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## Credit markets with private information

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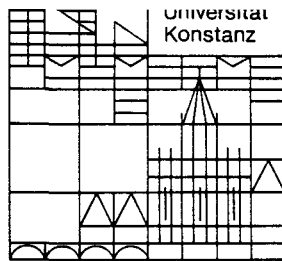
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**Credit Markets  
with Private Information**

Diskussionsbeiträge

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CREDIT MARKETS WITH PRIVATE INFORMATION

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Serie A: Volkswirtschaftliche Beiträge

Serie B: Finanzwissenschaftliche Arbeitspapiere

Serie C: Betriebswirtschaftliche Beiträge

## I. Introduction

There is general agreement that financial markets are informationally efficient. The efficient market hypothesis states that market prices fully reflect all publicly available information. Examples of such markets are the bond or the stock market. For a detailed discussion, see Fama (1970). There is, however, the problem of private or inside information. Sometimes managers may have better information than the market about a company's growth and investment opportunities. As long as the market does not possess the same information, the company's stock price will not change. Thus, any trader who knows more than the market can earn excess returns either by buying currently underpriced stocks or by selling those that are currently overpriced. See Treynor (1981) for examples. Associated with private information is the problem of verification. Any information can be either correct or false. Thus, the market will accept new information only if there is a possibility of independent verification. The process of verification or of transmitting reliable information can be impossible or very costly. However, with respect to financial assets (as opposed to real assets) prohibitively high cost of information transmission is believed to be unlikely.

Many recent contributions to the explanation of financial markets are based on the high information cost assumption. One example of a financial market with substantial information cost is the bank credit market. Associated with each bank loan is some default risk. The degree of such risk is an important determinant to the terms of loan contracts. Basically, a credit transaction is the purchase of a financial asset with uncertain quality. That is, information about the default probability is private because it is distributed asymmetrically between banks and borrowers. The borrowers have more information than the lender with respect to the quality of the traded asset. In order to overcome this informational asymmetry, economic agents may want to collect and transmit information.

An extreme informational situation is discussed by Akerlof (1970). He assumes a basic information asymmetry between buyers and sellers of used cars. The true quality of each car cannot be observed by the buyer but is known by the seller. For the Akerlof solution it is important that information transmission is prohibitively expensive; there must be no possibility to transmit quality information from the seller to the buyer. As a consequence prices do not reflect the true quality of the cars and buyers observe only the average quality of cars offered. The market equilibrium is characterized by a single "pooling" price which reflects the average quality. Consequently, all sellers with qualities above the pooling price will withdraw their cars from the market. Only the lowest quality cars, the "lemons", are traded. Thus informational asymmetry in combination with prohibitively high information costs results in a severe market failure. Mutually advantageous transactions are blocked due to the informational breakdown. It is important to note, however, that the

market solution would be totally different if there were a possibility of transmitting information at some positive but not prohibitively high cost.

Recent contributions to the understanding of the credit market behavior have used Akerlof's informational structure. See Jaffee/Russell (1976), Keeton (1979), and Stiglitz/Weiss (1981). In their model the bank cannot monitor the borrowers' actions and/or cannot distinguish between high and low default risk borrowers. In addition, there is no possibility to transmit information about differences in the default risk and actions to change default risk. As a result, the bank cannot charge different interest rates to different applicants with different projects. The market equilibrium is described by a single "pooling" rate. Given the pooling rate, credit rationing is explained as banks' optimal choice under asymmetric information. The results in these models follow basically from the assumption of informational breakdown. Some advantageous credit transactions which would otherwise have taken place will not be made partly because the applicants drop out of the market and partly because the bank refuses to grant a loan.

In this paper we first question the credit rationing solutions based on Akerlof's assumption and then provide alternative explanations of credit rationing. We shall argue that although it is costly to transmit information, it is not prohibitively costly in financial markets. Once we drop Akerlof's assumption, the credit market solution will change substantially. However, credit rationing will again occur if there are some other market imperfections. In section II we show that information transmission rules out the possibilities of rationing solutions presented in Jaffee/Russell, Keeton and Stiglitz/Weiss. In section III we provide alternative explanations of rationing solutions under some other market imperfections.

## II. The Signalling Solution

In this section we discuss the signalling process as a way of information transmission in the credit market. Lender design contracts in such a way that the applicant's unobservable quality can be revealed by their choice of contracts. Each contract is characterized by a fixed combination of the loan rate and the loan size. In equilibrium the credit market is characterized by a separating solution: Different quality borrowers choose different contracts, identical borrowers choose identical contracts, some applicants who do not find any acceptable contract drop out of the bank's pool. As a result, borrower's information is transmitted to the lender *uno actu* with the borrower's decision. Eventually, the separating contract dominates the pooling solutions presented in Jaffee/Russell, Keeton, and Stiglitz/Weiss.

For the bank the signalling solution is the cheapest way of collecting information. Since borrowers self-select, the bank does not need to spend for collecting information. All high quality borrowers prefer the separation solution as long as the information costs are lower than the costs of subsidizing low quality borrowers under the pooling solution. On the other hand, although low quality borrowers would prefer the pooling contract, they cannot but choose the separating contract if this is the only one that is offered.

In what follows, we first develop the basic model under public information assumption and then discuss the case of private information. For simplicity we make the following assumptions: There is universal risk neutrality. The one-period investment project is fully financed by a bank loan. A loan contract is characterized by  $\{R,L\}$  where  $R$  is the loan rate and  $L$  is the loan size. The bank's opportunity cost is denoted by  $I$  representing a riskfree borrowing or lending rate. The stochastic gross



return  $\tilde{X}$  of the project takes the multiplicative form,  $\tilde{X} = q(L) \theta \tilde{u}$ . The production function  $q(L)$  has decreasing returns to scale, i.e.,  $\epsilon(q,L) < 1$ , where  $\epsilon$  is the scale elasticity. The applicant's quality index denoted by  $\theta$  is universally known. The pure stochastic term  $\tilde{u}$  (which is responsible for the default risk) is non-negative and the density function is given by  $g(u)$  with  $E[\tilde{u}] = \bar{u}$  and the corresponding distribution function is  $G(u)$ .

Given these assumptions, the expected return  $\alpha$  of a type- $\theta$  applicant is

$$(1) \quad \alpha(R,L,\theta) = \int_{\hat{u}}^{\infty} (q(L) \theta u - RL) g(u) du,$$

where  $\hat{u} = RL/q(L)\theta$  is the critical value below which default occurs. On the other hand, the bank's expected profit  $\pi$  resulting from a loan contract to a type- $\theta$  applicant is

$$(2) \quad \pi(R,L,\theta) = (R - I)L + \int_0^{\hat{u}} (q(L) \theta u - RL) g(u) du \\ = q(L)\theta \bar{u} - IL - \alpha(R,L,\theta).$$

Following Jaffee (1972), Jaffee/Russell (1976) and others, it is convenient to use the iso- $\alpha$  and iso- $\pi$  curves, where the slope of each curve represents the marginal rate of substitution between  $R$  and  $L$  derived from (1) and (2) respectively. The borrower's marginal rate of substitution is the maximum future amount he is willing to pay in order to get an additional unit of loan now. On the other hand, the bank's marginal rate of substitution is the minimum future payment in exchange for an additional payment of one dollar now.

$$(3) \quad \left. \frac{dR}{dL} \right|_{\alpha} = (\epsilon(q,L) \Omega(\hat{u}) - 1) R/L \stackrel{\geq}{<} 0 \quad \text{and}$$

$$(4) \quad \left. \frac{dR}{dL} \right|_{\pi} = (I - q'(L) \theta \bar{u}) / L(1 - G(\hat{u})) + \left. \frac{dR}{dL} \right|_{\alpha} \stackrel{\geq}{<} 0,$$

$$\text{where } \Omega(\hat{u}) = \int_{\hat{u}}^{\infty} u g(u) du / \hat{u} (1 - G(\hat{u})) > 0.$$

According to (3) and (4), the marginal rates of substitution for the borrower and the bank can be positive, zero, or negative respectively. As shown in Jaffee (1972), Jaffee/Russell (1976), Keeton (1979), and Milde/Riley (1984) the iso- $\alpha$  and the iso- $\pi$  curves of a type- $\theta$  applicant in (R,L) space are concave and convex respectively.

$$\left. \frac{d^2R}{dL^2} \right|_{\alpha} < 0 \quad , \quad \left. \frac{d^2R}{dL^2} \right|_{\pi} > 0 .$$

Given the families of iso- $\alpha$  and iso- $\pi$  curves, one in each family indicates the  $\alpha=0$  and  $\pi=0$  level. In addition, it is easy to show that the iso-curve with  $\pi=0$  is upward sloping everywhere. The set of possible loan contracts is characterized by  $\alpha \geq 0$  and  $\pi \geq 0$  and is shown by the shaded section in Figure 1.

Next we consider the set of Pareto optimal contracts. Pareto optimality requires the equality between the marginal rates of substitution of the borrowers and the lenders.

$$\left. \frac{dR}{dL} \right|_{\alpha} = \left. \frac{dR}{dL} \right|_{\pi} .$$

From (4) we can see that the Pareto optimal locus is independent of R and satisfies  $I = q'(L^*) \theta \bar{u}$ , which is represented by the vertical line  $E_1M_1$  in Figure 1. Note that this is a revised version of a diagram in Jaffee (1972) where the Pareto optimal locus is not a vertical line.

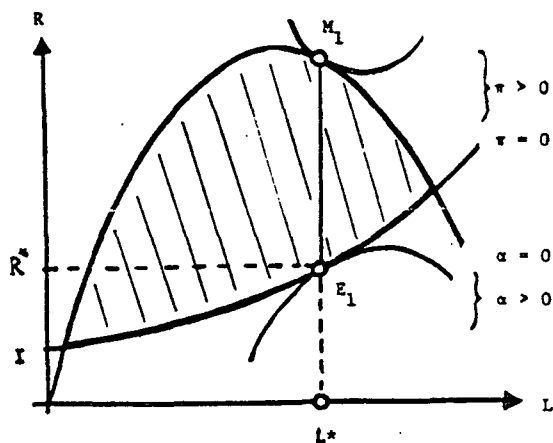


Figure 1

We assume that the banking industry is competitive in the sense that the expected bank profits are driven down to zero. As a result the equilibrium contract  $\{R^*, L^*\}$  is characterized by the intersection of the Pareto optimal locus with the zero profit line. This combination is denoted by  $E_1$  in Figure 1. According to Keeton, this is called "type-I rationing". At the given loan rate  $R^*$  the borrower would prefer a loan amount  $L$  which is larger than  $L^*$ . However, this argument is misleading, for given the zero profit constraint,  $E_1$  is the most desired contract the borrower can obtain. Any point off the Pareto optimal locus is inferior by definition. Note that  $E_1$  can be interpreted as the equilibrium loan contract in Jaffee/Russell (1976). While Jaffee/Russell (1976) base their argument on information asymmetry with respect to default costs (see also Vandell (1984) and Jaffee/Russell (1984)), it is interesting to see that information asymmetry is not necessary in Figure 1 or for the result in Keeton (1979).

We now introduce a second applicant with a different quality index. For this purpose let us assume  $\theta_1 < \theta_2$ , i.e., the second applicant has a higher quality (lower default risk) investment project than the first. We first consider the public information case. Given two different qualities, we can derive two optimal loan volumes  $L^*(\theta_1)$  and  $L^*(\theta_2)$  with  $L^*(\theta_1) < L^*(\theta_2)$ . The contract for better quality borrowers is characterized by a larger loan size. The optimal loan rate for them could be either higher, lower, or the same, depending on the probability distribution functions. Figure 2 shows the case of a lower loan rate. This separating contract is described by  $\{E_1, E_2\}$ . Because the bank is able to identify the applicants,  $E_1$  is offered to borrowers with type  $\theta_1$  only and  $E_2$  to type  $\theta_2$  only. With each type the bank breaks even.

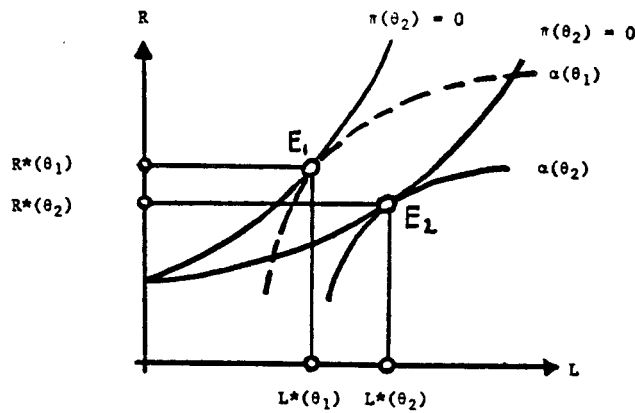


Figure 2

Now suppose that the lender can no longer observe the true quality of different applicants. Then the separating contract  $\{E_1, E_2\}$  based on the public information will disappear from the market, for if the bank would offer  $\{E_1, E_2\}$ , all applicants would choose  $E_2$  and hence the bank would make losses. Given Akerlof's assumption, if the bank offers the pooling contract, then there may be type-II rationing under some market conditions as presented in Stiglitz/Weiss. However, this is not the end of the credit market story if Akerlof's assumption is relaxed.

Suppose now that information transmission is not prohibitively costly, then the pooling solution will be dominated by a separating contract. However, the separating solution is no longer characterized by  $\{E_1, E_2\}$ . The new separating solution exploits the differences in the marginal rates of substitution of different quality borrowers. To make this point clear, let us compare a typical growth company with a no-growth company; in order to finance a new investment project the growth company can pay a higher loan rate to the bank than the no-growth company. In other words, given the multiplicative technology, it can be shown that the marginal rate of substitution is an increasing function of  $\theta$ . For a formal derivation of this result see Milde/Riley (1984).

From Figure 3 it can be seen that there is a set of contracts which separate different quality borrowers (shaded area). Low quality borrowers ignore all contracts within the shaded area and prefer  $E_1$ . High quality borrowers prefer contracts within the shaded area. Among all the possible separating contracts the one denoted by  $S_1$  is the best;  $S_1$  provides the highest level of  $\alpha(\theta_2)$  and satisfies  $\pi(\theta_2) = 0$ . In equilibrium, the best separating contract is  $\{E_1, S_1\}$ .

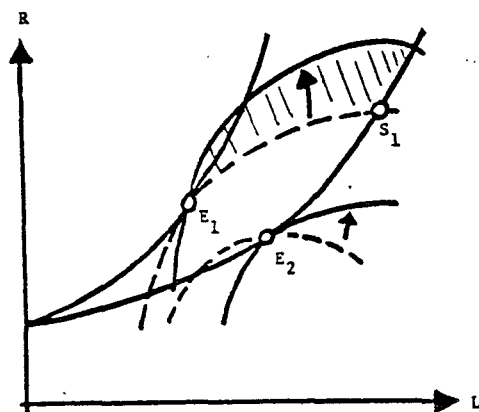


Figure 3

Another case of signalling solution can be found when technology is additive rather than multiplicative. To make this point clear, let us consider two loan applicants, an AAA firm and a BB firm. We assume that the AAA firm has a lower default risk and the BB firm has a higher default risk. As a consequence, the AAA firm is in a stronger position to reject high loan rates charged by the lender and the BB firm is in a weaker position and hence will be virtually compelled to accept any loan rate. Given the additive technology, increased quality  $\theta$  will decrease the marginal rate of substitution. Note in Figure 4 that the set of separating contracts is below  $E_1$ . In equilibrium, the best separating contract is  $\{E_1, S_2\}$ .

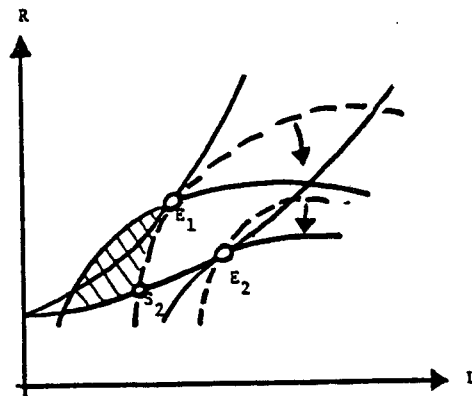


Figure 4

An additional comment deserves mention in this context. If the formal structure of the return function (whether the technology is additive or multiplicative) is universally known, then the loan size can be used as a signal. If the structure itself is uncertain, however, the loan size cannot. In the latter case the bank would employ some other variables as a signal; e.g., collateral. Banks can offer fixed combinations of loan rate and collateral in order to identify applicants. For models with collateral, see Chan/Kanatas (1985), Besanko/Thakor (1983), Chan/Thakor (1984), and Bester (1984).

### III. The Rationing Solution

In section II we found that there is no credit rationing if we allow the possibility of information transmission. However, credit rationing may exist if various aspects of market imperfections are taken into account, e.g., monopoly power, risk aversion, and/or default penalty costs. In this section we first make a few remarks on default costs and then discuss a credit rationing solution based on bank's monopoly power and private information.

As to default costs, we can distinguish between two types: On the one hand, there are dead weight penalty costs for default paid to a

"third" party as appearing in Jaffee/Russell (1976) and Devinney (1984). On the other hand, there is collateral transferred to the bank in the event of default as in Stiglitz/Weiss (1981), Besanko/Thakor (1983) and Watson (1984). Devinney (1984 and 1985) shows that credit rationing results due to dead weight penalty costs and uncertainty on both sides of the credit market; banks cannot observe default risks and borrowers do not know their evaluation by banks. In order to overcome the information asymmetry, banks invest in information acquisition. Depending on the results of the evaluation procedure, each borrower is allowed to choose among a specific subset of contracts only. In contrast to the signalling solutions discussed in section II, each borrower's choice set is now conditional upon his test results. Since there is a possibility that applicants are classified incorrectly according to the test results, it is possible that good quality applicants are allowed to choose low quality contracts only. If the contract terms are too bad for them, good borrowers will drop out of the bank's pool of applicants.

In Besanko/Thakor (1983) and Watson (1984), banks offer loan contracts which are designed such that borrowers of different default risk classes or different tastes for effort can be identified. All contracts include collateral requirements which are interpreted as default penalties. Besanko/Thakor (1983) show that contract choice can signal different risk classes and that insufficient collateral may result in rationing. Basically the same idea is presented in Watson (1984); all contracts are specified by fixed combinations of loan rate and collateral; the chosen contract reveals a specific taste for effort and insufficient collateral may result in rationing.

Several models either combine monopoly power and risk aversion or deal with each aspect separately in explaining credit rationing. With

respect to risk aversion, the obvious framework is implicit contract theory in which banks are risk neutral and borrowers are risk averse. The model developed by Fried/Howitt (1980) explains a loan transaction in terms of an insurance or a risk-sharing contract. The rationing solution depends crucially on the existence of positive adjustment costs involved in switching one's trading partner. Shim (1984) shows a possibility of rationing even under the assumption of zero switching costs. In both models, however, the loan size is assumed to be exogenously given. This assumption is essential for their credit rationing solutions.

The best known monopoly bank model is developed in Jaffee/Modigliani (1969). However, this model suffers from several defects. First, the bank is subject to the exogenously given constraint of a common loan rate for two different customers. Second, as noted in Azzi/Cox (1976), it is not clear why a company should accept a loan offer that is less than its demand. Third, the existence of differing borrowers is a necessary condition for their credit rationing solution. When two differing customers apply for loans given an interest rate, the bank rations the demand of larger size regardless of their return distributions. We doubt, however, that a bank rations on the basis of the size of applicants' loan demands only and that it rations the demand of larger size. Fourth, one can alternatively interpret the Jaffee/Modigliani model as analyzing the case of different groups of borrowers, where returns from investment projects are perfectly correlated within a group but are independent between groups. Under this interpretation, however, the credit rationing becomes nothing but a random selection out of a group of identical customers.

In what follows, we adopt Yoon (1984) in which the monopoly power of a bank with private information provides a credit rationing result when



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risk averse borrowers determine their loan demands optimally. Emphasizing a bank's information on customers' return distributions, Yoon views credit rationing as an additional instrument available to a monopoly bank when it can not use price differentiation in equilibrium of a credit market. Depending on whether the monopoly bank employs this additional instrument or not, its policy is distinguished between the credit rationing policy and the non credit rationing one. In a loan market with risk averse customers, it is assumed that the bank knows individual customer's return distribution correctly but not his loan demand, and the customers know their return distributions but not those of others. When the loan contract between the bank and an individual customer includes the loan rate only, price differentiation would reveal information of each customer's return distribution to the market and hence help customers exploit arbitrage opportunities resulting from interrelated nature of customers' return distributions.

Since the existence of arbitrage opportunities in a loan market is not compatible with equilibrium, the bank will use a single interest rate in equilibrium. In addition to the single interest rate, however, the bank would take advantage of its information by setting a rationing index based on success probabilities of consumers' investment projects. At a given loan rate, some customers are qualified in the sense that the bank's expected profits from loans to them are positive but others are not. Then, if the loan demands of the qualified customers are interest elastic at that interest rate, it will be profitable for the bank to decrease the rate. Since some unqualified customers would then also demand loans, it will be again profitable for the bank to ration their demands.

In most of the credit rationing literature it is taken for granted that the credit rationing interest rate is below the market clearing one

if there is an excess demand. However, this is shown to be unnecessary. Depending on the demand conditions, it can be optimal for a monopoly bank to set a credit rationing rate above or below the market clearing one. However, when the demands of the qualified group of customers are elastic, the former is expected to be below the latter.

As a result of credit rationing, the aggregate amount of credit supplied by the bank to the selected customers at the credit rationing interest rate will be less than the aggregate demand by all the customers at that rate. If credit rationing entails a lower interest rate, however, then this would lead the selected customers to increase their loan demands and hence the aggregate loan supply under credit rationing could be greater than that under non credit rationing. Since better customers are selected and would increase their investments at a lower interest rate, credit rationing could contribute to an increase in the expected aggregate net output of this economy. In the process, the bank controls both the quantity and quality of investments in an economy by means of the common interest rate and the credit rationing.

#### IV. Conclusion

In this paper we discuss credit market equilibria under private information. Information transmission may be possible by signalling. As the customers reveal their qualities, there is no longer a necessity for rationing. However, market imperfections may provide the possibility of rationing. We discuss the case of a monopoly bank being informed about the customers' investment projects. The bank may be unable to charge different loan rates in the presence of arbitrage opportunities among customers. In this situation the bank will use rationing to exploit its information.

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