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MARKET STRUCTURE IN BANKING AND DEBT-FINANCED PROJECT RISKS

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Abstract

We study the relationship between market structure and risk-taking in lending markets. Introduction of loan market competition will reduce lending rates and increase credit market fragility regardless of whether borrowers have access to investment projects displaying first-order or second-order stochastic dominance. We establish how fragility becomes a matter of increasing concern as we shift from a mean-increasing investment technology to one displaying a mean-preserving property. Our analysis identifies a systematic relationship between the agency costs of debt in the sense of distorted investment decisions and the character of the investment technology.

Keywords: Bank Competition, Credit Market Fragility, Stochastic Dominance.

JEL Classification: G21, G33, G34

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1. Introduction

One of the main goals of financial integration within the framework of the European Union is to encourage competition in banking. Conventional wisdom suggests that competition eliminates various restrictive practices and reduces margins between borrowing and lending rates, thereby improving the performance of the banking industry. The presence of asymmetric information, however, makes the banking industry very different from most other industries, making it difficult to evaluate the consequences of increased banking competition as it is not possible to rely directly on general insights from the literature in industrial economics. Our intention in this paper is to study the relationship between loan market structure and risk-taking, and thereby the fragility of credit markets.

Broecker (1990) and Riordan (1993) have studied the consequences of adverse selection resulting from the unobserved characteristics of borrowers. They argue that increased competition may make adverse selection problems more severe when borrowers that have been rejected at one bank can apply for loans at other banks so that the pool of applications that any bank attracts will exhibit lower average quality than the population as a whole. As the "winner's curse" problem is magnified when there are more banks, they become more conservative and charge a higher risk premium. In a different vein Petersen and Rajan (1995) have also studied the implications of bank competition. They argue that credit market competition imposes constraints on the ability of the firm and the creditor to intertemporally share the surplus from investment projects so that creditors in a competitive market may be forced to charge higher interest rates than creditors in a monopolistic market until uncertainty is resolved. With their attention restricted to the deposit side Matutes and Vives (1995) have demonstrated how competition for deposits and deposit insurance can lead to excessive risk-taking by banks.

Despite these contributions, having emphasized adverse selection as well as intertemporal aspects, the relationship between competition and risk-taking (project choice) in credit markets is still a largely unexplored topic. The purpose of this paper is to shed light on this issue. Since we are interested in the relationship between market structure in banking and risk-taking, we construct a model of project choice where investments affect the return distributions. There are two natural ways for investments to influence project payoffs, either through the expected level or the dispersion of returns. These ideas are captured in technical terms by the concepts of first-order and second-order stochastic dominance, respectively.[1] In the literature on credit rationing both concepts have been employed and many results are sensitive to whether projects display first-order or second-order stochastic dominance. In this paper our main emphasis is placed on second-order stochastic dominance whereby investments are assumed to increase the riskiness of project returns in a mean-preserving way. We have chosen to draw attention primarily to this case, because it exhibits the conflict of interests between lenders and borrowers as sharply as possible. Despite such a focus we also consider first-order stochastic dominance in order to characterize the relationship between the nature of the investment technology and lending rates in equilibrium. Analysing both cases makes it possible to explore how the relative effects of lending rate competition are related to the investment technology of the projects being funded.

We show that introduction of lending competition will reduce interest rates and increase credit market fragility regardless of whether the investment technology exhibits first-order or second-order stochastic dominance. Loan market competition is seen to increase the agency costs of debt in the sense of creating larger distortions in the project choice by increasing investment volumes. We also establish how fragility becomes a matter of increasing concern as we shift from a mean-increasing investment technology to one displaying a mean-preserving property. Our analysis thus identifies a systematic relationship between the agency costs of debt in the sense of distorted investment decisions and the character of the investment technology.

We proceed as follows. The basic model exhibiting a risk-increasing, but mean-preserving investment technology is presented in section 2, while the first best project choice is analyzed in section 3. In section 4 the projectholder's choice of optimal debt-financed project type is analyzed, whereas section 5 considers the determination of lending rates with and without

[1] See e.g. Mas-Colell et.al. (1995) [Chapter 6] for an excellent exposition of how to compare payoff distributions in terms of returns and risk.

competition in the lending market. By comparing these rates (in banking markets with and without competition) we characterize the consequences for interest rates and fragility of lending competition in section 6. Section 7 shows the extent to which the results carry over to technologies with first-order stochastic dominance. Finally, section 8 offers some concluding comments.

2. The Basic Model of Risk-Increasing Investment Technology

We consider an individual entrepreneur in possession of a risky investment technology. The entrepreneur has no access to equity capital, so that the project has to be fully financed by debt. In order to focus exclusively on aspects of riskiness, we initially consider investment technologies whereby investments increase the riskiness of the project returns in a mean-preserving way. In their widely-cited paper Stiglitz and Weiss (1981) also considered projects which had the same mean but different riskiness. However, they did not allow for endogenously determined investment volumes as we will do in the present paper. We assume that an investment of x generates a random return θ distributed continuously on the interval $[0,m]$ according to the density function $f(\theta;x)$ so that the distribution function is given by

$$F(\theta;x) = \int_0^\theta f(\gamma;x)\, d\gamma \ .$$

Letting $F_x(\theta;x)$ denote the partial derivative of $F(\theta;x)$ with respect to investment, we make

ASSUMPTION 1 [Rothschild & Stiglitz 1970] For every investment level x, (A1) and (A2) below hold

$$(A1) \qquad \int_0^m F_x(\gamma;x)\, d\gamma = 0 \ ,$$

$$(A2) \qquad \int_0^\theta F_x(\gamma;x)\, d\gamma > 0 \quad \textit{for all } 0 < \theta < m \ .$$

Assumption (A2) corresponds to the concept of an increase in risk while leaving the total expected outcome unchanged as shown by (A1).

Faced with an ordinary debt contract exhibiting a lending rate factor R = 1+ r, where r is the interest rate, and acting under limited liability, the risk-neutral entrepreneur decides on an investment level in order to maximize

$$(1) \qquad V(x) = \int_{\eta}^{m} (\gamma - Rx) f(\gamma;x)\, d\gamma \quad ,$$

where η = Rx denotes the "break-even" state of nature, in which the projectholder is just able to remain solvent.[2] From the point of view of our analysis it is important to note that η depends on the lending rate factor R as well as on the investment level x. The entrepreneur remains solvent for those states of nature which satisfy $\gamma \geq \eta$, while there is bankruptcy when $\gamma < \eta$. Consequently, conditional on an investment size x, the probability of bankruptcy is given by $F(\eta;x)$.

Our study of mean-preserving investment technologies is related to the choice of research strategy in patent races. In the patent race literature the question is whether firms competing for a patent select research strategies which are too risky from a social point of view or from the point of view of industry profits. An influential approach, initiated by Dasgupta and Stiglitz (1980) and importantly clarified by Klette and de Meza (1986), with its focus on mean-preserving investment technologies demonstrates how competition in patent races would typically generate excessive risk-taking. In contrast to patent races, where investments shift the

[2] The existing literature has devoted much attention to the form of optimal financial contracts. For example, it is well-known that the ordinary debt contract is the optimal incentive-compatible form of finance when lenders cannot observe a projectholder's return without costly monitoring (see Gale and Hellwig (1985)). However, we here directly focus on ordinary debt contracts without considerations of optimality as debt contracts empirically play a dominating role.

distribution describing the timing of success with an innovation of normalized size,[3] we focus on a more general relationship between investments and return distributions.

We return to a detailed analysis of the optimal project choice of the entrepreneur in Section 4. However, in order to outline the standard structure of our model briefly, we let $x^* = x^*(R)$ denote the solution of maximization program (1). We assume that the bank commits itself to a lending rate R according to which it finances the investment of the projectholder. In its lending rate commitment the bank takes the optimal investment response $x^*(R)$ of the projectholder into account. Thus, the risk-neutral bank decides on a lending rate factor R in order to maximize

$$(2) \qquad \Gamma(R) = \int_{0}^{\eta^*} \gamma f(\gamma;x^*)\, d\gamma + x^*[\, (1-F(\eta^*;x^*))R - R_0 \,] \quad ,$$

where R_0 denotes the (constant) opportunity cost factor of granting loans, while $\eta^* = Rx^*$ denotes the break-even state of nature generated by the optimal investment of the entrepreneur. Behind the assumption of constant opportunity costs of granting loans is the assumption that funds are supplied to the bank in a perfectly elastic fashion. The first term in the right hand side of (2) covers the bank's profit in those states of nature where the bank is the residual claimant as a consequence of bankruptcy. The second term expresses the bank's profits net of the opportunity cost of granting loans in those states of nature where the firm remains solvent.

The full analysis of the firm's project choice is presented in Section 4, while section 5 will focus on the optimal lending rate policy from the point of view of the bank. Before that we will characterize the socially optimal project choice to be used as a benchmark against which the performance of the credit market is evaluated.

3. Socially Optimal Investments

In this section we focus on the socially optimal project choice with a risk-increasing, but

[3] For this reason discounting plays an important role in the (social) consequences of mean-preserving, but risk-increasing investments.

mean-preserving investment technology. By this we mean the first-best level of investment that would be chosen by a projectholder not restricted to debt finance. Such a decision maker would choose a project type in order to maximize the total surplus generated by the family of investment technologies available.

The first-best investment size has to maximize the total expected outcome of the project

$$(3) \qquad W(x) = \int_0^m \gamma f(\gamma;x)\, d\gamma - R_0 x ,$$

where R_0 denotes the social opportunity cost factor of funds. By partial integration the objective function (3) is found to be a strictly decreasing function of the investment level, because from (A1) we find that

$$W_x = -\int_0^m F_x(\gamma;x)\, d\gamma - R_0 < 0.$$

Consequently, we can formulate

Proposition 1 *The risk-neutral projectholder would have no incentive at all to invest in a mean-preserving increase in risk if such investments had to be equity financed.*

Proposition 1 is quite natural, simply formalizing the idea that a risk neutral decision maker would not find it worthwhile to spend resources on risk-increasing investments as long as these are mean-preserving. Nevertheless, for the purpose of evaluating the performance of various lending market structures this represents a particularly simple benchmark of a first-best character. Of course, in reality mean-preserving investment technologies might very well be a crude oversimplification; however, we initially restrict our attention to such investment technologies in order to isolate the incentives of debt-financed projectholders to engage in risk-taking from other reasons (such as increases in the mean of the project return) for expanding investment projects.

4. Optimal Debt-Financed Project Choice

In this section we investigate the projectholder's optimal project choice as a function of the lending rate charged by the bank. For that reason we apply partial integration to find that the projectholder's objective function (1) can be rewritten according to

$$(1') \qquad V(x) = m - Rx - \int_\eta^m F(\gamma;x)\, d\gamma .$$

From this formulation we can find the following necessary condition for an optimal investment choice x directly:

$$(4) \qquad R\,(1 - F(\eta;x)) = -\int_\eta^m F_x(\gamma;x)\, d\gamma .$$

The left hand side of (4) denotes the marginal cost increase in debt from an additional unit of investment adjusted to those states of nature where the firm can afford to pay back its debt obligation fully. The right hand side of (4) expresses the marginal revenue increase from an additional unit of investment adjusted to states of nature where the firm remains solvent.

Introducing the ratio

$$H(\eta) = -\frac{\int_\eta^m F_x(\gamma;x)\, d\gamma}{1 - F(\eta;x)}$$

we see that (4) can be rewritten according to

$$(5) \qquad -R + H(\eta) = 0 .$$

According to this alternative interpretation (from (5)) of the optimal investment, the project is expanded to the point at which the lending rate factor is equal to the conditional marginal revenue from an additional unit of investment in those states of nature which keep the projectholder solvent. Now we have

Proposition 2 *Condition (5) is a sufficient condition for optimal investment provided that*

(H1) *the ratio $H(\eta)$ is a strictly decreasing function of η.*

Proof: Remembering the definition of η, we see that the sufficient second-order condition for the projectholder's investment decision can be written according to

$$H'(\eta)\, R \; < 0 \, ,$$

which will hold as long as property (H1) is valid. QED

The ratio $H(\eta)$ describes the conditional marginal revenue from an additional unit of investment in those states of nature which keep the projectholder solvent. Property (H1) thus means that risk-increasing investments from the point of view of the projectholder have decreasing marginal returns across non-default states of nature. This can be regarded as a plausible assumption, guaranteeing that the firm's investment problem is a concave program. In a different context Bagwell and Staiger (1990) have formulated conditions to ensure such concavity. Our model is slightly different from theirs as we concentrate on probability distributions which are truncated in order to reflect the bankruptcy possibility and limited liability.

Observing that Assumption 1 implies that

$$\int_0^{\eta^*} F_x(\gamma;x^*)\, d\gamma \;=\; -\int_{\eta^*}^{m} F_x(\gamma;x^*)\, d\gamma \quad ,$$

it is possible to attach an alternative interpretation to (H1). We can interpret the ratio $H(\eta)$ as a measure of how much profit mass is shifted into states of bankruptcy in response to an additional unit of investment conditional on no default prior to the investment increase. Put into this perspective we see that (H1) means that profits are shifted into bankrupt states at a decreasing pace as we reach higher levels of the break-even state η.

By totally differentiating (5) with respect to R we find, taking (H1) into account, that

$$(6) \qquad \frac{\partial \eta^*}{\partial R} \;=\; \frac{1}{H'(\eta^*)} \;<\; 0$$

and

$$(7) \qquad \frac{\partial x^*}{\partial R} \;=\; \frac{1 - x^* H'(\eta^*)}{R\, H'(\eta^*)} \;<\; 0 \, .$$

Consequently, property (H1) makes it possible for us to formulate

Proposition 3 *An increase in the lending rate factor will*

(a) cause the projectholder to decrease its optimal investment

and

(b) generate a lower equilibrium probability of default.

Proposition 3 is very interesting. With attention restricted to risk-increasing, but mean-preserving investment technologies, we see that an increase in the interest rate would reduce the entrepreneur's risk-taking incentives as long as (H1) holds. This is contrary to the relatively commonly held view in the literature that higher interest rates tend to be associated with choice of riskier projects.[4] Our analysis shows that when risk-taking is properly isolated from mean-shifting effects of investments the projectholder will find it worthwhile to contract the volume of its investment program when faced with a higher unit cost of investment, provided that the conditional marginal revenue is decreasing across non-default states of nature.

The simple structure of the first-best investment program as delineated in section 3 makes it possible to characterize important aspects of agency costs associated with debt finance. As soon as the available investment technology includes options of increasing risks in a mean-preserving

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[4] The conventional moral hazard argument for credit rationing is usually presented in terms of project choice of fixed size (see e.g. Stiglitz and Weiss (1981) or Clemenz (1986)). However, as Bester and Hellwig (1987) have shown, it is unclear whether credit rationing will occur with variable project size unless the production function satisfies some relatively stringent conditions.

way, projectholders will have incentives to exploit such options, thus generating agency costs. Proposition 3 outlines a relationship between the size of these agency costs and the interest rate charged by the bank. As Proposition 3 (a) makes clear, the agency costs associated with excessive risk-taking are a decreasing function of the lending rate.

In the next section we will study the impact of the market structure in the lending market on the interest rate decisions of banks. This analysis will enable use of Proposition 3 to establish a relationship between market structure in the lending market and the fragility of the credit market.

5. Lending Rates and Market Structure in Banking

Having analysed the investment decision of the projectholder, we now turn to consider the lending rate decisions. Initially we focus on a bank operating in the absence of competition. In making its lending rate commitment such a bank has to take into account how the interest rate will affect the investment decision of the firm as characterized by (2).

Differentiating (2) shows that the optimal interest rate of a lending monopoly, $R=R^M$, has to satisfy the first-order condition

$$(8) \quad \frac{\partial x^M}{\partial R} \left[(1 - F(\eta^M;x^M))R^M + \int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma - R_0 \right] = x^M[1 - F(\eta^M;x^M)] .$$

The right hand side of (8) denotes the direct revenue-increasing effect of an increase in the lending rate on the bank's profits. The left hand side of (8) summarizes the effects of a lending rate change generated through the investment volume of the projects financed. There are three components included in these indirect effects: (i) the change generated in revenues in solvent states of nature, (ii) the change in project revenues in bankrupt states of nature as well as (iii) the change in the opportunity cost of granting loans.

Defining the interest rate elasticity of project choice in the usual way as

$$\epsilon = - \frac{\dfrac{\partial x^M}{x^M}}{\dfrac{\partial R^M}{R^M}}$$

and making use of (5), we can express the necessary optimality condition (8) for the lending rate according to

$$(8') \quad [1-F(\eta^M;x^M)]\, R^M \left(1 - \frac{1}{\epsilon}\right) = R_0 + \int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma .$$

From (8') we can see precisely how the difference between average revenues in solvent states when adjusted for elasticity and the average cost of funds is related to the nature of the investment technology available.[5]

From (8') we can see that with optimal investment

$$\int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma$$

constitutes the difference between average revenues in solvent states when adjusted for elasticity and the opportunity cost of funds (R_0). From (8') we can conclude that the optimal lending rate factor is an increasing function of this difference. Further, from (8') it is possible to infer that a monopoly bank sets the lending rate to reflect two additional considerations at the margin. The lending rate R^M is higher (i) the higher the opportunity cost of granting loans (R_0) is, (ii) the lower the interest rate elasticity of the project choice is and thereby the higher the bank's market power (the term $(1-1/\varepsilon)^{-1}$) is. Of course, for there to be a lending rate optimum for the bank it must hold that $\varepsilon > 1$. In other words, an interior optimal interest rate has to generate a project

[5] As will be demonstrated in section 7, the sign of the second term on the right hand side of (8') will be reversed for mean-increasing investment technologies.

selection such that the investments take place on a scale within the elastic range.[6]

From (6) we know that the break-even state of nature is a decreasing function of the lending rate if and only if condition (H1) holds. On the other hand, making use of the definition of the interest rate elasticity, we find that

$$(9)\qquad \frac{\partial \eta^M}{\partial R} = x^M [\, 1 - \varepsilon \,] .$$

For this reason we can formulate an interesting connection between condition (H1) and the interest rate elasticity.

Proposition 4 *Condition (H1) is equivalent to an interest rate elasticity satisfying* $\varepsilon > 1$.

Having characterized the lending rate determination for a bank monopolist we now direct our attention to banking markets operating under competition. For this purpose we subscribe to the simplest possible characterization of Bertrand-type competition between lenders. Bertrand competition between lenders for financing the investment program of an individual projectholder means that the lending rates are scaled down to generate zero expected profits. Alternatively, a perfectly competitive lending market would, of course, also fit into such a scenario.

With reference to our model such Bertrand competition would predict a lending rate satisfying

$$\Gamma(R) = 0 ,$$

where Γ is defined by (2). Substitution into (2) shows that such a competitive lending rate factor $R=R^C$ has to satisfy

[6] With $\varepsilon \leq 1$ the bank's objective function would be strictly decreasing. Consequently, in such a case the bank would always face a loss in expected value terms, but the loss would be minimized at the lending rate R_0. Of course, at such a lending rate the investment programs would be expanded too much, thereby generating excessive risk-taking from the bank's point of view.

$$(10)\qquad (1 - F(\eta^C;x^C))R^C - R_0 = -\frac{1}{x^C}\int_0^{\eta^C} \gamma f(\gamma;x^C)\, d\gamma$$

or

$$(10')\qquad [1-F(\eta^C;x^C)]R^C + \frac{1}{x^C}\int_0^{\eta^C} \gamma\, f(\gamma;x^C)\, d\gamma = R_0 .$$

With competition in the lending market, the interest rate is determined so as to equalize the average project return to the bank with the average opportunity cost of granting loans which is simply R_0 as exhibited on the right hand side of (10'). The left hand side of (10'), denoting the average project return to the bank, consists of two parts: (i) the average project return conditional on reaching solvent states of nature and (ii) the average project return in bankrupt states of nature.

According to (10'), in a competitive situation the lending rate is set to reflect two considerations at the margin. The lending rate is higher (i) the higher the opportunity cost of granting loans is, and (ii) the lower the average return to the projectholder across states of nature characterized by bankruptcy is and thereby the lower the average return to the creditor (the second term of the left hand side in (10')) is as well. Thus banks operating under conditions of monopoly and competition share one common feature. Under both types of market structure the interest rate is an increasing function of the opportunity cost of granting loans across non-default states of nature. Unlike the case of a monopolistic banking industry the interest rate elasticity of project choice does not matter for the interest rate decisions of banks operating under conditions of competition. A bank operating under competition pays attention to the projectholder's average return across states of nature characterized by bankruptcy instead.

6. Banking Market Structure, Interest Rates and Bankruptcy Risk

In this section we investigate the impact of banking market competition on interest rate determination and project choice. Further, we examine the implications of competition in banking on the fragility of the loan market by investigating how such competition will affect the equilibrium bankruptcy risk.

In order to find out the impact on interest rates of introducing competition into the loan market we compare the necessary first-order conditions (8) and (10). We find the following proposition to hold.

Proposition 5 *Introduction of competition into the lending market will generate lower interest rates but higher fragility in the credit market.*

Proof: We can rewrite (8) according to

$$(8'') \quad (1 - F(\eta^M;x^M))R^M - R_0 = \int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma + \frac{R^M}{\epsilon}[1 - F(\eta^M;x^M)] .$$

Equations (8") and (10) have an identical left hand side. Further, we know from (6) that the common left hand side is a strictly increasing function of R, since

$$\frac{\partial LHS}{\partial R} = 1 - F(\eta^*;x^*) - Rf(\eta^*;x^*)\frac{\partial \eta^*}{\partial R} > 0 .$$

Thus, by comparing the right hand sides of (8") and (10) we find that it must always hold that $R^M > R^C$, because it always holds that

$$\int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma + \frac{R^M}{\epsilon}[1 - F(\eta^M;x^M)] > -\frac{1}{x^C}\int_0^{\eta^C} \gamma f(\gamma;x^C)\, d\gamma .$$

Consequently, competition in the lending market will reduce the interest rate. However, (9) shows that such a reduction in the interest rate will take place at the expense of an increased degree of fragility, because

$$\frac{\partial \eta^M}{\partial R} = x^M[1 - \epsilon] < 0$$

as long as $\epsilon > 1$.

QED

It follows directly from (7) that introduction of competition in the banking market will increase the investment volume of the projectholder as long as $\epsilon > 1$. Thus competition in the credit market would increase the incentives for risk-taking on behalf of the firm, since the firm would have access to credit at a lower interest rate. This mechanism explains why introduction of competition into the lending market will increase the fragility of the loan market in the sense of raising the probability of bankruptcy in equilibrium. In Figure 1 we illustrate how lending rate competition increases credit market fragility. In Figure 1 the solid line represents the return distribution with lending market competition, while the dotted line refers to the return distribution in the case of a monopoly bank.

INSERT FIGURE 1 HERE

According to Proposition 1 the first-best solution would be to not invest in increasing risks at all. Combination of Proposition 5 with property (7) shows that loan market competition will increase investment volumes. Hence, loan market competition will increase the agency costs of debt in the sense of creating larger distortions in the project (investment) choice.

Proposition 5 could also be given an alternative interpretation related to the consequences for credit market stability of a bank merger. Proposition 5 implies that a merger of two competing banks could increase the stability of the loan market in the sense of reducing the equilibrium probability of loan default. Such consequences of mergers between bilateral monopoly banks were also found to be valid in a slightly different context by Koskela and Stenbacka (1996). Our analysis thus conforms with the commonly used government policy of supporting bank mergers as a measure to increase the stability of financial markets. [The Economist, 1995].

7. Mean-shifting Investment Technology

So far our attention has been restricted to investments exhibiting second-order stochastic dominance. Here we ask whether the results reported in earlier sections carry over to mean-increasing investment technologies. How are the consequences of banking competition related to the nature of the available family of risk projects? In order to answer this question we will consider investment technologies based on first-order stochastic dominance as a benchmark for such a test of robustness. Such a research task is particularly well justified in the light of the substantial literature on credit rationing. Several studies, for example Black and de Meza (1994) and de Meza and Webb (1987), have established how many results in banking markets with asymmetric information are sensitive to the nature of the investment technology available to projectholders.

Shifting our attention to investment technologies displaying first-order stochastic dominance means that Assumption 1 will take the form

Assumption 1' For every investment level it holds that

$$(A1') \qquad F_x(\gamma;x) \; < \; 0 \quad \textit{for each} \quad 0 < \gamma < m \; .$$

Assumption 1' depicts the ordinary first-order stochastic dominance condition capturing the idea that an increase in investment shifts the density to higher returns.[7]

With technologies displaying first-order stochastic dominance the nature of the first-best investment will change dramatically. Replication of the argument carried out in section 3 shows that we would obtain an interior solution for the socially optimal investment level. This we formulate in

Proposition 1' *A risk-neutral projectholder with access to equity capital will invest in a mean-increasing project so as to equalize the marginal expected return with the social opportunity cost.*

Thus, under Assumption 1' the first-best investment would respond to incentives of exploiting the mean-shifting nature of the underlying technology. This is in sharp contrast to Proposition 1, according to which the first-best investment level is zero with a risk-increasing but mean-preserving technology.

Next we investigate the relation between the investment technology and equilibrium lending rate decisions. For that purpose we start with the case of a monopoly bank. The optimal lending rate is related to the investment technology according to

$$(8') \qquad [1 - F(\eta^M;x^M)]R^M(1 - \frac{1}{\epsilon}) \;=\; R_0 \;+\; \int_0^{\eta^M} F_x(\gamma;x^M)\, d\gamma \;,$$

where the second term on the right hand side of (8') is negative (positive) if the investment technology displays first-order (second-order) stochastic dominance. In particular, (8') implies that the optimal lending rate is higher in the case of second-order stochastic dominance. The intuitive reason for first-order stochastic dominance generating lower lending rates lies in the fact that the bank can afford to induce higher investments as these would be associated with higher returns in the default region. Also, in view of (6), a shift from second-order to first-order stochastic dominance will increase the fragility of the monopoly loan market. In shifting from a technology displaying second-order to first-order stochastic dominance the bank can afford to sustain a higher probability of default since the residual returns in default states are shifted towards higher levels.

Next we ask whether these results regarding the relationship between investment technology and equilibrium lending rates as well as fragility carry over to a lending market operating with

[7] We would like to draw attention to two features regarding Assumption 1'. Firstly, Assumption A 1' is stronger than what we actually need for our conclusions later on (see e.g. Mas-Colell et. al. (1995) p. 195-97). Secondly, strictly speaking in order to justify the first-order approach we need an additional assumption which guarantees that the shifting process takes place at a decreasing rate. Here we assume the sufficient second-order conditions to hold but we do not explicitly elaborate them since we focus on a characterization of the equilibrium. The sufficient second-order condition is formulated in detail as Assumption B on p. 140 in Bagwell and Staiger (1994).

Bertrand competition. Partially integrating (10') and applying the mean-value theorem to the second term on the left hand side we obtain

$$(11) \qquad R^C[1 - F(\tau;x^C)] = R_0 + \int_0^{\tau} F_x(\gamma;x^C)\, d\gamma ,$$

where we know (from the mean-value theorem) that $0 < \tau < \eta^C$. Again, as in (8'), the second term on the right hand side of (11) is negative (positive) if the investment technology displays first-order (second-order) stochastic dominance. From this observation we can infer that the equilibrium lending rate is higher in the case of second-order than in the case of first-order stochastic dominance. Replicating our arguments from the monopoly case a shift from second-order to first-order stochastic dominance technology will also increase the fragility of a competitive loan market.

Hence we have established the following general finding.

Proposition 6 *Introduction of competition into the credit market will generate lower interest rates but greater credit market fragility regardless of whether the investment technology exhibits first-order or second-order stochastic dominance.*

According to Proposition 6 the nature of the investment technology does not matter qualitatively for the implications of credit market competition. This raises the question of whether the nature of the investment technology affects the relative magnitude by which competition will affect lending rates and fragility.

In Figure 2 we illustrate the relationship between credit market competition and fragility in the case of first-order stochastic dominance. The probability of loan market default is larger with credit market competition because of (H1) (see also Proposition 4). In Figure 2 θ^C and θ^M denote expected return with and without credit market competition and the mean-shifting property is exhibited by $\theta^C > \theta^M$.

INSERT FIGURE 2 HERE

When comparing technologies with first-order and second-order stochastic dominance we find the following proposition to hold.

Proposition 7 *Introduction of competition into the credit market will both reduce lending rates and increase credit market fragility to a greater extent when the investment technology displays second-order stochastic dominance.*

Proof: Proposition 7 follows directly from comparing (8') with (11), keeping in mind that the optimal behavior of the bank monopoly requires that $\varepsilon > 1$.

QED

Proposition 7 gives us a deep understanding of how the nature of the investment technology will determine the relative strength of competition as a mechanism for interest rate reduction. In particular, it says that the interest rate differential between that of a lending monopoly and that of a Bertrand duopoly will increase as we shift from an investment technology exhibiting first-order to second-order stochastic dominance. In this sense, lending rate competition will have a stronger impact as we shift our attention from ordinary mean-increasing investment technologies to those which are mean-preserving, but increase dispersion.

Proposition 7 has profound implications for our understanding of the relationship between lending rate competition and the fragility of credit markets. First of all, interest rate competition increases the degree of loan market fragility independently of the nature of the investment projects available to borrowers. Thus, in evaluating the implications of competition in loan markets we will always have to face a tradeoff between interest rates and credit market fragility. But Proposition 7 tells us more than this. In relative terms fragility becomes a matter of increasing concern as we shift from the property of first-order to second-order stochastic dominance in the projects available to borrowers.

Through the relationship between the nature of the investment technology and the fragility of the credit market we have added an essential feature to our understanding of agency costs of debt. Namely, the agency costs of debt, whereby the conflict of interests between borrowers and lenders generates distortions in project choice, are associated with the character of the investment technology available to projectholders. These agency costs increase as we shift from first-order to second-order stochastic dominance.

8. Concluding Comments

In this paper we have analyzed the relationship between the market structure in banking and risk-taking (project choice) in credit markets, for which we have constructed a model of project choice where investments affect return distributions either by changing the mean or the dispersion of returns. In technical terms these ideas are captured by the concepts of first-order and second-order stochastic dominance, respectively. While the paper puts its main emphasis on second-order stochastic dominance in order to exhibit the conflict of interests between lenders and borrowers as sharply as possible, we also pay attention to robustness relative to changes in investment technology by considering the case with first-order stochastic dominance.

We have shown that introduction of competition into the credit market will both reduce lending rates and increase its fragility regardless of whether the investment technology exhibits first-order or second-order stochastic dominance. Competition, however, reduces lending rates and increases credit market fragility to a greater extent when the investment technology displays second-order stochastic dominance. In relative terms fragility becomes a matter of increasing concern as we shift from a technology exhibiting first-order stochastic dominance to one exhibiting second-order stochastic dominance. Increasing the size of the investment program loan market competition thus increases the agency costs of debt, which respond systematically to shifts in the investment technology.

In the present analysis we have restricted the strategy spaces of the banks to interest rates. In line with the insights generated by the substantial literature on credit rationing we know in qualitative terms that banks would have an incentive to operate with credit supply functions,

offering the entrepreneurs pairs of interest rates and volumes of credit. Bester and Hellwig (1989) present some progress along this line for the case of variable project size, but it would be a demanding analytical task to present a detailed analysis of optimal credit supply functions. As far as we know, there is no contribution where such a task would have been undertaken in presence of strategic interaction between creditors. Nevertheless, it is still unclear whether such a detailed analysis would provide much in addition to the qualitative aspects of credit rationing already known.

In our analysis we have abstracted from a number of potentially important features of banking competition. For example, we have excluded all aspects of competition between banks for deposits (see, for example, Matutes and Vives (1995)). Also, we have not considered the consequences of diversification based on size-related economies of scale (see, for example, Krasa and Villamil (1992)).

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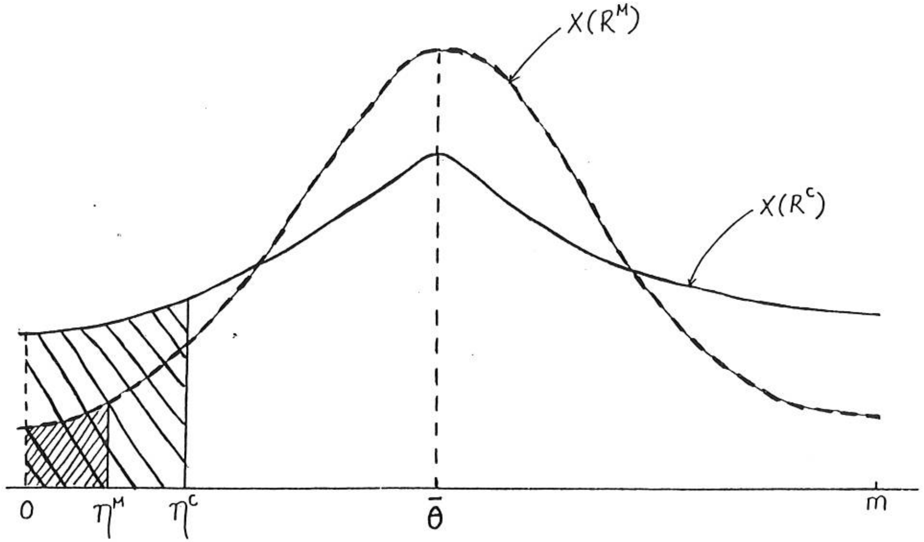

Figure 1. Illustration of how lending competition increases credit market fragility with second-order stochastic dominance ($\eta^M<\eta^C$).

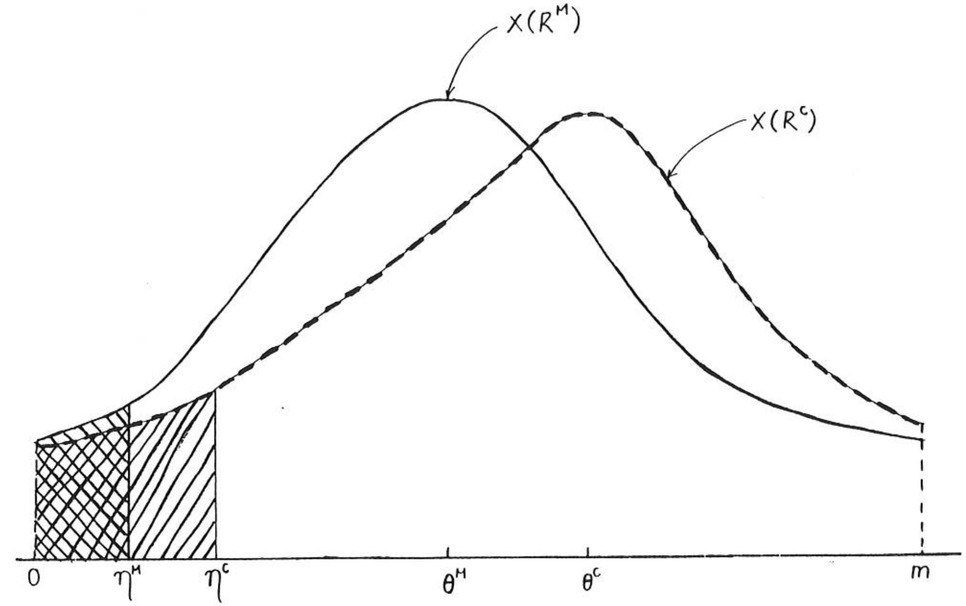

Figure 2. Illustration of how lending competition increases credit market fragility with first-order stochastic dominance ($\eta^M<\eta^C$).

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