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## Causes and effects of financing constraints at the firm level: Some microeconomic evidence

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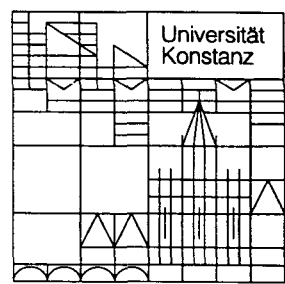
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**Sonderforschungsbereich 178**  
**„Internationalisierung der Wirtschaft“**

Diskussionsbeiträge



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wissenschaften und Statistik

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Peter Winker

**Causes and Effects of  
Financing Constraints at the Firm Level**  
Some Microeconomic Evidence

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**Causes and Effects of Financing Constraints  
at the Firm Level**

**Some Microeconomic Evidence<sup>1</sup>**

**Peter Winker**

Serie II - Nr. 292

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## Abstract

Asymmetric information between lender and borrower is made responsible for financing constraints at the firm level which may influence real activity. In this paper a standard model of credit rationing due to adverse selection and adverse incentive effects is used to derive hypotheses on causes of financing constraints.

Firms' age and size are among the factors which should influence availability of information and hence the probability of financing constraints. Furthermore, changing business prospects might strengthen the degree of informational asymmetry between firms and banks.

The main contribution of this paper is an econometric analysis of the derived hypotheses using German firm panel data. Both, hypotheses on the causes of limited access to the loan market and its effects on investment and innovative activities are tested. The estimation is based on microdata of the ifo institute for economic research, Munich. Neither the influence of asymmetric information on financing constraints nor their real effects can be rejected by the data.

# 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, for instance in the so called “availability doctrine”, 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. Then, it can be shown that the interest rate on loans influences the probability of loan repayment due 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. Consequently, 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 (1985) 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 some firm specific characteristics such as age, size, business relations with banks or business prospects for the degree of informational asymmetry. In particular, it will 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.

Firm panel data for the German manufacturing sector supplied by the ifo institute for economic research, Munich, offer the opportunity to test some of the derived hypotheses on the impact of business relations and asymmetric information on the prob-

ability of facing financial constraints. Moreover, real effects of financing constraints can be assessed directly.

The data for 1586 firms or operational units and the time period 1982 – 1991 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 direct 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 financial constraints. Section 3 gives a short sketch of the model by Stiglitz and Weiss (1981) 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 direct impact of credit rationing on the activities of firms is also estimated. The paper concludes with a summary of the main findings and an outlook upon areas of further research.

## **2 Stylized Facts on the Impact of Asymmetric Information**

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 indicating the empirical relevance of asymmetric information and its influence on the loan supply:

- The rate of insolvencies of firms in manufacturing in the FRG amounted to 0.8 to 3.3 percent per year during the 1970s, 1980s and early 1990s (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).
- Information problems are possibly more pronounced for newly founded enterprises on emerging markets. Thus, it is not too surprising that enterprises founded in 1990 in East Germany report financial constraints in 1994. However, the proportion of 49.2% given by the Deutsche Ausgleichsbank (1995) is impressive, and the fact that the firms with the highest growth rates are the most likely to face financial constraints accentuates the importance of this phenomenon.

The phenomenon of credit rationing is no chimera but as real as the rationing on labour markets, i.e. “unemployment”, as the survey data at the firm level of the ifo institute for economic research, Munich, exhibit. Table 1 shows the proportion of firms impeded in their innovative activities by missing external or internal funds. Realizing the important contribution of innovations for future growth and the close relationship between innovations and investments the relevance of financing constraints becomes evident.

Table 1: Impediments to Innovations 1982–1991

Year	Missing external funds	Missing internal funds	Missing funds (sum)
1982	8.20%	34.62%	35.08%
1983	4.32%	27.05%	27.05%
1984	5.06%	28.54%	28.54%
1985	6.05%	29.15%	29.60%
1986	5.33%	28.12%	29.23%
1987	5.00%	25.58%	25.96%
1988	3.85%	22.20%	22.75%
1989	4.37%	19.28%	19.48%
1990	3.31%	19.63%	20.04%
1991	14.39%	31.76%	32.51%

### 3 Theory of Credit Rationing

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 the returns of their own projects whereas the banks know only the aggregate distribution for all potential debtors in a specific group. 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 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. On the other side, in the case of insolvency the debtor 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 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 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, which might be attributed to unrevealable information.

### **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". They might be also described as effects of hidden action.

### **3.3 The Stiglitz–Weiss Model**

In this subsection a rather formal presentation of the basic model by Stiglitz and Weiss (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 owner's equity 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 equal to  $R^f$ , which can be zero. 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) 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 between 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  $\rho$ , they will prefer their investment project and ask for a loan as long as

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

Therefore, 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

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

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

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

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.

### 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. 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

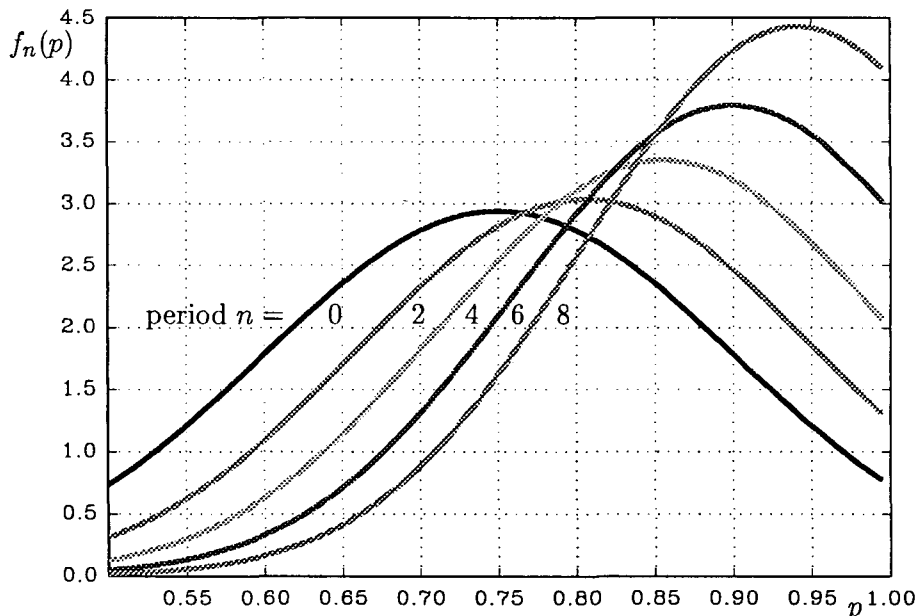
$$f_n(p) = \frac{f(p)p^n}{\int_0^1 f(p)p^n dp}. \quad (8)$$

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 (1987), Dunne, Roberts and Samuelson (1989), and Audretsch (1991). However, the bank still has no way of discriminating between firms within a given cohort.

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

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

Figure 1: Densities of repayment probabilities



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

$$\begin{aligned}
 E_n(\pi_b) = & (1+r)B \frac{1}{F_n(p^*)\kappa_n} \int_0^{p^*} p^{n+1} f(p) dp \\
 & + R^f \frac{1}{F_n(p^*)\kappa_n} \int_0^{p^*} (1-p)p^n f(p) dp,
 \end{aligned} \tag{10}$$

where  $p^*$  is defined as above by  $R - R^f - p^*((1+r)B - R^f) = (1+\rho)W$ ,  $F_n$  is the distribution corresponding to the density function  $f_n$  and  $\kappa_n \equiv \int_0^1 f(p)p^n dp$  for  $n \in \mathbb{N}$ .

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 Modeling

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 (1995b)). 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 (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. If 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 (examples of applications to the German credit market are Kugler (1987) and Winker (1995a)).

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 an indicator for information lacking at the aggregate level (cf. Stiglitz (1992) and Winker (1995b)). 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 as well as the impact on their investment decisions and innovation expenditures.

#### 4.1 The ifo firm panel data

The data set used for the empirical analysis in this paper consists of observations out of the business cycle, investment and innovation tests of the ifo institute for economic research, Munich (cf. Oppenländer and Poser (1989) for a general description of the surveys and the data gathering and Schneeweis and Smolny (1996) for a detailed description of the dataset). Annual data for the time period 1981 – 1991 are available for 1586 firms or plants in manufacturing which participated at least once in all three business surveys and still existed in 1988 (cf. appendix B for a list of industrial sectors and their weights in the dataset).

The data for 1981 could not be used for the analysis as the central question on financing constraints was not yet included in the same way as in the following years. Furthermore, the observations for those firms and time periods when no innovation activities were required for the current period, were excluded from the sample. Finally, missing observations reduce the number of available observations to 4997 out of the maximum possible number of 15860. There are three main sources for missing observations: firms leaving the panel, new firms entering the panel and missing willingness of the firms to answer to all questions (or even to fill in the questionnaire) for some waves.

The innovation test contains a question on principal impediments to innovative activities. Possible answers include “missing external funds” (*MEF*) and “missing internal funds” (*MIF*) which are used to proxy financing constraints (*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 way of avoiding this approximation, which might be admissible since innovative activities and investment decisions are closely linked and in section 5 financing constraints dummies are found to have a strong impact on real activity.

Furthermore, the differentiation between missing external or internal funds is questionable in particular for small firms; quite often firms are denied a loan because of missing equity. Whether a firm will describe this state as rationing by missing internal funds rather than by missing external funds is not clear. 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. Unfortunately, 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. 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 (1987)). In addition to proxying the age of firms,  $FE$  contains information on the risk of the firms due to diversification in larger firms, on its equity base, and on its legal form. In some specifications a diversification dummy ( $DIV$ ) controls for multi product firms.

A main advantage of the data set provided by the ifo institute is 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. Using such information on the actual and expected business situation of the firms an additional indicator can be constructed to identify those firms which probably face a higher degree of informational asymmetry and consequently a higher risk of being rationed. The banks may have good information about the current business situation of the firms ( $CB$ ) and on the expected development for a group of firms such as an industrial sector. However, individual firms may know better their business prospects ( $BP$ ). It may be difficult for banks to consider this information as firms with negative expectations ( $BP_{\downarrow}$ ) have no incentives to report their true expectations to the banks. Fortunately, the anonymous firm level data of the ifo institute seem not to be subject to these incentives, as the expectations expressed in the questionnaire show a high degree of consistence over time.

Assuming that firms expecting an improvement of their business situation ( $BP_{\uparrow}$ ) show a higher propensity to ask for credits or to ask for higher credits, this might induce a higher risk of credit rationing due to missing discrimination between firms with improving and stable or worsening expectations. Ceteris paribus, the risk of being rationed on the credit market should be correlated positively with improving business expectations.

In order to control for cyclical effects the degree of capacity utilization ( $Q_{-1}^{100}$ ) from the business cycle test is added. As many firms report degrees of capacity utilization

larger than 100 percent, the variable is censored at 100 percent and a dummy variable ( $Q_{-1}^{>100}$ ) for full utilization of capacities is generated. Table 2 provides means and standard deviations of the variables.

Table 2: Descriptive Statistics for the Used Variables

Variable		Scale	$\bar{x}$	$\sigma_x$
miss. external funds	$MEF$	share	0.047	0.212
miss. internal funds	$MIF$	share	0.214	0.410
missing funds	$MF$	share	0.218	0.413
employees in firm	$\log FE$	log.	2.494	0.695
< 50 employees	$SK_1 = 1$	share	0.121	0.326
50 – 199 employees	$SK_2 = 1$	share	0.275	0.446
200 – 999 employees	$SK_3 = 1$	share	0.384	0.486
good business sit.	$CB^+$	share	0.203	0.403
bad business sit.	$CB^-$	share	0.165	0.371
improving bus. sit.	$BP \nearrow$	share	0.094	0.292
worsening bus. sit.	$BP \searrow$	share	0.114	0.318
capacity utilization	$Q_{-1}^{100}$	percent	83.162	12.813
full cap. utilization	$Q_{-1}^{>100}$	share	0.028	0.164
investment ratio	$IQ$	share	0.051	0.066
lagged invest. ratio	$IQ_{-1}$	share	0.050	0.064
innovation ratio	$INQ$	share	0.030	0.052
diversification	$DIV$	share	0.684	0.465

## 4.2 Models for Causes and Effects of Financing Constraints

Based on the arguments given in section 3 the following modeling of the indicator variables for financial constraints ( $RAT$ ) is obtained

$$RAT = f(SI, BP, Q_{-1}, X), \quad (11)$$

where  $SI$  is a measure of firm size reflected by  $\log FE$  or size dummies  $SK_1, \dots, SK_4$  for firms with less than 50, 50–199, 200–999 and more than 999 employees, respectively,  $BP$  captures business prospects,  $Q_{-1}$  controls for business cycle effects and  $X$  includes other control variables such as industrial sector, year or diversification.

As the information about financing constraints in the data set is qualitative, limited dependent variable models such as Probit estimation have to be used for the estimation of equation (11).

The impact of financing constraints on investment behaviour and innovative activities is tested following the approach by Fazzari, Hubbard and Petersen (1988), Hoshi,



Kashyap and Scharfstein (1991), Blundell, Bond, Devereux and Schiantarelli (1992), Elston and Albach (1995) among others. In these studies standard investment functions or models for R&D expenditures are augmented with variables proxying financing constraints such as firm size, cash flow or access to the capital market. Although the estimation of (11) will show a significant influence of such observable individual characteristics on the probability of facing financing constraints a large part of the variance remains unexplained. Consequently, using indirect indicators for financing constraints one risks biased estimation results or even spurious inference as discussed by Faroque and Ton-That (1995).

In contrast to the cited studies the available ifo data contain both information on financing constraints ( $RAT$ ) and on expenditures for innovation activities and investment. Thus, the “most favourable” (cf. Faroque and Ton-That (1995), p. 312) direct approach is feasible.

In order to control for the firm size the expenditure data have to be normalized. Unfortunately, the preferable normalization by value added or capital stock is not possible as these variables are not contained in the data set. Therefore, a normalization by sales had to be used.

The estimation equation for the ratio of innovation expenditures to sales ( $INQ$ ) is specified as

$$INQ = \alpha_0 + \alpha_1 RAT + \alpha_2 X + \varepsilon, \quad (12)$$

where  $X$  captures all other explanatory variables such as firm size, business prospects, sectoral dummies, mean of innovation ratio of the sector in a given year etc. As the variable  $INQ$  is left-censored by zero a Tobit model is estimated in contrast to most of the cited studies using OLS estimates.

The investment ratio ( $IQ$ ) is analyzed based on a dynamic model of the firm allowing for effects of rationing on goods and labour markets. The resulting equation to be estimated is given by

$$IQ = \beta_0 + \beta_1 RAT + (\beta_2 + \beta_3 RAT) Q_{-1}^{100} + (\beta_4 + \beta_5 RAT) Q_{-1}^{\geq 100} + \beta_6 X + \varepsilon, \quad (13)$$

where  $X$  again captures all other explanatory variables. Apart from a level effect ( $\beta_1$ ) as for the expenditures for innovative activities, the model allows for the effect of financing constraints to depend on the degree of capacity utilization as expressed by  $\beta_3$  and  $\beta_5$ . For example, firms facing a low degree of capacity utilization may react stronger to financing constraints both for a cash flow effect and for lower expected future demand. Again, the estimation is performed as Tobit model due to the limited dependent characteristic of  $IQ$ .

## 5 Results of Estimations

### 5.1 Causes of Financing Constraints

Some results of the estimation of equation (11) for the causes of financing constraints are contained in tables 3 and 4. Except for the random effects specification (3) individual heterogeneity is controlled for only by the inclusion of sectoral and time specific means calculated for the exogeneous variables without the respective firm.

The dependent variable  $RAT$  is a dummy with value 1 if the firm faces a situation of financing constraints for the current period. Therefore, a positive coefficient for an explanatory variable indicates ceteris paribus a positive influence of this variable on the risk of being rationed by available funds. The  $t$ -values for the estimated coefficients are included in parentheses.

All three specifications in table 3 show a highly significant negative effect of firm size as a proxy for the age of firms. The larger a firm became, the lower is ceteris paribus the risk of facing financial limitations.

Current business situation ( $CB$ ) shows the expected effect as good current businesses reduce the rationing risk whereas bad current businesses tend to increase it. The reference category is defined by the firms considering their business situation as average.

An inverse effect is found for the future business prospects  $BP$  serving as a proxy for asymmetric information. If a firm expects an improvement of its business situation ( $BP \nearrow$ ) it has to face a higher risk of rationing compared to the reference category of firms expecting no change in their business prospects. This effect is not even compensated if the whole sector expects improving businesses. On the other hand, if a worsening is expected for the whole sector the financing limitations for a single firm become less binding ceteris paribus.

The business cycle indicator  $Q_{-1}^{100}$  is just slightly significant in specification (1) and becomes completely insignificant after controlling for individual heterogeneity in (3). The full utilization of capacities ( $Q_{-1}^{>100}$ ) seems to lower the risk of being rationed in specifications (1) and (2). Again, the results of (3) indicate that the variable captures also otherwise unobserved individual heterogeneity.

In specification (3) the potential problem of unobserved individual heterogeneity omnipresent in panel data econometrics was tackled by the estimation of a random effects model (cf. Chamberlain (1980), Buttler and Moffitt (1982)). The estimated coefficient  $\rho$  is large. However the Durbin-Wu-Hausman specification test (cf. Davidson and MacKinnon (1993), p. 389ff) indicates significance only at the 5% level but not at the 1% level. The qualitative results of (2) are confirmed with the sole exception of the already discussed effect of the full utilization of capacities. The increase in most of the parameter estimates is contributed to the fact that the standard deviation of the residuals is not normalized to 1 any more. Instead, the standard deviation is given by  $\sqrt{\rho^2 + 1} \approx 1.8$ .

In table 4 some further estimation results for (11) are given. Instead of the indicators

Table 3: Financing Constraints and Firm Size

	dependent variable: $MF$			
	Pooled Probit		Random Effects	
	(1)		(2)	(3)
Constant	-1.011 (-0.79)		-2.912 (-2.29)	-3.581 (-1.946)
$\log FE$	-0.588 (-14.77)	$SK_1$	0.993 (11.27)	1.586 (7.14)
		$SK_2$	0.742 (10.15)	1.270 (6.75)
		$SK_3$	0.282 (4.15)	0.578 (3.47)
$CB^+$	-0.266 (-4.40)		-0.264 (-4.39)	-0.265 (-2.77)
$\overline{CB^+}$	-0.255 (-0.66)		-0.231 (-0.60)	-0.369 (-0.68)
$CB^-$	0.229 (3.73)		0.230 (3.75)	0.181 (1.87)
$\overline{CB^-}$	0.211 (0.48)		0.242 (0.55)	0.363 (0.60)
$BP \nearrow$	0.249 (3.39)		0.224 (3.04)	0.279 (2.34)
$\overline{BP \nearrow}$	-0.087 (-0.15)		-0.067 (-0.12)	-0.600 (-0.73)
$BP \searrow$	-0.017 (-0.24)		-0.009 (-0.14)	0.052 (0.47)
$\overline{BP \searrow}$	-1.070 (-2.05)		-1.140 (-2.19)	-1.627 (-2.23)
$Q_{-1}^{100}$	0.002 (1.20)		0.001 (0.36)	-0.004 (-0.97)
$\overline{Q_{-1}^{100}}$	0.021 (1.40)		0.023 (1.51)	0.023 (1.06)
$Q_{-1}^{>100}$	-0.271 (-1.82)		-0.235 (-1.60)	0.008 (0.04)
$\rho$	-		-	1.508 (21.71)
Lik. Ratio $\chi^2$	577.291		534.327	1384.173
d.f.	46		48	49

$FE$  firm employment

$SK$  employment size classes

$CB/BP$  current and expected business situation

$Q_{-1}^{100}/Q_{-1}^{>100}$  degree of capacity utilization, dummy for full utilization of capacities

$\overline{XX}$  sectoral and time specific mean without analyzed firm

all specifications include dummies for industrial sector and time.

for the current and expected businesses dummy variables modeling the interaction of current and expected future business situation *CBS* are used. The first number in paranthesis indicates the current business situation (1 = good, 2 = average, 3 = bad) and the second number the business prospects. Thus, *CBS*(31) equals one for the firms with bad current businesses expecting an improvement for future periods. The significant positive coefficient for this variable confirms the insights of table 3: if business prospects change, banks will prefer to rely on the current state resulting in informational asymmetry and an increasing risk of rationing.

The dummy for multi product firms in specification (4) exhibits a significant negative coefficient indicating that diversification of production leads to a reduction of the risk perception by banks and hence to a reduced risk of facing financing limitations.

Although a clearcut distinction between financial limitations due to missing internal (*MIF*) or external funds (*MEF*) is difficult given the questionnaire data, in (6) and (7) only dummies for missing internal (*MIF*) or external (*MEF*) funds, respectively, are used as dependent variable. The significant negative effect of firm size persists as well as the effects of changing business prospects. However, for missing external funds the impact of firm size is smaller and the impact of the business prospects variable larger than for missing internal funds.

In order to assess the robustness of the results some specification tests with respect to the possible heteroscedasticity of the error terms, non random attrition and non random selection were performed. Although the hypothesis of heteroscedasticity with respect to some of the sector dummies and a partially non random selection could not be rejected, the estimation results of models correcting for these effects did not differ substantially from the ones presented in tables 3 and 4.

## 5.2 Effects of Financing Constraints

Table 5 summarizes the results of the estimation of equation (12). All specifications include wave specific time dummies to capture macroeconomic trends. In contrast to most of the above cited studies a pooled tobit estimator is used to take account of the left censored data. In (1) and (2) a parsimonious specification of equation (12) is used, whereas (3) and (4) in addition include the lagged endogenous variable and some of the explanatory variables for the financing constraints such as firm size dummies and dummies for changing business prospects.

For all specifications a highly significant negative influence of financing constraints on innovation expenditures is found. This effect remains significant even after including some explanatory variables for the rationing indicator. Therefore, it is not surprising that the effects on innovation expenditures found using the available direct information on financing constraints is larger than those reported in the literature using indirect approaches. In fact, the mean ratio of innovation expenditures to sales amounts to 4% in the whole sample and is reduced to 1.74% for the constrained firms. Hence, the innovation ratio is reduced by more than 30% due to financing constraints.

Table 4: Business Prospects and Missing Funds

	dependent variable			
	<i>MF</i>		<i>MIF</i>	<i>MEF</i>
	(4)	(5)	(6)	(7)
Constant	-0.698 (-0.65)	-0.716 (-0.67)	-0.636 (-0.59)	2.286 (1.36)
log <i>FE</i>	-0.562 (-13.75)	-0.586 (-14.64)	-0.580 (-14.49)	-0.356 (-5.57)
<i>CBS</i> (11)	0.036 (0.22)	0.032 (0.20)	-0.019 (-0.11)	-0.108 (-0.04)
<i>CBS</i> (12)	-0.334 (-3.17)	-0.324 (-3.07)	-0.315 (-2.98)	-0.115 (-0.62)
<i>CBS</i> (13)	-0.613 (-1.53)	-0.616 (-1.54)	-0.561 (-1.40)	-2.081 (-2.20)
<i>CBS</i> (21)	0.538 (3.32)	0.538 (3.32)	0.500 (3.07)	0.510 (1.98)
<i>CBS</i> (23)	0.245 (1.63)	0.248 (1.65)	0.270 (1.79)	0.419 (1.79)
<i>CBS</i> (31)	0.496 (2.14)	0.516 (2.23)	0.523 (2.26)	1.071 (3.39)
<i>CBS</i> (32)	0.436 (3.71)	0.432 (3.68)	0.433 (3.68)	0.598 (3.39)
<i>CBS</i> (33)	0.302 (2.23)	0.312 (2.30)	0.269 (1.98)	0.420 (2.03)
$Q_{-1}^{100}$	0.003 (1.48)	0.004 (1.85)	0.003 (1.65)	-0.001 (-0.31)
$\overline{Q}_{-1}^{100}$	0.014 (1.12)	0.013 (1.06)	0.012 (1.00)	-0.028 (-1.42)
$Q_{-1}^{\geq 100}$	-0.269 (-1.81)	-0.264 (-1.77)	-0.282 (-1.87)	-0.625 (-1.55)
<i>DIV</i> (100)	-0.133 (-2.75)			
Likelihood Ratio $\chi^2$ d.f.	601.601 47	594.053 46	590.957 46	210.295 42

*FE* firm employment

*CBS* changing business prospects

$Q_{-1}^{100}/Q_{-1}^{\geq 100}$  degree of capacity utilization, dummy for full utilization of capacities

$\overline{XX}$  sectoral and time specific mean without analyzed firm

*DIV*(100) dummy for multi product firms

Table 5: Effects of Financing Constraints on Innovation Expenditures

	dependent variable: $INQ$			
	Pooled Tobit			
	(1)	(2)	(3)	(4)
Konstante	0.0264 (6.722)	0.0312 (6.041)	0.0260 (4.633)	0.0264 (3.977)
$MF$	-0.0160 (-6.604)	-0.0139 (-5.695)	-0.0099 (-3.505)	-0.0085 (-2.936)
$INQ_{-1}$			0.4315 (21.363)	0.414 (20.267)
$\overline{INQ}$	0.6127 (10.292)	-0.2813 (-2.516)	0.2915 (4.094)	-0.1441 (-1.124)
sectoral dummies	without	with	without	with
firm size dummies	without	without	with	with
changing business prospect dummies	without	without	with	with
$\sigma$	0.0623 (83.281)	0.0614 (83.212)	0.0547 (66.188)	0.0542 (66.141)
Log-Likelihood	4428.2	4492.2	3121.2	3144.0

$MF$  dummy for financing constraints

$\overline{X\overline{X}}$  sectoral and time specific mean

$t$ -statistics in parenthesis

The large and highly significant effect of the lagged endogenous variable in specifications (3) and (4) points to the relevance of dynamic adjustment processes for innovation expenditures. The sectoral and time specific mean calculated without the value of respective firm loses importance as soon as sectoral dummies are included and becomes insignificant when other individual characteristics of the firm are included in the estimation. Hence, it might be concluded that  $\overline{INQ}$  mainly reflects heterogeneity at the sectoral level.

The results do not differ essentially if instead of the general financing constraints dummy a dummy for missing internal or missing external funds is used.

Table 6 summarizes the results of the estimation of equation (13) for the investment to sales ratio. Again, all specifications include wave specific time dummies to capture macroeconomic trends including wages and prices not available at the firm level. In (1) and (2) a parsimonious specification of equation (13) is used including variables for the degree of capacity utilization, the lagged endogenous variable and the sectoral and time specific mean of the endogenous variable. The variables  $Q_{-1}^{100}$  and  $Q_{-1}^{>100}$  are used with one lag in order to reduce a possible simultaneity bias. Specifications (3) and (4), in addition, include some of the explanatory variables for the financing constraints.

Again, a highly significant negative impact of financing constraints is found for

Table 6: Effects of Financing Constraints on Investment

	dependent variable: $IVQ$			
	Pooled Tobit			
	(1)	(2)	(3)	(4)
constant	-0.0058 (-0.562)	0.0356 (2.947)	0.0117 (1.038)	0.0569 (4.349)
$MF$	-0.0738 (-4.542)	-0.0759 (-4.672)	-0.0719 (-4.416)	-0.0728 (-4.480)
$Q_{-1}^{100}/100$	0.0209 (2.086)	0.0205 (2.013)	0.0032 (0.297)	0.0021 (0.193)
$Q_{-1}^{100}/100 \times MF$	0.0874 (4.449)	0.0901 (4.592)	0.0882 (4.484)	0.0898 (4.579)
$Q_{-1}^{>100}$	0.0210 (3.272)	0.0244 (3.798)	0.0193 (2.992)	0.0224 (3.476)
$Q_{-1}^{>100} \times MF$	-0.0481 (-2.493)	-0.0505 (-2.635)	-0.0516 (-2.684)	-0.0525 (-2.749)
$IVQ_{-1}$	0.3178 (17.890)	0.2943 (16.424)	0.3106 (17.494)	0.2875 (16.066)
$\overline{IVQ}$	0.6247 (10.865)	-0.0172 (-0.154)	0.6088 (10.501)	-0.0239 (-0.215)
sectoral dummies	without	with	without	with
firm size dummies	without	without	with	with
changing business prospect dummies	without	without	with	with
$\sigma$	0.0639 (87.398)	0.0633 (87.379)	0.0635 (87.399)	0.0629 (87.384)
Log-Likelihood	5049.1	5082.0	5072.8	5107.7

$MF$  dummy for financing constraints

$\overline{XX}$  sectoral and time specific mean

$t$ -statistics in parenthesis

the investment expenditures. Hence, it may be concluded that the possibly subjective assessment of financial constraints at the firm level is in fact closely connected to their real decisions; in other words: financial constraints do matter!

In contrast to the estimation results for the innovation expenditures a significant effect of the degree of capacity utilization is found for the investment to sales ratio. If firm size dummies and dummies for changing business prospects are included ((3) and (4)) only the positive effect of a full utilization of existing capacities remains significant. The mean investment to sales ratio in the sample amounts to about 5%. This ratio increases by more than 50% for firms with full utilization of existing capacities.

Equation (13) allows for an affine linear influence of the degree of capacity utilization on the investment to sales ratio for firms not using all existing capacities. Furthermore, the effect of full utilized capacities can differ between rationed and non rationed firms. Both the financing constraint dummy itself and all interaction terms with the utilization variables are significant in all specifications.

While the dummy  $MF$  and the interaction with the full utilization dummy have a negative impact on investment, the interaction with  $Q_{-1}^{100}$  shows a positive sign indicating a higher sensitivity of investment with regard to the degree of capacity utilization for rationed firms. This might be explained by the fact that the rationing dummy mirrors the existence but not the extent of financing constraints. Thus, firms with a *ceteris paribus* higher degree of capacity utilization in the last period might face a smaller extent of the financing constraint due to an increased cash flow (this effect is used by Fazzari, Hubbard and Peterson (1988) to estimate the impact of financing constraints on investment).

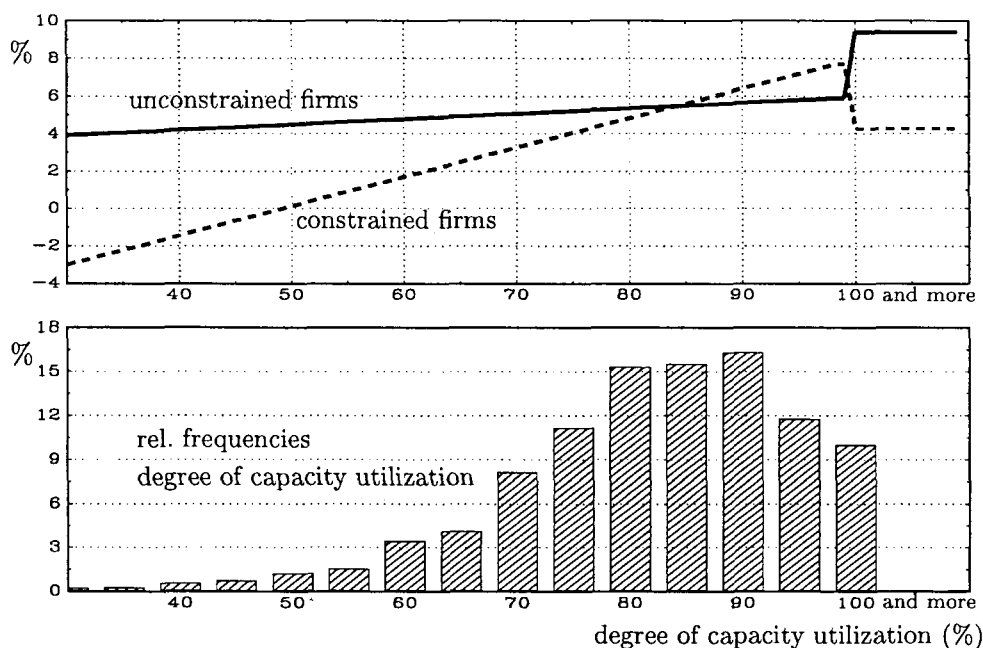
The overall effect of financing constraints is not uniform. While firms with a low degree of capacity utilization reduce their investment expenditures heavily when facing financing constraints, a slight increase can be found for firms with near to full utilization of capacities. Finally, firms using all existing capacities again have to reduce their investment expenditures drastically when facing financing constraints.

Figure 2 plots, in the upper part, the overall effect of the capacity utilization variables on the investment to sales ratio for unconstrained firms as a solid line and for constrained firms as a dashed line. These long run effects have been calculated from specification (2) correcting for the lagged endogenous variable and holding all other explanatory variables at their sample means.

The significant influence of the rationing indicator and the interaction terms with the degree of capacity utilization persists if instead of the general financing constraints dummy a dummy for missing internal or missing external funds is used. However, when using the dummy for missing external funds this effect is larger for firms using all existing capacities whereas it is somewhat smaller for the other firms.



Figure 2: Long Run Effect of the Degree of Capacity Utilization



## 6 Conclusion

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 framework of the Stiglitz and Weiss model was used to demonstrate the impact of age, size 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. *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 important for a deeper understanding of the monetary transmission mechanism.

It will be the subject of further research to assess the quantitative importance of credit rationing on an aggregate level (cf. Winker (1995b)).

# 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

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

on  $[0, p^*]$ , where  $\kappa_n \equiv \int_0^1 f(p)p^n dp$  for  $n \in \mathbb{N}$ .  $\tilde{f}$  and  $\tilde{f}_n$  are densities, i.e.

$$\int_0^{p^*} \tilde{f}(p) dp = \int_0^{p^*} \tilde{f}_n(p) dp = 1. \quad (14)$$

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

$$\tilde{f}_n(p) < \tilde{f}(p) \text{ for all } p \in [0, \epsilon[. \quad (15)$$

From equation (14) 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 (14) 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  $p^* > 0$ .

□

## B Manufacturing Sectors

Table 7: Manufacturing Sectors

ifo	Sypro	Sector	Sample Share
21	25	Mining and quarrying	3.24%
22	27/30	Drawing and cold-rolling mills	1.06%
23	28/29	Cast iron and nonferrous metal foundry products	1.88%
24	22	Petroleum refineries	0.50%
25	24/40	Industrial chemicals	0.46%
26	53	Sawn timber, plywood, and other worked wood	3.70%
27	55	Wood pulp, cellulose, paper and paperboard	1.86%
28	59	Rubber products, tyres and tubes	0.56%
31	31	Structural-steel products and rolling stock	1.26%
32	32/50	Machinery (including farm tractors)	19.03%
33	33/34/35	Road vehicles (excluding farm tractors)	3.36%
34	36	Electrical products	8.16%
35	37	Precision and optical goods, clocks and watches	4.04%
37	30	Steel	3.60%
38	38	Ironware, sheet-metal ware, and hardware	6.22%
411	51	Fine ceramics	1.60%
412	52	Glass and glassware	1.54%
42	54	Wood products	5.22%
43	39	Musical instruments, toys, sporting goods, jewelry, etc.	0.66%
441	56	Paper and paperboard products	3.26%
442	57	Printed and duplicated matter	6.74%
45	58	Plastic products	5.26%
46	61/62	Leather, leatherware, and footwear	1.82%
471	63	Textiles	5.84%
472	64	Apparel	1.70%
50	68/69	Food, beverages, and tobacco products	7.43%

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