Section 3 Capital Markets and Moral Hazard

Moral Hazard and Equilibrium Credit Rationing: An Overvi of the Issues

Helmut Bester and Martin Hellwig

Summary: One of the more intriguing puzzles in microeconomics is pr sented by the phenomenon of credit rationing. If funds are so scarce to require rationing, why do lenders not raise the interest that the demand? We survey recent developments that seek to explain this pher menon by appealing to incentive problems in the relation between the borrower and the lender. A simple example, due to Stiglitz and Weiss shows that under certain circumstances, lenders will not use their b gaining power to raise interest rates because the adverse incentive fects of such a move outweigh any direct effect on the lender's payo To examine the robustness of this argument, we discuss how the analy is affected by the use of collateral, variations in loan size and in vestment, or alternative forms of the finance contract. Finally, we analyse the relation between the credit-rationing problem and the ge ral theory of optimal incentive schemes under imperfect information.

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1. Introduction

A would-be borrower is said to be rationed if he cannot obtain the loan that he wants even though he is willing to pay the interest that the lenders are asking, perhaps even a higher interest. In practice such credit rationing seems to be commonplace: Some borrowers are constrained by fixed lines of credit which they must not exceed under any circumstances; others are refused loans altogether. As far as one can tell, these rationing phenomena are more than the temporary consequences of short-term disequilibrium adjustment problems. Indeed they seem to inhere in the very nature of the loan market.

For the ordinary microeconomist, such rationing phenomena present a puzzle. The equilibrium of a market is commonly identified with the balance of demand and supply. According to the law of demand and supply, prices in the market should adjust until any excess of demand over supply or of supply over demand has been eliminated, at which point there is no more room for rationing. By this logic, any credit rationing should be accompanied by increases of interest rates that reduce the demand for loans and raise the supply of loans until the need for credit rationing has disappeared.

The law of demand and supply is usually justified by the more general principle that economic agents act in their own perceived self-interests. An excess supply or excess demand would enable the agents on the short side of the market to move prices in a direction which makes them better off. Thus a seller should be expected to exploit excess demand by charging higher prices.

The argument against rationing as an equilibrium phenomenon is to some extent independent of the market structure. While the law of demand and supply has been proposed for competitive markets, the underlying behavioural principle may be applied to monopolistic markets as well. A monopolist too will prefer to raise his prices rather than ration demand at given, low prices.

Given the general principle that rationing is at most a transitory disequilibrium phenomenon, economists have found it difficult to come to terms with the phenomenon of credit rationing. In many cases of course, credit rationing can be explained by government interference with the market: Usury laws, interest rate and bank regulation, and certain types of central bank intervention. However, there has always been a suspicion that this is not the whole story. Beginning with Hodgman (1960), a s of papers in the early sixties discussed the possibility that credit be rationed because a lender does not want to grant a loan that exce the borrower's ability to repay. This observation was soon found to besides the point because a borrower typically does not want to have loan that he knows he cannot repay (for an excellent discussion of t issues, see Clemenz (1986), Chapter 1). The deeper problem of credit rationing relative to what the borrower wants was not addressed by t literature; indeed this problem remained unsolved for a long time.

In recent years, economists have tried to relate the phenomenon of c rationing to problems of imperfect information. Such problems arise the lender tries to evaluate the borrower's promise of repayment at later date. The quality of this promise depends on the behaviour and characteristics of the borrower. In both respects, the borrower typi has private information. Thus an entrepreneur may have better inform than his bank about the objective prospects of his enterprise. At th time, he is in a better position to control the risks that he takes the amount of effort that he puts into his firm. All these factors a the value of the lender's claim, and yet he is unable to control the directly.

In this situation, the lender must take account of the effects of th credit contract on the mix of loan applicants or on their behaviour. increase in interest rates might lead borrowers with fairly safe pro to drop out of the market, or it might induce them to replace their projects by riskier ones. Such considerations may cause a lender to frain from raising interest rates even though he has the bargaining to do so.

The incomplete information approach to interest rigidity and credit tioning was first developed by Jaffee and Russell (1976), Keeton (19 and Stiglitz and Weiss (1981). In particular, Stiglitz and Weiss (19 show that credit rationing can be an equilibrium phenomenon if eithe the lender is imperfectly informed about the borrower's characterist or the lender is unable to directly control the borrower's behaviour In the following we discuss the latter phenomenon where credit ratio is a consequence of moral hazard in the borrower-lender relationship In view of the extensive surveys by Baltensperger and Devinney (1985) as well as Clemenz (1986), we do not aim for completeness in our tre ment of the literature. Instead, we shall discuss the original Stigl Weiss example and look at several modifications in order to see whic structural elements of the example are crucial. At the same time, we propose to relate the theory of credit rationing under moral hazard to the general theory of incentive problems as treated e.g. by Grossman and Hart (1983).

2. Moral Hazard and Equilibrium Credit Rationing: The Leading Example

2.1 Loan Contracts and Risk Taking

Consider an entrepreneur who can choose between two investment projects, indexed $i=a,b$. Both projects require the same fixed investment I. The returns to both projects are risky; for $i=a,b$, project i earns the return

(1) $$\tilde{X}_i = \begin{cases} X_i & \text{with probability } p_i \\ 0 & \text{with probability } 1-p_i , \end{cases}$$

where

(2) $$p_a X_a > p_b X_b > I, \quad 1 > p_a > p_b > 0, \quad X_b > X_a .$$

For simplicity, both projects have only two possible outcomes, success and failure. Project a is more likely to succeed, but project b has the higher return in the case of success. In the case of failure, neither project yields anything. Project a has the higher expected return, but even project b's expected return exceeds the cost I.

The entrepreneur has no initial wealth. He uses debt finance to undertake the investment. A debt contract is characterized by a gross interest payment R which the entrepreneur must pay the lender in the case of success. If the project fails, the entrepreneur goes bankrupt, and the lender receives nothing. Given the interest payment R, the entrepreneur's expected payoff from undertaking project i is given as

(3) $$U_i(R) = p_i(X_i - R) .$$

The entrepreneur is taken to be risk neutral so that he applies for a loan as long as his expected payoff is nonnegative.

Lenders, too, are taken to be risk neutral. Given the contractual interest payment R, a lender's expected payoff from financing the entrepreneur's investment in project i is given as

(4) $$\pi_i(R) = p_i R - I .$$

Given R, the lender prefers the entrepreneur to undertake the pr[oject] with the higher success probability. Under perfect information the loan contract would therefore prescribe not only the interest pa[y]ment R, but also the choice of the project i that is to be under[]taken.

However we assume that the relation between the entrepreneur and an[y] lender is subject to moral hazard because the lender cannot observe the entrepreneur's choice of project. Therefore the loan contract ca[n]not effectively prescribe the project that is to be undertaken. The loan contract can only specify the interest R which the entreprene[ur] pays if his project - whichever one he chooses - happens to succeed.

Given the interest obligation R, the entrepreneur selects the pro[]ject which maximizes his expected payoff. As Stiglitz and Weiss (198[] have observed, this decision depends on R. From (3), the entrepre[]neur is willing to choose project a if and only if

(5) $$p_a(X_a - R) \geq p_b(X_b - R) .$$

If we write $i(R)$ for the entrepreneur's project choice under a con[]tract with interest payment R, we see that there is a critical le[]

(6) $$\hat{R} := \frac{p_a X_a - p_b X_b}{p_a - p_b}$$

such that

(7) $$i(R) = \begin{cases} a & \text{if } R \leq \hat{R} , \\ b & \text{if } R > \hat{R} . \end{cases}$$

As R rises above $\hat{R}$, the entrepreneur switches from project a t[o] project b, which has the higher probability of failure. Quite generally, high interest obligations lower the entrepreneur's payoff in t[he] case of success and reduce his incentives to avoid bankruptcy.

For $R = \hat{R}$, the entrepreneur is indifferent between the two project[s]. For simplicity, we assume that in this case he chooses project a, i.[e.] we set $i(\hat{R}) = a$.

Lenders must take account of the effects of R on the entrepreneur's behaviour. Given a lender's inability to monitor the entrepreneur's project choice, his expected payoff from a contract with interest payment R is

(8) $$\pi^*(R) = \pi_{i(R)}(R) = \begin{cases} p_a R - I & \text{if } 0 \leq R \leq \hat{R} , \\ p_b R - I & \text{if } \hat{R} < R \leq X_b . \end{cases}$$

The form of $\pi^*(.)$ is illustrated in Figure 1. Since $p_a > p_b$, $\pi^*(.)$ is not monotonically increasing in R. At $R = \hat{R}$, any small increase in the interest payment leads to a discontinuous drop in $\pi^*(R)$ as the entrepreneur switches to the project with the higher bankruptcy probability. This nonmonotonicity of the lender's expected payoff function is the basis for the theory of credit rationing proposed by Stiglitz and Weiss (1981).

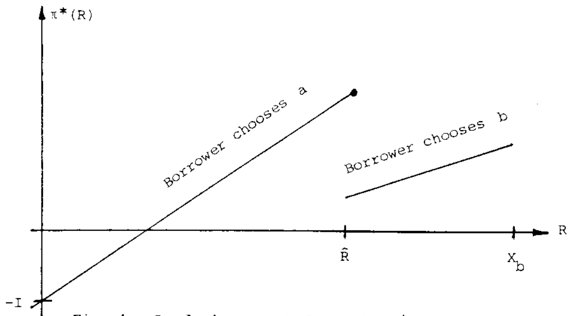

Fig. 1: Lender's expected payoff $\pi^*(R)$ is a nonmonotonic function of the contractual interest payment R.

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We first consider the case of a monopolistic loan market. Suppose that there is a single risk neutral lender who owns an amount L of loanable funds. Furthermore suppose that there are N identical entrepreneurs of the type described above, and let $I \leq L < N\,I$. Then funds are scarce, and the lender is unable to finance all entrepreneurs.

In this situation, the lender has all the bargaining power. He can set the terms of the contract to maximize his return. In particular, he can impose an interest obligation R^* at which the value of his expected payoff π^* is maximal. By inspection of (8), there are two possibilities for this choice. If

(9a) $\quad p_a \hat{R} < p_b X_b$,

then $\pi^*(\hat{R}) < \pi^*(X_b)$, and the lender's payoff is maximized at R^* = Alternatively, if

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Under the parameter constellation (9b), we must have equilibrium cre rationing. The lender announces the contractual interest payment R' which maximizes his payoff expectation. Given the interest obligatic $\hat{R}$, an entrepreneur who gets a loan can expect the payoff $U^*(\hat{R}) = U_{i(\hat{R})}(\hat{R}) = p_a(X_a - \hat{R})$. By inspection of (6) and (2), we have

(10) $\quad U^*(\hat{R}) > 0$,

i.e., any entrepreneur has a strict preference for undertaking the i vestment. Therefore all entrepreneurs apply for loans, and the lende must somehow select L/I applicants to distribute his funds. The re maining $N - L/I$ applicants are rejected and envy their colleagues w undertake their investments and earn positive profits. Indeed any ap plicant who is rejected would gladly offer to pay more than $\hat{R}$ in order to get a loan. However the lender will refuse such an offer be cause it would effectively make him worse off.

It may be useful to compare the credit market equilibrium under the parameter constellation (9b) with the equilibrium under the parameter constellation (9a). Under the parameter constellation (9a), the lender announces the required interest payment $R^* = X_b$. Given this ar nouncement, an entrepreneur who gets a loan can expect the payoff $U^*(X_b) = U_{i(X_b)}(X_b) = p_b(X_b - X_b) = 0$, i.e., any entrepreneur is indi ferent about whether he undertakes his investment or not. As before, the lender provides loans to L/I entrepreneurs, leaving $N - L/I$ en trepreneurs without funds. However, in this case an entrepreneur who fails to get a loan does not envy his colleagues; moreover he is neither willing nor able to pay more than the announced interest payment $R^* = X_b$.

Under the parameter constellation (9a), there is thus no credit ratio ing in equilibrium. To be sure, in equilibrium, some would-be borrowe receive loans and others do not. However the latter are just as happy as the former because they all receive the same payoff. In contrast, under the parameter constellation (9b), those entrepreneurs who receive loans are strictly better off than the others.

In order to see more clearly the connection between rationing and moral hazard, it is also helpful to consider the equilibrium which emerges under perfect information. In this case, the only restriction that the lender has to observe is that the terms of the contract be acceptable to the borrowers. He can monitor the behaviour of firms and determine the choice of project. Given the scarcity of funds, he appropriates the entire surplus. Given that he appropriates the entire surplus, he asks that project a be undertaken because by (2), it yields the higher expected return. The interest payment to the lender is fixed at $R = X_a$.

Under perfect information again, the scarcity of funds does not entail rationing. As before, the lender finances L/I entrepreneurs. Each of these entrepreneurs undertakes project a and receives the payoff $U_a(X_a) = 0$, the same as what he would get without a loan.

Under imperfect information, this outcome is no longer feasible. If $R = X_a$, any borrower will switch to project b by which he obtains $U_b(X_a) = p_b(X_b - X_a) > 0$. Thus the lender can no longer do both, extract the entire surplus <u>and</u> implement project a at the same time. Given that he must choose between these alternatives, under the parameter constellation (9b), he prefers to implement project a even though this requires him to leave some of the surplus to the borrower. More generally, under imperfect information, one may find it more important to induce cooperative behaviour from one's partner than to appropriate the entire surplus from the partnership.

The phenomenon of equilibrium credit rationing is not limited to the case of a monopolistic loan market. Rationing may also occur when there are many lenders and the supply of funds is variable. To demonstrate this, consider an aggregate (competitive) supply function $L(.)$ for loanable funds. $L(.)$ may be taken to be an increasing function of the lenders' rate of return π/I so that for π sufficiently large, it may well be the case that $L(\pi/I) > N I$. In this case there are at least potentially enough funds for all firms to undertake the investment project. Nevertheless, under the parameter constellation (9b), this market has a credit rationing equilibrium if

$$(11) \qquad L(\pi^*(\hat{R})/I) < N I \quad .$$

The equilibrium loan contract specifies the interest payment R so that lenders receive the rate of return $\pi^*(\hat{R})/I$. At this rate of return, the supply of funds is too small to satisfy total demand so that some entrepreneurs must go without loans. As before, the entrepreneurs who do not get loans envy those who do, and we have credit rationing.

To see that this outcome indeed constitutes an equilibrium, we note that none of the lenders has any incentive to deviate from it under any circumstances. The rate of return $\pi^*(R)/I$ that lenders receive is already the highest rate that is at all achievable in the market. Moreover at this rate of return, lenders lend out all the funds that they want to lend out. Those entrepreneurs who are denied credit wil therefore find it impossible to change the situation. As in the mono poly case, we have a credit rationing equilibrium because (i) under the parameter constellation (9b), lenders achieve the highest return at the interest payment $\hat{R}$ at which borrowers have strictly positiv payoff expectations, and (ii) at the rate of return $\pi^*(\hat{R})/I$, the supply of funds falls short of the demand.

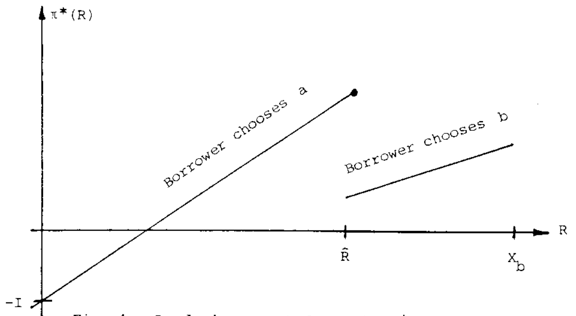
How robust is the preceding analysis to changes in the basic model? In the following, we consider several modifications and extensions of the simple example that we have used so far. Our purpose is to de termine more precisely which of the specific features of the example are responsible for the occurrence of equilibrium credit rationing.

3. Extensions and Modifications of the Analysis

3.1 Collateral as an Incentive Device

In addition to the assumptions of Section 2, we now suppose that eac entrepreneur is endowed with some amount W of collaterizable weal This wealth cannot be used to finance investment directly, say becau it consists of illiquid assets, or it represents the entrepreneur's future outside income. However, this wealth may be used as collatera for a loan. A loan contract then specifies not only a required inte payment R, but also a collateral $C \leq W$. The borrower loses C when he goes bankrupt. Accordingly, (3) has to be modified, and the entrepreneur's expected payoff from undertaking project i under a contract (R,C) becomes

The form of $\pi^*(.)$ is illustrated in Figure 1. Since $p_a > p_b$, $\pi^*(.)$ is not monotonically increasing in R. At $R = \hat{R}$, any small increase in the interest payment leads to a discontinuous drop in $\pi^*(R)$ as the entrepreneur switches to the project with the higher bankruptcy probability. This nonmonotonicity of the lender's expected payoff function is the basis for the theory of credit rationing proposed by Stiglitz and Weiss (1981).



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According to Stiglitz and Weiss (1981), credit rationing occurs when some loan applicants receive loans and others do not, although the latter would accept even higher interest payments. We now show that even a credit market equilibrium may involve rationing when there is moral hazard.

We first consider the case of a monopolistic loan market. Suppose that there is a single risk neutral lender who owns an amount L of loanable funds. Furthermore suppose that there are N identical entrepreneurs of the type described above, and let $I \leq L < N I$. Then funds are scarce, and the lender is unable to finance all entrepreneurs.

In this situation, the lender has all the bargaining power. He can set the terms of the contract to maximize his return. In particular, he can impose an interest obligation R^* at which the value of his expected payoff π^* is maximal. By inspection of (8), there are two possibilities for this choice. If

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Under the parameter constellation (9b), we must have equilibrium cre[...] rationing. The lender announces the contractual interest payment R[...] which maximizes his payoff expectation. Given the interest obligatic[...] $\hat{R}$, an entrepreneur who gets a loan can expect the payoff $U^*(\hat{R}) = U_{i(\hat{R})}(\hat{R}) = p_a(X_a-\hat{R})$. By inspection of (6) and (2), we have

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It may be useful to compare the credit market equilibrium under the parameter constellation (9b) with the equilibrium under the parameter constellation (9a). Under the parameter constellation (9a), the lender announces the required interest payment $R^* = X_b$. Given this an[...] nouncement, an entrepreneur who gets a loan can expect the payoff $U^*(X_b) = U_{i(X_b)}(X_b) = p_b(X_b-X_b) = 0$, i.e., any entrepreneur is indi[...] ferent about whether he undertakes his investment or not. As before, the lender provides loans to L/I entrepreneurs, leaving $N - L/I$ en[...] trepreneurs without funds. However, in this case an entrepreneur who fails to get a loan does not envy his colleagues; moreover he is neither willing nor able to pay more than the announced interest payment $R^* = X_b$.

Under the parameter constellation (9a), there is thus no credit ratio[...] ing in equilibrium. To be sure, in equilibrium, some would-be borrowe[...]

(12) $V_i(R,C) = p_i(X_i - R) - (1-p_i)C$

$= U_i(R-C) - C$.

The lender's valuation of C is not necessarily the same as the borrower's. Taking possession of collateral and liquidating it typically involves transactions costs. For simplicity, these will be represented by a factor $1-\beta$, with $0 \leq \beta \leq 1$, so that the lender's evaluation of C equals βC . The lender's expected payoff from financing the entrepreneur's investment in project i through a contract (R,C) is therefore given as

(13) $\varphi_i(R,C) = p_i R + (1-p_i)\beta C - I$

$= \pi_i(R - \beta C) + \beta C$.

In the present context, collateral is not used as a means to enforce repayment. All along, we have assumed that contracts are enforceable, and that the borrower never defaults if his realized return permits repayment. In practice this willingness to repay the lender in the event of success may be motivated by the fact that the firm has been pledged as security for the loan. However, we are not concerned with such collateral inside the firm which is worth nothing when the firm fails. The collateral C that we consider here is an asset outside the firm which only comes into play when the firm fails so that its assets are worth nothing.

Under perfect information, such outside collateral should not play any significant role. From (12) and (13), it follows that any contract (R,C) with $C > 0$ is (weakly) dominated by another contract with $C = 0$. Indeed if $\beta < 1$, both the lender and the borrower can gain by reducing C to zero and increasing R appropriately because this operation yields a surplus of $(1-p_i)(1-\beta)C$. Thus the costs of collateralization will preclude its use under perfect information.

However, as shown by Bester (1985, 1987), under imperfect information, collateral may play a significant role. In the present context, the lender may use the collateral requirement to influence the entrepreneur's project choice. Given a loan contract with the terms (R,C) , the entrepreneur is willing to choose project a if and only if

(14) $p_a(X_a - R) - (1-p_a)C \geq p_b(X_b - R) - (1-p_b)C$,

or

(15) $R \leq \hat{R} + C$,

where $\hat{R}$ is defined as in (6). If we compare (15) with the previc
incentive constraint $R \leq \hat{R}$, we see that the use of collateral ç
the lender more scope for inducing the entrepreneur to choose pro:
In contrast to interest payments, collateral requirements have pos
incentive effects. They effectively punish the borrower when his p
ject fails, thus creating a motive to lower the probability of bar
ruptcy by choosing project a . For $\beta C \leq R$, this incentive effe
favourable for the lender because it increases the probability of
payment.

The positive incentive effect of collateral requirements may induc
lender to impose such a requirement even if the transactions costs
high so that β is close to - or even equal to - zero. The point
that an increase in C gives the lender more room for increasing
without any adverse incentive effects. In particular, condition (1
shows that a simultaneous and equal increase in R and C will n
have an incentive effect at all. From (13) it follows that such an
equal increase in R and C will unambiguously raise the lender'
payoff - even if $\beta = 0$ so that the collateral does not actually
enter the lender's receipts directly.

Because of its incentive effects, the use of collateral requiremen
substantially affects the scope for equilibrium credit rationing.
before, we consider the case of a monopolistic lender whose funds
insufficient to satisfy all the borrowers' needs. The lender can i
an interest payment R^* and a collateral requirement $C^* \leq W$ sub
only to the constraint that the borrower's expected payoff should
be negative. Again the lender must choose whether he wants to impl
project a or project b . If he decides to implement project b , l
can appropriate the entire surplus of the enterprise, e.g. by sett
$R^* = X_b$, $C^* = 0$, for an expected payoff $p_b X_b - I$. If he want
implement project a , it is most profitable for him to set $R^* = \hat{R} +$
the maximum compatible with condition (15), and to set $C^* = \min[W$
$p_a(X_a - \hat{R})]$, the maximum compatible with both the constraints $C^* \leq$
and $V_a(\hat{R}+C^*, C^*) \geq 0$.

We must now distinguish three possible parameter constellations. I

(16a) $p_a \hat{R} + [p_a + (1-p_a)\beta] \min[W, p_a(X_a - \hat{R})] < p_b X_b$,

the lender prefers to implement project b and to appropriate the e
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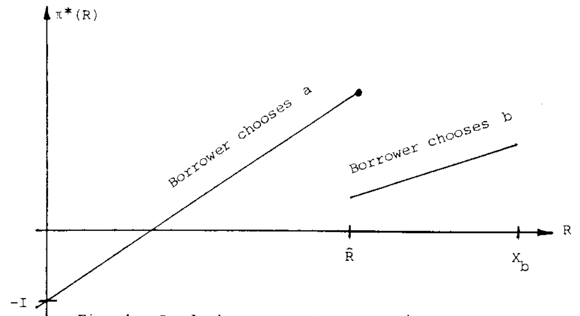
indifferent about whether they receive loans or not.

The form of $\pi^*(.)$ is illustrated in Figure 1. Since $p_a > p_b$, $\pi^*(.)$ is not monotonically increasing in R. At $R = \hat{R}$, any small increase in the interest payment leads to a discontinuous drop in $\pi^*(R)$ as the entrepreneur switches to the project with the higher bankruptcy probability. This nonmonotonicity of the lender's expected payoff function is the basis for the theory of credit rationing proposed by Stiglitz and Weiss (1981).



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It may be useful to compare the credit market equilibrium under the parameter constellation (9b) with the equilibrium under the parameter constellation (9a). Under the parameter constellation (9a), the lender announces the required interest payment $R^* = X_b$. Given this an nouncement, an entrepreneur who gets a loan can expect the payoff $U^*(X_b) = U_{i(X_b)}(X_b) = p_b(X_b-X_b) = 0$, i.e., any entrepreneur is indi ferent about whether he undertakes his investment or not. As before, the lender provides loans to L/I entrepreneurs, leaving $N - L/I$ en trepreneurs without funds. However, in this case an entrepreneur who fails to get a loan does not envy his colleagues; moreover he is neither willing nor able to pay more than the announced interest payment $R^* = X_b$.

Under the parameter constellation (9a), there is thus no credit ratio ing in equilibrium. To be sure, in equilibrium, some would-be borrowe

Alternatively, if

$$(16b)\qquad \begin{cases} W < p_a(X_a-\hat{R}) & \text{and} \\ p_a\,\hat{R} + [p_a + (1-p_a)\beta]W > p_b\,X_b\,, \end{cases}$$

the lender finds it most profitable to set $R^* = \hat{R} + W$ and $C^* = W$, thus implementing project a . In this case, the borrower's payoff is $V_a(\hat{R}+W,W) = p_a(X_a-\hat{R}) - W$, which is strictly positive. The insufficiency of the lender's funds leads to equilibrium credit rationing because again the loan applicants who are rejected envy those who are accepted and would gladly offer to pay more than the interest $\hat{R} + W$ that the lender is asking.

Finally, if

$$(16c)\qquad \begin{cases} W \geq p_a(X_a - \hat{R}) & \text{and} \\ p_a\,\hat{R} + [p_a + (1-p_a)\beta]p_a(X_a-\hat{R}) > p_b\,X_b\,, \end{cases}$$

the lender again wants to implement project a , this time however by setting $R^* = p_a\,X_a + (1-p_a)\hat{R}$ and $C^* = p_a(X_a-\hat{R})$. The borrower's expected payoff then is zero, i.e. the individual rationality constraint $V_a(R^*,C^*) \geq 0$ is binding. Even though some loan applicants are rejected, the equilibrium does not involve rationing because those loan applicants who are rejected do not care and are unwilling to offer more than the lender is asking.

To assess the impact of collateral requirements on the possibility of equilibrium credit rationing, we compare condition (16b) with condition (9b), our previous condition for equilibrium credit rationing. Obviously the two conditions coincide if $W = 0$. For $W > 0$, we must distinguish two possibilities: If W is very high, equilibrium credit rationing is impossible because the use of collateral enables the lender to appropriate the entire surplus from project a in an incentive-compatible way. However, if $p_b\,X_b > p_a\,\hat{R}$ and if W lies in some intermediate range, the use of collateral may actually cause equilibrium credit rationing as it becomes more profitable for the lender to implement project a and to replace the contract $(X_b,0)$ by $(\hat{R}+W,W)$.

The different possibilities are illustrated graphically in Figure 2. In this figure, the line AA represents the equation $W = p_a(X_a-\hat{R})$, or $V_a(\hat{R}+W,W) = 0$. For parameter constellations above this line, there never is any credit rationing because the lender can always use collateral to push the borrower to the point where he is indifferent about borrowing at all. Contour BBB represents the equation

$p_b\,X_b = p_a\,\hat{R} + [p_a + (1-p_a)\beta]\min[W, p_a(X_a - \hat{R})]$. To the right of th contour, the lender prefers to implement project b , to the left, project a .

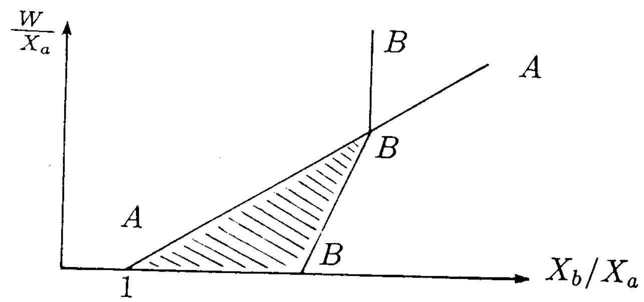

Fig. 2: Credit rationing occurs only in the hatched triangle in which the lender wants to implement project a and the borrower's collateralizable wealth W is insufficient for the lender to appropriate all the surplus

It is of some interest to note that e.g. for $p_b\,X_b > p_a\,\hat{R}$, the e librium choice of project depends on the borrower's wealth. This co trasts with the well-known Modigliani-Miller theorem in corporate f nance according to which the firm's production and financial decisi are independent of each other. Under imperfect information, this th rem fails because finance contracts have incentive effects which ar relevant for production decisions.