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Credit rationing at the firm level: Some microeconomic evidence

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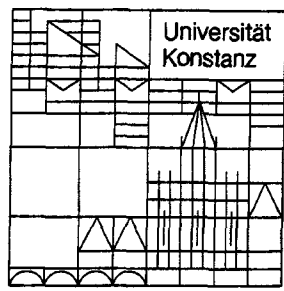
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Sonderforschungsbereich 178
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Diskussionsbeiträge



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Credit Rationing at the Firm Level
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Abstract

Over the last decade credit rationing has been regarded increasingly as the outcome of asymmetric information. Profit maximization of the banks might lead to interest rates lower than the market equilibrium rate. Administering loans at a higher interest rate to the rationed customers will decrease the expected return due to adverse selection and adverse incentive effects.

This paper deals with the effects of age and business relations of firms on the degree of informational asymmetry between banks and firms. The resulting impact on the probability of rationing on the loan market is also studied.

The main contribution of this paper is a direct test of the resulting hypotheses with data at the firm level. Both, the influence of the age of firms and a measure of informational asymmetry on the probability of being rationed on the loan market is estimated. The estimation is based on microdata of the IFO Institute for economic research, Munich.

1 Introduction

“There is, that is to say, in Great Britain an habitual system of rationing in the attitude of banks to borrowers – the amount lent to any individual being governed not solely by the security and the rate of interest offered, but also by reference to the borrower’s purposes and his standing with the bank as a valuable or influential client. Thus **there is normally a fringe of unsatisfied borrowers** who are not considered to have the first claims on a bank’s favours, but to whom the bank would be quite ready to lend if it were to find itself in a position to lend more.” (Keynes (1930) II, p. 365)

Following earlier attempts to formalize his thoughts, for instance in the so called “availability doctrine” (Scott (1957); Roosa (1960)), Stiglitz and Weiss (1981, 1983) develop a model of credit markets with asymmetric information. The loan granting institutions, here generally referred to as “banks” or “creditors”, can distinguish only some groups of firms based on their observable features, such as age or duration of business relations. In contrast, the probability of a single firm repaying its loan is unknown to the creditors; they merely know the distribution of the repayment probabilities within a given group of firms. Furthermore, it can be shown that the interest rate on loans influences the probability of loan repayment. This is ascribed to the adverse selection effect described in Akerlof (1973). When interest rates rise, the demand for loans by firms with relatively low risk decreases, leading to an increase in the proportion of high risk debtors in the remaining demand. Thus, profit maximization might lead to interest rates lower than the market equilibrium rate which, in turn, results in credit rationing. The same effect might result from adverse incentive effects if profit maximizing entrepreneurs undertake projects with higher risks when the interest rate increases.

Baltensperger and Devinney (1984) and Jaffee and Stiglitz (1990) offer a survey of the literature on credit rationing based on asymmetric information. Several researchers stress the importance of business relations between banks and debtors. In particular, it can be shown that the option to withdraw improves the banks’ possibilities to distinguish between high and low risk firms in multi-period loan contracts (Stiglitz and Weiss (1983)). Multi-period loan contracts will also lead to stronger quantitative effects of a change in interest rate or expectations about future business prospects (Gertler (1992)).

This paper provides a direct approach to assessing the importance of age and business relations of firms for the degree of informational asymmetry.

It can be shown that even if only the distribution of the repayment probabilities of a group of firms starting up business is known, this distribution will evolve due to the elimination of bankrupt firms. The distributions of repayment probabilities of a cohort of firms changes *ceteris paribus* over time establishing the value of business relations. Older firms with longer lasting business relations will be served first when loans are rationed.

The data supplied by the IFO Institute for economic research, Munich, offer the opportunity to test some derived hypotheses on the impact of business relations and asymmetric information on the probability of credit rationing. The data at the firm level include, along with selected individual characteristics, a variable asking for restrictions in innovative activities due to financial limitations. This variable is used as a proxy for credit rationing. Furthermore, given the industrial sector and other individual characteristics of the firm, plant size might be a valuable indicator for firm age. Finally, some business expectation variables allow for constructing a measure of informational asymmetry at the firm level.

This paper is structured as follows. Section 2 provides some stylized facts and evidence on the importance of asymmetric information for credit markets and for credit rationing. Section 3 introduces the model by Stiglitz and Weiss and stresses the effect of the age of firms. An econometric model for microdata is derived in section 4. It allows testing of the hypotheses on the importance of business relations and asymmetric information on the probability of facing financial constraints. The subsequent section discusses the results of estimations based on microdata supplied by the IFO Institute. The impact of credit rationing on the activities of firms is also sketched. The paper concludes with a summary of the main findings and an outlook upon areas of further research.

2 Some Empirical Evidence on Credit Rationing

Although the theoretic reasoning on credit rationing due to asymmetric information seems quite convincing, it is often argued that the phenomenon lacks empirical relevance. While it might be difficult to measure the effects of asymmetric information directly (see section 4 for an empirical approach), there are several observational facts which indicate the empirical relevance of credit rationing:

- The rate of insolvencies of firms in manufacturing in the FRG amounted to 1.2 to 6 percent per year during the 1970s and 1980s (cf. Statistisches

Bundesamt, Wiesbaden, Fachserie 2, Reihe 4.1 Insolvenzverfahren). Thus, insolvency of a firm is not a rare exception to the rule. Even large firms had to admit financial difficulties (e.g. Metallgesellschaft).

- On the supply side of the credit market, banks write off doubtful loans or extend them in order to avoid loan default. Loan write-offs in banks' balances grew from 1.627 billion DM in 1970 to 16.740 billions in 1990 (cf. Monatsberichte der Deutschen Bundesbank, Tabelle IV 27 c)). This is nearly three times as much as the profit balance and still twice as much as the gross balance of the banking sector in 1990.
- The effects of adverse selection become most evident for consumer loans. The proportion of "bad" debtors is highest for the creditors demanding the highest interest rates. In order to reduce the resulting danger of encumbrance of private households, Switzerland introduced interest ceilings. They are fixed at 19 percent at the federal level and at only 15 percent for the Kanton Zürich (see Neue Züricher Zeitung, March 20, 1993).
- The fact that larger enterprises attempt to transform riskier parts of the firm into independent units of liability can be interpreted as an adverse incentive effect. As a result, projects which were secured by other projects in a large enterprise become small, risky projects with high return expectations and high default risk. Examples of this kind are exploration firms and R&D companies.

The phenomenon of credit rationing is no chimera but as real as the rationing on labour markets, i.e. "unemployment". The survey data at the firm level of the IFO Institute for economic research, Munich, provide further evidence. Table 1 shows the proportion of firms impeded in their innovative activities by missing external or internal funds. The figures were obtained from Penzkofer, Schmalholz und Scholz (1989, pp. 56-60), aggregating over innovating and not innovating firms for the last two columns. In the questionnaire, the problem of too low expectations of future returns on innovations was captured by other questions. Assuming that innovations and investments are closely related the relevance of credit rationing becomes evident.

Early attempts to explain the empirical evidence of credit rationing were based on institutional reasons (cf. Jaffee (1971)). In fact, until February 5, 1965 interest rates on loans were linked to the "Lombardsatz" of the Bundes-

Table 1: Impediments to Innovations 1982–1986

Year	Firms without innovative activities		All firms	
	Missing external funds	Missing internal funds	Missing external funds	Missing internal funds
1982	17.0%	50.4%	8.0%	35.1%
1983	8.0%	33.4%	5.3%	24.5%
1984	18.4%	50.6%	7.0%	29.1%
1985	21.4%	57.4%	7.1%	28.9%
1986	18.0%	44.1%	6.0%	25.4%

bank; short term loans were linked until April 1, 1967 (See Zimmermann-Trapp (1988), pp. 249ff). Today, there exist no such institutional reasons for credit rationing in the FRG. Therefore, other explanations for the observed facts have to be identified. Similar to the case of the labour market, the theory of asymmetric information promises meaningful results in explaining rationing on credit markets.

3 Theory of Credit Rationing

For this section, a micromarket of the credit market is defined by a group of firms which cannot be distinguished by the banks based on some observable characteristics. Then, the term credit rationing is used when at least on some micromarkets some firms can obtain a requested loan whereas others are rationed completely (in Keeton (1979), this type of rationing is defined as “true” rationing). It is quite easy to explain credit rationing if the interest rate on loans is subject to some institutional restrictions (Jaffee (1971)). One example was the regulation Q for the United States. It established ceilings on interest rates for different types of loans until the early 1980s. Apart from the development of secondary loan markets, the main effect of these regulations was excess demand for loans at the given interest rate. Given that in the FRG no such institutional restrictions existed during the last 20 years this argument will not be developed further.

The more recent literature on credit rationing stresses the argument of incomplete or asymmetric information (cf. Jaffee and Stiglitz (1990) and

the literature cited therein). It is supposed that creditors do not dispose of the same information as do debtors. A central assumption is that potential debtors know the probability distribution of their projects' returns whereas the banks know only the aggregate distribution for all potential debtors. There are two reasons for creditors to ration the amount of granted loans rather than to increase the interest rate charged when there is excess demand for credits:

- Adverse selection
- Adverse incentives

In standard loan contracts, the bank's expected return depends on the interest rate charged and on the repayment probability. If the debtor becomes insolvent or goes bankrupt the repayment of the credit is smaller than the amount fixed by the loan contract. It is limited by the liability of the debtor. If for a group of potential debtors the mean of the repayment probability is given, the bank's expected return will decrease with a growing variance of the repayment probabilities. The opposite is true for the debtor. In the case of insolvency he cannot be forced to repay his debt completely. For a given expected gross return of his project his expected net return, i.e. the gross return minus the repayment to the bank, will increase with the variance of the gross returns.

3.1 Adverse Selection

It is assumed that out of a given fixed group of potential debtors individuals ask for credit depending on the interest rate charged. If a bank as a potential creditor increases its interest rate – possibly in reaction to changing conditions on the money market – the expected net return for debtors with relatively riskless projects, i.e. for debtors with a small positive expected net return at the old interest rate, will become negative. Therefore, they will no longer seek a loan. Consequently, the marginal debtor, i.e. the individual out of the given group with an expected net return of zero for the new interest rate, will have a higher risk leading to a lower repayment probability. Thus, an increase of the interest rate will lead to a decrease in the overall repayment probability for the individuals of the remaining credit requesting group. Eventually, a further increase in the interest rate will lead to a decrease in the bank's expected return. In other words, the share of "bad" debtors among the individuals in the group still asking for a loan will increase with the interest rate charged. An adverse selection takes place.

3.2 Adverse Incentives

A slight modification of the framework studied for the effects of adverse selection allows the firms a choice between different projects with differing risks. The banks now know the distribution of the risks over the projects but can neither observe the project chosen by a firm nor prescribe which project to choose. As the firm's expected net return from a loan contract increases with decreasing repayment probability given the expected gross return, an increase of the interest rate will give an incentive for the debtor to choose riskier projects in the sense described by Rothschild and Stiglitz (1970). The expected return to the creditor, which was to increase with the higher interest rate charged, might eventually decrease due to this effect working in the opposite direction. These incentives running counter to the banks' interests are called adverse incentives or "moral hazard".

3.3 The Stiglitz–Weiss Model

In this subsection a rather formal presentation of the basic model by Stiglitz and Weiss (1979, 1981) (cf. Blanchard and Fischer (1989), pp. 480ff) is presented. It is needed in the following subsection to examine the influence of the age and business relations of firms on rationed credit markets.

The model by Stiglitz and Weiss assumes a continuum of firms. Each firm disposes of exactly one project. This project might be thought of as an investment plan including several smaller projects. Then, the probability distribution of the returns to this aggregate project result from the common distribution for the smaller projects. In order to realize the project, an indivisible initial endowment of K units of capital is necessary. The own capital of each firm is given by $W < K$. The expected return of all projects is assumed to be equal and is denoted by R . If the project i succeeds its return is R_i^s . The return to a failed project is independent of the project and equal to R^f , which can be zero. Instead of the discrete outcomes a continuous distribution of returns R with $0 \leq R \leq R_{max} < \infty$ and corresponding density function $p(R)$ could be assumed. The qualitative results would not change but the formal complexity would increase considerably. Therefore, the version with discrete outcomes will be used for the exposition of the model. The probability of success of project i is given by p_i , and the distribution of p_i over the firms by the distribution function $F(p)$ with density $f(p)$.

In order to realize their projects, the firms have to borrow $B \equiv K - W$

units. This might be done with standard loan contracts at interest rate r . Diamond (1984) and Williamson (1986, 1987) show that standard loan contracts are the optimal way to raise funds under normal conditions. For every firm i it is supposed that

$$R_i^s > (1 + r)B > R^f. \quad (1)$$

The central assumption about asymmetric information is that every firm knows its probability of success p_i whereas the banks only know the distribution function $F(p)$ for a given group. In particular, it is impossible for the banks to distinguish the firms in a given group or micromarket with regard to their risk. Given a reasonable definition of the group or micromarket, this assumption seems compatible with reality.

The external funds come from identical, competitive, risk neutral and expected profit maximizing banks. Then, the expected net return of firm i is given by

$$E(\pi_i) = p_i(R_i^s - (1 + r)B). \quad (2)$$

For a given expected gross return the expected net return of firm i decreases with the success probability p_i of its project because (2) together with $R = p_i R_i^s + (1 - p_i)R^f$ leads to

$$E(\pi_i) = R - R^f - p_i((1 + r)B - R^f). \quad (3)$$

Consequently, firms with riskier projects will *ceteris paribus* accept higher interest rates on loans. If the entrepreneurs have the alternative to invest their initial endowment W in a secure asset, with rate of return ρ , they will prefer their investment project and ask for a loan as long as

$$E(\pi_i) \geq (1 + \rho)W. \quad (4)$$

Therefor, risk neutrality of the entrepreneurs has been assumed. The introduction of risk aversion for the entrepreneurs would not change the qualitative results. Thus, an increase in the interest rate charged r will *ceteris paribus* result in a higher risk of the marginal project, i.e. the project at which an entrepreneur is indifferent between undertaking it or choosing the secure asset. Let p^* be the success probability of the marginal project, i.e. $E(\pi_i) \geq (1 + \rho)W \iff p_i \leq p^*$. Then, it follows that $dp^*/dr < 0$. If the initial endowment W_i is not assumed to be fixed and equal for all firms and if it is supposed that the banks know only the expected value of W_i , it follows that $dW/dr < 0$, too. Consequently, as the interest rate increases, the fraction of internal capital in the marginal project will decrease.

Since only firms with a success probability of less than p^* will ask for a loan, the bank's expected return on a loan is given by

$$\begin{aligned} E(\pi_b) &= (1+r)B \frac{1}{F(p^*)} \int_0^{p^*} p f(p) dp + R^f \frac{1}{F(p^*)} \int_0^{p^*} (1-p) f(p) dp \\ &= ((1+r)B - R^f) \frac{1}{F(p^*)} \int_0^{p^*} p f(p) dp + R^f, \end{aligned} \quad (5)$$

where $F(p^*)$ is the fraction of firms demanding a loan at the given interest rate r .

The adverse selection effect formalized by the negative influence of the interest rate on the marginal success probability ($dp^*/dr < 0$) has consequences on the bank's expected return as well. Differentiating (5) with regard to r results in

$$\begin{aligned} \frac{dE(\pi_b)}{dr} &= B \frac{1}{F(p^*)} \int_0^{p^*} p f(p) dp + \\ &\quad ((1+r)B - R^f) \frac{1}{F(p^*)} \frac{dp^*}{dr} \left(p^* f(p^*) - f(p^*) \frac{1}{F(p^*)} \int_0^{p^*} p f(p) dp \right). \end{aligned} \quad (6)$$

Given the density function f there always exists an interest rate for which the positive effect of higher repayment commitments due to a further increase in the interest rate is overcompensated by the decrease in the repayment probability. A profit maximizing bank will charge r with $dE(\pi_b)/dr = 0$. As the "price" of loans will not immediately react to an excess demand, "true" credit rationing might occur.

The presented model oversimplifies the real world behaviour of credit markets. Nevertheless, some extensions of the basic model have shown that the main conclusion on credit rationing due to asymmetric information is rather robust (see, for example, Stiglitz and Weiss (1983) and Gertler (1992) who analyse a multi-period setting, and Gale (1989) who studies the influence of collateral on rationed credit markets).

3.4 The Age of Firms and Repayment Probabilities

This and the next section analyse the impact of business relations on rationed credit markets. The central argument is that the duration of business relations represents an additional screening device for the banks towards otherwise indistinguishable firms. It is shown that the distribution of the repayment probabilities depends on the age of the firms. Consequently, on

credit markets with an excess demand for loans “old” customers will have priority. In comparison to the solution without this additional information, the partial possible discrimination leads to an increase of both the interest rate and the transacted volume. However, some informational asymmetry between banks and customers will persist. In particular, firms with a high repayment probability will still be rationed on the credit market due to missing business relations, i.e. they will not obtain the requested loan. At the same time, firms with a comparably low repayment probability will receive loans because they managed to stay in the market and therefore in business relations for some time by chance. Thus, some groups of firms as defined by age and duration of business relations may still face rationing on the credit market.

3.5 A Simple Cohort Model

The considerations on the significance of business relations can be elucidated in a simple example. As in the Stiglitz and Weiss model the banks cannot distinguish between firms at the moment they ask for a loan for the first time. The only information the bank has on new customers is the distribution of the repayment probability over all those firms given by its density $f(p)$. It is assumed that in each period a continuum of new customers with the features described in section 3.3 comes to the bank. Furthermore, all the firms in the market in the previous period will again ask for a loan, except if they went bankrupt during the last period.

Due to the selection process over time, the repayment distribution for a given cohort of enterprises starting up business in the same period evolves over time. Firms with a low repayment probability have a high risk of leaving the market soon due to a bankruptcy occurring. As the probability to stay in the market for T years equals the probability to stay in the market for one year to the power T , after a few years the remaining members of a cohort will include a relatively low proportion of high risk firms.

Under these assumptions the density of the repayment probabilities for a group of new customers is given by $f(p)$, and a bank will choose its optimal interest rate for this group accordingly. For a cohort of firms which had business relations with the bank for one year the density becomes

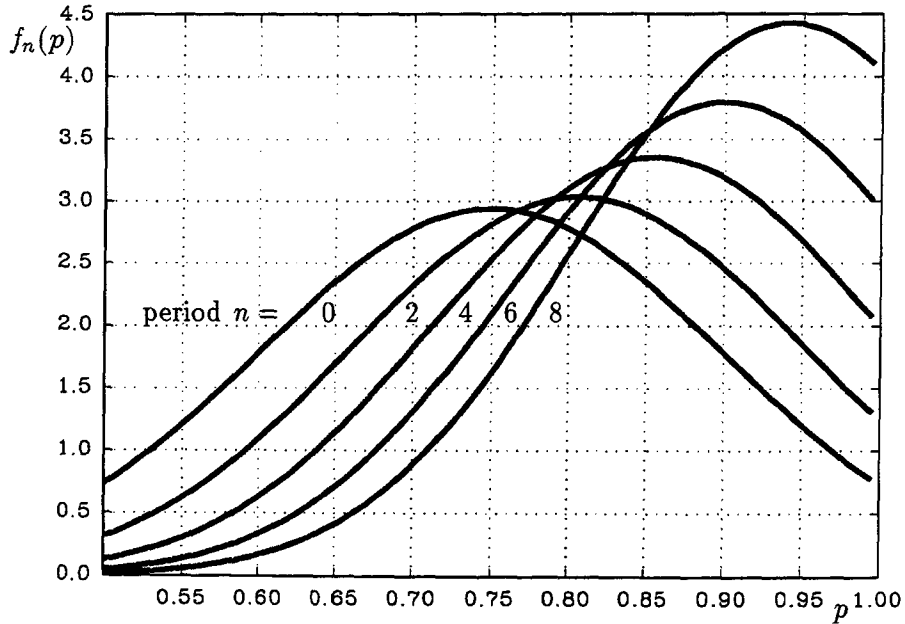
$$f_1(p) = \frac{f(p)p}{\int_0^1 f(p)p dp} \quad (7)$$

and for firms with n periods of business relations

$$f_n(p) = \frac{f(p)p^n}{\int_0^1 f(p)p^n dp}. \quad (8)$$

Figure 1 demonstrates how the repayment distribution evolves for a given cohort of firms during their business relations with a bank. For the presented plot, $f(p)$ was chosen as a curtailed normal density on $[0.5, 1]$ with mean 1 and standard deviation 0.15. As can be seen clearly, the fraction of low risk firms increases whereas the fraction of high risk firms (p close to 0.5) decreases rapidly. This obvious result of the simple model is supported by the empirical findings in Evans (1987a;1987b), Dunne, Roberts and Samuelson (1989), Preisendörfer, Schüssler and Ziegler (1989), and Audretsch (1991). However, the bank still has no possibility to discriminate firms within a given cohort.

Figure 1: Densities of repayment probabilities



It can be shown that the expected return out of credit to a firm in a cohort with longer lasting business relations is higher than of credit to a new customer. Using the model introduced in section 3, the expected return of

a credit to a new customer is given by equation (5) as

$$E(\pi_b) = (1+r)B \frac{1}{F(p^*)} \int_0^{p^*} p f(p) dp + R^f \frac{1}{F(p^*)} \int_0^{p^*} (1-p) f(p) dp, \quad (9)$$

and to a firm with n years of business relations with the bank as

$$E_n(\pi_b) = (1+r)B \frac{1}{F_n(p^*)} \int_0^{p^*} p^{n+1} f(p) dp + R^f \frac{1}{F_n(p^*)} \int_0^{p^*} (1-p) p^n f(p) dp, \quad (10)$$

where p^* is defined as above by $R - R^f - p^*((1+r)B - R^f) = (1+\rho)W$ and F_n is the distribution corresponding to the density function f_n .

The proof of the following proposition is given in appendix A:

Proposition 3.1 *If $p^* > 0$, i.e. if there is a demand for loans at the given interest rate, then for all $n > 0$ $E_n(\pi_b) > E(\pi_b)$.*

4 Econometric Model

In order to undertake an empirical investigation of the impact of asymmetric information on credit markets several approaches are possible. An aggregate model can be constructed based on the theory of banks and firms (Winker (1994)). Then, hypotheses derived from the micromodel may be tested within this framework. This approach is most widely used in existing disequilibrium modeling. The reason for temporary disequilibrium or rationing states is ascribed to price rigidities due to adaptation costs or asymmetric information (for an econometric model for the goods and labour market of the FRG the reader is referred to Smolny (1993) and Franz and Heidbrink (1992); a rationing model of this type for the credit market of the UK can be found in Martin (1991)).

A main problem of disequilibrium models on the aggregate level is the measurement of the share of rationed individuals. For the labour market it is comparably easy to measure supply and demand separately since the figures for vacancies and unemployed are available. In order to quantify rationing on goods markets, spillovers on foreign markets can be considered. When there seems to be no possibility to measure the rationing directly, other effects related to rationing may be analysed. Quite often, rigidities of the price mechanism are studied for this purpose (applications to credit markets can be found in Kugler (1987), Scholnick (1991) and Winker (1993)).

A further problem of models on the aggregate level is the modeling of the impact of incomplete information. In principle, global measures for information inefficiencies can be derived. For the credit market, the rate of insolvencies is regarded as such a measure (cf. Stiglitz (1992) and Winker (1994)). However, such global measures can reflect the actual information structure at the firm level only to some extent.

Therefore, data at the firm level are used in this paper to test the hypotheses derived in the previous sections. Using such data it becomes possible to study the rationing probability of individual firms depending on their characteristics.

For the results presented in the sequel, only a small data set was at hand. It consists of results of the business cycle, investment and innovation tests of the IFO Institute in the years 1984 to 1986 for four selected industrial sectors. For all tests, only the last observation for each year was included in the sample. The estimation results presented in section 5 are based on the largest two sectors in the data: mechanical engineering with 858 and electrical engineering with 536 firms. It should be noted, however, that only for about a third of those firms results for all three tests were available.

The innovation test includes questions on impediments to innovative activities. Possible answers include "missing external funds" (*MEF*) and "missing internal funds" (*MIF*) which are used to proxy credit rationing (*RAT*). Two possible problems have to be taken into account. Firstly, a variable measuring financial limitations for innovative activities might not reflect the financial situation of the whole firm one to one. As the IFO Institute asked for financial limitations only within this context, there seems to be no possibility to avoid this approximation, which might be admissible since innovative activities and investment decisions are closely linked. Furthermore, the differentiation between rationing due to missing external or internal funds is questionable in particular for small firms; quite often firms are denied a loan because of missing own capital. Whether a firm will describe this state as rationing by missing internal funds rather than by missing external funds is not obvious (for the sector mechanical engineering, all firms stating rationing due to missing external funds feel also rationed due to missing internal funds). Hence, the empirical analysis is based on both rationing variables as well as on a variable indicating either missing external or internal funds (*MF*).

In order to test the hypotheses derived in the previous section, the explanatory variables of central interest are the age of the firm and measures for the informational asymmetry between the firm and the banks. Unfortu-

nately, the age of the firms is not contained in the data set. Instead, there are variables for the number of employees for the firm (*FE*) or for a single plant (*PE*). Given the industrial sector, it might be assumed that *FE* is a good proxy for the age of the firm in the sense that firms starting up business are comparably small (cf. Audretsch (1991); Dunne, Roberts and Samuelson (1989); Evans (1987a, 1987b)). In addition to proxying the age of firms *FE* contains information on the risk of the firms due to diversification in larger firms.

A main advantage of the data set provided by the IFO Institute lies in the fact that it includes not only past and actual realizations of several variables, but as well the expectations of the firms on important variables. For the purpose of this paper, the business prospects of the firms are used as valuable indicators. It is assumed that the banks have good information about the current business prospects of the firms, whereas they know less about the expectations of future developments at the firm level; they might have merely some ideas about the future development for the whole sector. Then, an informational asymmetry results if a firm expects improving business prospects ($IBP = 1$). This might induce credit rationing due to missing discrimination between firms with improving and stable or worsening expectations. *Ceteris paribus*, the risk to be rationed on the credit market should be correlated positively with *IBP* (a concurrent effect is described in the model of Jovanovic (1982) if firms need some time to learn about their real efficiency).

While the variables indicating financial limitations are related to the current period, *IBP* measures changing expectations with regard to future periods. The horizon for the relevant question in the business cycle test is given as 6 months. Although there is no possibility to assure that the answers of the firms are really related to a period of 6 months, it can be assumed that the variable *IBP* in fact expresses expectations about a future change in the business prospects.

In order to control for cyclical effects the degree of capacity utilization (*DUC*) from the business cycle test is added. A further interesting variable would be the capital intensity of the firm which should have a positive influence on the risk of being rationed on the capital market (cf. Audretsch (1991)). Unfortunately, this variable is not contained in the IFO questionnaire. Table 2 provides means and standard deviations of the variables for the sectors mechanical engineering (*ME*) and electrical engineering (*EE*).

Table 2: Descriptive Statistics for the Used Variables^{a)}

		Mechanical engineering		Electrical engineering	
	Scale	\bar{x}	σ_x	\bar{x}	σ_x
<i>MEF</i>	share	0.026	0.160	0.027	0.164
<i>MIF</i>	share	0.185	0.389	0.129	0.335
<i>MF</i>	share	0.185	0.389	0.132	0.338
<i>FE</i>		1410.185	4486.712	5676.547	24781.631
$\ln FE$	logarithmic	2.642	0.651	2.817	0.799
<i>IBP</i>	share	0.194	0.396	0.192	0.394
<i>DUC</i>	percent	84.47	18.50	81.92	16.32
$\ln DUC$	logarithmic	1.903	0.207	1.892	0.200
$\ln IE$	logarithmic	2.980	0.773	3.216	0.968

a) $\ln DUC$ is the natural logarithm of the degree of capacity utilization, $\ln FE$ the logarithmic number of employees in the firm and $\ln IE$ the logarithm of the innovation expenditures.

The following modeling of credit rationing is obtained:

$$RAT = f(SI, IBP, DUC),$$

where SI is a measure of firm size reflected by $\ln FE$ or size dummies FE_1, \dots, FE_5 for firms with less than 50, 50–199, 200–499, 500–999 and more than 999 employees, respectively.

As a natural consequence of this modeling the question about the effects of credit rationing on the innovative activities or investment decisions of the firms arises. The limited number of observations available for all three tests prevented an analysis of the investment behaviour, whereas for the innovations (IE) at least a simple ad hoc specification seems possible:

$$IE = g(RAT, DUC, X),$$

where X contains further relevant explanatory variables for the innovative activities.

5 Results of Estimations

As the rationing indicators are qualitative data adequate econometric methods have to be used. The data provided by the IFO Institute allow for pooled

sector estimations. Furthermore, the data exhibit a panel structure since some of the firms are interviewed repeatedly. Unfortunately, the subset of data available for the presented analysis contained only a small number of repeated observations for the same firm. Thus, the use of panel estimators was not yet possible. Therefore, the estimations were restricted to pooled sector regressions. For the model presented in the previous section, logit estimators were used for qualitative dependent variables.

Tables 3 and 4 report the essential results of the estimations for the different rationing indicators using the size dummies FE_1, \dots, FE_5 as size indicators. The few firms, which report that no innovative activities were required for the current period, were excluded from the sample. The t -values for the estimated coefficients are included in parentheses.

Table 3: Logit Estimation of Credit Rationing (Mechanical Engineering)

	dependent variable					
	missing external funds		missing internal funds		missing funds ^{a)}	
Constant	-1.981 (-3.71)	-2.101 (-3.86)	-0.305 (-0.87)	-0.355 (-1.00)	-0.305 (-0.87)	-0.355 (-1.00)
FE_2	-1.154 (-1.64)	-1.223 (-1.73)	-0.277 (-0.69)	-0.305 (-0.76)	-0.277 (-0.69)	-0.305 (-0.76)
FE_3	-2.079 (-2.33)	-2.138 (-2.39)	-1.225 (-2.87)	-1.251 (-2.92)	-1.225 (-2.87)	-1.251 (-2.92)
FE_4	-0.963 (-1.49)	-1.040 (-1.60)	-1.042 (-2.59)	-1.078 (-2.66)	-1.042 (-2.59)	-1.078 (-2.66)
FE_5	-2.982 (-2.62)	-3.046 (-2.67)	-2.187 (-4.64)	-2.218 (-4.69)	-2.187 (-4.64)	-2.218 (-4.69)
IBP	—	0.772 (1.51)	—	0.404 (1.54)	—	0.404 (1.54)
Likelihood Ratio χ^2	11.963 (0.018)	14.035 (0.015)	41.670 (0.000)	43.957 (0.000)	41.670 (0.000)	43.957 (0.000)

- a) Since all firms reporting missing external funds also report missing internal funds for the sector mechanical engineering, the results in columns 3 and 4 coincide with those in the last two columns.

For both sectors, a highly significant effect of firm size as a proxy for

Table 4: Logit Estimation of Credit Rationing (Electrical Engineering)

	dependent variable					
	missing external funds		missing internal funds		missing funds	
Constant	-2.079 (-2.77)	-2.079 (-2.77)	-1.253 (-2.21)	-1.253 (-2.21)	-0.956 (-1.82)	-0.956 (-1.82)
FE_2	-0.086 (-0.10)	-0.577 (-0.63)	0.710 (1.15)	0.577 (0.92)	0.413 (0.71)	0.279 (0.47)
FE_3	-3.466 ^a (-2.77)	-4.019 ^a (-3.05)	-1.050 (-1.36)	-1.251 (-1.59)	-1.347 (-1.81)	-1.548 (-2.04)
FE_4	-3.466 ^a (-2.77)	-4.019 ^a (-3.05)	-0.784 (-1.17)	-0.981 (-1.43)	-1.081 (-1.70)	-1.278 (-3.44)
FE_5	-3.466 ^a (-2.77)	-4.019 ^a (-3.05)	-2.005 (-2.76)	-2.116 (-2.89)	-2.303 (-3.31)	-2.414 (-3.44)
IBP	—	1.543 (2.01)	—	0.618 (1.54)	—	0.618 (1.54)
Likelihood Ratio χ^2	19.672 (0.000)	23.521 (0.000)	40.192 (0.000)	42.488 (0.000)	41.647 (0.000)	43.943 (0.000)

a) Since only one of the firms with more than 199 employees reported missing external funds the coefficients for FE_3 , FE_4 and FE_5 had to be restricted to equality in this equation.

the age of firms can be found. The larger a firm became, the lower is ceteris paribus the risk of financial limitations. An inverse effect is found for IBP indicating changes in business prospects expectations and serving as a proxy for asymmetric information. Informational asymmetry between firms and banks leads to an increase of the risk of the firms to be limited by available funds.

If instead of the four dummy variables FE_2, \dots, FE_5 the logarithm of the number of employees in the firm ($\ln FE$) is included in the estimation the qualitative results do not change. For the sector electrical engineering the business cycle indicator DUC becomes also significantly positive indicating that the risk of credit rationing rises ceteris paribus with a higher rate of capacity utilization, i.e. when the firm approaches its supply constraint.

Then, the firms have stronger incentives to invest and to innovate. The corresponding estimation results are given in table 5.

Table 5: Logit Estimation of Credit Rationing

sector	dependent variable					
	missing external funds		missing internal funds		missing funds	
	EE	ME	EE	ME	EE	ME
Constant	-1.764 (-1.25)	-1.897 (-1.59)	-0.575 (-0.65)	0.891 (1.35)	-0.412 (-0.47)	0.891 (1.35)
$\ln FE$	-3.267 (-3.76)	-0.737 (-1.89)	-1.327 (-4.47)	-0.858 (-4.44)	-1.385 (-4.65)	-0.858 (-4.44)
<i>IBP</i>	1.671 (2.06)	0.437 (0.70)	0.853 (2.15)	0.460 (1.56)	0.818 (2.06)	0.460 (1.56)
<i>DUC</i>	0.061 (2.66)	0.003 (0.20)	0.023 (2.09)	-0.003 (-0.42)	0.023 (2.13)	-0.003 (-0.42)
Likelihood Ratio χ^2	26.633 (0.000)	4.135 (0.247)	28.620 (0.000)	27.922 (0.000)	30.665 (0.000)	27.922 (0.000)

The overall impression of the estimation results is in accordance with the hypotheses derived from the theory of asymmetric information. Nevertheless, more detailed and even more conclusive results probably can be obtained for a larger data sample allowing the use of panel estimators.

As a consequence of the limited data sample, the following results on the impacts of credit rationing on the innovative activities of firms should be considered as preliminary. In principle, the data of business cycle, investment and innovation tests allow for the analysis of the impact of financial limitations on the decisions of firms over time. Unfortunately, due to the small sample this is not possible yet.

Consequently, the study was restricted to the impact on the innovative activities of the current period. It should be noted that the information of firms about their innovative expenditures is subject to a higher error probability than statements on their employment. The following simple log-linear estimation was used for the innovative expenditures because a

multiplicative influence of rationing was supposed:

$$\ln IE = \alpha_1 + \alpha_2 \ln FE + \alpha_3 \ln DUC + \alpha_4 RAT ,$$

where $\ln IE$ stands for the logarithm of innovative expenditures, $\ln FE$ for the logarithm of the number of employees in the firm, $\ln DUC$ for the logarithmic degree of capacity utilization and RAT for the rationing indicators. Table 6 provides the essential results of the estimations.

Table 6: Impact of Credit Rationing on Innovation Expenditures

sector	log. innovation expenditures $\ln IE$					
	EE	ME	EE	ME	EE	ME
Constant	-0.022 (-0.07)	-0.453 (-1.71)	0.009 (0.03)	-0.432 (-1.62)	0.009 (0.03)	-0.432 (-1.62)
$\ln DUC$	0.481 (2.63)	0.758 (5.07)	0.470 (2.56)	0.770 (5.14)	0.467 (2.54)	0.770 (5.14)
$\ln FE$	0.834 (16.15)	0.751 (15.781)	0.835 (15.95)	0.741 (15.34)	0.836 (15.86)	0.741 (15.34)
MEF	-0.535 (-1.96)	0.241 (1.35)	-	-	-	-
MIF	-	-	-0.194 (-1.59)	-0.060 (-0.80)	-	-
MF	-	-	-	-	-0.173 (-1.43)	-0.060 (-0.80)
\bar{R}^2	0.642	0.536	0.640	0.535	0.639	0.535
SEE	0.585	0.527	0.587	0.528	0.587	0.528

As could be suspected, innovative activities increase with firm size. However, the elasticity of innovation expenditures with respect to employment is significantly less than 1, indicating that small firms *ceteris paribus* feature higher innovation expenditures per employee. Another interesting result is the positive influence of the business cycle indicator DUC . The cyclical situation has two possible effects on innovation working in opposite directions. First, intertemporal substitution between innovative activities and production might lead to an anticyclical effect. Second, the demand expectations depend positively on the current business situation inducing a procyclical development of innovation expenditures. The estimation results indicate

that the second effect dominates. Furthermore, the impact of credit rationing has the expected negative sign in five of six equations, although it is only significant for missing external funds in the sector electrical engineering. However, the effect is very strong in this case, indicating a bisection of the innovative activities if *ceteris paribus* external funds are not available. These preliminary results call for further research on the impact of financial limitations on the activity of firms.

6 Conclusion

Contrary to most empirical work on credit rationing (one exception is Berger and Udell (1992) using microdata on loans), a microeconomic method was used in this paper to assess the relevance and impact of credit rationing at the firm level. The main advantage of this approach is that rationing of individual firms can be explained by individual characteristics of the firms including asymmetric information.

The model of Stiglitz and Weiss was used to demonstrate the impact of the age and business relations of firms on the probability of being rationed on the credit market. Furthermore, the microdata of the IFO Institute allowed for constructing a variable closely correlated with the informational asymmetry between the firm and its possible creditors.

The empirical results confirm the impact of these variables, although a limited sample does not allow final conclusions yet. *Ceteris paribus*, older firms face a lower risk of being rationed on the credit market, whereas asymmetric information due to changing business expectations will increase this risk.

The answers of the firms on the question about impediments to innovation allow the conclusion that credit rationing is a relevant phenomenon for the German credit market. Furthermore, the impact of financial limitations on the activities of firms lead to the deduction that rationing on credit markets might be another monetary transmission mechanism.

It will be the subject of further research with an enlarged data set and on an aggregate level to assess the quantitative importance of credit rationing. With a sample including more observations it will become possible to include firm specific effects by means of panel estimation methods.

Appendix

A Proof of Proposition 1

Let \tilde{f} and \tilde{f}_n be given by

$$\tilde{f}(p) = \frac{1}{F(p^*)} f(p)$$

and

$$\tilde{f}_n(p) = \frac{1}{F_n(p^*)} p^n f(p)$$

on $[0, p^*]$. \tilde{f} and \tilde{f}_n are densities, i.e.

$$\int_0^{p^*} \tilde{f}(p) dp = \int_0^{p^*} \tilde{f}_n(p) dp = 1. \quad (11)$$

Furthermore, $\tilde{f}(0) = \tilde{f}_n(0) = 0$ by definition. Setting $C_n = F(p^*)/F_n(p^*)$ and $\epsilon = \min \{ \sqrt[n]{\frac{1}{C_n}}, p^* \}$ one obtains

$$\tilde{f}_n(p) < \tilde{f}(p) \text{ for all } p \in [0, \epsilon[. \quad (12)$$

From equation (11) it follows the existence of $p_0 \in]0, p^*[$ with $\tilde{f}_n(p_0) = \tilde{f}(p_0)$; hence, $C_n p_0^n f(p_0) = f(p_0)$ and finally

$$\tilde{f}_n(p) > \tilde{f}(p) \text{ for all } p \in]p_0, p^*[.$$

In particular, p_0 is unique, and again with equation (11) it follows

$$-\int_0^{p_0} (\tilde{f}_n(p) - \tilde{f}(p)) dp = \int_{p_0}^{p^*} (\tilde{f}_n(p) - \tilde{f}(p)) dp.$$

Due to the monotony of the integral operator one obtains

$$-\int_0^{p_0} p(\tilde{f}_n(p) - \tilde{f}(p)) dp < \int_{p_0}^{p^*} p(\tilde{f}_n(p) - \tilde{f}(p)) dp,$$

and with $(1+r)B > R^f$ the proposition $E_n(\pi_b) > E(\pi_n)$ results for $n \geq 1$ and $p^* > 0$. \square

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