ASYMMETRIC INFORMATION, SIGNALLING AND COMPETITION IN THE CREDIT MARKET

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This paper examines how credit market structure affects signalling under asymmetric information between banks and firms. In particular, it is shown that competition can be inconsistent with separating equilibria and, in turn, with efficient pricing rules. Under low competition contract differentiation is important, and good firms credibly signal their quality by choosing informatvie financial contracting. However, as competitive pressures increase the value of information necessary to separate shrinks and financial contracts becomes uninformative about quality. Then, separating equilibria do not exist and banks fail to price loans according to quality of applicant firms. Moreover, when all projects are viable, full competiton imposes a trade-off between investment financing and price-efficiency. With non-viability such a trade-off desappears.

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1 Introduction

In this paper I investigate the links between credit market structure and asymmetric information. In particular, I address the question of whether the competition in the loan market is consistent with self-selection of firms and efficient pricing in the context of a spatial competition model *à la* Salop (1979). By endogenizing the location of firms around the circle, a relationship between the signalling decision and the level of competition is established: if banking competition is intense, singalling incentives of good firms dramatically shrink and no separating equilibria exist. Instead, with less competition incentives for signalling arise and at least a partial separating equilibrium is achieved. It follows that in highly competitive environments banks fail to price loans according to quality of applicant firms.

The result relies on the following intuitions. Good firms, experiencing the credit market for the first time, have to send a signal to obtain high-quality pricing. The way to signal is to relocate on the circle towards positions associated to the preference for what I call "complex" or "informative contracts", which consist in a simple loan contract plus the costly provision of information about the quality and the characteristics of the project. The bank believes that all relocated firms are good in separating equilibria because relocation is costly and relatively more affordable to good firms. The key point is that the incentive to relocate crucially depends on the number of competitors and also on the degree of horizontal contract differentiation. I distinuish between local monopoly and competition. Under full competition there is a large variety of contracts with high informative content: banks add more information to their supply of standard contracts. As such informative content increases, the informative power of contracts declines because cheaper and more substitute-highly informative products are available to *all* firms. In fact, low-quality firms can afford informative financial contracting and are incentivated to mimic high-quality firms. As a result asking for compelx contracts no longer provides indications about quality.

While more competition reduces the amount of information required for separation, less contract differentiation lowers the unitary cost of the signal. The combined effect of contract differentiation and competition is to affect the *informative value*

of financial contracts and, in turn, the signalling process.
In the case of local monopoly the separating equilibrium conditions do not depend on the number of competitors, but on the degree of contract differentiation, i.e. the cost of the signal. If such a cost is sufficiently greater than zero, i.e. the degree of financial contract differentiation is high, signalling pay and separation is achieved. The monopolisitc framework is analysed to outline the role horizontal contract differentiation (heterogeneity in preferences) plays in the signalling device. While markets shares are undoubtly relevant only in the latter configuration, differentiation affects the equilibrium conditions in both local monopoly and competition. I shall see in more details how heterogeneity in preferences is determinant in the signalling game of high-quality firms.
The paper also provides some consideration in terms of efficiency. In particular, it is shown that, under viability of all projects, less than full competition generates signalling equilibria, but it is inconsistent with financing all investement projects. Instead, under nonviability of low-quality firms this trade-off desappears, both signalling equilbria and investmente efficiency are achieved.
This paper refers to the literature on banking market structure and asymmetric information. Recent works find several links between market structure and asymmetric information in the banking industry. Boas and Mohr (1999) show that, in more concentrated markets, banks screen borrowers more intensively because they compete more aggressively for highly profitable borrowers[1]. Dell'Ariccia, Friedman and Marquez (1999) find that adverse selection may be a source of entry barrier. Incumbent banks face informative advantages over potential entrants because they know more about their clients. As a result, informational asymmetries between lenders have deterrent effects on entry decisions.
Dell'Ariccia (2000) studies the relationship between screening incentives and competition. As the ratio between new-untested and old-rejected borrowers increases, banks tend to relax screening standards and expand credit. This may lead to a deterioration in portfolios and in banking profitability.
While many works pay attention to screening, this paper focuses on signalling as the key mechanisms to contrast informational asymmetries. I consider relocation

[1]For further details, see Boas and Morh (1999).

as a signal of quality and any decision to relocate pays only in non-fully competitive markets. Such a result is relevant because predicts that competition may prevents agents to overcome asymmetric information, and generates the standard results of inefficient pricing rules.

Recent literature examines credit market competition in a lender-borrower relation setting. Boot and Thakor (2000) have shown how competition influcences the decision to invest in relationship lending. The authors find that more competition in the banking sector induces lenders to invest more in relationship lending, while capital market competition produces the opposite effect.

Hauswald and Marquez (2000) investigate how competiton impacts the ability of banks to extract informational rents from lending relationships. Competition erodes the informational rents of banks, which specialize in their core segment, investing more in stable relationships with borrowers.

This model does not directly involve relationship banking. Banks are not *ex-ante* interested in long run relationships with clients because they offer simple contracts or transactional loans. Rather, we can think of relocation as the demand for a stronger bank-firm relationship. Good firms demand high-quality credit conditions, consulting and financial assistance by choosing complex contracting and sharing information with the bank: in this sense, banks are somewhat asked to be more involved into firms' activity.

Finally, Petersen and Rajan (1995) show that young firms receive more credit at low rates in concentrated markets: creditors smooth interest rates over the life cycle, charging lower-than-competitive rates when firms are young and higher-than-competitive rates when firms are old. Market power gives banks room for initial loss but future profit sharing.

The rest of the paper is organized as follows. Section two presents the hypotheses underlying the model, which is solved for the equilibrium prices under symmetric information in section three. In section four I introduce informational asymmetries and I study the linkages between market structure and singalling equilibria. The condition for separating equilibrium are derived for the case of local monopoly and full competition. Section five analyses some welfare and efficiency properties of signalling mechanisms. The concluding remarks are to be found in section six.

2 The Model

I consider a simple risk-neutral economy composed of lenders (banks) and borrowers (firms)[2]. Lenders compete in prices to attract heterogenous firms which invest on risky projects. In point I-IV I describe investment projects, the agents and their information set and the structure of the market in which lenders and borrowers operate.

I. Borrowers.

Borrowers have no private funds to finance thier projects and demand credit from a bank. They ask 1 unit of capital. Firms are endowed of a technology which transforms the uniraty capital into a random cash flow $\tilde{Z}$, which has the following schedule:

$$\tilde{Z} = \begin{cases} Z > 0 & p_\theta \\ 0 & 1 - p_\theta \end{cases}$$

where Z is the cash flow, $\theta \in \{h, l\}$ denotes the borrower's "type" and p_θ its repayment/success probability. More precisely, borrowers come in two types, "good" (h) and "bad" (l), or high-quality types and low-quality types.

For a type θ the expected cash flow is $E_\theta[\tilde{Z}] = p_\theta Z$, while the expected gross profit is $p_\theta(Z - R)$, where $R > 1$ is the repayment due to the bank. For the moment I assume the viablility of all projects, $p_\theta Z \geq R \; \forall \; \theta$ (I will remove this hypothesy ahead), whilst the repayment probability is higher for good projects, i.e. $p_h > p_l$.

II. Lenders.

As it will be explained in point IV, I assume N banks to produce one good, "loans", which are granted to borrowers in a unitary fixed size. Lending is realized at fixed per-project cost or costant marginal cost c. Borrowers receiving the loan are asked to repay the gross rate R_i.

Lenders seek to maximize expected profits, taking into account the cost of lending

[2]Hereafter I will use firms, projects and borrowers as synonimus as well banks and lenders.

and the repayment probability of firms.

III. Information.

Asymmetric information arises on θ because borrowers are informed about their type and but lenders are uninformed. Instead, the poportions of high-quality and low-quality projects in the economy are publicly observable and are known to be λ and $1-\lambda$ respectively.

IV. Market structure.

The market is described by a circular city *à la* Salop (1979) of length 1. Banks are located equidistantly around the cirle and their number is equal to N. I focus on the interactions between two adjacent banks, say i, with $i = 1, 2, ..., N$ and j, with $j = 1, 2, ..., N-1$, $i \neq j$, and suppose that there is a bank i located at an arbitrary point $x = 0$ and another bank j located at $x = \frac{1}{N}$ from i. The distance x is meant to be a borrower-lender distance, that is the distance between the borrower and the specific bank i serving it.

The population of firms is uniformly distributed on the circle. In particular, in each point of the circle there is a high-quality firm with probability λ and a low-quality firm with probability $(1-\lambda)$[3]. Firms face travel costs to borrow from a generic bank i and the cost per-unit of distance is β. Hence to travel distance x, a total cost βx must be sustained.

In a non-spatial view, β measures the degree of product differentiation and the market power of the banks. For $\beta = 0$ there is no horizontal product differentiation, and the system turns back to the competitive case[4]. I interpret β the degree of "financial contract complexity" or *informative power of contracts*, with the distance providing a measure of the preference for such a complexity. Complex contracts are

[3]Alternatively, we can say that in each point of the circle there is a mass λ of good borrowers and a mass $(1-\lambda)$ of bad borrowers.

[4]Interpreting the "location model approach" to horizontal product differentiation is way to introduce "location" or "address" into consumers's preferences, and to provide a measures of how close the brands actually produced are to the consumer's ideal brand. Also, the distance between the consumer and the firms may be a measure disutitlity to buy a less-than-ideal product (Oz Shy, 1996 p.149).

those contracts which involve the additional provision of a range of services including consultancy, project financing, accounting services, internet banking and so on. Moreover, complexity is refered to the information that contracts provide about quality. In other words, asking for a certain degree of complexity also means that firms spend resourses in the provision of infromation to proove credit-worthyness. Given that the generic bank i offers a simple loan contract, borrowers located close to it are “simple contract-lovers” or *non-informative-contracts lovers*, while borrowers located far away are “complex contracts-lovers” or *informative-contracts lovers*.

An important assumption is that θ and x are independent. *Ex ante* there is no reason to believe that good (bad) firms prefer to settle informative contracts (non-informative contracts). In fact, when information is symmetric, borrowers maintain their location and are priced according to type, and when the information is asymmetric types h need to relocate in order to signal their quality. In that case, good firms are required to express a preference for informative contracts.

Given the market structure described above, borrowers have to decide about two actions: i) whether to demand for credit; ii) which bank to apply to.

i) Demand for credit occurs if the net profit from borrowing and investing is non-negative. Thus, a borrower θ will apply to bank if and only if his participation constraint (hereafter PC) holds, this constraint is given by $p_\theta(Z-R)-\beta x_\theta \geq 0$. Solving for x_θ with equality:

$$x_\theta = \frac{p_\theta(Z-R)}{\beta}. \tag{1}$$

PC (1) states that for a type θ the application is profitable up to x_θ, beyond which transportation costs overwhelm the expected gross profit. Notice that while a type h can apply for credit up to x_h, a type l can only apply up to $x_l < x_h$. Low-quality borrowers are less capable of sustaining credit costs due to their lower probability of success.

ii) All else being equal, firms choose to borrow from the nearest bank, i.e the one that entails the lowest distance-cost. Consider a borrower θ located between two adjacent banks, say i and j. Such a borrower weakly prefers bank i's offer if the profit obtained is no less than the profit obtained form bank j's offer. Hence, by standard considerations we have:

$$p_\theta(Z - R_i) - \beta x_\theta \geq p_\theta(Z - R_j) - \beta(\frac{1}{N} - x_\theta)$$

or

$$p_\theta R_i + \beta x_\theta \leq p_\theta R_j + \beta(\frac{1}{N} - x_\theta), \tag{2}$$

where R_i and R_j are the gross rates charged by banks i and j respectively. Thus, bank i will be chosen if the total cost of credit is no greater than the one associated with bank j. Solving (2) for x_θ under equality conditions, we have the following indifference condition (IC)[5]:

$$x_\theta = \frac{1}{2N} + \frac{p_\theta(R_j - R_i)}{2\beta} \tag{3}$$

It follows that the demand for bank i is:

$$Q_i^c(\theta) = 2x_\theta = \begin{cases} \frac{1}{N} + \frac{p_h(R_j - R_i)}{\beta} \text{ for } \theta = h \\ \frac{1}{N} + \frac{p_l(R_j - R_i)}{\beta} \text{ for } \theta = l, \end{cases}$$

where the subscript "c" indicates the demand in a competitive environment. The (linear) demand function for the bank i has standard properties: it is declining in N and in its own price, and increasing in the direct competitors' price.

An important point about PC (1) and IC (3) is that they represent the demand for the bank in two specific market configurations. In fact, for $\frac{1}{2N}$ large enough, i.e. N low, we get that $x_l < x_h < \frac{1}{2N}$. In this case any of the N banks competes for the two types of firm. Thus, exploiting the relations between x_l, x_h, and $\frac{1}{2N}$ and we can state the following definition:

[5] The IC establishes the location of the "marginal borrower" of type θ, i.e the borrower who is indifferent with respect to the offers of two adjacent banks.

Definition 1.
Under condition $\mu > 2p_h(Z - R_i) = \overline{\mu}$ *the market is a local monopoly (with* $\mu = \beta/N$*).*
Under local monopoly the number of banks low enough to eliminate baniking competition.
If N is such that $x_l < \frac{1}{2N} < x_h$, the bank starts to compete for high-quality borrowers, maintaining the monopoly power on low-quality ones. We are now in an *intermediate case* where banks compete for high-quality firms only.

Definition 2.
Under condition $\underline{\mu} = 2p_l(Z - R_i) \leq \mu \leq \overline{\mu}$ *the market structure is intermediate between local monopoly and full competition: I define it as partially competitive.*
Partial competion dominates when all good borrowers are able to demand credit up to $x_h > \frac{1}{2N}$ (their participation constraint is slack with many banks) and then to compare the bank i's offer with the closest competitor's offer. This means that now alternative prices matter.
Finally, when $\frac{1}{2N} < x_l < x_h$, banks compete for all types, and all firms are able to compare the offers of two adjacent banks. Hence, we obtain this last definition:

Definition 3.
Under condition $\mu < 2p_l(Z - R_i) = \underline{\mu}$*, bank* i *competes for all types of borrowers, i.e. the market is fully competitive.*
The parameter μ measures the *intensity of competition* or the *competitive pressure* in terms of both number of incumbents and degree of market power achieved by banks via product differentiation. It will be clear in the next sections that this parameter is crucial to our analysis.

3 Symmetric information

In this section I study the framework of symmetric information: lenders freely observe θ and make their loan policies accordingly. First, I describe bank's profit and then derive the equilibrium loan rates under local monopoly and competition.

Banks' Profits.

The existence of symmetric information allows lenders to distinguish between good and bad borrowers and to price them differently. In other words, we have the standard result $R_i = R_i(\theta)$. The expected average bank profit form financing high-quality projects is given by $\pi_i(h) = \lambda p_h R_i(h) - (1+c)$, in the case of low-quality projects we have $\pi_i(l) = (1-\lambda)p_l R_i(l) - (1+c)$, where $R_i(h)$, $R_i(l)$ are the gross rates that bank i charges on borrowers of type h and l respectively. As we shall see, under informational symmetry we obtain standard results: banks offers two separated contract with independent prices.

3.1 Pricing under local monopoly

Exploiting definition 1, the demand for the bank under local monopoly is:

$$Q_i^m(\theta) = 2x_\theta = \begin{cases} \frac{p_h(Z-R_i(h))}{\beta} \text{ for } \theta = h \\ \\ \frac{p_l(Z-R_i(l))}{\beta} \text{ for } \theta = l \end{cases}$$

The problem for the monopolistic bank is to maximize profits over the mass of borrowers up to x_h. This problem is:

$$\max_{R_i(h),R_i(l)} \Pi_i(\theta) = \pi_i(h)[\frac{p_h(Z-R_i(h))}{\beta}] + \pi_i(l)[\frac{p_l(Z-R_i(l))}{\beta}] \tag{4}$$

Differentiating (4) with respect to $R_i(h), R_i(l)$ yields to the following monopoly pricing rule:

$$R^m(\theta) = \begin{cases} R^m(h) = \frac{1}{2}[Z + \frac{1+c}{\lambda p_h}]] \\ R^m(l) = \frac{1}{2}[Z + \frac{1+c}{(1-\lambda)p_l} \end{cases} \tag{5}$$

Rule (5) reflects lending costs, the borrowers' probability of success and the fact that banks and firms share the cash flow generated by the project. Note also that $R^m(l) > R^m(h)$ for $\frac{p_h}{p_l} > \frac{1-\lambda}{\lambda}$ and it is always satisfied for $\lambda = \frac{1}{2}$.

3.2 Pricing under full competition

When the environment is fully competitive, the demand faced by the bank i is given by $Q_i^c(\theta)$ (see point IV of section 2). To have a simpler notation I define $R_i(h) \equiv R(h)$ and $R_i(l) \equiv R(l)$. Because of equidistant positions, each bank will price borrowers according to type: $R_{j,h}$ and $R_{j,l}$ are the rates that bank j charges on type h and l respectively.
The bank maximizes profits over the mass of borrowers up to x_θ. The program is:

$$\max_{R(h),R(l)} \Pi_i(\theta) = \pi_i(h)[\frac{1}{N} + \frac{p_h(R_{j,h} - R(h))}{\beta}] + \pi_i(l)[\frac{1}{N} + \frac{p_l(R_{j,l} - R(l))}{\beta}]. \quad (6)$$

The profit function (6) has standard properties: it decreases with N, β and the cost c, and it increases with λ and p_θ. Substituting into (6) the values of $\pi_i(h)$ and $\pi_i(l)$ as defined in section 3, we compute the symmetric Nash equilibrium in prices by differentiating the profit function respect to R_h, R_l. We obtain the following separating pricing rule:

$$R^c(\theta) = \begin{cases} R^c(h) = \frac{1}{p_h}[\frac{(1+c)}{\lambda} + \frac{\beta}{N}] \\ R^c(l) = \frac{1}{p_l}[\frac{1+c}{1-\lambda} + \frac{\beta}{N}], \end{cases} \quad (7)$$

Rule (7)[6] is consistent with what has been mentioned above. Each borrower is priced according to its type and for a sufficent degree of heterogeneity between firms we have the standard result $R^c(l) > R^c(h)$ [7] (see appendix A.1 for proof). Being $\mu = \frac{\beta}{N}$, N and β are interpreted in the same manner; as competition gets sharper ($N \to \infty$ and $\beta \to 0$) rates converge to the competitive levels, and are determined by p_θ, λ and c only.

[6]The second derivatives $\frac{\partial \Pi_i}{\partial R_i(\theta)} < 0 \; \forall \; \theta$ guarantee that problems (4) and (6) are both concave.

[7]Given prices (7) the bank i's per-loan rate of return is $p_\theta R_i(\theta) - (1 + c)$. Such a rate of return is equal to $p_h R_i(h) - (1+c)$ in the case of a good firm and equal to $p_l R_i(l) - (1 + c)$ in the case of a bad one. Because rule (7) depends on λ, the two rates are equalized only for an even distribution of the types in the economy.

4 Asymmetric information

As long as lenders do not observe θ, their price policy cannot be based on rules (5) and (7). It is well known that under informational asymmetry the economy is out of the first best world. Despite this, the market is not prevented from generating devices enabling some forms of type-discrimination. Indeed, in our model there can be a mechanism whereby borrowers are able to signal their quality. As we shall see that this mechanism is distance related. The idea relies on the fact that high-quality borrowers may switch (or relocate) in order to send a signal of quality to lenders. Hence, the "x" finally chosen can be a variable from which banks infer the borrowers' true type.

4.1 Endogenous location and signalling

Under informational asymmetry I allow for *endogenous* location, in the sense that firms are given the possibility to relocate to other points of the circle in order to signal their type. Relocation is costly and such a cost is given by $s = |x - x_0|$, where x is the "final destination" and x_0 the initial location. In other words, borrowers wanting to move, *regardless* of type, incur in a cost proportional to the traveled distance[8]. The module implies that s is symmetric with respect to the location: wherever the firm moves from its initial position, it incurs in s.

In the space of financial contracts, moving towards locations far away from the bank means demanding highly informative contracts, while moving towards locations closer to the bank implies demanding simple loan contracts or non-informative loan contracts. Firms with initial location close to the bank incur in low travel costs because they are not particularly interested in sofistication. Instead, firms located far away are non-standard contracts lovers and give informational more importance. In other words, the distance from the bank reflects the preference for

[8]The cost of the signal is assumed to be the same for all types. *Ex-ante* there is no reason to believe that good firms are willing to invest more in information because this element is refered to location and not to type. Then, I depart from the assumption that signalling costs are different according to types, like in Spence (1973). For further details about signalling models see also Myers and Majluf (1984).

informative contracts.
For a given location, borrowers' evaluation contracts is *ex-ante* the same; however, high-quality firms have to demand more information to send a signal of quality [9]. To clarify this point note that a borrower located at y from a bank, gives information the total value βy *regardless of type*. Under informational asymmetry, good firms must relocate in order to obtain high-quality pricing and *ex-post* give information more value. In this way, they invest contract complexity but are returned with lower interest rates on loans.
The linear cost s is a simple but effective way to model a class of costs relevant in credit markets. In fact, we can think of s as the payment due to a rating agency certifying the quality of the project, or as the effort an entepreneur must put into the project to make it profitable, e.g. accurate feasability studies, forcasting how production and demand may evolve over the time, market research to ensure that the final product is worth selling. Thus, signalling may become a "pass" for high-quality credit application. Such a mechanism imposes an effort on good firms but allows banks to avoid costly screening.

4.2 The signalling game

I concentrate on bank i (hereafter I omit i). This bank is uninformed about θ, but does know that below x_l all firms apply for credit and for $x_h > x_l$ only high-quality firms will apply. Given $x_h > x_l$, high-quality borrowers may switch to the non-profitable region for low types, $[x_l, x_h)$, to signal their higher quality. More precisely, x_l is the point to which all good borrowers can switch in order to sustain the mininum cost consistent with separation. Accordingly, the game is based on the following sequence of actions:

1. borrowers move first. By comparing the pay-off of their current location with the payoff enjoyed at x_l they decide whether to relocate;

[9] The location of some firms is consistent with separation. It will be shown ahead that these firms have location sufficient for signalling and they are not involved in the relocation process.

2. lenders offer two separating contracts or one pooling contract depending on the signal observed;
3. borrowers take their application decisions;
4. equilibrium is reached and final payoffs are assigned.

The distance x from the bank is the signal. I denote by $x(\theta)$ the location to be chosen by the type θ *conditional* on his actual position x_0, and by $\phi(x)$ the probability that the type is h having observed x.

At location $x(\theta)$ the bank charges the expected rate $R[x(\theta)] = \phi[x(\theta)]\bar{R} + (1 - \phi[x(\theta)])\underline{\mathrm{R}}$, where $\bar{R} \equiv R(h), \underline{\mathrm{R}} \equiv R(l)$, respectively; later on it will also be specified which market structure these rates refer to.

The concept of equilibrium used in these class of models is the perfect Baysian equilibrium (PBE). The PBE of this game is a set of $\{x^*(h), x^*(l), R^*, \phi^*\}$ such that the profit for a borrower sending the signal $x(\theta)$ is maximized $\forall\theta$. Hence, $x^*(\theta)$ solves:

$$\max_{x(\theta)}[(p_\theta(Z - R^*[x(\theta)]) - \beta x(\theta))|x_0]$$

where $R^*(\theta) = \phi^*(x)\bar{R} + [1 - \phi^*(x)]\underline{\mathrm{R}}$ is the equilibrium rate, which is anticipated by the borrower and included in the maximization problem. The rates borrowers consider in their maximization problem are also optimal for the bank because derived from problems (4) and (6).

In separating equilibria the bank faces the following system of beliefs[10]: $\phi^*(x) = 1$ $\forall\ x \geq x_l$; $\phi^*(x) = 0\ \forall\ x < x_l$.

[10]This system of beliefs means that in equilibrium the bank assigns probability 0 of being a good borrower for all the locations $x < x_l$ even if there are some good borrowers "locked" in the region $[0, x_l)$ that cannot separate. This is consistent with the result of separation, but does not imply the outcome of complete separation.

4.3 Local monopoly

I first analyse relocation decisions under local monopoly and then I will extend the analysis to the competitive. For the sake of simplicity, I define the monopoly rates $R^m(l) \equiv \underline{R}$ and $R^m(h) \equiv \overline{R}$.

Optimal location for low-quality firms.
Low-quality borrowers located above x_l will not ask for a loan because those locations produce high distance costs and negative profits. But it can be the case that a borrower of type l with initial locaton $x_0 = x_l$ profitably applies for a loan because of the lower equilibrium interest rate the bank charges at x_l. In fact, if signalling is possible the bank charges the rate $R^*(x_l) = \overline{R}$ in the region $x \in [x_l, x_h)$ and all borrowers l located in x_l could potentially apply for loan making positive profits. In order to obtain a separating equilibrium we have to find the condition under which that situation does not occur. Such a condition is:

$$p_l[Z - R^*(x_l)] - \beta x_l = p_l[Z - \overline{R}] - \beta x_l \leq 0.$$

By substituting the expression for x_l we get:

$$p_l[Z - R^*(x_l)] - \beta x_l = p_l[Z - \overline{R}] - \beta \frac{p_l[Z - \overline{R}]}{\beta} = 0. \tag{8}$$

and the condition is satisfied for all β.

Result (8) indicates that low-quality borrowers located a $x = x_l$ makes zero profits even if charged $\overline{R} < \underline{R}$ and thus they do not apply for credit at x_l or above.
Two important implications of (8) are that all borrowers of types l located below x_l have no incentive to switch and those who are already located at x_l or above will not apply for credit because it is not profitable.
In the signalling game, the equilibrium values for low-quality borrowers are:
a) firms with initial location $x_0 \in [0, x_l)$, choose $x^*(l) = x_0$ and are assigned $\phi^*(x) = 0$. All borrowers continue to stay in that region and will apply for credit

at the rate $R^*[x^*(l)] = \underline{R}$;
b) firms with initial location $x_0 \in [x_l, x_h)$ will not apply for credit.

Optimal location for high-quality firms.

All borrowers of type h located above x_l will continue to stay in that region; their initial location x_0 is sufficient for signalling. We know from (8) that low-types will never demand credit above x_l. A *necessary condition for a separating equilibrium* is that high-quality borrowers located below x_l find profitable switching to x_l. If *all* of them switch, we obtain complete separation.

Then, the analysis is focused on good borrowers located below x_l, who would need to move above to signal their quality. That is the case if the following relation holds: $\{[x^*(h) \geq x_l, \bar{R}]|x_o\} \succ \{[x^*(h) < x_l, \underline{R}]|x_0\}$. More precisely, a good borrower with initial location $x_0 \in [0, x_l)$, charged $R^*(x_0 < x_l)$, prefers to switch up to x_l if and only if

$$p_h R^*[x < x_l] + \beta x_0 \geq p_h R^*[x \geq x_l] + \beta x_l + (x_l - x_0)$$

or

$$p_h[\underline{R} - \overline{R}] \geq (1+\beta)s \tag{9}$$

where $R^*(x \geq x_l) = \overline{R}$ and $R^*(x < x_l) = \underline{R}$.

In Condition (9) borrowers compare gains (the left-hand side) with costs (the right-hand side one) of relocation. The latter are the switching costs depending on the distance $(x_l - x_0)$, while the former is the price differential. Solving (9) for s we find that:

$$s \leq \frac{p_h(\underline{R} - \bar{R})}{1+\beta} \equiv \bar{x}, \tag{10}$$

Notice that rearranging 10 we have:

$$H(\beta) = x_0 - \frac{p_l(Z - \bar{R})}{\beta} + \frac{p_h(\underline{R} - \bar{R})}{1+\beta} \geq 0 \tag{11}$$

.

and then we have that $\lim_{\beta\to 0} = -\infty$, while $\lim_{\beta\to+\infty} = x_0$. This implies the existence of a value $\underline{\beta}$ such that $\forall\beta \geq \underline{\beta}\; H(\beta) \geq 0$.

Lemma 1. *A necessary condition for a separating equilibrium of at least one firm with location x_o is $\beta > \underline{\beta}$.*

Imposing $x_0 = 0$ for complete separation we have that $s = x_l \leq \frac{p_h(\underline{R}-\bar{R})}{1+\beta} \equiv \bar{x}$. Solving for β:

$$H[(\beta)|_{x_0=0}] \geq 0 \iff \beta \geq \frac{1}{\frac{p_h}{p_l}\frac{(\underline{R}-\overline{R})}{(Z-\overline{R})} - 1} = \overline{\beta}$$

Proposition 1.

$\beta > \overline{\beta}$ is a necessary and sufficient condition for a complete separating equilibrium.

Because (8) is not affected by β the only relevant condition is (10). The function $H(\beta)$ is positive and is consistent with full separation only under condition $\beta > \overline{\beta}$: this means that of market non-competitivness and heterogeneity in preferences do matter in the signalling process. If β is low, the degree of contract differentiation is low because preferences of firms become more similar. The non existence of signalling equilibria stems form the impossibiliy faced by good firms to settle differentiated contracts; in fact under low degree of differentiation demanding for differentiated-informative contracts is costly and it is likely to occur that such cost is greater than the benefits in terms of loan rates differential $\underline{R} - \overline{R}$. Instead, if heterogeneity exists, loan contracts attract borrowers in different measures and this allows young firms to reveal their type by expressing a preference "informative-contracts". If heterogenity did not exist relocation would be type-revealing all firms would ask for the same contract [11]. Also notice that if $\beta = 0$ condition (10) is never satisifed because the market is perfectly competitive and

[11] Note that the gretaer heterogeneity $\frac{p_h}{p_l}$ the lower the required minimum β, because high-quality borrowers gain more from the price differential and higher costs can be sustained for separation

heterogeneity vanishes.

Proposition 2.
A necessary and sufficient condition for a semi-separating equilibrium is $\beta \in [\underline{\beta}, \overline{\beta}]$*.* $\beta > \overline{\beta}$ *is a necessary and sufficient condition for complete separation.*

Corollary 2.
In a semi-separating equilibrium good firms with location $\bar{x} < x \leq x_l$ *will separate and good firms with location* $0 \leq x < \bar{x}$ *remain in that region and will be priced* $\underline{R} > \overline{R}$*. Under complete separation all good firms choose to relocate and are finally located at* x_l *or above.*

Proof. See appendix A.

Proposition 2 says that, for some values of β, signalling equilibria are characterized by incomplete separation, with some good firms locked in the no-signalling region, where separation is for them unfeasible.
Notice that not *all* good borrowers incur in signalling costs. Such costs are in fact sustained only by those firms located below x_l. Good firms located above x_l will not incur in s because their initial location is sufficient for signalling[12]. The latter are known to be efficient and to undertake good investment projects: they have already singalled their type in previous periods and are now reaping the benefits. The former, on the other hand, are those young firms experiencing the credit market for the first time, and need to emerge from the mass of new firms applying for credit.
Differentaiting the profit/incenitve function (11) with respect to β, we find that $\frac{\partial H(\cdot)}{\partial \beta} > 0$ if and only if:

$$-\frac{p_h(\underline{R} - \bar{R})}{(1+\beta)^2} + \frac{p_l(Z - \bar{R})}{\beta^2} > 0.$$

[12]The initial location can also be seen as the firm's *reputation endowment*. This reputation is high for $x \geq x_l$ and low for $x < x_l$.

Solving for β, we obtain:

$$\beta < \frac{1}{\sqrt{\frac{p_h}{p_l}\frac{(\underline{R}-\overline{R})}{(Z-\underline{R})}} - 1} \equiv \beta^* \tag{12}$$

Lemma 3.
For $\beta \in [\underline{\beta}, \beta^*]$, $H(\beta)$ is increasing in β, for $\beta > \beta^*$ $H(\beta)$ is decreasing.

Interpreting expression (12) and (14) toghether means that, the incentives to relocate arise for a minimum value $\underline{\beta}$. Beyond this value, signalling is activated and high-quality borrowers start to separate. Complete separation is obtained for $\beta > \overline{\beta}$. But for $\beta > \beta^*$, the marginal incentive to switch decreases. This result is consistent with signalling, but implies that as the market power of banks increases profits and surplus are reduced. In other words, firms pay more for a marginal increase in the market power parameter to continue the signalling game.

4.4 Signalling under full competition

In the case of local monopoly borrowers face the following situation: $x_l < x_h < \frac{1}{2N}$. In the intermediate structure, $x_l \leq \frac{1}{2N} \leq x_h$, banks compete for high-quality borrowers and still have market power on low-quality ones. In this latter framework signalling still works, but now the set X_i of types h located above x_l and sending the signal to the bank i depends on N: $X_i(N) = \{x; x^*(h) = x_0, \forall x \in [x_l, 1/2N < x_h]\}$. As $\frac{1}{2N} \to x_l$, the set $X_i \to \oslash$, and the only feasible $x^*(h)$ is $x^*(h) \leq \frac{1}{2N}$ for all the good borrowers. As the number of banks grows, X_i tends to be smaller and smaller, at the limit an empty set when $\frac{1}{2N} < x_l$. This is the case in which good firms are locked in their initial location (participation constraints are slack for all firms), and there exists no location consistent with signalling equilibria. The fall of X_i reduces the room for relocation of firms with location $x \in [0, x_l)$; bank i's market share involving firms with locations $x \in [x_l, \frac{1}{2N}]$ also shrinks, and a larger proportion of these latter firms send their signal to the closest competing bank.
To show that under full competition signalling is no longer active, I proove that

there exists no point $x \in [0, \frac{1}{2N}]$ at which high-quality borrowers are in condition to relocate and credibly signal. Hence, it is sufficient to show that at the extreme point, $\frac{1}{2N}$ or below it, low-quality firms are able to profitably ask for credit (the sufficient condition for signalling does not hold). Consider again condition (8):

$$p_l[Z - R^*(x = x_l)] - \beta x_l = p_l[Z - \overline{R}^c] - \beta x_l$$

and evaluate it in the case of full competition, $\frac{1}{2N} = x_l$, where x_l is the signalling threshold. No signalling equilibria exist if:

$$p_l[Z - R^*(\frac{1}{2N})] - \frac{\beta}{2N} = p_l[Z - \overline{R}^c] - \frac{\beta}{2N} \leq 0 \tag{13}$$

and solving for $\mu = \frac{\beta}{N}$, we have the following condition[13]:

$$\frac{\beta}{N} \geq [p_l Z - \frac{p_l(1+c)}{p_h \lambda}][\frac{2p_h}{2+p_h}] \equiv \hat{\mu} \tag{14}$$

Proposition 3.

For $\mu < \hat{\mu}$ the competitive pressure is such that no sparating equilibrium exists. A necessary condition for a separating equilibrium is $\mu \geq \hat{\mu}$.

Corollary 3.

For $\mu < \hat{\mu}$ high-quality firms do not relocate and will be priced the same rate of low-quality firms. The outcome is a pooling equilibrium.

For $\frac{1}{2N} \in [x_l, x_h)$, competition involves high-quality firms only. The signalling mechanism still works and the condition for separation is:

$$p_h[\underline{R} - \overline{R}^c] > (1+\beta)(x_l - x_0) \tag{15}$$

Good borrowers compare the gain in term of price differential[14] with the sum of the

[13] Solving (15) for the market share $\frac{1}{N}$ we have no singalling for $\frac{\hat{1}}{N} < (\frac{2+p_h}{\beta})[p_l Z - \frac{(1+c)}{p_h \lambda}]$.
[14] See appendix A.2 for details.

switching costs and the travel costs. The left-hand side term in square bracket of (15) is the difference between the low-quality monopoly rate that is applied in the region $[0, x_l)$ and the high-quality competitive rate that is applied from $x \geq x_l$[15]. Solving (15) for the market share, we have that:

$$\frac{1}{N} \geq \frac{Z\rho - (1+\beta)x_0 - (1+c)\omega}{\alpha} \equiv M_I, \tag{16}$$

Setting $x_0 = 0$

$$\frac{1}{N} \geq \frac{Z\rho - (1+c)\omega}{\alpha} \equiv M_C \tag{17}$$

which gives the market share consistent with full separation[16]. M_I and M_C identify the minimum market share consistent with incomplete and complete separation respectively. It is straightforward to see that $M_C > M_I$. Moreover $M_I > 2x_l$ if the heterogeneity among types is large enough (see appendix A.3 for proof). This means that the market share associated to complete separation is larger than the market share that yields full competition. Using (16) and (17) we can state the following propostition:

Proposition 4.
The existence of separating equilibria depend on the competition. The characterization of the equilibria in terms of market share is the following:
1. Normalizing $c = 1$, under condition $(1 - \lambda) \geq \frac{x_0 p_h}{2p_l}$ the market share $\frac{1}{N} \geq M_I$ is a necessary and sufficient condition for any separating equilibrium.
2. $\frac{1}{N} \geq M_C$ is a necessary and sufficient condition for complete separation.

[15]Remember that in the "low-quality region", the bank believes that all firms are of low-quality and price them accordingly. Further more, given that we are in a partially competitive environment, the bank maintains its market power on low-quality, and this explains why the rate charged in the region $[0, x_l)$ is $\underline{R} = R^m(l)$. Instead, at x_l the high-quality rate is applied, but from that threshold the bank competes for high-quality borrowers; there, the prevailing rate is the high-quality competitive rate $\overline{R}^c$.

[16]We have that $\alpha = \frac{(1+\beta)p_l}{p_h}$, $\rho = [\frac{(1+\beta)}{\beta} - \frac{1}{2}]$ and $\omega = (\frac{p_h}{2(1-\lambda)} - \frac{1}{\lambda} - \frac{(1+\beta)p_l}{p_h\lambda})$.

Intuitions behind propositions 3-4. With N fixed, the degree of differentiation is exogenously given and it is equal to $\Delta = \beta dx$, where dx is the distance between the bank and the marginal borrower, which has location $x = \frac{1}{2N}$. Then, $\Delta = \frac{\beta}{2N} = \frac{\mu}{2}$ is a positive funcion of μ. The overall product differentiation shrinks as the competition gets more intense. The parameter β and N act in the same direction. When N increases, many banks populate the market and offer cheaper subsitute financial contracts. Given the cost β, the greater substituibility implies lower costs of information provision and make the signalling possible to all borrowers. The intensity of competition relaxes partiticipation constraints and makes informative contracts affordable to all firms. On the one hand, the effect of β is to vary the heterogeneity in preferences and the degree of contract differentiation. In particular, for β small the cost of the signal is low, and good firms relocation incentives are weakened. On the other hand, larger values N yield more competition (due to the increased variety of informative contracts) and, in turn, induce mimicking of low-quality firms that demand cheaper-informative contracts.
It is important to underline that the market share is interpreted as the quantity of information incorporated in contracts, while β is the unitary cost of such an information[17]. In other words, β represents the *price*, while the market share represents the *quantity* of information required for separation[18]. When the price is

[17]More contract differentiation (N small) indeed makes relocation costly; instead, less differentiation (N large) increases the informational content of contracts (that become more substitute) and lowers relocation costs. As a result the incentives driving good firms to relocate decline, while mimicking incentives of bad firms increase. This point helps to clarify the relationship between of informational content and information power of contracts. N small implies the supply of few contracts with low informational content but high informational power. As competition increases, a larger variety of informative, cheaper and more subsititute contracts is supplied, and these contracts are characterized by more informational content but less informational power.

[18]The raise of N reduces the borrower-lender distance and relax partitipation constraints. The distance is a measure of the amount of information incorporated in the signal, i.e. the informative power of relocation. As N increases, the collapse of overall distances makes switching less costly for low-types: as a result, signalling loses its informational power. Also note the interesting trade-off between market share and the contract differentiation parameter β: when the information power of contracts is low (N large), the

low all firms are in condition to buy the contract necessary to separate and the information extracted from the relocation process is not sufficient to guarantee credible signalling. Moreover, when market shares are too small, low-types can afford to the reduced amount of information required for separation, loosening again the credibility of the signalling process. In conclusion I interpret μ as the value information has in the signalling mechanism[19]. The fall of μ due to competitive pressures lowers the value of information to advantage of low-quality firms. Then, the informative power of relocation dramatically shrinks and signalling is no longer believed credible.

4.5 Nonviability and competition

Assuming nonviability of low-types, $p_l Z < R$, asymmetric information is indeed severe because low-quality firms are not credit-worthy. With respect to the viability case, signalling is more important because if separation is reached good firms are financed (at the high-quality interest rate) and banks avoid to finance nonviable firms. If only partial separation is reached, some good firms are locked in the no-financing region because believed to be of type l. As a result, a fraction of the most profitable firms does not obtain credit[20].

Under nonviability the necessary condition for separating equilibria is still (14): the profit for a firm of type l located at x_l must be non-positive. The necessary condition for separation is:

$$\frac{1}{N} > \frac{1}{\beta}[p_h(Z - \frac{x_o}{e - p_h}) - \frac{1+c}{\lambda}] \equiv \underline{M}_{NV} \tag{18}$$

price β must be high in order to have $\mu > \hat{\mu}$ and vice versa.

[19]Note that condition (8) is expressed in terms of μ, while the conditions for complete and incomplete separation are expressed in terms of market shares. This does not affect the interpretation of the results because β and N act in the same direction, i.e. they lower the value of information in required for signalling. Notice that if $\beta = 0$, the right-hand side of (16) explodes and there exists no market share consistent with separation.

[20]The implication of severe asymmetric information is the destruction of profitable firms and, in turn, a loss in terms of efficiency.

where $e = \frac{p_l(1+\beta)}{\beta}$. Setting $x_0 = 0$ for full separation, we obtain:

$$\frac{1}{N} \geq \frac{1}{\beta}[p_h(Z - \frac{1+c}{\lambda})] \equiv \overline{M}_{NV} \tag{19}$$

Proof. See appendix A.4.

By (18) and (19) we state the following proposition:

Proposition 5.

Under nonviability of low-quality projects:

1. Normalizing $c = 1$, if $\beta \geq p_l/(p_h - p_l)$, then $\frac{1}{N} \geq \underline{M}_{NV}$ is a necessary and sufficient condition for the existence of separating equilibria.

2. $\frac{1}{N} \geq \overline{M}_{NV}$ is a necessary and sufficient condition for complete separating equilibria.

Proof. See appendix A.4.1.

It is straightforward to see that $\overline{M}_{NV} > \underline{M}_{NV}$ (NV indicates the market shares under nonviability). Conditions (18)-(19) constraint the markets share of banks to be no smaller than $\underline{M}_{NV}$ for minimum separating condition and no smaller than $\overline{M}_{NV}$ for full separation. If competition is intense (14) does not hold and no separating equilibria exist.

Corollary 5.

Because $Z \geq R$ by assumption, $\underline{M}_{NV} \geq M_I$ and $\overline{M}_{NV} \geq M_C$.

Under nonviability asymmetric information is severe and the information required for separation is even greater than the one associated to viability.

It is interesting to note that $\overline{M}_{NV} > 2x_l$, i.e. the market share that yields full competition is lower than the one associated to full separation. Competition generates two opposite effects: it increases the number of financed firms (the market is covered only in full competition) but reduces the proportion of good firms able to relocate. Indeed, there is no way to increase efficiency when the competition is greater than the level consistent with full separation. Other and more detailed considerations about efficiency are reported in the next section.

5 Efficiency properties of signalling

In this section I study some efficiency and welfare properties generated by the signalling device. I shall mainly refer to the case of competition.

Before analyzing the competitive case, I make one point involving local monopoly. Under local monopoly there exists value of β that maximizes the profits of high-quality switching firms, and this value is β^*. This result does not depend on the initial location x_0 and is conditional on the relocation decision formalized in (12). Instead, the no-switching condition for low-quality borrowers is not affected by β, even though, for them the higher β the lower the profit and surplus. Moreover, we know that $\beta^* > \hat{\beta}$, which implies that, once full separation is achieved, there is still room for welfare improving of high-quality firms. With $\beta = \beta^*$ singalling yields full separation and the maximum welfare is achieved by good-switching firms. Now I turn to competition.

When banks compete for both types of firms the no-signalling framework dominates. In such a context the aggregate profits of high-quality firms are:

$$\Gamma_H = \lambda[p_h(Z - R^p) - 2N \int_0^{\frac{1}{2N}} \beta x dx]$$

and aggregate profits of low-quality firms are:

$$\Gamma_L = (1 - \lambda)[p_l(Z - R^p) - 2N \int_0^{\frac{1}{2N}} \beta x dx]$$

where R^p is the rate obtained in absence of signalling (see appendix A.5 for derivation) [21]. The firms' aggregate profits are:

[21] The rate R^p is obtained from the maximization problem of bank i under no signalling. In that case the bank cannot distinguish the borrowers' type and charges the pooling rate

$$\Gamma = \Gamma_H + \Gamma_L = p(Z - R^p) - 2N \int_0^{\frac{1}{2N}} \beta x dx \tag{20}$$

with $p \equiv p_h\lambda + p_l(1-\lambda)$ denoting the average probability of repayment in the economy. When signalling is not active, all borrowers incur in travel costs only. The aggregate travel costs are $2N \int_0^{\frac{1}{2N}} \beta x dx = \frac{\beta}{4N}$. Substuting this latter integral and the expression of R^p in (20) we find that:

$$\Pi_f = pZ - (1+c) - \frac{\beta}{N}(\frac{1}{4} + \frac{2p}{p_h + p_l}) \tag{21}$$

Aggregate profits are increasing in N and declining in β. Borrowing firms gain more when the number of incumbents is large and travel costs low.
Under singalling welfare evaluations are more complex because net profits of good switching firms are also affected by signalling costs and gains. Under complete separation aggregate profits of good firms are $\Pi_{cs} = \lambda(\frac{1}{2N} - x_l)(Z - \overline{R}^c)$. As competition increases $\Pi_{cs} \to 0$, and profits converge to pooling equilibria values, that is $x_h(Z - R^p)$.
It is interesting to note some aspects connected to costs. Aggregate costs of good firms are given by:

$$C_s = 2\lambda N[\int_{x_l(N)}^{\frac{1}{2N}} \beta x dx + \int_{x_i(N)}^{x_l(N)} \beta x dx]$$

where x_i is the location of the borrower indifferent between switching or not. The first integral in C_s is the sum of travel costs of all good firms finally located at x_l or above, and the second one is the sum of the switching costs for those previously located below x_l.

a) Distance-costs.
Competition affects good firms aggregate profit and costs in several direction. If, on the one side, competition lowers prices and increases gross profits, on the other,

R^p to all firms belonging to its market share.

it reduces overall travel costs above $N = N_{sh}$ (see appendix A.6). Overall travel costs provide a measure of the informational power of the contracts settled by firms. In the case of good firms, these costs are increasing up to N_{sh} and decreasing above. The intuition behind this result is that low competition is consitent with informative contracts and high distance-costs and, in turn, with signalling. When competition is intense the value of information incorporated in the contracts shrinks, distance-costs fall and signalling equilibria no longer exist.

b) Relocation costs.
Competition increases switching costs via $x_l'(N) > 0$ but, at the same time, it reduces them by lowering the proportion of switching firms, because $x_i(N)$ tends to x_l for N large. The idea is that when N increases starting from low values, relocation costs increase because of the outward shift of x_l; this effect dominates the "proportion" effect, that is a lower fraction of firms are in condition to swtich. As a result, signalling costs increase and relocation does have a rilevant informative power. When N is very large, the fraction of switching firms becomes smaller and relocation costs fall: contracts become less informative, making "mimic" possible for low-types and signal not credible.
Gross profits of low-quality firms are:

$$TCL = (1-\lambda)[p_l(Z - \underline{R}) - 2N \int_0^{x_l(N)} \beta x dx] \tag{22}$$

Under signalling travel costs for low-quality firms are increasing above $N = N_{sl}$ (see appendix A.7) because the competition implies a larger proportion of financed investment projects, involving, in turn, higher overall travel costs for borrowers. Given that high costs enhance the informational power of low-types contracts relative to high-type ones, this is a source for potential mimic and non-credible signalling. Below N_{sl} the competition is not intense, travel costs are decreasing and the informational value of low-type contracts is negligble.
Travel costs for all types are decreasing in N when the no-signalling regime works[22].

[22]In fact, by equation (20), total travel costs are $TC = \frac{4}{\beta N}$. Differentiating TC with respect to N we obtain $\partial TC/\partial N = -\beta/4N^2$.

As a result, the volume of information contened in the contracts becomes irrelevant.

It is worth noting that under signalling there exists a *trade-off between price efficieny and investment efficiency*. In fact, in the case of full competition the market is covered, all projects are financed and the highest level of investment in the economy is reached[23]. Under *viability* of all firms, less than full competition, on the one hand, implies the existence of non-financed viable projects and it also yields levels of output lower than its efficient level; on the other hand, non-full competition is consistent signalling and efficent pricing. It follows that *full competition yields efficiency in terms market coverage - investment efficiency - but not price efficiency*[24].

Under *nonviablility* of low-quality firms our results are strengthened. In fact, adverse selection is more severe because low-quality firms are not credit-worthy. Signalling becomes even more crucial to banks because the problem is not to price efficiently but also to separate good firms from bad-insolvent firms. Signalling is fondamental for good firms to separate and for lenders to avoid bankrupty risks due to potential inefficent credit policies. The important implication of nonviability is that full competition no longer implies investment inefficiency because banks finance the largest proportion of firms but face the impossibility to separate good firms from insovent firms. Then, *if low-quality firms are not credit-worthy, the trade-off between price efficiency and investment efficiency desappears*. The consequence of more competition than the level consistent with full separation is that more investments projects would be financed but a lower fraction of good firms is able to signal and obtain credit. In that case, indeed there is no way to increase efficiency by increasing competition.

[23]When $\frac{1}{2N} > x_h$ all the projects in the region $[0, x_l)$ are financed; a proportion λ is financed in the region $[x_l, x_h)$; zero projects are financed in the region $[x_h, \frac{1}{2N}]$. The larger N, the greater the fraction of good profects that obtains credit.

[24]This paper mainly aims to show how competition generates efficiency trade-offs as mentioned above, but it would be interesting in future research to provide quantification. In particular, it is worth investigating if, under signalling, the loss of efficiency is offset by the gains of relocation.

6 Concluding remarks

This model predicts that competition can limit the possibility to overcome asymmetric information between lenders and borrowers.

Conditional to local monopoly I find that what matter in the signalling process is contract differentiation. Because self-selection of good firms is based on the demand of differentiated-informative contracts, signalling is possibile only if such a differentiation is important, and preferences are sufficiently heterogeneous to allow relocation of good firms.

In the interesting case of competition I obtain the following results. The existence of separating equilibria depends on contract differentiation but also on market shares. If market shares are not small, both separation and efficient pricing are achieved. The results rely on the fact that, with sharp competition, banks supply informative substitute contracts, which become affordable to low-quality firms as well. It follows that signalling is weakened and relocation no longer provides information about quality.

I also argue that, under viability of all firms, less than full competition yields efficient pricing but inefficient levels of investment. However, this trade-off vanishes if informational asymmetries are more important. This is because under nonviability of bad firms full separation allows good firms to obtain high-quality loan contracts, while bad firms are denied credit. It follows that all good firms are financed (efficient investment) and are charged the high-quality interest rate (efficent pricing).

Appendix

A.

The function $H(\beta)$ is such that:

$$H(\beta) \geq 0 \iff \beta \geq \frac{p_l[Z - \overline{R}] - p_h\gamma}{x_0 + p_h\gamma} = \underline{\beta},$$

with $\gamma = \underline{R} - \overline{R}$. This is the lower bound for β, i.e. the minimum value consistent with separation. For all $\beta < \underline{\beta}$ no separating equilibria exist.

Setting $x_0 = 0$, with some handling we have:

$$H[(\beta)|_{x_0=0}] \geq 0 \iff \beta \geq \frac{1}{\frac{p_h}{p_l}\frac{\gamma}{(Z-\overline{R})} - 1} = \overline{\beta}$$

with $\overline{\beta} > \underline{\beta}$. This is the upper bound of β, that is the value of β consistent with incomplete sepratation. In fact, above $\overline{\beta}$ we have complete separating equilibria.

A.1.

For $\lambda = \frac{1}{2}$ low-quality borrowers are charged $R^c(l) > R^c(h)$, reflecting their lower probability of repayment. In general, we have that

$$R^c(l) > R^c(h) \iff \frac{1}{p_l}[\frac{(1+c)}{1-\lambda} + \frac{\beta}{N}] > \frac{1}{p_h}[\frac{(1+c)}{\lambda} + \frac{\beta}{N}],$$

which is verified for $\frac{p_h}{p_l} > \frac{1-\lambda}{\lambda}[\frac{(1+c)+\lambda\mu}{(1+c)+(1-\lambda)\mu}]$, then for sufficiently large heterogeneity among borrowers.

A.2. The gain in terms of price differential is positive under condition $\underline{R} > \overline{R}^c$, which occurs when $Z > (1+c)[\frac{1}{2p_h\lambda} - \frac{1}{1-\lambda}] + \frac{2\beta}{N}$.

A.3

$M_I \geq 2x_l|_{M_I}$ if:

$$M_I \equiv \frac{1}{N} > \frac{Z\rho - (1+\beta)x_o - (1+c)\omega}{\alpha} \geq 2x_l = \frac{2p_l[Z - \overline{R}^c|_{M_I}]}{\beta}$$

Normalizing the cost $c = 1$, we have:

$$Z(\frac{1+\beta}{\beta} - \frac{1}{2})(\frac{p_h}{(1+\beta)p_l}) - \frac{p_l Z}{\beta} \geq \frac{B(1+2p_l)}{p_l} - \frac{4p_l}{p_h+\beta}$$

where $B = -\frac{(1+\beta)x_o - 2\omega}{\alpha}$. Sustituting B and handling we obtain:

$$Z[\frac{2+\beta p_h(p_l+2p_l)}{2\beta(1+\beta)p_l^2} - \frac{p_l}{\beta}] \geq$$
$$-\frac{4p_l}{p_h+\beta} + [\frac{p_h(1+2p_l)}{p_l^2(1+\beta)}][(1+\beta)x_0 - \frac{p_h}{(1-\lambda)} - \frac{1}{\lambda} - \frac{p_l(1+\beta)}{p_h}]$$

The left-hand side of this inequality is always positive because $Z > 0$ and

$$[\frac{2+\beta p_h(p_l+2p_l)}{2\beta(1+\beta)p_l^2} - \frac{p_l}{\beta}] > 0 \iff (2+\beta)p_h(p_l+2p_l) > 2p_l^3(1+\beta)$$

This is verified if $p_h p_l + 2p_h p_l > 2p_l^3$ and this is always verified because $p_h > p_l$ implies $p_h > p_l^2$. Moreover, the right-hand side of the inequality is always negative if the second term is negative as well. This is the case if:

$$-\frac{4p_l}{p_h+\beta} + [\frac{p_h(1+2p_l)}{p_l^2(1+\beta)}][(1+\beta)x_0 - \frac{2p_h}{2(1-\lambda)} - \frac{1}{\lambda} - \frac{p_l(1+\beta)}{p_h}] \leq 0$$

Manipulating we get:

$$B1 \equiv (1+\beta)x_0 - \frac{2p_h}{2(1-\lambda)} - \frac{1}{\lambda} - \frac{p_l(1+\beta)}{p_h} \geq \frac{4p_l^2}{(p_h+\beta)(1+2p_l)} \equiv B2.$$

$B2$ is always positive, then the condition is verified if $B1 < 0$. It is straightforward to see that $B1 < 0$ if $(1-\lambda) \geq \frac{x_0 p_h}{2p_l}$. Notice that the condition tends to be satisfied in any case when $x_0 \to 0$, that is when equilibrium converges to full separation.

A.4

Good firms located at $x \in [0, x_l)$ compare the profit of remaining in that region, which is zero because the bank believes them to be of low type (and then denies credit), with the profit associated to relocation. The switching condition for good firms located below x_l is:

$$p_h(Z - \overline{R}^c) - \beta x_l - s > 0.$$

Then,

$$p_h(Z - \overline{R}^c) - \beta x_l - (x_l - x_0) > 0 \iff \overline{R}^c(\delta - p_h) > z - \frac{x_0}{\delta - p_h}.$$

with $\delta = \frac{(1+\beta)p_l}{\beta}$. Substituting the expression for $\overline{R}^c$ and solving for $\frac{1}{N}$ we have:

$$\frac{1}{N} > \frac{1}{\beta}[p_h(Z - \frac{x_0}{e - p_h}) - \frac{1+c)}{\lambda}] \equiv \underline{M}_{NV}$$

and, conditional on $x_0 = 0$

$$\frac{1}{N} > \frac{1}{\beta}[p_h(Z - \frac{1+c}{\lambda})] \equiv \overline{M}_{NV}$$

we obtain the separating and full separating equilibrium conditions. *Q.E.D.*.

A.4.1

Comparing $\overline{M}_{NV}$ with $2x_l|_{M_I}$ and normalizing $c = 1$ we have that:

$$\overline{M}_{NV} \geq 2x_l|_{M_I} \iff p_h(Z - \frac{1+c}{\lambda}) > \frac{2p_l[Z - \overline{R}^c|_{M_I}]}{\beta}$$

With some handling we obtain:

$$[Z - \frac{x_0}{e - p_h} - \frac{2}{\lambda}][p_h + 2p_l] - 2p_l Z \geq -\frac{4p_l}{p_h \lambda}$$

This yields:

$$p_h Z \geq -\frac{4p_l}{p_h \lambda} + [p_h + 2p_l][\frac{x_0}{e - p_h} - \frac{2}{\lambda}]$$

Because the left-hand side of this last inequality is always positive, it is sufficient to show tha the right-hand side is non positive. Then we have that:

$$[p_h + 2p_l][\frac{x_0}{e - p_h} - \frac{2}{\lambda}] \leq 0$$

Given that $e \equiv \frac{p_l(1+\beta)}{\beta}$ it can be verified that the condition is satisfied for $\beta \geq \frac{p_l}{p_h - p_l}$.

A.5.

The pooling price R^p solves the following program:

$$\max_{R^p} \{[pR_i^p - (1+c)][(\frac{1}{N} + \frac{p_h(R_j^p - R_i^p)}{\beta}) + (\frac{1}{N} + \frac{p_l(R_j^p - R_i^p)}{\beta})]\} =$$

$$\max_{R^p} \{[pR^p - (1+c)][\frac{2}{N} + \frac{(p_h + p_l)(R_j^p - R_i^p)}{\beta})]\}.$$

Imposing symmetric prices, the first order condition implies:

$$\frac{2p}{N} = [pR_i^p - (1+c)]\frac{(p_h + p_l)}{\beta}$$

and solving for R_i^p:

$$R_i^p = R^p = \frac{(1+c)}{p} + \frac{2\beta}{(p_h + p_l)N}.$$

A.6.

Under signalling, travel costs for high-quality firms are:

$$TCH = 2N \int_{x_l}^{\frac{1}{2N}} \beta x dx = \beta N \frac{x_l^2}{2} \Big|_{x_l}^{\frac{1}{2N}} =$$

$$2N\beta[\frac{1}{4N^2} - x_l^2] = \frac{\beta}{4N} - \frac{N}{\beta}[p_l(Z - \overline{R}^c)]^2 =$$
$$\frac{\beta}{4N} - ABN^2 - \frac{BD^2}{N} > 0$$

where, $A \equiv (Z - \frac{1+c}{p_h\lambda})$, $B \equiv \frac{p_l^2}{\beta}$ and $D = \frac{\beta}{p_h}$. differentiating with respect to N:

$$\frac{\partial TCH}{\partial N} = -\frac{\beta}{4N^2} + \frac{BD}{N^2} - AB^2 =$$
$$\frac{1}{N^2}[\frac{BD^2}{N} - \frac{\beta}{4}] - AB > 0.$$

By substituting A, B, D and manipulating we have that

$$N < \frac{\beta[\frac{p_l}{p_h} - \frac{1}{2}]}{p_l(Z - \frac{1+c}{p_h\lambda})} \equiv N_{sh}.$$

The singnalling threshold, x_l, is increasing in N. In fact.

$$\frac{\partial x_l}{\partial N} = x_l'(N) = \frac{\partial(p_l[Z - \frac{1}{p_h}(\frac{1+c}{\lambda} + \frac{\beta}{N})]\beta^{-1})}{\partial N} = \frac{\partial}{\partial_N}(-\frac{p_l}{p_h}\frac{\beta}{N}),$$

then,

$$x_l'(N) = \frac{p_l}{p_h}\frac{\beta}{N^2} > 0.$$

A.7.

Under signalling travel costs for low-quality firms are:

$$TCL = 2(1-\lambda)N\int_0^{x_l} \beta x dx = 2\beta N x\Big|_0^{x_l} = N\beta x_l^2$$

With some handling and using , A B and D, we obtain

$$TCL = 2(1-\lambda)BN[A - \frac{D}{N}]^2 = (1-\lambda)[BA^2N + \frac{BD^2}{N} - 2DB]$$

.

Differentiating TCL with respect to N.

$$\frac{\partial TCL}{\partial N} = BA^2 - \frac{BD^2}{N^2} > 0$$

and substituting A, B, and D, this latter derivative is positive for

$$N > \frac{\frac{\beta}{p_h}}{Z - \frac{1+c}{\lambda p_h}} \equiv N_{sl}.$$

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