Investment Behavior and Financing Constraints in German Manufacturing and Construction Firms
A Bivariate Ordered Probit Estimation

by Claudia Ploetscher and Horst Rottmann

Abstract

This paper investigates the effects of financing constraints on the dynamics of investment behavior for a sample of German firms. In contrast to most of the literature on this issue we use an indicator for financing constraints which we explain endogenously. The econometric method consists of a bivariate ordered probit model. We find that for firms facing financing constraints, the growth of investment is significantly lower than for non-constrained firms and is positively related to the growth rate of sales which has no influence for the unconstrained firms.

JEL Classification: G30, C35, D92

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Horst Rottmann (e-mail: h.rottmann@fh-amberg-weiden.de; phone: 49-961-382179)
Fachhochschule Amberg-Weiden
Hetzenrichter Weg 15
92637 Weiden, Germany

Claudia Ploetscher (e-mail: claudia.ploetscher@hypovereinsbank.de; phone: 49-89-37826708)
HypoVereinsbank AG
Arabellastr. 12
81925 Munich, Germany

1 Introduction

There are many papers starting with the work of Fazzari, Hubbard and Petersen (1988) that examines the effect of financing constraints on investment behavior by estimating Euler equtions or Q-models augmented by proxies for liquidity. Sensitivity of investment to liquidity is attributed to financing constraints. The problem of these studies is that the existence of financing constraints cannot be observed in the data sets they use. Therefore the sample at hand is split into two subsamples according to some criteria which is thought to be associated with the likelihood of facing financing constraints (like e.g. size, age or dividend policy) and the cash flow sensitivities of investment in both subsamples are compared. A higher sensitivity in one subsample (e.g. smaller or younger forms) is interpreted as evidence for financing constraints. But is investment really related to cash flow because of the existence of financing constraints? This interpretation has recently been challenged by Kaplan and Zingales (1997) and Cleary (1999). They criticize that the traditional studies a la Fazzari, Hubbard and Petersen never verified whether their sample split criteria and hence cash flow sensitivity of investment indeed have something to do with financing constraints. Our paper wants to contribute to this open discussion. We have a data set that contains an indicator for financing constraints which allows us to directly investigate the effects of financing constraints on the dynamics of investment behavior of firms and to explain financing constraints endogenously. We thereby integrate two strands of literature that are unrelated with each other, namely the mentioned empirical work on firm investment behavior under imperfect capital markets that treat financing constraints as exogenous to the firm and the empirical literature on the determinants of financing constraints.

The paper is organized as follows: The next section briefly reviews the basic arguments about imperfect capital and credit markets. Section 3 gives a short discussion of the existing empirical studies about firm investment behavior under financing constraints and is the motivation for the different approach used in this paper. Section 4 describes the data set. In Section 5 the econometric specification and the estimation results are presented. Section 6 summarizes the results.

2 Information Problems and Finance

The lack of financial means is often claimed to be a reason for too little investment and innvation activity of firms. Especially small and young firms are said to be unable to raise enough capital to finance valuable investment projects. It is commonly agreed in the economics of information literature that one important explanation for financing constraints is that credit and capital markets are characterized by asymmetric information between the supply and the demand side.

Myers and Majluf (1984) show that if investors are imperfectly informed about investment project quality or riskiness, adverse selection in equity markets arises. Investors will demand a premium on all firms' shares in order to compensate the risk of purchasing "lemons". In the credit market adverse selection and moral hazard problems arise if project quality or riskiness and firm behavior are unobservable for lenders. As pointed out by Stiglitz and Weiss (1981) a compensation by charging higher interest rates on loans may not be suitable because the interest rate is a sorting and incentive device. An increasing interest rate makes safe firms drop out of the market and induces the remaining firms to undertake riskier projects. Rather than raising the interest rate lenders ration some of the borrowers. Credit rationing may also occur if it is costly for lenders to verify the earnings of a firm (Townsend 1979, Gale and Hellwig 1985). The consequence of information problems is that external finance is either more costly than internal finance or not available at all, which may be regarded as an infinitely high cost. Thus, firms facing information problems may be constrained in their ability to raise outside funds, which is likely to have a negative impact on investment and innovation behavior (see e.g. Kukuk and Stadler 2001).

3 Empirical Literature on Investment under Financing Constraints

In the last decade there has been an increasing interest in studying the determinants of a firm's investment decisions under imperfect capital markets. As a result a large number of empirical studies using firm level panel data emerged in this area (for survey see Schiantarelli (1996 and Hubbard (1998)). Most of these studies estimate a structural equation derived from an intertemporal maximization problem with a quadratic adjustment cost function. For empirical implementation either a Q model of investment or a Euler equation are estimated. The common idea in these studies is to estimate an investment model under the assumption of perfect capital markets which in the presence of financing constraints would lead to misspecification. Therefore a sample split is performed according to some criteria associated with the likelihood of facing financing constraints, and estimation is done for both subsamples separately. While the specification should be correct for a priori unconstrained firms the model should be rejected for the firms likely to be constrained. The criteria used for the sample split are associated with information problems such as the affiliation to industry groups or banks (Hoshi, Kashyap and Scharfstein 1990, Albach and Elston 1995) firm size (Audretsch and Elston 2002) and age (Devereux and Schiantarelli 1990), bond rating (Whited 1992) and dividend policy (Fazzari, Hubbard and Petersen 1988, Bond and Meghir 1994).

The main disadvantage of both the Q model and the Euler equation is that if the standard model is rejected it cannot be concluded that this is because of the presence of financing constraints. Both models rely on strong assumptions such as a geometric depreciation rate, convex adjustment costs for the Euler equation, and a quadratic adjustment cost function for the Q model

(Schiantarelli 1996).[1] If these assumptions are not met both models are misspecified. A second drawback of the Q model and the Euler equation is that they need to rely on presumptions about which firms face financing constraints. Classification is predominantly performed according to just one criterion.[2] However, the existence of financing constraints is not determined by a single factor. An empirical study by Petersen and Rajan (1994) shows that the existence of financing constraints depends on many firm characteristics such as size, age, the legal form and indebtedness.

Because of these difficulties we choose a different approach in this paper. We combine information on investment activities and on financial aspects of firms. This enables us to directly explain financing constraints and to estimate their effect on investment behavior simultaneously.

4 The Data

4.1 Description of the Data Set

Our data set contains firm level information from the manufacturing and the construction sectors in east and west Germany. It was created from the combination of two surveys conducted by the Ifo Institute: a yearly investment panel survey that mainly collects information on sales, number of employees, investment as well as on the firm's assessment of their prospects.[3] The second source is a single survey on financing aspects among the same firms conducted in May 1997. Matching the two data sets resulted in a sample of 867 firms with complete observations.

The Ifo investment sample is not limited to big and medium-sized companies. Figure 1 shows that in both the investment survey sample and in the matched sample used in our analysis, small firms with less than 50 employees represent roughly one third of all firms. By including firms of all sizes we avoid the critical point of the Q model of restricting the analysis to quoted firms which - at least for the case of Germany - are predominantly large firms that are unlikely to have difficulties in raising funds. Besides, it can be seen from Figure 1 that the matching of the two data sets did not lead to a bias in the size distribution.

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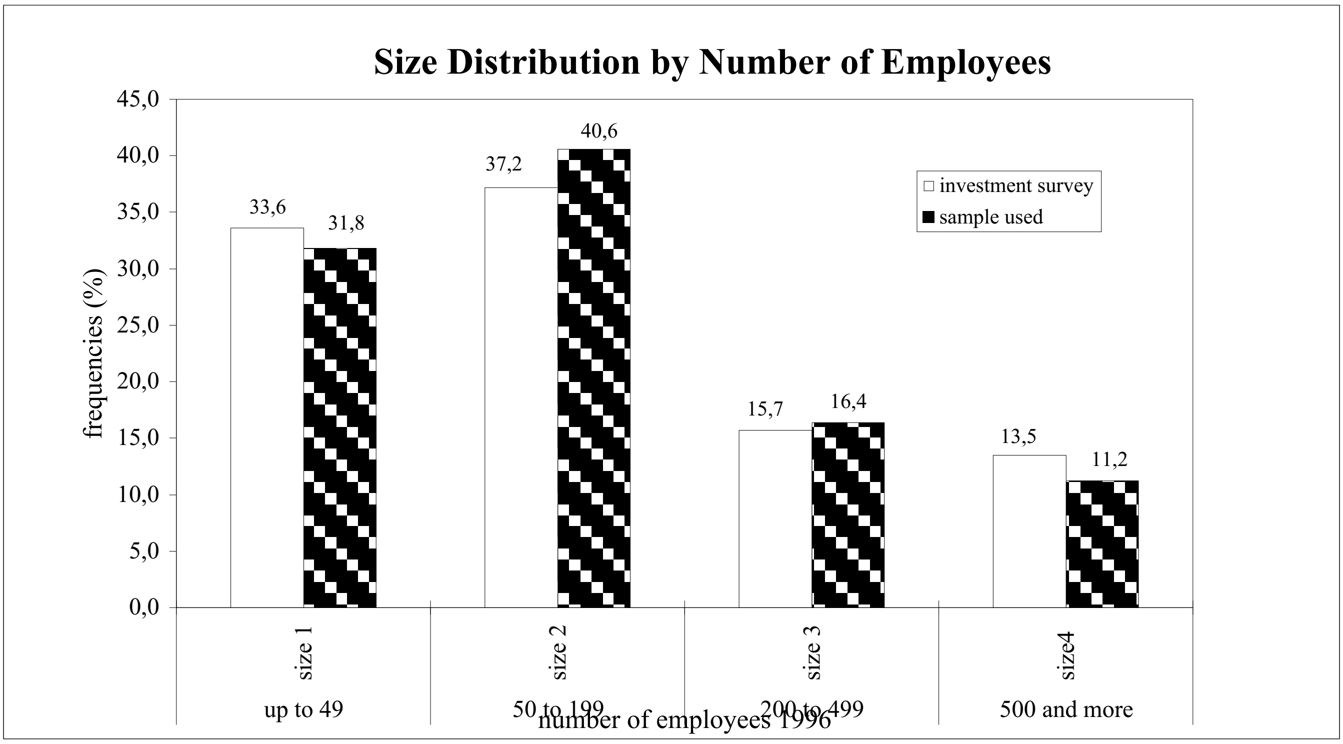
[1] See Hamermesh and Pfann (1996) for a discussion of different types of adjustment cost and their implications for factor demand.

[2] An exception is Hu and Schiantarelli (1994), who estimate a switching regression model where the probability of a firm being constrained is a function of the firm's characteristics.

[3] More information on the sample of the Ifo Investment Survey may be found in Oppenländer and Poser (1989).

Figure 1



The advantage of our data set is that it contains information on past, current and expected values of the central variables. A description as well as summary statistics of the variables in the data set are provided in table 1. Data are partially continuous and partially categorical or binary. All data refer to the year 1996.

The change of investment expenditures ΔI is a categorical variable taking the value 0 if the firm invested last year but did not invest this year. The value 1 stands for a strong decrease in investment, 2 for a small decrease, 3 for no change and 4 for an increase.[4] $lag\,\Delta I$ is the lagged value of ΔI. Almost 90% of all firms with no investment either this year or last year have less than 50 employees suggesting that small firm investment is less continuous than investment by bigger firms. The assumption of only quadratic adjustment costs and a geometric depreciation rate leads to continuous investment behavior. Our observation of discontinuous investment emphasizes the inappropriateness of these assumptions for all firms usually made to derive structural investment equations.

[4] Categories higher than 3 (no change) were subsumed in category 4 (increase). More information on the construction of the variables and on the sample can be found in Ploetscher (2001).

Table 1

Variable Description and Summary Statistics

Variable	Description	Mean	Standard deviation
ΔI	change in investment expenditures (5 categories)	2.70	1.19
$Lag\,\Delta I$	lagged change in investment expenditures (5 categories)	2.85	1.13
$\mu(\Delta \ln Y)$	average sales growth rate over the last (max) 8 years	0.09	0.21
$\sigma^2(\Delta \ln Y)$	variance of sales growth rate over the last (max) 8 years	0.19	1.08
$\Delta \ln Y$	actual growth rate of sales	0.02	0.24
FC	=1 if firm faces financing constraint	0.16	0.37
$FC\,\Delta \ln Y$	financing constraint multiplied by growth rate of sales	0.002	0.08
return	return measured by pretax profit margin (4 categories)	1.83	1.00
$\Delta ExpReturn$	change in expected net return (5 categories)	3.18	1.27
$lag\Delta ExpReturn$	lagged change in expected net return (5 categories)	3.46	1.17
eqrat	Equity ratio (4 categories)	3.18	0.99
age	firm age in years (upper limit 30 years)	20.84	10.98
legal	= 1 if the firm is a partnership = 0 if the firm is a corporation	0.13	0.33
subs	= 1 if the firm is subsidiary = 0 if the firm is independent	0.17	0.38
east	=1 if the firm is located in eastern Germany	0.39	0.49

The mean and the variance of the sales growth rate $\mu(\Delta \ln Y)$ and $\sigma^2(\Delta \ln Y)$ are calculated for each firm from information on sales from the investment panel surveys of the last years. The number of observations per firm used to calculate the firms' individual means and variances over time vary, depending on the age of the firms and on how often they took part in the survey. The minimum number per firm is three and the maximum number is eight. The actual sales growth rate $\Delta \ln Y$ is just the increase of sales from 1995 to 1996. The difference between the means over firms of $\Delta \ln Y$ and of $\mu(\Delta \ln Y)$ is striking. While sales increased by only 2% between 1995 and 1996, the average annual growth rate of the past years was as high as 9%, where data have been adjusted to inflation. This is due to the strong expansion in east Germany that started from a relative low level of economic activity after reunification. 39% of the firms in our sample are from East Germany (*east*). The sample is not representative in the sense that it shows exactly the same parameters as the population of German firms in the manufacturing and construction sectors. E.g. firms from East Germany and bigger firms are oversampled in our data set compared to their share in the German economy. However, the variables show sufficient variation for estimation.

The presence of a financing constraint is measured by the dummy variable *FC*, which will be explained in detail below. The pretax profit margin defined as the ratio of pretax profits to sales serves as an indicator for the *returns* and is divided into four categories, where 1 stands for a profit margin of below 3%, 2 for between 3% and 7%, 3 for between 7% and 10% and 4 for 10% and more. The change in expectations about future net returns $\Delta ExpReturn$ is again an ordered variable with the categories 1 for a strong deterioration to 5 for a strong improvement. The equity ratio is divided into four categories, numbered from 1 to 4 for below 5%, between 5% and 10%, between 10% and 25% and 25% and more.

The data set contains both independent firms and subsidiaries. Subsidiaries were excluded from the sample if they are mainly financed by their respective parent companies since in these cases the existence of financing problems and probably also the investment behavior of the subsidiaries is likely to depend on characteristics and decisions of the parent companies for which no data are available.

Small firms with less than 200 employees differ from larger ones in some aspects. Firstly, their share of partnerships (0.15), of independent firms (mean(subs) = 0.11) as well as of east Germany (0.47) is higher and maybe more importantly they are younger (18.95) and more likely to suffer from financing constraints (0.20).[5] Table A1 in the appendix contains variable means for constrained (*FC* = 1) and unconstrained firms (*FC* = 0), respectively.

4.2 Measuring financing constraints

Measuring whether a firm faces financing constraints is a difficult task. Taking the refusal of a credit application as an indicator for financing constraints is not practical, because firms that did not apply for a credit would be excluded from the analysis. This would lead to a sample selection problem, thus the turndown of a credit application is not an appropriate indicator. Simply asking the firms whether they feel financially constrained would be an unreliable indicator. An alternative indicator that has proved useful to identify financing constraints in the literature is the use of trade credit (Petersen and Rajan 1994, Harhoff and Körting 1998).

Trade credit is a method of financing provided by suppliers to their clients. One form of trade credit is to forgo discounts offered for early payment. A typical discount scheme offers a discount of 2% if a bill is paid within ten days. After the discount date the full amount is usually due within another 20 days. Forgoing the discount and paying at the due date implies that a firm

[5] The figures in parenthesis represent the means of the respective variables.

borrows at an annual rate of about 43%.Trade credit is probably one of the most expensive sources of external finance (Elliehausen and Wolken 1993) and it is argued that firms will only resort to it if cheaper sources are not available. Firms that rely heavily on trade credit are therefore said to face financing constraints.

One could argue that the use of trade credit is not a good indicator for the presence of financing constraints because it may also be regarded as a way to avoid transaction costs (Ferris 1981, Petersen and Rajan 1997). However, even if trade credit fulfills this function it is unlikely that firms will use it *always*. Our measure for financing constraints *FC* takes this idea into account. Firms were asked whether they forwent discounts always, often, rarely or never during the year 1996 if they were offered some at all. *FC* is a binary variable taking the value one if the firm *always* or *often* forwent discounts and 0 if it *never* or *rarely* forwent any discounts.

Alternatively, firms could also report that their suppliers usually did not offer discounts at all. It is not clear how this case should be interpreted. Suppliers may not offer discounts because their clients are not creditworthy or just because the suppliers themselves are subject to financing constraints or for any other reason only known to the suppliers. Firms that were not offered any discounts were excluded from the analysis. As this was the case with only 11 firms in the sample we think that the potential bias is negligible.

5 Empirical Analysis

5.1 Econometric Specification

The decision rule for optimal investment during a given period entails weighting the cost of investment against the return from using more capital. Due to dynamics like delivery and decision lags as well as adjustment costs and partial irreversibility the firms' expected rather than actual values are relevant. Therefore, the firms' investment decisions are determined by the *expected* marginal returns and costs i.e. by the *expected* net return from an additional unit of capital. In other words, investment is profitable if the expected net return from the new capital stock with the investment exceeds the expected profits from the old capital stock without the investment. This implies that net investment depends on whether the firm's expectations of the net return of the existing capital stock has changed, which is measured by $\Delta ExpReturn$. Because of adjustment costs or uncertainty about the production technology, that is, how much output a firm will produce for given level of capital, the firm's current investment decisions also depend on their past investment behavior (Zeira 1987). So investment is a function of $\Delta ExpReturn$ and past investment.

Therefore we can state that by taking first differences, the change in investment depends on the past change of investment and the change of $\Delta ExpReturn$. In order to control for the role of return expectations we should also include first differences of $\Delta ExpReturn$. In order to avoid differencing of an ordinal variable we prefer to simply use both the contemporary and lagged values of $\Delta ExpReturn$ instead. Thus, the parameter estimates of the contemporary and the lagged $\Delta ExpReturn$ should show opposite signs. So far the specification assumes that firms can freely borrow on financial markets. But in practice firms might be unable to raise enough external capital to carry out additional investment projects even if the projects are profitable. Financing constraints decrease firms' investment demand, and for constrained firms investment does not only depend on expected profitability but also on the availability of internally generated funds. So we assume the following function for the change in investment ΔI^* for firm i, where the superscript * denotes latent variables:

$$\Delta I_i^* = \beta_1' x_i + \beta_2' FS_i + \varepsilon_{1,i}, \tag{1}$$

β_1 and β_2 are vectors of parameters. x_i contains the changes of past investment decisions (lag ΔI) and of firm's expectations ($\Delta ExpReturn$ and $lag\,\Delta ExpReturn$) as explanatory variables where $\Delta ExpReturn$ controls for investment opportunities. [6] FS_i is a vector of variables describing the financial situation of the firm that contains the dummy variable FC_i indicating whether a firm faces financing constraints and the interaction term $FC_i\ \Delta \ln Y_i$ of FC_i and the growth rate of sales $\Delta \ln Y_i$. Internal liquidity is usually measured by cash flow which we do not have in our data set. We therefore use the sales growth rate as an indicator for the change in liquidity. In order to test the hypothesis that this indicator for liquidity only matters for the constrained firms x_i also contains the growth rate of sales. The last term $\varepsilon_{1,i}$ denotes a normally distributed error term with $\varepsilon_{1,i} \sim iid(0, \sigma^2_{\varepsilon_1})$.

As ΔI is an ordinal variable (see the discussion below) we could in principle estimate equation (1) by an ordered probit model. But this procedure would neglect the endogeneity of FC_i leading to potentially biased parameter estimates. It is clear that FC_i rather than being exogenous is a function of firms' characteristics.

The extent to which a firm faces problems in raising outside funds FC_i^* depends on how well it can convince investors of the profitability of an investment. As insiders cannot credibly communicate their earnings expectations to outsiders, investors must partly rely on information about the performance of the firm in the past, hoping that past performance is related to future

[6] We also tested a specification where investment opportunities were additionally controlled for by sales expectations. See section 5.

performance. The relationship between the mean of the sales growth rate over the past years $\mu(\Delta \ln Y)_i$ and FC_i^* is expected to be negative. The variance of the sales growth rate $\sigma^2(\Delta \ln Y)_i$ is an indicator for the uncertainty of a firm's prospects. Higher uncertainty means higher risk of bankruptcy and should increase financing problems. The $returns_i$ of a firm measured by the profit margin are an indicator of the ability to generate cash. Firms with high returns are less likely to need outside finance and if they need it they are more likely to get it. The equity ratio $eqrat_i$ reflects the indebtedness. The higher the equity ratio the lower the default probability and the smaller financing problems should be. Because of possible simultaneity problems we use the lagged equity ratio. Firms without financing problems could have raised outside finance, which would lead to a change in the equity ratio. Thus, the contemporary equity ratio depends on whether a firm faces financing constraints.

One possibility for firms to reduce information problems is reputation acquisition, which has been formalized for debt markets e.g. by Diamond (1989). The older a firm the longer it has been servicing its debt without going bankrupt and hence the more likely it is to be safe and trustworthy and the less risky is the loan for the lender. Financing problems should decrease with a firm's age_i. To account for its diminishing influence an upper limit of 30 years has been imposed on age_i. A second means to relieve information problems is close relationships between firms and banks (for a survey on bank relationships see Ongena and Smith 2000). For Germany Harhoff and Körting (1998) find evidence that close bank relationships increase credit availability. As we do not have an adequate indicator for relationships for all firms in our sample we are not able to test the hypothesis that close relationships reduce information problems and hence financing problems.

The $legal_i$ form proxies for both liability rules and for disclosure requirements. While liability is limited for corporations it is not for partnerships. Hence it may be hypothesized that partnerships have fewer financing problems than corporations. On the other hand, corporations are generally subject to more rigorous disclosure requirements than partnerships. Thus, investors lending to corporations may be better informed than investors lending to partnerships. Hence corporations should have less financing problems than corporations.

Firm $size_i$ measured by dummies for different size classes serves as an indicator for the ability of firms to pledge collateral, which should have a negative impact on financing constraints. Industry dummies, a dummy for location in eastern Germany ($east_i$), and a dummy for subsidiaries $subs_i$ are included as proxies for the prospects and risk of the firm which might not be directly observable for investors.

If we collect the explanatory variables in the vector, z_i the degree to which firm i suffers from financing problems FC_i^* may be written as

$$FC_i^* = \gamma' z_i + \varepsilon_{2,i} \tag{2}$$

where $\varepsilon_{2,i}$ denotes a normally iid error term. Then, the *i*th firm's *FC* status is

$$\begin{aligned} FC &= 1 \qquad \text{iff } FC_i^* > 0 \\ &= 0 \qquad \text{otherwise} \\ \text{and} \quad & \text{Prob}(\text{FC}_i = 1 \mid z_i) = 1 - \Phi(-\gamma' z_i) = \Phi(\gamma' z_i) \end{aligned} \tag{3}$$

We usually, have to work on the assumption that the error term of equation (1) and (2) are correlated, because they represent unobserved factors that may be relevant for both processes. Defining $d_i = 2 * FC_i - 1$ the conditional expected value of ΔI_i^* is

$$\begin{aligned} E[\Delta I_i^* | x_i, FC_i] &= \beta_1' x_i + \beta_2' FS_i + \rho\sigma_{\varepsilon_1}\lambda_i \\ \text{and} \quad \lambda_i &= \frac{d_i \varphi(\gamma' z_i / \sigma_{\varepsilon_2})}{\Phi(d_i \gamma' z_i / \sigma_{\varepsilon_2})} \quad , \end{aligned} \tag{4}$$

where λ_i is the inverse Mill's ratio and ρ is the correlation coefficient of ε_1 and ε_2. Thus, estimating equation (1) alone produces inconsistent parameter estimates, because of omitting variable λ_i. This corresponds to the well-known measurement problem of treatment effects in the human capital literature. For this kind of problem the following two step estimation procedure by Heckman (1976, 1979) is frequently applied: Estimate (3) by probit maximum likelihood, calculate the inverse Mill's ratio, add the inverse Mill's ratio as a regressor to (1) and estimate the augmented (1). Our endogenous variable in (1) is ordered, so we can principally use this two step estimation procedure and estimate (1) by an ordered probit model. But this procedure has one drawback: The two step estimation procedure creates a heteroskedastic error term with $\sigma_i^2 = \sigma_{\varepsilon_1}^2 (1 - \rho^2 (\lambda_i^2 + \lambda_i \gamma' z_i))$ in the augmented (1). Yatchew and Griliches (1984) showed that heteroskedastic errors lead to inconsistency of the maximum likelihood probit estimator where the size of the bias depends on the extent of the heteroskedasticity problem. In addition to the two-step procedure, we therefore will estimate (1) and (2) simultaneously by a bivariate ordered probit model.[7]

[7] The bivariate ordered probit model has been illustrated e.g. in Butler and Chatterjee (1997). For an easy exposition of the special case of a bivariate probit model see Greene (1997).

5.2 Results

Table 2 and Table 3 show the two step estimation results and the maximum likelihood estimation respectively.[8] Both estimation procedures give nearly identical parameter and t-values suggesting that the heteroskedasticity problem of the two step estimation is not very severe. Both the coefficient of the inverse Mill's ratio λ in the two step estimation and the correlation coefficient ρ in the ML estimation are significant. This implies that ignoring the correlation of the error terms by estimating (1) only by a simple ordered probit would lead to biased parameter estimates. Almost all coefficients show the expected signs. We will first discuss the results of the estimates for *FC* and then for ΔI.

The coefficient of the mean sales growth rate $\mu(\Delta \ln Y)$ and the variance of the sales growth rate $\sigma^2(\Delta \ln Y)$ are negative and positive, respectively, suggesting that high growth relaxes and uncertainty increases financing problems. As expected high returns and a high lagged equity ratio reduce the risk of financing problems compared to low values of these two variables ($return = 1$ and $eqrat = 1$), which have been omitted from the regression as the base cases respectively. Contrary to what could have been expected, *age* as an indicator for a firm's reputation has no significant effect on financing problems. The reason is the high correlation between *age* and the regional dummy *east* that does not allow a separation both effects. The young firms in the sample are mostly located in east Germany whereas west German firms are predominantly old. When *east* is omitted from estimation the coefficient of *age* shows the expected negative sign and is significant. Alternative specifications would have been to use different upper limits for the construction of age_i, a dummy variable for old firms or the logarithm of age_i. None of these changed the regression results. The coefficient of *legal* has a positive sign and is significant implying that partnerships are more likely to face financing constraints than corporations. This result suggests that disclosure requirements are more important for raising external finance than liability rules. The coefficients of the size dummies support the hypothesis that small firms are more likely to face financing problems than larger firms, though only one coefficient is significant.

Investment dynamics are largely explained by past investment and by firms' expectations about future returns. Firms that increased their investment expenditures in the last period are likely to reduce them this period. The coefficients of all dummies for $lag\,\Delta I$ are negative and significant where the reference category is the firms that did not invest at all last year ($lag\,\Delta I = 0$). These firms represent the group with the strongest decrease in investment because no investment implies a drop of 100%. Compared to the firms that did not invest last period, the probability for the remaining firms to reach the category with an increase in investment ($\Delta I = 4$) decreases with

[8] The maximum likelihood estimation was performed by a modified version of Molenberghs' and Lesaffre's Gauss implementation of the multivariate probit model. We thank the authors for providing their program.

the investment growth of last year. The absolute values of the coefficients increase with the categories of $lag\,\Delta I$. This shows a tendency of investment expenditures to return to an equilibrium level and hence the stability of investment. Improvements of expectations about future returns induce firms to invest more. All coefficients of the $\Delta ExpReturn$ dummies are positive where the category representing a strong deterioration of expectations about returns ($\Delta ExpReturn = 1$) has been omitted as the base case. The coefficients of the $lag\Delta ExpReturn$ dummies all show the expected negative signs.

Table 2

Two Step Estimation

observations		867			
χ^2 (degrees of freedom)		239.48(26)***		116.29(31)***	

dependent variable	*FC*		ΔI		
explanatory variables	coefficient	Asymptotic t-value	explanatory variables	coefficient	Asymptotic t-value
$\mu(\Delta \ln Y)$	-1.22	-2.85 ***	$lag\,\Delta I = 1$	-0.72	-1.98 **
$\sigma^2(\Delta \ln Y)$	0.21	2.46 **	$lag\,\Delta I = 2$	-0.93	-2.47 ***
$return = 2$	-0.31	-2.08 **	$lag\,\Delta I = 3$	-1.27	-3.54 ***
$return = 3$	-0.65	-2.82 ***	$lag\,\Delta I = 4$	-1.44	-4.06 ***
$return = 4$	-0.81	-2.55 **	$\Delta ExpReturn = 2$	0.28	2.06 **
$eqrat = 2$	0.02	0.07	$\Delta ExpReturn = 3$	0.15	1.00
$eqrat = 3$	-0.74	-3.59 ***	$\Delta ExpReturn = 4$	0.39	3.05 ***
$eqrat = 4$	-0.84	-4.47 ***	$\Delta ExpReturn = 5$	0.70	4.43 ***
legal	0.43	2.20 **	$lag\Delta ExpReturn = 2$	-0.33	-1.93 *
subs	-0.20	-1.04	$lag\Delta ExpReturn = 3$	-0.29	-1.64
age	-0.00	-0.23	$lag\Delta ExpReturn = 4$	-0.30	-1.87 *
east	0.94	2.03 **	$lag\Delta ExpReturn = 5$	-0.36	-2.04 **
size 2	-0.10	-0.60	*FC*	-0.81	-2.88 ***
size 3	-0.33	-1.50	$FC\,\Delta \ln Y$	0.91	1.81 *
size 4	-1.00	-2.81 ***	$\Delta \ln Y$	-0.05	-0.27
			size 2	-0.12	-1.14
			size 3	0.19	1.72 *
			size 4	0.06	0.41
			east	-0.01	-0.07
cut1	1.20	1.71 *	*cut1*	-3.34	-7.78 ***
			cut2	-1.90	-4.56 ***
			cut3	-1.25	-3.01 ***
			cut4	-0.62	-1.51
			λ	0.36	2.12 **

Industry dummies are included in all equations and not reported.
* statistically significant at the 10% level
** statistically significant at the 5% level
*** statistically significant at the 1% level

Table 3 **ML Estimation**

observations	867
χ^2 (degrees of freedom)	347.15 (57)***

dependent variable: *FC*

explanatory variables	coefficient	asymptotic t-value
$\mu(\Delta \ln Y)$	-1.22	-2.90 ***
$\sigma^2(\Delta \ln Y)$	0.20	2.40 **
return = 2	-0.33	-2.26 **
return = 3	-0.63	-2.74 ***
return = 4	-0.83	-2.67 ***
eqrat = 2	0.07	0.34
eqrat = 3	-0.74	-3.65 ***
eqrat = 4	-0.80	-4.27 ***
legal	0.42	2.16 **
subs	-0.21	-1.10
age	-0.01	-0.50
east	0.82	1.74 *
size 2	-0.11	-0.63
size 3	-0.31	-1.42
size 4	-1.00	-2.74 ***
cut1	1.04	1.49
ρ	0.21	1.69 *

dependent variable: ΔI

explanatory variables	coefficient	asymptotic t-value
$lag\,\Delta I$ = 1	-0.71	-1.96 **
$lag\,\Delta I$ = 2	-0.91	-2.55 **
$lag\,\Delta I$ = 3	-1.24	-3.51 ***
$lag\,\Delta I$ = 4	-1.41	-4.03 ***
$\Delta ExpReturn$ = 2	0.28	2.08 **
$\Delta ExpReturn$ = 3	0.16	1.08
$\Delta ExpReturn$ = 4	0.39	3.07 ***
$\Delta ExpReturn$ = 5	0.70	4.46 ***
$lag\Delta ExpReturn$ = 2	-0.32	-1.92 *
$lag\Delta ExpReturn$ = 3	-0.29	-1.64 *
$lag\Delta ExpReturn$ = 4	-0.29	-1.83 *
$lag\Delta ExpReturn$ = 5	-0.35	-1.98 **
FC	-0.58	-2.67 ***
$FC\,\Delta \ln Y$	0.89	1.79 *
$\Delta \ln Y$	-0.03	-0.19
size 2	-0.11	-1.08
size 3	0.21	1.84 *
size 4	0.09	0.64
east	-0.06	-0.56
cut1	-3.28	-7.74 ***
cut2	-1.86	-4.51 ***
cut3	-1.21	-2.96 ***
cut4	-0.59	-1.45

Industry dummies are included in all equations and not reported.
* statistically significant at the 10% level
** statistically significant at the 5% level
*** statistically significant at the 1% level

$\Delta ExpReturn$ may be a poor indicator for investment opportunities. We therefore also used a categorical variable reflecting the change in firms' expectations about future sales which is frequently used in accelerator models to control for investment opportunities. In contrast to $\Delta ExpReturn$ neither the contemporary nor the lagged changes in expected output have any influence on investment decisions and therefore were dropped in the actual specification. This result suggests that output expectations do not have any additional explanatory power.[9]

Financing constraints (*FC*) restrict investment activities significantly. The coefficient of *FC* is negative and highly significant. The actual sales growth relaxes the financing constraint to some extent as can be seen from the positive and significant parameter of the interaction term between *FC* and the sales growth rate ($FC\Delta \ln Y$). However, it would take a firm a sales growth rate of about 65% to outweigh the negative effect of financing constraints.[10] As it is often suspected that small firms' investment differs from larger firms' investment we also ran regressions for a subsample of small firms with less than 200 employees leading only to marginal changes in our results (see table A2 in the appendix).

This result supports the hypothesis that higher sales usually lead to a greater availability of internal funds that may be used for financing investment. In contrast, for firms without financing problems the actual sales growth ($\Delta \ln Y$) does not change their investment activities.

6 Conclusions

This paper is a contribution to the question raised in the literature whether and how firm investment depends on financing constraints. In contrast to most of the empirical literature on this question we do not perform sample splits according to one determinant of financing constraints. Instead we take the use of trade credit as an indicator for the existence of financing constraints and explain it endogenously in the model. We find that for firms facing financing constraints according to this indicator the growth of investment is significantly lower than for non-constrained firms and it is positively related to the growth rate of sales, which we use an an indicator for liquidity growth. For the unconstrained firms the liquidity proxy has no influence. These results are in line with the idea that the investment of financially constrained firms is limited by their ability of self-financing and may be regarded as support for the traditional view on investment and financing constraints. They suggest that financing constraints are indeed the reason for investment to depend on liquidity measures.

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[9] Details may be obtained from the authors upon request.

[10] This figure can be obtained from the regression coefficients: $-0.58+0.89\,\Delta \ln Y=0$

Appendix

Table A1 Descriptive Statistics for Constrained and Unconstrained Firms

Variable	Constrained Firms (*FC* = 1)	Unconstrained Firms (*FC* = 0)
ΔI	3.46	3.74
$\Delta \ln Y$	0.01	0.02
$\mu(\Delta \ln Y)$	0.09	0.09
$\sigma^2(\Delta \ln Y)$	0.32	0.16
return	1.39	1.91
$\Delta ExpReturn$	3.25	3.17
$lag\Delta ExpReturn$	3.56	3.44
eqrat	2.59	3.30
age	12.16	22.55
legal	0.13	0.13
subs	0.11	0.18
east	0.78	0.31

Table A1 shows that firms facing financing constraints differ in various aspects from non-constrained firms. Investment is less dynamic in constrained firms, on average. Additionally constrained firms have a higher variance of sales growth and both their profitability and their equity ratio are lower. They are younger, less likely to belong to an industry group and predominantly from Eastern Germany.

Table A2 ML Estimation for Small Firms (less than 200 employees)

observations	628
χ^2 (degrees of freedom)	250.81 (57)***

Dependent variable: FC

explanatory variables	coefficient	asymptotic t-value
$\mu(\Delta \ln Y)$	-0.98	-2.19 **
$\sigma^2(\Delta \ln Y)$	0.18	2.04 **
return = 2	-0.43	-2.70 ***
return = 3	-0.60	-2.49 **
return = 4	-0.83	-2.54 **
eqrat = 2	0.04	0.19
eqrat = 3	-0.69	-3.23 ***
eqrat = 4	-0.87	-4.38 ***
legal	0.38	1.85 *
subs	-0.22	-0.97
age	-0.02	-0.95
east	0.60	1.23
size 2	-0.08	-0.44
cut1	0.69	0.95
ρ	0.22	1.39

Dependent variable: ΔI

explanatory variables	coefficient	asymptotic t-value
$lag\,\Delta I$ = 1	-0.67	-1.84
$lag\,\Delta I$ = 2	-0.83	-2.31 **
$lag\,\Delta I$ = 3	-1.13	-3.16 ***
$lag\,\Delta I$ = 4	-1.41	-4.00 ***
$\Delta ExpReturn$ = 2	0.36	2.34 **
$\Delta ExpReturn$ = 3	0.22	1.32
$\Delta ExpReturn$ = 4	0.36	2.49 **
$\Delta ExpReturn$ = 5	0.73	4.05 ***
$lag\Delta ExpReturn$ = 2	-0.39	-1.95 *
$lag\Delta ExpReturn$ = 3	-0.41	-1.97 **
$lag\Delta ExpReturn$ = 4	-0.34	-1.86 *
$lag\Delta ExpReturn$ = 5	-0.31	-1.49
FC	-0.58	-2.20 **
$FC\,\Delta \ln Y$	0.57	1.06
$\Delta \ln Y$	0.16	0.76
size 2	-0.11	-1.06
east	-0.04	-0.30
cut1	-3.17	-7.05 ***
cut2	-1.76	-4.03 ***
cut3	-1.17	-2.69 ***
cut4	-0.62	-1.43

Industry dummies are included in all equations and not reported.

* statistically significant at the 10% level

** statistically significant at the 5% level

*** statistically significant at the 1% level

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