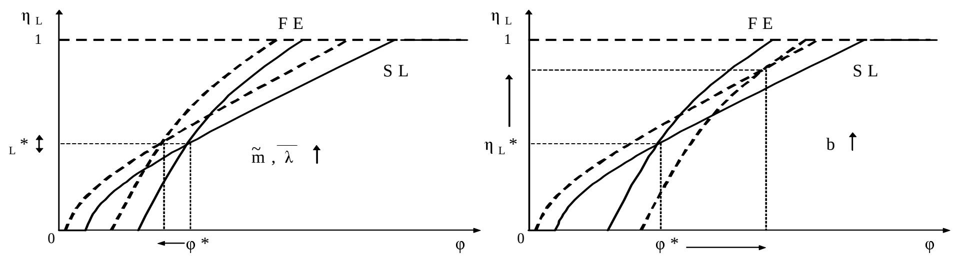

Figure 5: Comparative statics of a steady state

typically been set on the financiers' active role in operating the selection of profitable investments. Instead, in our model the emphasis is shifted on the entrepreneurs' role in project selection, and financial sector 'competitiveness' seems to facilitate efficiency. Koskela and Stenbacka (2000) provide a somewhat similar approach and also conclude that increased competition in financial intermediation tend to decrease the probability of default.

3.2.2 Comparative static properties of the general equilibrium

The left panel of Figure 5 illustrates how the steady state changes if there is an increase either in the 'matching efficiency' (parameter $\tilde{m}$) or in the fraction of the type-θ_H entrepreneurs. The negative relationship between matching frequency and allocational efficiency verified in the partial equilibrium does not necessarily arise in general equilibrium. The reason is that more frequent contacts with loan applicants encourage market entry by financiers alleviating credit market tightness. As the number of financiers increases, entrepreneurs' 'bargaining power', and thereby the efficiency of self-selection, is improved. A similar comparative static property arise if there is an increase in the fraction of type-θ_H entrepreneurs. For exactly the same reasons as in the case of improving matching technology, the negative relationship between $\bar{\lambda}$ and efficient resource allocation does not necessarily hold in general equilibrium.

The graph on the right hand side of Figure 5 depicts what happens if there is an increase in financiers' opportunity cost, b, that may have resulted from tightening monetary policy. The 'credit channel' theory of monetary policy transmission asserts[17] that, due an increase in external finance premium, informational frictions may sharpen during periods of tight monetary policy. Here, a rise in b is immediately transmitted into loan prices in a way that makes the cross-subsidized risky project a more attractive investment opportunity for the type-θ_L; ie η_L is larger at every level of φ (the SL-curve shifts up and left in Figure 5). On the other hand, higher opportunity cost discourages financier

[17]Bernanke and Gertler (1995), among many others, provide an excellent survey on the credit channel.

to enter and the FE-curve shifts down and right. Congestion on entrepreneurs' side of the market is worsened, which further undermines entrepreneurs' incentives to choose investment projects efficiently. Hence, our model predicts that tighter monetary policy is likely to lead to greater credit market tightness and poorer allocation of financial resources.

The steady state pool of unmatched entrepreneurs, E^*, is unambiguously smaller after an increase in either exogenous matching efficiency ($\tilde{m}$) or the fraction of type-θ_H entrepreneurs ($\bar{\lambda}$). The opposite is true after monetary tightening occurs. However, the total effect of these changes on the overall volume of trading depends on the specification of the matching function.

4 Concluding remarks

The paper develops a bilateral trading mechanism that enables introduction of informational asymmetries into a credit market model with search frictions. The model incorporates heterogeneity not only in the borrowers' types but also in the intrinsic riskiness of the available entrepreneurial projects. The observable riskiness of the chosen project could work as an informative signal about the unobservable type of the entrepreneur. The efficiency of trading is determined by relative loan prices and borrower's self-selection among the available business opportunities. Perfect Bayesian equilibrium is used as a solution concept.

The efficient allocational regime, the separating equilibrium, is stable only if borrowers' share of the surplus is large enough. This is the case if the market conditions are sufficiently liquid; ie the volume of available financial resources is sufficiently large compared to the number of entrepreneurs seeking finance. Efficiency deteriorates gradually as credit market 'tightness' increases. In general equilibrium, where the underlying market conditions are endogenized, we find that steady states with greater credit market tightness are associated with increasingly excessive investment in risky projects. Since greater market tightness implies less competition among financiers, default risk (or *financial fragility*) is more prominent under less competitive (tight) rather than more competitive (liquid) market conditions.

Finally, monetary tightening may hurt efficiency in two ways: Firstly, financiers' higher opportunity cost directly increases the external finance premia, making the cross-subsidized risky investments excessively attractive for the entrepreneurs with low success probability. Secondly, tighter money discourages market entry by financiers leading to greater credit market tightness which indirectly reinforces the adverse effect on the allocational efficiency.

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Appendix A1

Proof of Proposition 1

Proof. (i) Under separating regime, Bayes' rule gives $\mu^*(\omega_\sigma) = 1$. Moreover, $\xi^{SE} = p_H$ and $\tau = \bar{\lambda}$, which together with Lemma 2.1 imply

$$\begin{aligned} U_\sigma^{H,SE} &= \hat{U}_\sigma^{SE} = \frac{\alpha(\alpha+r)(p_H-b)+\alpha\left(1-\bar{\lambda}\right)\beta(p_H-w_s)}{(\alpha+r)(\alpha+\beta+r)r} \\ U_s^{SE} &= \frac{\alpha(\alpha+r)(w_s-b)-\alpha\bar{\lambda}\beta(p_H-w_s)}{(\alpha+r)(\alpha+\beta+r)r}. \end{aligned}$$

It is easy to check that type-θ_H has no incentives to deviate from the first-best separating equilibrium:

$$U_\sigma^{H,SE} = \frac{\alpha}{\alpha+r}(p_H-w_s)+U_s^{SE} > U_s^{SE}.$$

Hence, type-θ_H will never deviate. On the other hand, type-θ_L will not deviate only if

$$U_\sigma^{L,SE} = \frac{p_L}{p_H}U_\sigma^{H,SE} \leq U_s^{SE},$$

which can be written as

$$\beta \leq \frac{p_H(w_s-p_L)-(p_H-p_L)b}{(p_H-w_s)\psi}(\alpha+r) \equiv \hat{\beta}^{SE}(\alpha),$$

which in turn coincides with the condition that implies $\eta_L \leq 0$.

(ii) Under PE$_I$, $\mu^*(\omega_\sigma) = \bar{\lambda}$, $\tau = 1$ and $\xi = \bar{\lambda}p_H + \left(1-\bar{\lambda}\right)p_L \equiv \psi$. By Lemma 2.1 and Corollary 2.2 U_σ^{L,PE_I} and $U_s^{PE_I}$ yield respectively

$$\begin{aligned} U_\sigma^{L,PE_I} &= \frac{\alpha}{(\alpha+\beta+r)r}\frac{(\psi-b)}{\psi}p_L, \\ U_s^{PE_I} &= \frac{\alpha(\alpha+r)(w_s-b)-\alpha\beta(\psi-w_s)}{(\alpha+r)(\alpha+\beta+r)r}. \end{aligned}$$

Thus, $U_\sigma^{L,PE_I} \geq U_s^{PE_I}$ iff

$$\beta \geq \frac{\psi(w_s-b)-p_L(\psi-b)}{\psi(\psi-w_s)}(\alpha+r) \equiv \hat{\beta}^{PE_I}(\alpha),$$

which is the same as the conditions that implies $\eta_L \geq 1$.

(iii) Points (i) and (ii) confirm that no pure-strategy equilibrium is feasible if $0 < \eta_L < 1$. Eq (2.14) was derived given the condition $U_\sigma^{L,SSE} = U_s^{SSE}$, which is the necessary and sufficient condition for having a SSE. ■

Appendix A2

Proof of Lemma 3

Proof. At least some risky investments are implemented in SE, SSE and PE$_I$. Evidently, by Assumption 1, $\xi^{SE} = p_H > b$. Moreover, PE$_I$ is stable only if $\xi^{PE_I} = \psi \geq w_s > b$. Now, if $\psi - w_s < 0$, the condition that would guarantee the stability of PE$_I$ would obtain $\beta \leq \hat{\beta}^{PE_I}(\alpha) < 0$, which is impossible because negative arrival rates are ruled out.

Regarding SSE, if $\psi - w_s < 0$, there must be a threshold $\bar{\eta}_L \in (0,1)$ s.t.

$$\xi^{SSE} \mid_{\bar{\eta}_L \in (0,1)} - w_s = 0.$$

But $\xi^{SSE} \mid_{\bar{\eta}_L \in (0,1)} - w_s = 0$ implies that $\hat{U}_{\sigma}^{SSE} \mid_{\bar{\eta}_L \in (0,1)} - U_s^{SSE} = 0$, which in turn implies that $U_{\sigma}^{L,SSE} \mid_{\bar{\eta}_L \in (0,1)} - U_s^{SSE} < 0$. Thus, in order to have $U_{\sigma}^{L,SSE} = U_s^{SSE}$, one must have $\eta_L^* < \bar{\eta}_L$, which directly implies $\xi^{SSE} \mid_{\eta_L^* \in (0,1)} > w_s > b$. ■

Appendix A3

Stability of the *pooling equilibrium II* (PE_{II})

Under PE_{II} both types choose safe projects with probability 1; ie $\{1-\eta_H^*, \eta_H^*\} = \{1, 0\}$ and $\{1-\eta_L^*, \eta_L^*\} = \{1, 0\}$. Since choosing risky project is a 'zero-probability' event, Bayes' rule has no bite. Financiers' beliefs can simply be any distribution in Θ.

Under PE_{II}, $\tau = 0$. Then according to Lemma 2.1,

$$U_s^{PE_{II}} = \frac{\alpha (w_s - b)}{(\alpha+\beta+r) r}, \; \hat{U}_\sigma^{PE_{II}} = \frac{\alpha(\alpha+r)\left(\xi^{PE_{II}} - b\right) + \alpha\beta\left(\xi^{PE_{II}} - w_s\right)}{(\alpha+r)(\alpha+\beta+r) r}.$$

Obviously, since $U_\sigma^{H,PE_{II}} > U_\sigma^{L,PE_{II}}$, it suffices to derive the condition under which type-θ_H does not deviate from PE_{II}. The condition, $U_\sigma^{H,PE_{II}} \leq U_s^{PE_{II}}$ obtains

$$\beta \geq \frac{p_H\left(\xi^{PE_{II}} - b\right) - \xi^{PE_{II}}(w_s - b)}{p_H\left(w_s - \xi^{PE_{II}}\right)}(\alpha+r) \equiv \hat{\beta}^{PE_{II}}(\alpha),$$

if $\xi^{PE_{II}} - w_s < 0$. Otherwise, PE_{II} is not feasible.

The magnitude of the threshold $\hat{\beta}^{PE_{II}}$ depends on the equilibrium beliefs $\hat{\mu}(\omega_\sigma)$. Hence, there is a continuum of stable PE_{II}s supported by different beliefs. In order to limit the amount of stable equilibria, one needs to restrict the way in which beliefs can be updated in the case of 'zero-probability' events. One option is to require 'off-equilibrium path rationality' of beliefs; ie if

$$\sum_{\theta_j \in \Theta} \lambda(\theta_j)\, \eta_j^*(\omega) = 0,$$

then there exists a sequence of strategies, $\{1-\eta_i^n, \eta_i^n\}$, such that

$$\begin{aligned}
1)\ \eta_i^n &= \varepsilon^n, \text{ and } \lim_{n\to\infty} \varepsilon^n = 0, \\
2)\ \eta_i^* &= \lim_{n\to\infty} \eta_i^n, \text{ and} \\
3)\ \mu^*(\omega) &= \lim_{n\to\infty} \frac{\lambda(\theta_H)\, \eta_H^n(\omega)}{\sum_{\theta_j\in\Theta} \lambda(\theta_j)\, \eta_j^n(\omega)}.
\end{aligned}$$

Thus, the 'off-equilibrium path rationality' of beliefs presume that financiers' beliefs can be regarded as limits of totally mixed strategies and associated beliefs converging to the candidate equilibrium. Conditions 1–3 state that, 1) nth strategy in the sequence puts positive probability on both ω_s and ω_σ, 2) these strategies converge to entrepreneur's candidate equilibrium strategy, and 3) the beliefs calculated from Bayes' rule using strategies in the sequence converge to the candidate equilibrium beliefs.

Now, assuming 'off-equilibrium path rationality' of beliefs, we get

$$\mu^*(\omega_\sigma) = \lim_{n\to\infty} \frac{\lambda(\theta_H)\, \eta_H^n}{\sum_{\theta_j\in\Theta} \lambda(\theta_j)\, \eta_j^n} = \bar{\lambda}, \tag{4.1}$$

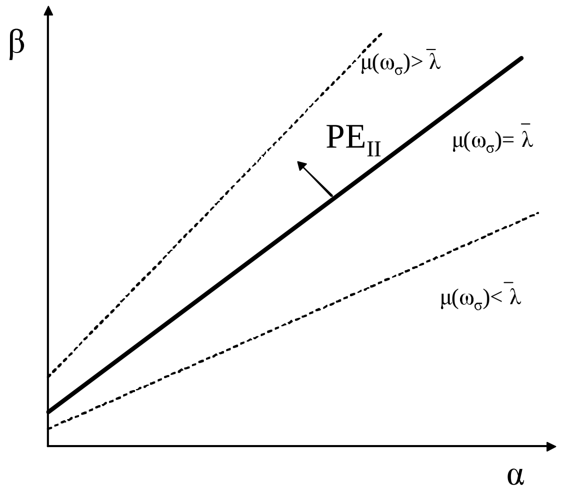

Figure 6: Feasibility of PE_{II}

which implies that

$$\xi^{PE_{II}} = \bar{\lambda} p_H + \left(1 - \bar{\lambda}\right) p_L = \xi^{PE_I} \equiv \psi.$$

Figure 6 represents the frontiers above which the PE_{II} – under different equilibrium beliefs – is stable in the $\alpha\beta$-plane. The bold line represents the frontier associated with the 'off-equilibrium path rational' beliefs.

Under PE_{II}, no risky investments are ever implemented, which guarantees that trading will always take place (Lemma 2.6). Note that PE_{II} is globally stable if $\xi^{PE_{II}} < p_H b / \left(p_H - w_s + b\right)$.

Appendix A4

Proof of Lemma 5

Proof. The proof is probably easiest to carry out if one consider the free-entry condition,

$$V_0 = \frac{\beta\left(\bar{\lambda}p_H + \left(1-\bar{\lambda}\right)w_s - \left(1-\bar{\lambda}\right)\eta_L\left(w_s - p_L\right) - b\right)}{\left(\alpha+\beta+r\right)r} = \phi,$$

in $\alpha\beta$-plane. Assume first that we are in a SE; ie $\eta_L^* = 0$. Then the FE-condition can be solved for β to yield

$$\beta \mid_{\eta_L^*=0} = \frac{r\phi}{\bar{\lambda}p_H + \left(1-\bar{\lambda}\right)w_s - b - r\phi}\left(\alpha+r\right),$$

so that the FE-locus is linearly upward-sloping in $\alpha\beta$-plane. Now, the steady state may occur under SE regime only if at least part of the FE-locus fall in the region where the SE is stable, which happens when

$$\beta \mid_{\eta_L^*=0} \leq \hat{\beta}^{SE}\left(\alpha\right) = \frac{p_H\left(w_s - p_L\right) - \left(p_H - p_L\right)b}{\left(p_H - w_s\right)\psi}\left(\alpha+r\right).$$

It is easy to see that the FE-locus either falls completely in the region where SE is stable or never hits the region. Similarly, if one assumes $\eta_L^* = 1$, the FE-condition can be solved for β to yield

$$\beta \mid_{\eta_L^*=1} = \frac{r\phi}{\bar{\lambda}p_H + \left(1-\bar{\lambda}\right)p_L - b - r\phi}\left(\alpha+r\right),$$

so that the steady state may occur under PE_I regime if

$$\beta \mid_{\eta_L^*=1} \geq \hat{\beta}^{PE_I}\left(\alpha\right),$$

a condition which again rules out the possibility that the FE-locus could take place under some other regime. Thus, we may conclude that if the steady state is characterized by a pure-strategy allocational regime, the steady state is necessarily unique. ■

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