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CREDIT MARKETS WITH ASYMMETRIC INFORMATION: A SURVEY*

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We attempt to survey the most important implications of informational asymmetries in credit markets. First, we review the various explanations of equilibrium credit rationing, then we discuss their robustness if collateral and loan size are used as signals of credit worthiness. Then we show the importance of the modelling strategy for the conclusions derived about credit market equilibria. Finally, we discuss the role of different contracts and conclude by suggesting areas of further research.

1. Introduction

The purpose of this paper is to survey some of the main implications of asymmetric information in credit markets. The necessity of an explicit consideration of the information structure in analysing markets became apparent with the development of the »New Information Economics» in the 60ies and 70ies. It turned out that several properties of the Arrow-Debreu model do not longer hold if the assumption of perfectly informed agents is dropped. In particular, asymmetric information may have the following consequences for market equilibria:

a) An equilibrium need not exist.
b) There may exist equilibria with price dispersion.
c) There may exist equilibria with rationing.
d) There may exist Pareto-inefficient equilibria.

Considering the special information structure of credit markets is interesting mainly for two reasons. First, credit markets play a crucial role in every modern economy, and second there are severe information problems particularly in this market. The first point goes without saying and will not concern us in this paper. At the core of the second point is the timing of the transactions in credit markets. The borrower gets a loan against a promise of repayment at later points of time. When and to what extent he honors his commitments, however, is uncertain from the point of view of the lender, and may depend on

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various factors, which are quite often under the control of the debtor, or at least he is better informed about them than the creditor. As a consequence, lenders have an incentive to take measures in order to obtain information about borrowers, their credit worthiness, the riskiness of their income, the actions they take after signing the contract etc. One implication concerns the role of the loan rate of interest, which traditionally has been viewed as the price of the loan. As it turns out, it may also serve as a screening or incentive device, and this may prevent market clearing through adjustment of the interest rate. This possibility of »equilibrium credit rationing»[1] motivated much of the recent research in credit markets with asymmetric information, since it provided a rationale for this phenomenon whose importance had been recognized for a long time by economists of different persuasions, and in particular by adherents of the so called »availability doctrine». The latter holds that monetary policy can influence the level of aggregate investment by affecting the total volume of loans even if investment is independent of the interest rate.[2]

As it happens, taking account of the asymmetric information has improved our understanding of the peculiarities of credit markets far beyond just providing an explanation of credit rationing: The role of collateral, the specification of loan contracts or, more fundamentally, the very existence of financial intermediaries could be explained in a novel and, in many instances, more plausible way than had been possible before. In the remainder of this paper we shall give an overview over the main developments in this area without, however, claiming complete coverage of all issues.

The paper is organized as follows. In the next section we set up a simple model which allows us to present the main approaches to explaining equilibrium credit rationing. In section 3 we generalize the basic model by taking into account collateral and variable loan size. Section 4 contains a discussion of some problems of modelling competition between intermediaries, starting with the well known existence problem posed first by Rothschild and Stiglitz (1976) for insurance markets. We proceed by discussing some recently proposed equilibrium concepts in game theory and their bearing on credit markets, and conclude this section by demonstrating by means of a simple example the importance of the assumed mode of competition. In section 5 we illustrate the role of contracts in lender-borrower relationships, and section 6 contains some concluding remarks and suggestions for further research.

2. Credit Rationing Models

2.1 The Basic Credit Market Model

There are three groups of agents, namely savers, banks and borrowers. The savers offer their deposits as a function of the sure deposit rate of interest i to the banks, formally

$$(1) \quad L^s = L(i), \qquad L' \geq 0.$$

The borrowers, who are assumed to be risk neutral, apply for credits lasting one period and with a fixed loan size normalized to equal one. These credits are used for an investment project which, after one period, yields a random return x with distribution function $F(x)$ and density function $f(x)$.

To make things easier we assume that only two possible outcomes can occur: Either the project yields a return $x>1$ or it yields a return equal to zero. The first case has probability q, the second therefore $(1-q)$, that is $F(0)=1-q$, $F(x)=1$, $f(0)=1-q$, $f(x)=q$.

In this special case the borrower's expected return is

$$(2) \quad g(r, C, B) = q(x-(1+r)) - (1-q)(C+B),$$

where r denotes the loan rate of interest, $C \geq 0$ is the collateral and $B \geq 0$ are borrower's bankruptcy costs.

The competitive banks attract savings and grant loans at the loan rate r. Since they are

[1] *Henceforth, rationing means for some loan applicants to receive no credit at all. Keeton (1979) defines this as Type II Rationing, in contrast to Type I Rationing, where at least some borrowers get a smaller loan than they desire at the prevailing interest rate.*

[2] *Brief surveys of the availability doctrine are found in Baltensperger and Devinney (1985) or Clemenz (1986, Introduction).*

also assumed to be risk neutral, they are maximizing their expected profit.

The only costs a bank has to bear are the payments of the interest rate for deposits. In the two outcome case described above the expected gross return of the bank is

$$(3) \quad p(r, C, M) = q(1+r) + (1-q)(C-M),$$

where $M \geq 0$ stands for the costs of monitoring which have to be incurred if the borrower defaults.

Perfect competition between banks implies that in equilibrium the expected bank profit is equal to zero, i.e. $p(r, C, M) = 1 + i$.

In what follows we shall discuss various economic reasons for which q may be a decreasing function of the loan rate of interest. If $q'(r) < 0$, then the bank-optimal interest rate r^* is derived from maximizing (3) with respect to r.

$$(4) \quad \frac{\partial p}{\partial r} = q + q'(r^*)(1 + r^* - C + M) = 0.$$

At this »bank optimal» interest rate the negative effect of a marginal increase of r on the probability of default is exactly equal to its positive effect on p via increasing payments from successful borrowers. Obviously, $q'(r) = 0$ implies that $p(r, C, M)$ is always increasing in r. On the other hand if $q'(r) < 0$ a bank optimal interest rate may exist which induces an upper limit for the deposit rate i banks are able to offer to savers. Now, if this deposit rate attracts a smaller volume of deposits than credits demanded, equilibrium credit rationing occurs.

Our aim is to investigate economically plausible explanations for a positive correlation of loan rate r and probability of default $1-q$, consistent with the assumption of rational individual behaviour.

In the following section five versions of rationing models from the relevant literature are described. They are all based on the supposition that the borrower is better informed about at least one factor influencing the profitability of a loan contract. So the models assume that before making the loan contract, the lender cannot estimate the borrower's honesty, his ability, his effort in carrying out the investment project, or the riskiness of the project. The last model deals with informational problems after the loan contract has been signed. In this case the lender may not know the actual returns of the project or the wealth position of the borrower, who has an incentive to declare default unless the lender can provide appropriate incentives for truthtelling.

2.2 Models in Literature

2.2.1 Honesty

The first approach that gives an explanation for the positive correlation of loan rate and default probability was suggested by Jaffee and Russell (1976).

Their model differs from the other models presented below in two aspects: First, in its original version it is a consumption loan model, while in all other models loans are needed for carrying out investment projects. And second, nobody has the possibility to prevent the borrower from not paying back his loan. His decision depends only on his bankruptcy costs, which may reflect either economic or moral costs.

In the following the idea underlying the model of Jaffee and Russell will be presented in its simplest version. We assume $C = M = 0$ and two types of borrowers, which are differing only with respect to the size of their bankruptcy costs, with $B_2 > B_1$.

The fraction of »honest» borrowers, i.e. those with the high costs of default B_2, is β, and a borrower only repays his liability if $1 + r < B_i$, $i = 1,2$.

Let us now turn to the bank. It knows β, but it cannot recognize to which group an individual customer belongs to.

By considering the expected income of the bank one has to distinguish different possibilities.

$$(5) \quad p(r) = \begin{cases} 1+r & \text{if } 1+r \leq B_1 \\ \beta(1+r) & \text{if } B_1 < 1+r \leq B_2 \\ 0 & \text{if } B_2 < 1+r. \end{cases}$$

Equation (5) states that as long as total repayment is smaller than the bankruptcy costs of the »dishonest» borrower all loans are repaid. As soon as total repayment is between the expected bankruptcy costs of the two types of borrowers only the honest ones honor their commitments. Obviously $r_1 := B_1 - 1$ is the optimal interest rate for the bank if

$$(6) \quad B_1 > \beta B_2 \quad \text{respectively } \beta < \frac{B_1}{B_2},$$

that means if the fraction of honest customers is sufficiently small.[3]

2.2.2 *Riskiness*

Another possible explanation for the connection between loan rate and default probability was suggested by Stiglitz and Weiss (1981) and Keeton (1979).

Here as in the remaining models with asymmetric information ex ante, borrowers are assumed to use the loan for an investment project, and to discharge their debt if they are able to do so.

One can easily show the ideas of their model as follows. There are two different investment projects. The more risky one yields a return x_1 with success probability q_1, the less risky project yields a return x_2 with probability q_2. In the case of failure both projects have a return of zero.

Furthermore, it is assumed that $1 > q_2 > q_1 > 0, 1 < x_2 < x_1$ and $q_2 x_2 > q_1 x_1$.

In the adverse selection version each investor has only one of the two projects; the fraction of the »safe» projects is denoted as β.

The bank knows β, but is not able to see which type of project a customer has.

Concerning the expected return of the bank one has to distinguish the following cases (again for $C=0$):

$$(7) \quad p(r) = \begin{cases} [\beta q_2 + (1-\beta) q_1](1+r) \\ \qquad \text{if } 1+r \le x_2 \\ q_1(1+r) \quad \text{if } x_2 < 1+r \le x_1. \end{cases}$$

Equation (7) shows that safe projects become unprofitable for borrowers at a lower interest rate than risky ones. Since for the lender the safe project yields a higher expected return than the risky one, a bank-optimal interest $r_2 := x_2 - 1$ exists if

$$(8) \quad \beta > \frac{q_1(x_1 - x_2)}{x_2(q_2 - q_1)},$$

that is rationing is more probable if the difference between the returns is low and between the success probabilities it is large.

In the moral hazard version each investor has the possibility to choose between the two projects, without the bank being able to verify his decision.

The risk neutral investor is indifferent between the projects at interest rate r^* if

$$(9) \quad [x_2 - (1+r^*)] q_2 = [x_1 - (1+r^*)] q_1.$$

For $r \le r^* = \frac{q_2 x_2 - q_1 x_1}{q_2 - q_1} - 1$ the investor takes the safe project, whereas with $r > r^*$ he decides for the risky one, and r^* is the bank-optimal loan rate if

$$(10) \quad q_1 x_1 < q_2 (q_2 x_2 - q_1 x_1)/(q_2 - q_1),$$

that is if with $r = x_1 - 1$ the bank's return is lower than it is with r^*.

2.2.3 *Ability*

In contrast to the Stiglitz-Weiss model, Clemenz (1986) assumes a positive correlation between return and success probability.

The idea is that there are different types of investors: Investors with relatively high ability and project q_2, x_2 and those with relatively low ability and projects q_1, x_1. Formally it is assumed $x_2 > x_1 > 1$, $1 > q_2 > q_1 > 0$.

Moreover, the more qualified investors can receive a sure income A_2 if they refrain from undertaking the project. Therefore they apply for credits if and only if the loan rate does not exceed the critical rate r_2, which is obtained from

$$(11) \quad q_2(x_2 - (1 + r_2)) = A_2.$$

Now the bank again only knows the fraction of better qualified investors β, but can-

[3] *Imagine the bank would require the loan rate $r_2 := B_2 - 1$ in the case of $\beta < \frac{B_1}{B_2}$, then only the (few) honest borrowers will fulfill the credit contract. Hence the bank's expected return would be lower as when requiring the lower interest rate $r_1 := B_1 - 1$.*

not observe the ability of the individual customer.

The bank's expected return then is

$$(12)\quad p(r)=\begin{cases}[\beta q_2+(1-\beta)q_1](1+r) \\ \qquad \text{if } 1+r\leq x_2-\frac{A_2}{q_2} \\ q_1(1+r)\ \text{ if } x_2-\frac{A_2}{q_2}<1+r\leq x_1.\end{cases}$$

Therefore, $r^*=x_2-\frac{A_2}{q_2}-1$ is optimal for the bank if $\beta>q_1(x_1-x_2+\frac{A_2}{q_2})/(q_2-q_1)(x_2-\frac{A_2}{q_2})$, that is if there are enough investors with high ability.

2.2.4 Effort

In the moral hazard version of the Clemenz model there exists only one investment project, which in the case of success yields a return x and in the case of default yields a return of zero (see also Watson (1984)).

The probability of success q, however, depends on the effort e, such that an increase of e implies an increase of q. The effort itself causes costs according to the cost function $c(e)$ with $c', c''>0$.

The borrower, as usual assumed to be risk neutral, maximizes his expected income

$$(13)\quad g(r,\ e)=q(e)[x-(1+r)]-c(e)$$

by optimal choice of his effort e. For the first order condition one gets

$$(14)\quad \frac{\partial g}{\partial e}=q'(e)[x-(1+r)]-c'(e)=0.$$

Implicit differentiation leads to

$$(15)\quad \frac{de}{dr}=\frac{q'(e)}{[x-(1+r)]q''-c''}<0.$$ [4]

That implies that the optimal effort e^* is decreasing in r.

The bank now maximizes its expected return through optimal choice of r^*, taking into account the borrower's behaviour, thus

$$(16)\quad \max_r\ p(r)=q(e)[1+r] \quad \text{with } e=e(r)$$

with the first order condition

$$(17)\quad [1+r]=-\frac{q}{q'}\left(\frac{\partial e}{\partial r}\right)^{-1}.$$

Hence the bank-optimal interest rate decreases with an increasing impact of e on q and of r on e.

2.2.5. Monitoring Costs

In the models presented so far, asymmetric information always existed ex ante. Williamson (1986) supposes asymmetric information ex post, namely with respect to the realized return of the investment project.

The model is specified as follows. All borrowers are identical and have the same investment project with random return x with the continuous distribution function $F(x)$ and density function $f(x)$. The density $f(x)$ is common knowledge, but after the project has been carried out, only the investor is informed about the actual realization of x. Now, if a borrower declares his insolvency, the bank is forced to verify this statement in order to get the entire proceeds from the project.[5]

This, however, entails monitoring costs of $M>0$ to the bank. Since the insolvency is more probable with a higher loan rate, there can be a bank-optimal interest rate in this case, too.

These statements can be shown analytically as follows: The bank maximizes its expected return through optimal choice of r in consideration of the connection between r and M through the probability of default, thus

$$(18)\quad \max\ p(r)=(1-F(1+r))(1+r) + \int_0^{1+r} xf(x)\,dx-F(1+r)M.$$

The first term of the r.h.s. denotes the payment to the bank if $x\geq(1+r)$. The remaining two terms equal the lender's expected income

[4] *The sign of the term follows from the second order condition for the above maximization problem.*

[5] *The option to renounce monitoring and accept the lower amount is not optimal because then it would always be profitable for the borrower to declare insolvency.*

if the borrower defaults. In this case the bank gets the proceeds of the project,[6] but it has to incur the monitoring costs.[7] The first order condition is

$$(19)\quad p'(r) = (1 - F(1+r)) - f(1+r)M = 0.$$

With implicit differentiation one gets

$$(20)\quad \frac{\mathrm{d}r}{\mathrm{d}M} = \frac{f(1+r)}{-f(1+r) - f'(1+r)M} < 0,^{8}$$

that is the bank-optimal loan rate r^* is decreasing in the monitoring costs M.

Four main objections have been raised against these models which explain credit rationing endogenously. These are

a) The collateral is assumed to be exogenous.
b) The individual loan size is assumed to be exogenous.
c) The analysis is restricted to one period.
d) The type of contract between lender and borrower is exogenous.

In the following sections we discuss these points in more detail.

3. *Collateral*

In this section we examine the implications of endogenous collateral for the possibility of equilibrium credit rationing.

We concentrate on the model of Stiglitz and Weiss, presented in detail in section 2.2.2. but now with endogenous collateral. Furthermore, following Bester (1984), the borrower is no longer assumed to be risk neutral, but risk averse.[9]

Carrying out the investment project a borrower of type i with initial wealth W has an expected utility according to Neumann-Morgenstern of

$$(21)\quad U_i(r,\ C) = q_i u(W + x - (1+r)) + (1 - q_i)\mathrm{u}(W - C).$$

Thus the slope of the borrower's indifference curve in $r-C-$space is:

$$(22)\quad \frac{\mathrm{d}r}{\mathrm{d}C} = -\frac{(1-q_i)u'(W-C)}{q_i u'(W + x - (1+r))} < 0.$$

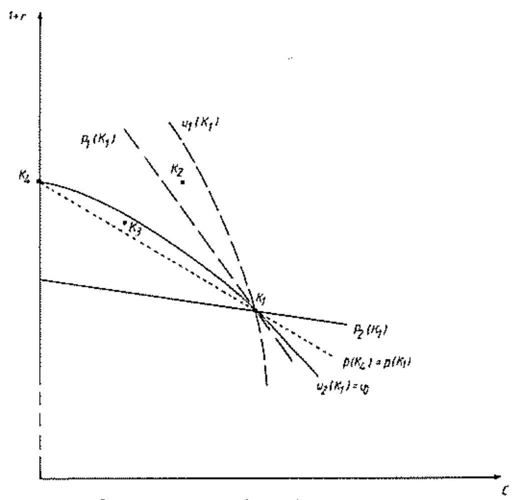
As one can easily see this curve is negatively sloped, concave, and steeper at any point $(r,\ C)$ for the riskier project. This is economically plausible too, because the borrowers with the less risky project are more willing to provide a higher collateral for a fixed reduction of the loan rate.

The slope of the bank's iso-profit curve is derived from (3) for $M = 0$

$$(23)\quad \frac{\mathrm{d}r}{\mathrm{d}C} = -\frac{1-q_i}{q_i}$$

which implies that the borrower's iso-utility curve is steeper than the bank's iso-profit curve at any point $(r,\ C)$.

From figure 1, which shows the described situation graphically, it is obvious that in the case of perfect information contracts with $C = 0$ would be optimal for both, the bank and the borrower, because of their different risk preference. With $C > 0$ a Pareto improvement



——— refers to save projects (type 2)
— — refers to risky projects (type 1)
- - - - bank's iso-profit curve for population average

Figure 1.

[6] *These are the provisions of a »standard debt contract», see section 5 below.*

[7] *For similar ideas see Gale and Hellwig (1985) and Diamond (1984).*

[8] *Again one gets the sign of the term under consideration from the second order condition.*

[9] *If risk neutral borrowers are assumed, a similar argument may hold if $B > 0$, see Clemenz (1986), p. 105.*

would be possible, because a risk neutral bank would require a smaller increase of the interest rate for a decrease of C than the risk averse borrower would be willing to pay. Notice that the borrower's risk in the case of default is increasing in C.

Now a contract with credit rationing as described in section 2 has to lie on the critical iso-utility curve of the safe project at which the borrower is indifferent between getting a loan or being rejected.[10]

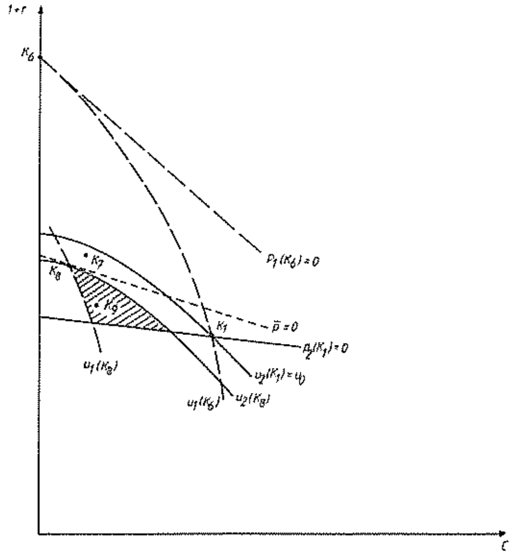
Bester (1984), however, has shown that there cannot be a pooling Nash equilibrium[11] with endogenous collateral: With a contract with $C>0$, like K_1 in figure 1, a bank could in addition to K_1 offer a contract K_2 which is between the bank's and the type 1 borrower's indifference curves passing through K_1 and therefore preferred by both to K_1. Such a contract is to the left of the original contract and thus feasible since the wealth constraint is not binding.

Similar reasoning can be used for a contract with $C=0$, that is the contract K_4 in figure 1. In this case a bank can increase its expected return by offering contract K_3, which only the owner of the safe project would buy. In fact, contract K_4 would become unprofitable and therefore would be withdrawn by the bank. But K_3 remains profitable even if all investors buy it. Thus it is shown that there can be neither a pooling equilibrium with $C>0$ nor one with $C=0$.

In a separating equilibrium, however, credit rationing is not possible. A separating equilibrium has to satisfy three conditions:

i) zero profits of banks,
ii) incentive compatibility, i.e. each borrower prefers (weakly) the contract designed for him to all others, and
iii) the usual Nash-condition, i.e. there do not exist additional profitable contracts.

Such a separating equilibrium is given by the contracts K_1 and K_6 in figure 2.



—— refers to save projects (type 2)
— — refers to risky projects (type 1)
---- bank's iso-profit curve for population average

Figure 2.

In this equilibrium configuration a bank would never ration the demand for K_6 because otherwise these loan applicants would ask for K_1, which results in a lower return for the bank. Consequently, a bank would only deny loans at K_1.[12]

These borrowers, however, are indifferent between carrying out the project or being denied a credit and thus cannot be considered as rationed.

Thus it has been shown that in this model credit rationing cannot be explained endogenously if one drops the assumption of a fixed collateral.

This result, however, need not hold for more general versions of the Stiglitz-Weiss model.[13]

Before we move on, let us briefly consider the possibility of credit rationing if the investor's effort influences the probability of success.

[10] *Otherwise a bank could increase its profit by requiring higher interest rates, since the rationed borrower would accept this. See Bester (1984 a), p. 7, 8, and Besanko and Thakor (1987) for similar ideas.*

[11] *A »Nash» equilibrium in such a market is defined as a set of contracts such that no further contracts exist which, if offered additionally, yield a strictly positive profit. At a pooling equilibrium only one contract is offered.*

[12] *If the supply of loanable funds is so small that the bank could not satisfy the entire demand for K_6, r would rise until the demand can be satisfied or the investors with the risky projects also reach their critical iso-utility curve. But this case cannot be termed rationing, even if some borrowers do not receive a loan.*

[13] *For more details see Clemenz (1986), ch. 4, and Stiglitz and Weiss (1986).*

In this case the expected income of a risk neutral borrower is

$$(24)\quad g(r, e, C) = q(e)[x + C - (1+r)] - c(e) + (1 - q(e)[-C].$$

One gets the optimal e from the first order condition:

$$(25)\quad q'[x + C - (1+r)] - c'(e) - q'[-C] = 0$$

with

$$(26)\quad \frac{de}{dC} = -\frac{2q'}{q''[x + C - (1+r)] - c'' - q''[-C]} > 0.$$

This implies that the borrower's effort is increasing in the amount of collateral. With unlimited wealth credit rationing no longer exists, because it is always more profitable for the bank to require higher collateral than to ration credit. Only if the wealth constraint becomes binding before the market is cleared we would still have equilibrium credit rationing.

Before concluding this section we would like to mention the fact that very similar results can be obtained if the individual loan size is determined endogenously. As Bester (1986), Clemenz (1986, chs. 5—7), Milde and Riley (1988) and others have shown, loan size can be used as a signal of credit worthiness in similar fashion as collateral. Whether a larger loan volume signals a better or a worse project, however, depends on rather subtle details of the randomization of the project return. Similarly, problems concerning the existence of equilibria are analogous to those discussed in the following two subsections.

4. *How to Model Competition*

4.1 The R-S Existence Problem

In the previous section it was shown that the only possible Nash equilibrium in the Stiglitz-Weiss model with endogenous collateral and risk averse borrowers is characterized by the screening contracts K_1 and K_6 (see figure 2).

Now, as Rothschild and Stiglitz (1976) have demonstrated for an insurance market, a Nash equilibrium may fail to exist because of asymmetric information, and this is also true in the present model of a credit market. To see this possibility consult again figure 2.

The pair of separating contracts [K_1, K_6] cannot be an equilibrium if a contract like K_7 exists, which would be bought by both types of borrowers and yields a positive profit for the bank. Graphically, K_7 would have to be above the banks zero-profit line for the population average of all borrowers. This happens with larger probability the larger the fraction of safe projects. But as has been shown in the previous section a pooling Nash equilibrium never exists, so we have no equilibrium at all.

This line of reasoning has been criticised on the grounds that no game has explicitly been specified and hence a Nash equilibrium is not properly defined.

Subsequently, Hellwig (1987) has modeled the above credit market as a two-stage game: In the first stage banks offer debt contracts, in the second stage the borrowers choose among them. In this game it is indeed true that no Nash equilibrium in pure strategies exists in general.

In addition to this two-stage game, however, Hellwig has examined three-stage games in which this non-existence result does not hold. We shall sketch his arguments in the next subsection.

4.2 Sequential Games

In a three-stage game, in which the bank in stage 3 has the possibility to reject the applications from borrowers in stage 2, a Nash equilibrium can be shown to exist in general.

In fact, in signalling games of this type usually a continuum of Nash equilibria exists (Cho and Kreps 1987), and even invoking certain refinements of Nash equilibria need not be sufficient to get rid at least of the intuitively less plausible ones. The reason is that the response of the uninformed players (in our model: the banks) to actions of the informed ones (the loan applicants) depends on their interpretations of those actions, in particular on their »beliefs» concerning the type of a borrower. A set of contracts may be an equilibrium if it is believed that borrowers who apply for a contract which is offered in addition are of the risky type. In an equilibrium such beliefs are never refuted even if they don't make much sense. An appealing way to single out a plausible equilibrium is the »Intuitive Criterion» proposed by Cho and Kreps (1987). Essentially it implies that a borrower should be believed to have a safe project if he takes an action that would harm the owner of a risky project even if his project were considered as safe. As Hellwig has shown, in this case the only Nash equilibrium we get in situations in which no equilibrium exists in the two-stage game is a pooling equilibrium. The argument is as follows.

Consider the situation represented in figure 2 where the pooling contract K_8 is Pareto superior to the contract pair [K_1, K_6]. In the two stage game K_8 cannot be an equilibrium, because given K_8 a bank would have the possibility to increase its profits by offering any contract in the hatched area, for example K_9, which only the investors with the safe project would demand.

In a three-stage game, however, no investor would apply for this contract, because he knows that his application would be rejected by the bank in the third stage.

To see the reason why suppose the bank accepts applications for K_9. The bank will do this only if the contract yields a positive expected profit. For this to occur, it has to be bought mainly from the investors of type 2. But in this case, the contract K_8 would be demanded mainly by bad risks, which would induce the bank to reject all applications in order to avoid losses. As a consequence all investors realizing this, ask for K_9. This, however, is a contradiction to the above assumption, that mainly type 2 borrowers apply for K_9.

Consequently a deviation from K_8 by some bank will not be profitable.

It is noteworthy that the same equilibrium obtains for certain modified equilibrium definitions which have been proposed before the precise specification of multi-stage games became the dominant approach. One is due to Wilson (1977) who suggested that a deviating bank would anticipate the withdrawal of unprofitable contracts and thus refrain from offering a contract like K_9. Similarly, Grossman (1979) argued that bad risks have an incentive to imitate the behaviour of the good ones, hence breaking a pooling equilibrium would not be profitable.

To sum up, when adding a third stage, there always exists a Nash equilibrium in the Stiglitz-Weiss model, which is equivalent to the Wilson equilibrium. In particular, a pooling equilibrium results if this is Pareto superior. So in this case, again, the possibility of credit rationing exists.

Interestingly, the opposite outcome occurs if in such a three-stage game the informed agents make the first move. In this case the borrowers announce their prefered collateral *C*, then the bank announces $r(C)$, and finally the borrowers choose among the offers they receive.

As was shown by Cho and Kreps (1987), the only stable equilibrium (in the sense of Kohlberg and Mertens (1986)) equals the separating Riley equilibrium, which excludes the possibility of credit rationing. According to Riley's equilibrium definition (1979) a deviating bank would take into account that competitors would react by offering additional contracts if they are profitable. If this implies a loss for the first deviating contracts, they would not be offered to begin with. In the present framework, a Riley equilibrium is always separating.

This subsection has shown that conclusions concerning the properties of equilibria in markets with imperfect information are often sensitive with respect to rather subtle details of the models employed. The next subsection contains another example of this sort.

4.3 Modes of competition between intermediaries

A last example for the sensitivity of properties of credit market equilibria with respect to the assumed mode of competition provides also an opportunity to illustrate how asymmetric information may provide a rationale for the very existence of specialized financial intermediaries. Leland and Pyle (1979), Diamond (1984) and others argued that with imperfect information a borrower-lender relationship requires costly information gathering activities of the latter like screening, evaluating risks, monitoring actions of borrowers and the outcomes of their projects etc. In many instances there are increasing returns to scale in collecting and processing such information, in particular, if several lenders supply funds to one borrower. Specialized intermediaries increase the efficiency of a credit market by avoiding replication of monitoring by several independent lenders.

In this section we do not pursue this line of argument any further, but assume instead a particularly simple form of increasing returns to scale in financial intermediation in order to illustrate the importance of the mode of competition. Following the version of Clemenz (1988) of a model proposed first by Williamson (1986) we assume that the supply of loanable funds to intermediaries is infinitely elastic at the deposit rate of interest i. There is a continuum of identical borrowers which is normalized to have measure 1. The loan demanded by a representative borrower is given by

$$(27) \quad L = 1/2(1+r)$$

The only information problem a lender faces concerns the whereabouts of the borrowers when repayment of the loan is due. It is assumed that a lender has to pay a fixed amount M in order to be able to identify all borrowers and get his money back. This fixed cost element implies increasing returns of financial intermediation and creates a role for intermediaries. The characteristics of an equilibrium in this model depend crucially on the way competition is modelled, and we shall look at three possibilities in turn.

4.3.1 Cournot competition

Williamson assumed that each intermediary takes the loan rate of interest r as given, and uses the volume of his loan supply, denoted as L_m, as the only strategic variable. From (27) it is obvious that with n intermediaries the market clearing loan rate of interest is obtained from

$$(28) \quad 1+r = 1/[2 \sum_{m=1}^{n} L_m]$$

and finally, we assume free market entry, which implies a zero profit for each intermediary in equilibrium. Each intermediary solves

$$(29) \quad max\ p(L_j) = L_j/[2 \sum_{m=1}^{n} L_m] - (1+i)(L_j+M)$$

and using the condition $p(L_j)=0$ it is straightforward to compute the Cournot-Nash equilibrium of this market. In particular we get

$$(30) \quad n^* = [1/2(1+i)M]^{1/2}$$

$$(31) \quad L_j = M[n^*-1]$$

It is clear that this equilibrium is not Pareto-efficient: Since there is more than one intermediary there is a waste of resources devoted to gathering information, and as Williamson has shown one can make everybody better off by taxing interest payments and subsidizing loans. However, as Clemenz (1988) has argued Cournot behaviour does not seem to make a lot of sense in this market, and a Bertrand-Nash equilibrium would look quite different.

4.3.2 Bertrand-Nash equilibrium

Under the above conditions it is obvious that Bertrand-behaviour rules out an equilibrium with more than one active intermediary: It would always be possible for one competitor to lower the loan rate of interest (the only strategic variable under Bertrand competition), attract all borrowers and hence to make a positive profit by lowering the information costs per client. It is straightforward to show that the unique Bertrand equilibrium is given by

$$(32) \quad n^{**} = 1$$

$$(33) \quad L_j = [1-2(1+i)M]/2(1+i)$$

and clearly, this is Pareto better that the above described Cournot-Nash equilibrium. However, there is still room for government intervention, as under Bertrand-competition the market does not achieve a constrained Pareto-efficient allocation. But as has been shown by Clemenz (1988) this is due to the restrictive assumption concerning the strategy spaces of the intermediaries.

4.3.3 Contract equilibrium

If an intermediary is allowed to be a bit smarter than has been assumed so far he could break the above Bertrand-Nash equilibrium by offering a loan contract (L, r) in which loan volume and interest rate are chosen in such a way that the utility of a borrower is maximized subject to a non-negativity constraint on the lender's profit. Now in order to do so the intermediary has to know the utility function of the borrowers, and it is well known that demand function (27) can be derived from a Cobb-Douglas utility function with the disposable income in period 1 (when the loan is obtained) and in period 2 (after the debt has been repayed) as arguments. Assuming that a borrower's income equals zero in period 1, and one in period 2, the lender solves

$$(34)\quad max\ U = lnL + ln(1-(1+r)L)$$
$$s.t.\ (1+r)L-(1+i)(L+M)\geq 0$$

and it is straightforward to show that in the contract equilibrium we have one active intermediary and

$$(35)\quad L=(1-((1+i)M)/2(1+i)$$

$$(36)\quad 1+r=(1+i)[1+(1+i)M]/[1-(1+i)M]$$

Clearly, this equilibrium is constrained Pareto-efficient.

It is noteworthy that the demand for loans at the equilibrium r would be smaller than the loan volume of the contract equilibrium. Such »overinvestment» results occur quite frequently in credit market models with imperfect information, e.g. in Bester (1986), Clemenz (1986), Milde und Riley (1988), De Meza and Webb (1987), usually because a larger loan volume serves as a signal for credit worthiness, or, as in the last paper, lenders cannot differentiate between good and bad projects. In the contract equilibrium just described the larger loan size helps to mitigate the fixed costs caused by imperfect information.

Another lesson that can be learned from this subsection is the importance of the contract between lenders and borrowers for the properties of credit market equilibria. We discuss this point in more detail in the next section.

5. Contracts

So far we have assumed that the type of contract between lender and borrower is given and has the form of a standard debt contract (SDC). An SDC is characterized by the following mode of payment: If the borrower is liquid he pays a fixed amount equal to principal plus interest. If he is not liquid the lender takes over the project plus the collateral. It has been argued, however, that for certain information structures other types of contracts may yield Pareto-better outcomes and could resolve adverse selection or incentive problems leading to credit rationing. We shall consider a pure equity contract (PEC) as an alternative to SDCs. A PEC states that the lender gets a fixed share of the project return. We shall give below a few examples for conditions under which either a SDC or a PEC is Pareto-better.

5.1 Ex post asymmetry

Gale and Hellwig (1985) have derived the optimal contract design from a maximization problem in the case of asymmetric information ex post, that is the borrower knows the actual project return, but the bank has to bear monitoring cost to obtain this information.

They show that in this case the SDC is the optimal contract. With the SDC no monitoring takes place if the borrower announces a return $x \geq 1+r$, and the bank receives $1+r$. Only if the borrower announces $x < 1+r$ the bank has to verify his announcement and has to bear the monitoring costs. It then receives the actual return.

Intuitively the Pareto-efficiency of a SDC can easily be made clear. Incentive compatibility requires that the borrower's repayment is independent of his announced return if the bank does not monitor since otherwise he would cheat. The acquisition of the full return in the case of monitoring follows from the requirement of minimizing the total expected costs of the credit. Note that the borrower has to bear these costs. The expected return of the bank has to equal $1+i$ plus the expected monitoring costs. Now, if in the monitoring case it would be payed less than the realized x, the limit $1+r$ above which the bank has to check the borrower's announcement has to be increased. This, however, increases the probability of default and hence the expected monitoring costs, and could not be Pareto efficient.

Three points are worth mentioning at this stage. As Krasa and Kubitschek (1987) have shown the SDC may no longer be optimal if the bank can go bankrupt. Second, the SDC is no longer optimal if the borrower lender relationship lasts for more than one period (see e.g. Chun Chang (1990)). And third there is a problem of time consistency: If the difference between $1+r$ and announced project returns is small in comparison to the monitoring costs the threat of monitoring is not credible unless the bank can precommit itself.

5.2 Moral Hazard I: Effort

If in the moral hazard case of Clemenz's model (1986) not only the probability of success but also the project return depends on the borrower's effort, the SDC is more efficient than the PEC.

With PEC, the bank's gross return is

(37) $p(x)=\alpha x, \quad 0<\alpha<1.$

The borrower chooses his optimal effort by solving

(38) $\max_{e} \ (1-\alpha)q(e)x(e)-c(e)$

with the first order condition

(39) $(1-\alpha)[q'x+qx']-c'=0.$

With a SDC one obtains

(40) $\max_{e} \ q(e)[x-(1+r)]-c(e)$

and the first order condition is

(41) $q'[x-(1+r)]+qx'-c'=0.$

If the bank receives the same expected return with either contract, this implies

(42) $\alpha q(e)x(e)=q(e)(1+r)$

and therefore

(43) $(1+r)=\alpha x.$

Combining this with equation (31) and comparing with equation (29) one recognizes that

(44) $(1-\alpha)q'x+qx'>c'.$

This expression shows that with a SDC the borrower chooses a higher effort. Therefore, with a SDC the bank receives the expected return equal to a PEC, but the borrower realizes a higher expected income. In a recent paper R.D. Innes (1990) has given conditions ensuring that the SDC is the optimal contract.

5.3 Moral Hazard II: Riskiness

The opposite is true in the moral hazard version of the Stiglitz-Weiss model in which the borrower can choose between a risky project $[q_1, x_1]$ and a less risky one $[q_2, x_2]$. As in section 2.2.2 it is assumed that $q_2>q_1$, $x_2<x_1$, $q_2x_2>q_1x_1$.

As was shown in section 2.2.2, the borrower prefers the risky project if

(45) $r>r^*=\dfrac{q_2x_2-q_1x_1}{q_2-q_1}-1.$

This implies that with a SDC the safe projects disappear from the market if a critical interest rate is exceeded. This cannot happen with a PEC, however, because if the investor receives a share $(1-\alpha)$ of the project return then $(1-\alpha)q_2x_2>(1-\alpha)q_1x_1$ is always true, provided $q_2x_2>q_1x_1$ holds. This is true no matter what the level of α is.

Consequently, here a PEC is more efficient than a SDC, and in addition, the rationale for credit rationing in the Stiglitz-Weiss model disappears. The question is why in reality banks usually offer SDCs, even if PECs or other, more sophisticated contracts would be Pareto-better. As with contract theory in general, there is no really satisfactory answer. The best one can probably offer at this stage is that in reality the information structure and the possible contingencies are so complex that it is impossible to write complete contracts, and too costly to attempt to replace standardized contracts by more sophisticated ones. In any case, even the introduction of the most sophisticated contract does not seem to rule out the possibility that circumstances exist which yield a rationing equilibrium.

6. Conclusions

We have tried to take stock of what has been achieved so far in the theory of credit markets with asymmetric information. Rather than summarizing once more the main findings we would like to conclude by pointing out areas in which further research needs to be done.

One important extension of the basic model concerns the consideration of more than one period. Work in that direction is still at its beginning. In particular, it is still unclear whether in borrower-lender relationships which last for several periods rationing becomes more or less likely than in one period models. On the one hand a multi period framework provides the lender with additional possibilities to obtain information, and to create incentives for full loan repayment. On the other hand, as Stiglitz and Weiss (1983) have argued, one such incentive is to deny loans to defaulters, and this threat becomes pointless if it is never carried out. Preliminary work e.g. by Clemenz (1986) suggests that credit rationing is unlikely to disappear altogether in multi period versions, but the definite answer has not yet been found.

A second direction for further research would be a merging of credit market models with approaches to the saver-bank relationship. In particular, bank run models like that of Diamond and Dybvig (1983) and others could be relevant also for some of the results mentioned above. The possibility that banks could also go bankrupt certainly changes their strategic behavior.

A third area worth exploring takes us back to the concerns of the availability doctrine: The way credit markets function is crucial for the performance of an economy as a whole, and rethinking macro-economics on the basis of insights gained from the economics of information looks like a worthwhile enterprise. First steps have been taken by J.E. Stiglitz and others (e.g. Blinder (1987), Greenwald and Stiglitz (1987), Stiglitz and Weiss (1987, 1988)), but clearly much work still needs to be done. It goes without saying that also in areas which have been covered in this survey the subject is far from being exhausted. Especially further progress in contract theory may affect some of the views on credit markets currently held. We hope that our paper will help to stimulate interest in this exciting and lively area of research.

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