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Financial investment constraints. A panel threshold application to German firm level data

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Financial investment constraints. A panel threshold application to German firm level data.

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Abstract

This paper attempts to test whether financial supply-side shifts explain the low-investment climate of private firms in Germany. The core contention is that a firm's financial position contributes to its access to external finance on credit markets. Special emphasis is put on small and medium-sized enterprises as these are usually assumed to be more informationally opaque. The application of a non-linear panel threshold model makes it possible to group firms endogenously according to their financial position. Various observable balance sheet indicators such as leverage, interest coverage ratio or measures of solvency are used as potential threshold variables. The firm-level panel dataset covers the period between 2006 and 2012. We find strong evidence for a positive but non-linear nexus between cash flow and fixed investments, suggesting that financially fragile firms rely more heavily on internal funds. Surprisingly, firm size does not seem to be a relevant grouping variable.

JEL Classifications: C23; D24, E22, E30, G31

Key Words: Non-linear panel model, Firm investment, Corporate finance, Business cycle, Financial frictions, Credit rationing, Cash flow, Monetary policy

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1 Introduction

The analysis of firm-investment behaviour plays an important role in growth as well as business cycle theory and related empirical work. As private firm-level investments are highly volatile over time, showing substantial differences in the cross-sectional behaviour, it is a relevant variable for monetary policy, economic growth as well as industrial policy aspects. Whereas monetary policy is mainly interested in the transmission mechanisms of monetary operations on investment and its propagation effects on the business cycle, industrial policy is concerned with the long-term impact of capital accumulation as well as issues related to market competition, growth and innovation.

Private investment growth was rather low in Germany over the past fourteen years. Figure 1 depicts growth of aggregate gross fixed investment and investment into machinery (both in real terms). Between 2000 to 2012 the annual mean growth rates are 0.28% for the former and 1.06% for the latter time-series, respectively. Private investment rates already had been low between 2000 and 2005. A temporary increase after 2005 broke down dramatically as a result of the recent great financial crisis (GFC henceforth). Between 2008 and 2009 real gross fixed capital formation dropped by almost 15% and real gross investment into machinery even by 25%. Over the whole period low private investment rates were accompanied by low credit growth to non-financial firms operating in Germany (around 2.3% at mean).¹ During the GFC overall credit growth was still positive (except in 2010 where the growth rate was about -2.5%) but its rate decreased.

Thus, one can observe a close relationship between firm investments and developments. The discussion about financial frictions and its repercussions on investment, growth and employment has gained importance again in the aftermath of the GFC. Our article attempts to study whether financial supply-side shifts can explain a significant part of the low investment climate in Germany since the mid 2000s. We explicitly do not deal with the repercussions of the recent financial crisis on firm investment but focus on the general relationship between a firm's financial position and its investment decision, instead. The standard literature examining the consequences of asymmetric information in credit markets (Myers and Majluf, 1984; Bernanke and Gertler, 1989; Greenwald and Stiglitz, 1993) or lenders who are risk-averse against default (Fischer, 1986; Gröfl-Gschwendtner, 1993; Gröfl-Gschwendtner et al., 1995) stresses the importance of a firm's financial position for its investment decisions and availability to external finance. In particular we seek to analyse if indebtedness affects fixed capital formation of German companies with a focus on unlisted small and medium-sized firms.

The distinction between firm sizes takes up a crucial point in the literature on financial frictions, see e.g. Berger and Udell (1998, 2006). Typically for large firms economies-of-scale effects are at work which makes them more efficient in terms of productivity and costs. Furthermore, large firms face better diversification opportunities w.r.t. to their product portfolio, geographical business areas and access to external finance. Also SMEs are assumed to be informationally more opaque and face higher risk of default. Thus, SMEs operate in a totally different economic

¹The average change in debt financing of German non-financial corporations was rather low in comparison to other Euro area countries between 2000 and 2008. For a cross-country overview see ECB (2013, 20 pp.).

environment compared to large companies, and there is some evidence that credit availability is more severely restricted during recession periods for SMEs compared to large firms (see e.g. Duchin et al. (2010) and more recently ECB (2014, pp. 80)). This type of firms accounts for 99% of all firms in Europe where 60% of all employees work and produce about 50% of total value added (Vetter and Köhler, 2014, 2) and thus a detailed analysis of this firm group appears to be relevant.

The close relationship between financial frictions and economic conditions is frequently analysed and updated by the ECB using the bank lending survey. Survey data indicate that supply-driven frictions have intensified as banks' perception of risk increased and reached its highest level at the peak of the crisis. Lending rates as well as lending standards were tightened between 2006 and 2009.² German firms' perception regarding the mismatch between financing needs and availability increased between 2010 and 2012, but much less than in crisis countries (ECB, 2013, 64). Thus, supply-driven contraction may have been a source of reduced investment (ECB, 2013). Current policy discussions stress in particular the situation of small- and medium-sized enterprises (SMEs henceforth) and their hampered access to external finance which transmits into rather poor economic dynamics on the aggregate.

Place Figure 1 about here!

Several empirical studies, close to the methodological tradition of the papers by Fazzari and Athey (1987) and Fazzari et al. (1988), considering firm-level investment equations find that cash flow variables have predictive power to explain fixed-investments. Early examples are among others Hoshi et al. (1991), Whited (1992), Oliner and Rudebusch (1992), Gertler and Gilchrist (1994), Bond and Meghir (1994) and more recently Martinez-Carrascal and Ferrando (2008). However, most of these studies use databases only comprising listed companies which are theoretically assumed being less informationally opaque and thus asymmetric information issues are not expected to be a prevalent issue *a priori*. Recent German studies, in contrary, have exploited more heterogeneous databases including listed as well as unlisted firms of various size, including small and medium-sized ones, which much more represent the actual firm landscape, see e.g. Chirinko and von Kalckreuth (2002); Engel and Middendorf (2007); Lenger and Ernstberger (2011). The results indicate that firm level investment of financially constrained firms indeed respond more sensitively to cash flow dynamics.³

The value-added of this paper is twofold: First, our empirical work exploits a database which comprises listed as well as unlisted firms from various industrial sectors of different firm size and legal status in Germany using recent data. This dataset allows us to test the cross-sectional hypotheses of the theoretical work on imperfect capital markets and financial constraints. Most of these theories predict that informationally opaque firms, such as small and medium-sized (un-

²For instance, for German firms the average lending rate on credit below 1 Million EUR had increased between 2006 and beginning of 2009 from 4.5% to 6% before the rate fell down to about 3.5% at the end of 2011. A similar picture can be observed for the lending rate of bank loans above 1 Million EUR which reached its peak at the end of 2008 at around 5.6% before the price of loans has decreased to nearly 3% in 2011. The gap between these two lending rates remained almost stable during 2007 and 2013 (Vetter and Köhler, 2014, 17 pp.).

³For detailed literature review see the Working Paper version of this article.

listed) ones, operate in a totally different economic environment compared to their large and listed counterparts. Second, a main issue in the context of estimating firm-level fixed-investment functions concerns the sample selection criteria to group firms, and distinguish between financially constrained and unconstrained ones. To circumvent an often applied—but to some kind *ad hoc*—sample-split procedure, we choose an econometric framework which offers a consistent data-driven way for grouping firms. The procedure we choose relies on the panel threshold regression method suggested by Hansen (1999), and is in fact a linear piecewise model. Hansen’s framework allows us to estimate specific regimes which can be associated with different degrees of financial frictions firms are facing. As potential threshold variables seven different balance sheet variables are used. This allows us to distinguish between firms operating either within a financially unconstrained regime or others which face more intense financial supply-side restrictions.

Our analysis reveals that some German non-financial firms indeed face imperfect capital markets. We find strong empirical evidence that the accumulation rate of firms, after controlling for various firm-level as well as macro-level effects, depends significantly on cash flow. This is in contrast with the standard investment model assuming perfect capital markets according to which every positive NPV project can be financed by external funds, even if internal finance is not sufficiently high. Furthermore, for some specifications the results indicate that the strength of the dependence of fixed investment on available cash flow is positively but non-linearly related to a firm’s financial situation, measured by various balance sheet indicators. Thus, the cash flow sensitivity of fixed investment is highly regime-dependent. Interestingly, firm size does not seem to be a reasonable predictor for the degree of financial frictions a firm faces. Rather, balance sheet quality plays an important role for a firm’s regime-belonging. For instance, the marginal effect of cash flow on investment is about three to four times higher for firms with rather low interest-to-coverage ratios compared to companies exceeding a certain interest-coverage ratio.

This paper proceeds in 5 sections. In Section 2, we introduce the methodology applied to measure financial investment constraints, describe the econometric framework as well as our data sources. In Section 3 we provide some initial summary statistics of balance sheet variables and cash flow, and give a first overview about the relationship between these variables and how they are related to firm fixed investment over time. In Section 4 we present the threshold estimation results and analyse which type of firms (according to size) fall into financially (un-)constrained regimes, before the regime-dependent coefficient estimates of the cash-flow-sensitivity of investment are reported. Section 5 concludes, while details of the dataset and its construction may be found in the Data Appendix. Further details supporting the results of the paper may be found in the Annex that is available online.

2 Methodology, Econometric Framework and Dataset

This section describes the research methodology to answer the question of interest and gives an overview about the existing approaches. Furthermore the econometric framework will be described as well as the underlying dataset.

Methodology – The literature proposes two approaches in order to test empirically whether firms face investment constraints due to imperfect capital markets.⁴ The first approach builds on a standard q -model of firm investment and tests the validity of the underlying Euler equation. The approach tests whether a firm "...is able to equate the discounted marginal rates of return on assets across time..." (Fazzari and Petersen, 1993). A financially constrained firm is not able to do so. An advantage of the Euler-equation approach is that it does not rely on average q as a measure of expected profitability. It is well-known that Tobin's *marginal* q only coincides under restrictive assumptions with average q (Hayashi, 1982), and thus often used average q is only a poor proxy variable for profit opportunities. However, there are some serious issues related to the Euler equation approach. First, the test on over-identifying restrictions may not reject the null of no financial constraints if the available sample is too short in time dimension. This is especially the case if the tightness of the constraint is only marginally changing over time (Schiantarelli, 1995, 190). Furthermore, instability, for instance of adjustment costs over time, may lead to a rejection of the null of perfect capital markets even though firms do actually operate under such circumstances. Thus, misspecification of production technology, adjustment costs or inappropriate instruments may bias the empirical outcomes. Also Euler-equation estimations do not allow to quantify the degree of market imperfections (Fazzari and Petersen, 1993, 329). A last point concerns the "...choice of the maximand itself..." (Schiantarelli, 1995, 191): if the management is actually behaving in a non-value maximizing manner (Jensen, 1986), the resulting Euler equation differs from the standard one.

Fazzari and Athey (1987) and Fazzari et al. (1988) have proposed an alternative way to test financial frictions by analysing the relationship between investment, cost of capital and internal funds. According to the standard literature Tobin's q should fully predict firm investment decisions on perfect capital markets, and hence financial factors such as cash flow should have no additional predictive power. A standard investment function augmented by financial factors is estimated in order to test this hypothesis. If investment depends on other financial variables, conditional on Tobin's q , this is interpreted as evidence for an imperfect substitution between internal and external funds (Gertler, 1988). Information asymmetries between lenders and creditors, or risk-averse lending behaviour may give rise to the relevance of other variables such as a firm's wealth for easing credit constraints. It is expected that the investment-to-cash-flow sensitivity increases (maybe in a non-linear manner) in the degree of information asymmetry on credit markets or the degree of the lender's risk-aversion against default. Hence, for unconstrained firms one expects a low cash flow sensitivity of investment or none at all, as any positive NPV project could be fully financed by external funds.

As financially constrained and unconstrained firms exist at the same time, one need to capture these heterogeneities appropriately by grouping firms according to some signalling variable. A popular grouping variable used in the literature is the dividend-payout ratio. Unconstrained firms are supposed to pay more dividends compared to constrained ones (Fazzari et al., 1988; Bond

⁴There exists a third approach based on survey data. For instance, Beck et al. (2006) use a massive survey dataset and evaluate how successful *a priori* classifications are in distinguishing between financially constrained and unconstrained firms, and what are the determinants of financing obstacles. However, as the approach is very different to our one and applies a different kind of data, we do not discuss it further in this paper.

and Meghir, 1994). Also firm size and firm age serve as a proxy for the degree of information asymmetries as older and bigger firms can provide some historical market record to potential investors and signal some reputation. Additionally, older firms have most likely established close-ties with creditors as well as suppliers which helps to mitigate information asymmetries (Hubbard, 1998; Oliner and Rudebusch, 1992; Gertler and Gilchrist, 1994). In line with the literature on relationship-lending (Petersen and Rajan, 1994; Boot, 2000), according to which information asymmetries may be reduced by long-lasting and close relationships between firms and banks, Hoshi et al. 1991 have used the degree of bank affiliation as another classification criteria. Others have suggested to use existing bond ratings as a grouping criteria (Whited, 1992) or constructed measures of debt default risks as Chirinko and von Kalckreuth (2002) or Martinez-Carrascal and Ferrando (2008) have done. After firms are grouped accordingly, it is tested whether the premium on external finance is correlated with a firm's financial position. Thus, differences in the cash flow investment sensitivity between groups of firms provide information on the actual importance of financial supply-side effects for investment.

However, there are certain drawbacks of this approach. First of all, Kaplan and Zingales (1997) and Cleary (1999) give theoretical reasons for the case that the relationship between cash flow and investment may be different from the one proposed by Fazzari et al. They argue that the cash flow sensitivity of investment may be higher for apparently unconstrained firms which is confirmed by their empirical results. Furthermore, there is no clear consensus as how firms can be classified into financially 'highly' constrained and 'less' constrained ones, and which criterion should be used. The choice of the grouping variables used in the empirical literature may be appealing theoretically (Berger and Udell, 1998), but not so from an empirical (data-driven) perspective as the sub-sampling may take an arbitrary form. Some of the grouping-variables, for instance the dividend-payout ratio, are likely to be endogenous, and it may be plausible that firms adjust their dividend-payout ratio to their investment plans rather than the other way around (Schiantarelli, 1995; Hansen, 1999). Also, firms are typically classified according to a single indicator alone which is a strong assumption as other indicators may be relevant as well. On the other side, the inclusion of further variables may increase the dimension of the econometric model substantially affecting statistical inference negatively. Third, the belonging of a firm to a specific group is often assumed to be fixed over the sample period. It is more realistic to assume that a firm switches from one group to another during its life-time (Hu and Schiantarelli, 1998). For further issues on sample separation criteria see Schiantarelli (1995, 192 pp.).

Given these critical points, Hu and Schiantarelli (1998) and Hansen (1999) have suggested alternative separation frameworks. Both authors apply methods which separate groups endogenously using a data-driven approach. More concrete, Hu and Schiantarelli estimate endogenous switching regressions. They use different balance sheet indicators which trigger the probability of a firm being in a constrained or unconstrained regime, respectively. The cash-flow-to-investment sensitivity depends on the respective regime a firm operates in. Alternatively, Hansen derives the statistical properties of a piecewise-linear panel model with fixed-effects. He proposes an algorithm to test for multiple thresholds and derives the asymptotics for further inference. This

threshold panel model is in fact a special case of the more general switching model but much simpler to implement and estimate. In the following we introduce Hansen’s idea in more detail before the database and econometric results are presented.

The econometric framework – For grouping the data we apply a fully *data-driven* approach by assessing the signalling properties of balance sheet indicators for the cash-flow-to-investment nexus. The econometric method proposed by Hansen allows us to split the sample according to a specific threshold variable which determines specific regimes endogenously in a first step before the parameters of interest are estimated. In this case, the latent of being constrained or unconstrained is determined by a transition function which depends on a vector of firm characteristics itself. This framework enables us to A) estimate whether specific firm groups (so called *regimes*) actually exist or not, and B) estimate and compare the marginal effect of cash flow on investment for each regime.

Hansen’s model belongs to the class of static non-linear panel models. The basic idea is to split the sample into a small number of classes (regimes) and for each class the regime-dependent coefficients of interest are estimated. The transition across regimes is assumed to be instantaneous (non-gradually) and driven by a transition variable being below or above a to-be determined–threshold value. The structural equation for a 2-regime (one threshold) model, taken for illustration, is given by

$$y_{it} = \mu_i + \alpha' z_{i,t} + \beta'_{LOW} CF_{it} \mathbf{I}(D_{it} \leq \gamma) + \beta'_{HIGH} CF_{it} \mathbf{I}(D_{it} > \gamma) + e_{it} \quad (1)$$

where y , z , CF , D , I and γ refer to investments, an exogenous control variable, a measure of cash flow, the threshold variable, an indicator term and the threshold value. The indicator term takes unity if the threshold variable exceeds the threshold value γ . The eq. can be written compactly as

$$y_{it} = \mu_i + \alpha' z_{i,t} + \beta' CF_{it}(\gamma) + e_{it} \quad j = 0, 1, \dots, T \quad (2)$$

where $CF_{it}(\gamma) = \begin{pmatrix} CF_{it} \mathbf{I}(D_{it} \leq \gamma) \\ CF_{it} \mathbf{I}(D_{it} > \gamma) \end{pmatrix}$ and $\beta = (\beta'_{LOW}, \beta'_{HIGH})'$. The coefficient vector α captures the regime-independent effects, whereas β depends on the regime (here denoted by low and high, respectively). For identification it is required that CF_{it} is time-variant. The assumption that e_{it} is *i.i.d.*, requires that lagged dependent variables are not included in CF_{it} (Hansen, 1999). The analysis holds for fixed T as $n \rightarrow \infty$. The regression model is estimated for $i = 1, \dots, n$ firms and $t = 1, \dots, T$ observations.

For a given γ the regime-dependent β coefficient can be estimated by OLS after the fixed effects transformation. In order to estimate γ , Chan (1993) and Hansen (1999) have shown the validity of the least square technique in this context:

$$\hat{\gamma} = \arg \min(\gamma) S_1(\gamma) \quad (3)$$

where $S_1(\gamma)$, the sum of squared errors (SSE), only depends on γ through the indicator function. Thus, the sum of SSE is a step function with at most nT steps occurring at distinct values of

the observed threshold variable $D_{i,t}$. A standard procedure is to sort the distinct values of the threshold variable in an ascending order and to eliminate the smallest and largest η -% values. Next, one can search for $\hat{\gamma}$ over the N remaining values of γ by running regressions over all N values. The estimate of $\hat{\gamma}$ is given for the regression with the smallest SSE. Hansen (1999) suggests to divide the N values of the set of γ values into specific quintiles, which reduces the number of regressions performed, but nevertheless is most likely to be sufficiently precise.

The null hypothesis of no threshold is:

$$H_0 : \beta_1 = \beta_2 . \quad (4)$$

This hypothesis can be tested by a standard LR test. As the threshold parameter is not identified under the null hypothesis, the distribution of the test statistics is non-standard (Andrews and Ploberger, 1994; Hansen, 1996). However, the FE model belongs to the class of models considered by Hansen (1996), and hence his proposed bootstrap procedure can be applied to simulate the asymptotic distribution of the LR test which is based on the test statistics

$$F_1 = \frac{S_0 - S_1(\gamma)}{\hat{\sigma}^2} \quad (5)$$

where S_0 and S_1 refer to the sum of squared errors under the null and the alternative, respectively. For further information on the inference part and determination of multiple thresholds see Hansen (1999).⁵

The described approach has two major advantages: first the threshold values are endogenously determined making it possible to classify firms according to their financial position (regime belonging) in a data-driven way. Second the different regime models are sequentially tested against one another using a bootstrap technique. This allows us to check empirically how many regimes or groups of firms exist. In fact we test for multiple thresholds in the application below. First a linear model is tested against a two-regime (one threshold) model. If the null of linearity against a two-regime model is rejected, the null of a two-regime against a three-regime model is tested, and so on.⁶

However, a drawback lies in the assumption that the regime-dependent effect, which is supposed to capture cross-sectional heterogeneity across firms, is assumed to be constant over time.⁷

⁵For the following empirical applications we use a grid with 300 quintiles after eliminating the $\eta = 5\%$ extreme values of the threshold variable. To compute the simulated asymptotic distribution of the LR test, we run a bootstrap procedure (draw with replacement from the empirical distribution) with 399 iterations. All computation was done by using the open-source econometric software package *gretl* (Cottrell and Lucchetti, 2013). The code is available from the author upon request. The original *GAUSS* code is provided by Bruce Hansen from http://www.ssc.wisc.edu/~bhansen/progs/joe_99.zip.

⁶A more general class of models is known as smooth transition regression models (see Gonzalez et al. (2005); Fok et al. (2005) on panel models). The parameters are allowed to change smoothly between multiple regimes, depending on the value of a transition variable and critical location values. However, theoretically it is quite plausible to assume that lenders classify in a manner reasonable in line with threshold behaviour. For instance, banks have a standard classification scheme and rank potential clients according to a vector of bankruptcy indicators which is consistent with a threshold approach. Furthermore, smooth transition models are much more complex to estimate. The estimation of the non-linear part involves complex optimization issues and standard procedures such as grid searches may result in a local instead of global optimum. Nevertheless, this does not rule out the application of this approach in future work.

⁷Do not mix this with the possibility that a firm can switch between regimes over time. This is actually allowed

Recently, Bordo and Haubrich (2010) have emphasized that historically the credit channel is strongest during economic downturns. This is somehow confirmed by the empirical results by Gaiotti (2013) based on firm-level Italian data. Gaiotti argues that the impact of bank credit on a firm's investment is time-varying and most pronounced during contraction periods when alternative sources of finance also become restricted. Nevertheless, we leave this issue open for future research as the simultaneous consideration of time-varying effects would require a more complex model framework. Additionally, as the time dimension of our panel is rather small, it remains under debate how much time-variation actually can be found in the data.

Data Series Used – The largest German credit rating agency Creditreform and Bureau Van Dijk provide the DAFNE database which is used in this paper. The database comprises current and historical accounting data of a representative pool of German firms. We only select firms from non-financial and non-public industry sectors ranging from mining, manufacturing over construction to information and communication (for details see Table 1 in the Appendix). The final panel includes stock companies, limited liability companies and others. Limited liability companies represent the most prevalent legal firm type in Germany. The dataset is checked for missings, outliers and implausible values. Again we refer to the Appendix for details on data manipulation.

The econometric analysis is based on a balanced panel for three reasons. First, the econometric technique applied requires balanced panel data (Hansen, 1999). Second, a balanced panel eliminates the problem of biased estimates of the threshold parameter due to changing sample compositions over time. Last, as we want to assess the evolution of a firm's financial position and its impact on investment, we need to monitor firms over the whole time period.

In line with the literature the dependent variable is defined as the change in gross tangible capital over lagged gross tangible capital. This definition of capital is widely used and assumes that capital is homogeneous (Barnett and Sakellaris, 1998, 268). Cash flow is measured by current retained earnings re-scaled by lagged capital stock. The set of control variables consists of information on the firm- as well as macroeconomic level:

- Firm-level variables:
 - $D_{i,t-1}$, lagged value of the respective threshold variable
 - $w_{i,t-1}$, lagged number of workers, in logs
 - $gt_{i,t-1}$, lagged growth of real sales revenues
 - $roi_{i,t-1}$, lagged real return of investment
 - $d_{i,t}$, current depreciation rate
- Macroeconomic variables:
 - gfc_t : Takes unity for years ≥ 2008 , otherwise zero

in our framework.

– gdp_t and gdp_{t-1} , current and lagged output gap

We rely on lagged values to circumvent possible endogeneity problems. Both the growth of real sales revenues and real return on investment capture the real side of investment decisions. These two variables may control for various effects. For instance, Franke and Semmler (1997) present evidence in their study that the estimated effect of real return on capital is highly correlated with a measure of capacity utilization. Furthermore, growth of sales revenues may encompass potential accelerator effects, and thus control for further relevant investment demand factors. Critics of reduced-form models argue that the positive cash flow effect on investment mainly results from omitted demand factors (Fazzari and Petersen, 1993, 333). Following the argumentation by Hu and Schiantarelli (1998, 469) and Himmelberg and Petersen (1994); Lenger and Ernstberger (2011) our sales growth measure may also capture profit expectations on imperfectly competitive output markets. Expected profitability also approximates prospective profit opportunities of an investment project (Fazzari et al., 1988).

A short note should be given to a related problem. The standard q -model of investment with perfect capital markets predicts that investments react to a positive output shift not due to higher levels of retained earnings today but as expected profitability increases and makes capital more valuable. High cash flows may reflect a firm’s sound market position and indicate high future profitability. Hence, current cash flow will be correlated with future profitability. This makes it hard to distinguish whether investment changes because of changes in current cash flow or due to expected profitability shifts. As a result one will observe a positive correlation between cash flow and investment even on perfect capital markets as cash flow simply proxies future expected profitability (see Schiantarelli (1995, 180 pp.) for more on this). Indeed, Cummins et al. (2006) find in their firm-level study that the cash-flow-investment relationship breaks down after one controls for expected earnings. This finding is robust even among apparently financially constrained firms and may explain why firm fundamentals are more relevant than the presence of financial constraints in the U.S. economy—at least according to these authors. Both the growth of real sales revenues and real return on investment should, however, appropriately capture these expectation effects and make sure that cash flow actually does not capture future profits and investment opportunities.

The number of workers per firm (in logs) controls for differences in the accumulation rate due to firm size. The effect of firm size is ambiguous: it is typically positively related to firm age and older firms are assumed to be more diversified and more transparent as they may have longer track records with investors, lenders, suppliers and customers. Overall, this may make older companies less prone against bankruptcy risks, and hence associated agency costs should be relatively low. On the other hand small firms may face lower agency costs as their ownership structure (typically a small number of managers own large portions of the firm) is less prone to conflicting interests. Current depreciation is added as another important source of funding.

The econometric specification also consists of additional macroeconomic variables to control for non-idiosyncratic effects. The contemporaneous and lagged output gap helps to account for business cycle effects, and reflects the current and expected state or climate of the overall

economy which may also affect optimal investment. The dummy variable *gfc* simply corrects for level shifts in firm investments caused by the recent financial crisis.

The pool of possible threshold variables consists of standard balance sheet indicators such as leverage, long-term leverage, interest-coverage rate, collateral and a measure of solvency. These are often used to predict corporate defaults in practice.⁸ Additionally, we conducted a principal component analysis using these five balance sheet variables in order to capture eventual common factors driving a firm’s financial position. This common factor may contain superior predictive information for the investment decision making process. The following variables are used as threshold variables in the estimation part, and reflect a common selection of balance sheet variables as shown by the recent survey by Silva and Carreira (2012):

- $lev_{i,t}$, total liability to total equity ratio as a measure of leverage
- $lglev_{i,t}$, total long-term liability to total equity
- $icov_{i,t}$, net interest expenditures over cash flow as a measure of interest coverage ratio
- $col_{i,t}$, sum of the stock of inventory, tangible assets and cash holdings to total tangible assets as a measure of collateral
- $sol_{i,t}$, cash flow to total debt
- $factor1_{i,t}$ first factor of the principal component analysis including $lev_{i,t}$, $lglev_{i,t}$, $icov_{i,t}$, $col_{i,t}$ and $sol_{i,t}$.
- $factor2_{i,t}$ second factor of the principal component analysis including $lev_{i,t}$, $lglev_{i,t}$, $icov_{i,t}$, $col_{i,t}$ and $sol_{i,t}$.

Factor 1 from the principal component analysis is strongly negatively correlated with both *lev* and *lglev* ($\rho \approx -0.85$), *icov* ($\rho \approx -0.63$) and positively with solvency ($\rho \approx 0.69$) but not at all with collateral. Factor 2 is strongly positively correlated with collateral ($\rho \approx 0.94$) but only marginally with both leverage measures ($\rho \approx 0.18$). Thus, both factors capture some specific but different balance sheet information effects. For details on the principal component analysis see the Technical Annex online. Theoretically, it is expected that a firm is more likely to operate in a constrained regime when balance sheet indicators such as the two leverage measures and the interest-coverage-ratio are high, and when firms’ degree of solvency or collateral proxies are rather low.

3 Summary Statistics

In this section we present some initial statistical key properties. Firms are grouped according to the number of workers, *W*, as follows:

⁸See for instance Moody’s premier private firm probability of default model for the German market which relies heavily on financial ratios as predictor variables. URL: <http://www.moodyanalytics.com/~media/Brochures/Enterprise-Risk-Solutions/RiskCalc/RiskCalc-Germany-Fact-Sheet.ashx>.

- Micro firms: $W < 20$
- Small firms: $20 \geq W < 50$
- Medium firms: $50 \geq W < 250$
- Large firms: $250 \geq W < 1000$
- Big firms: $W \geq 1000$

About 10% of all firms in the sample are stock corporations but almost 86% are classified as limited liability companies (LLC) whereas other legal types are almost negligible. A decomposition according to size reveals that 75% of all firms fall into the category of SMEs. About 45% of all firms are of medium size, 15% are large companies and about 7% of our sample firms are big ones.

Figure 2 in the appendix depicts the distribution of key variables according to firm size (see Table 2 for a tabular form). The median values of the accumulation rate (Figure 2(a)), growth of sale revenues (Figure 2(b)) and interest-coverage rate (Figure 2(f)) are positively related in size. However, given the wide inter-quartile range it seems difficult to derive general tendencies. According to Figure 2(c) SMEs tend to be more profitable than their large and big counterparts. When it comes to indebtedness the data suggest that big and large firms hold less leverage compared to SMEs. The median leverage of SMEs is around 1.6 whereas the median for big and large firms is slightly above 1.25. This also holds for long-term leverage where we find a median around 1.03 for micro firms compared to 0.71 for big firms. Thus, SMEs issue more debt and hold a higher share of long-term debt instruments relative to big and large firms, which is probably due to the fact that larger firms issue more equity instead. Nevertheless, the overlapping of the inter-quartile range makes it again hard to find clear evidence of firm-size-dependence. Interestingly, as mentioned before, the median of the interest coverage rate is positively related to firm size indicating that the median micro firm spends around 9% of its cash flow on interest whereas the ratio is about 14% for the big counterpart (Figure 2(f)). As expected our measure of solvency is positively related to size and SMEs hold less cash flow over total debt (Figure 2(g)). Furthermore, it seems that SMEs hold more collateral (Figure 2(h)) compared to larger firms. This may be interpreted in line with the hypothesis that lenders typically demand more collateral from SMEs in order to signal their creditworthiness.

Place Figure 2 about here!

In Table 3 (see Appendix) the median values of key variables according to legal firm type are given. The data reveal that the accumulation rate of stock companies is around 0.048 and thus slightly higher compared to limited liability companies (0.032) and others (0.038). Stock companies tend to be larger, but growth of sale revenues is of similar magnitude across the three legal company types. As expected, stock companies issue less debt: the median leverage is only 1.14 compared to 1.54 (1.43) of limited liability firms (rest). The median interest-coverage ratio

(around 0.12) and level of solvency (around 0.18) are of similar size across the firms. Alike holds for collateral which ranges from 1.9 to 2.1 in our sample.

To get a some first evidence on the relationship between a firm's accumulation rate and its financial position, we plot investment ratios over time according to different levels of creditworthiness. For this we compare the investment ratios of firms for which the respective pre-period financial indicator⁹ stands below the 15th percentiles (denoted by *low*), with firms for which the financial indicator is between 40th and 60th percentile (denoted by *medium*) and firms with values above the 85th percentile (denoted by *high*).

Place figure 3 about here!

For instance, Figure 3(a) depicts the accumulation rate for each of these three firm classes. Companies with high interest-coverage ratios show on average the lowest investment ratio between 2006 and 2012, firms with low *icov* ratios show some higher investment activities. Interestingly, the highest accumulation rate was realized by firms with medium values of the interest-coverage ratio. One can also observe that the investment ratio of these latter companies was even higher during the GFC.

The distinction using leverage measures makes the *dual character* of leverage obvious. On the one side higher leverage allows firms to invest at higher speed: the accumulation rate of high-leveraged firms (see Figure 3(b)) was almost as high as for medium-leverage ones between 2006 and 2008, whereas low-leveraged firms show a much lower accumulation rate at least up to 2010, which may be explained by their low creditworthiness, and which goes hand-in-hand with rather limited access to external finance. However, investment growth of high-leveraged firms declined much stronger in 2009 compared to medium-leveraged ones. Furthermore, one can see that investment growth of low-leveraged firms was the highest in 2011 before the investment ratio converged for all three groups in 2012. A very similar pattern can be observed on basis of long-term leverage, as depicted in Figure 3(c). Highly indebted firms have experienced the highest investment ratios between 2006 and 2008 in comparison to others. However, the shock of the GFC in 2008/9 has led to a much stronger and more persistent decline in investment growth rates during the following periods. This may be explained by the fact that lenders became more risk-averse and applied more strict lending standard, which made it harder for firms with a debt-overhang to obtain credit at all or at least at reasonable conditions. Thus, high-leveraged firms did not continue to grow at pre-periods rates, and have initiated a de-leveraging process.

Another striking impact of finance on firm-level investments can be seen in Figures 3(d) and 3(e). Over the whole period less solvent firms show the lowest accumulation rate on average (around 2%) whereas medium-/high-solvent firms invested at rates about 5% p.a. Also the impact of the recent GFC is less pronounced for medium-/high-solvent companies in comparison to firms with low solvency levels for which the negative impact was even more persistent. However, the picture looks slightly different if one groups firms according to collateral: firms with rather low levels of collateral (sum of stock, tangible assets and cash) show the highest investment ratio

⁹The pre-period value is chosen to minimize the endogeneity issue.

in Germany over time. Furthermore, their investments did not react to the GFC shock at all. However, medium- and high-collateralised firms have experienced similar investment growth in 2007/8 but the crisis hit them much stronger and has led to a persistent decline in investment growth. Given the previous observations, it seems that low-collateralised firms rather refer to financially stable companies for which lenders do not demand high collateral in exchange for credit. Lastly we look at the cash-flow-investment relationship (see Figure 3(h)). According to the data, firms with low cash flows show the lowest accumulation rates. Firms with medium levels of cash flows experienced similar investment ratios as high-cash-flow ones up to 2009, but the adverse effect on investment was much stronger for former firms. High-cash-flow firms were able to stabilize investment between 2009 and 2010, before a strong reduction in 2011.

Overall, this simple graphical description provides some first evidence for an existing link between a firm's financial position and its investment. Furthermore, there maybe non-linear relationships, in line with recent findings on the Euro area firm-level (ECB, 2013, 59), between financial pressure and fixed-investment growth. Low-/medium-solvent(-collateralised) firms show much different accumulation rates compared to high-solvent(-collateralised) companies. For a more detailed country-wise analysis of the impact of the recent GFC on fixed-investment see ECB (2013, 60 pp.).

4 Threshold-Panel Estimation Results and A Word of Caution

Next we can present the estimation results. We estimate the fixed-investment model in eq. (2) for five different specifications which only deviate w.r.t. the applied threshold variable. The first step of the analysis involves the determination of the number of thresholds (regimes). Thus, we check whether a simple linear model fits the data well enough or any threshold effects exist. For all specifications we test for up to three thresholds (four regimes). In no case we have found more than two significant thresholds at least at the 10% significance level, that is why we only report results for up to three regimes in the following. After the determination of the number of regimes, the actual estimation of the regime-dependent parameters follows. If no threshold-effects are found a simple linear panel FE model is estimated, instead. Lastly, some limitations of the applied framework are presented and discussed.

Threshold-Panel Estimation Results –Table 4 summarizes the regime test results. In the first column the applied threshold variable is denoted. The test sequence starts with the null hypothesis of no threshold against a single threshold (T0 vs. T1). If the null is rejected, one proceeds by testing the null of a single threshold against two thresholds (T1 vs. T2). The second column computes the respective bootstrapped p -value, and the last two columns tabulate the point estimates (plus confidence intervals) of the threshold value(s), γ . In case more than one threshold is found the refinement threshold values are provided.

Place Table 4 about here!

According to the results, we cannot reject the null that no threshold exists for both leverage series *lev* and *llev* as well as the collateral variable, *col*, at standard levels. Thus, an arbitrary grouping of firms into financially constrained and unconstrained ones may result in biased coefficient estimates in this case, as a sample-split is not appropriate here. However, the results indicate a significant threshold effect for the interest-coverage ratio, our solvency measure and the two principal component factors, respectively. The null of no threshold against a single threshold can be rejected at the 5% for *sol* and *factor2* and at least at the 10% for *icov* and *factor1*.

In Table 5 we compute the fraction of firms, according to firm size, falling into a specific regime. For instance, one can observe that around 75% of all micro firms have an interest-coverage rate below the estimated threshold value of 0.25. Hence, three-quarters of all micro firms fall into a so called 'low-premium' regime according to our estimation. It is interesting to see that the share of firms falling into this unconstrained regime is stable across firm sizes: 69% of all big firms operate under a regime which we also could refer to as financially unconstrained. Thus, it seems that the probability to fall into a specific regime does not depend on firm size.

According to our solvency measure around 25% of all SMEs have a level of solvency below 0.09. For big firms the fraction is about 20% whereas only 13% of large firms fall into a 'high-premium' regime. This confirms the results for *icov*, as again the majority of firms could be called financially unconstrained. Overall, the share of firms falling into a specific regime does not seem to depend on firm size. The only exception may be large firms where a higher fraction of firms are found to be financially solid. Overall, the correlation between firm size and regime-belonging is rather weak.

Very similar numbers are obtained for *factor1* and *factor2*, respectively. The estimation results show that only 10% (around 25%) of all micro (others than micro) firms fall into the financially constrained regime.¹⁰ This difference may be explained by the low number of observations for micro firms using the principal component factors. Lastly, the result using *factor2* as a threshold variable confirm this picture: again about 25% of all firms fall into the 'high-premium' regime, but the majority can be defined as financially solid. Again no correlation between firm size and regime-belonging seems to exist.

Overall, it is interesting to observe that in no case—irrespective of the chosen threshold variable—the probability to fall into a 'low-' / or 'high-premium' regime does not seem to depend on firm size in a strict way.

Place Table 5 about here!

We proceed with the estimation of the investment-to-cash-flow nexus where the threshold variables enter the model simply as an additional control variable. In a benchmark specification we assume a linear relationship between investment and cash flow, and thus rule out any threshold effects. This model corresponds to most baseline specifications we have discussed in the literature

¹⁰Remember that *factor1* is negatively correlated with leverage but positively with solvency. Thus, a low value indicates a 'high-premium' firm.

review. The respective linear coefficients are denoted by β_{Lin}^{cf} and are reported in Table 6. For all seven models we find a positive and significant (at the 1% level) relationship with a coefficient ranging from 0.061 to 0.16. The marginal effect of cash flow is positive as expected if firms face some kind of capital markets imperfections.

However, estimations are biased in case of existing non-linearities, that means if any threshold effects are existing. As we found significant threshold-effects for the models using the threshold variables *icov*, *sol*, *factor1* and *factor2*, respectively, we report the regime-dependent coefficients only for these cases. The corresponding regime-dependent β -coefficients substantially deviate from their linear counterparts in some of the cases.¹¹ For instance, for 'low-premium' firms with interest-coverage ratios below $icov < 0.25$ the marginal effect is $\beta_{Low}^{cf} = 0.104$ whereas it is about two times higher, $\beta_{High}^{cf} = 0.213$, for high-premium firms for which $icov \geq 0.25$. Both marginal effects are significant at the 1% level. Similarly, firms with low cash-flow-to-debt ratios ($sol < 0.09$) spent about 0.216 units of each additional cash flow unit on investment, whereas the marginal effect is almost three times lower for solvent firms for which the marginal effect is about 0.07. Again both coefficients are statistically different from zero at the 1% level. This is in line with the theoretical prediction that financially constrained firms rely more heavily on cash flows compared to unconstrained ones.

Place Table 6 about here!

Based on the two variables obtained from the main component analysis, we find that the marginal effect of cash flow on investment is larger for 'high-premium' firms (low values of *factor1* and *factor2*) compared to the financially solid ones. For instance, for the model with *factor1* we find a point estimate around $\beta_{Low}^{cf} = 0.223$ (significant at the 5% level) for high-premium firms whereas the point estimate is around 4 times lower, $\beta_{High}^{cf} = 0.051$, for unconstrained firms. For the latter the estimate is even not significantly different from zero, indicating that the average unconstrained firm does not rely on cash flow to fund their investments. A very similar pattern can be seen for *factor2*, and is not further described.

Summing up, we find strong evidence for capital market imperfections following the methodology proposed by Fazzari and Athey (1987) and Fazzari et al. (1988). The identification strategy to distinguish between financially constrained and unconstrained firms by means of testing for threshold effects results in plausible coefficient estimates. We find no evidence that firm size is an appropriate characteristic to discriminate between firms. The results rather suggest that balance sheet indicators contain crucial information for the classification of funding-regimes German firms operate in. In accordance with the theoretical predictions the cash flow sensitivity of investment is much stronger for financially constrained firms in our data sample.

A word of caution – A critical point in estimating reduced-form fixed-investment functions concerns the issue whether the control variables such as Tobin's q or growth in sale revenues fully capture demand effects. Otherwise the positive cash flow effect may be interpreted as shifts on the

¹¹The estimates of the regime-independent variables are provided in the online Appendix.

demand-side rather than on the supply-side, stemming from capital market imperfections. Hence, for identification we need to make sure that the control variables fully capture shifts in demand in order to interpret the marginal effect of cash flow as reflecting supply-side factors. In their, unfortunately, less often cited paper Fazzari and Petersen (1993) have suggested an extension of the standard approach. The authors emphasize the crucial dual role of working capital as a *use of funds* as well as a *source of liquidity*.¹² Their first theoretical prediction starts from computing the correlation between working capital and fixed-investment. As working capital behaves pro-cyclically and is positively correlated with sales and profits, the inclusion of working capital into the fixed investment function should result in a positive effect on fixed investment. However, this only holds true if working capital as a use of funds does not compete with fixed investment under a binding finance constraint. Thus, for firms facing imperfect capital markets the marginal effect of working capital is expected to be negative.

Secondly, Fazzari and Petersen claim that the standard reduced-form fixed investment model underestimates the full effect of capital market imperfections. They argue that the coefficients estimated only reflect some "...average 'short-run' impact of cash flow shocks, after the firm engages in optimal investment smoothing" (Fazzari and Petersen, 1993, 329). To fully capture financing constraints one has to control for endogenous changes in working capital as a source of fund mitigating cash flow shocks. If one does not control for working capital in the fixed investment function, one cannot rule out that e.g. negative cash flow shocks are compensated by the liquidity working capital (especially cash holdings) provides. If a firm holds a large stock of working capital, this negative cash flow shock may be mitigated. However, the same shock will have a much larger impact on investment if the stock of working capital is too small to smooth investment plans. Our results, due to the non-consideration of working capital in our investment function, may only capture the very short-run cash-flow-to-fixed-investment sensitivity but not the long-run effects. In Fazzari and Petersen's study the marginal effect of cash flow on fixed-investment is indeed three to four times higher after considering working-capital as an additional regressor. Unfortunately, we are not able to consider these aspects here, mainly due to the large number of missing observations for working capital in the DAFNE dataset. However, this short paragraph is added to outline some remaining limitation of our own work and of others on measuring financial investment constraints.

Another aspect concerns the substitution effects in non-financial corporations' financing, as firms can choose from a pool of external financing instruments. These instruments include, for instance, equity, bank loans, debt securities, inter-company loans, trade credit facilities or informal loans. This leads to some degree of flexibility in their financing of working capital and investment. But it should be kept in mind that this flexibility is rather limited for (opaque) SMEs. On the aggregate level there is some evidence that in some Euro area countries corporations have replaced bank loans with market-based financing such as equity and debt securities as well as intra-sectoral financing between firms and trade credit (ECB, 2013, 21 pp.).¹³ A strong

¹²Working capital is defined as the difference between short-term assets comprising accounts receivable, inventories and cash, minus the sum of accounts payable plus short-term debt.

¹³See also Casey and O'Toole (2013) for empirical evidence on the use of alternative sources of finance by European SMEs during the financial crisis.

substitution channel may mitigate the relevance of financial frictions. However, to control for substitution effects might be demanding, as an appropriate model requires a multivariate or instrumental variable set up in order to control for endogeneity issues.

Lastly one should mention the potential repercussions of the recent financial crisis on the estimation results. It might be the case that the relationships between the variables have changed as a result of deeper structural changes due to the GFC. In this work we have dealt with this by including a simple shift dummy which accounts for possible changes in the conditional mean of the accumulation rate. This may be justified for two reasons: First, the paper does explicitly not deal with the effects of the financial crisis on investment decisions, but is generally about the relationship between realized firm investment, cash flow and balance sheet aspects. Thus, the GFC, captured in the data, may even provide information on rare events which helps us to identify specific regimes. Second, as the time span covered by the data is rather small, it may be difficult to detect parameter changes due to breaks over the time with the econometric tool applied in this paper. Nevertheless, the question how the GFC might have impacted on this relationship is also of importance but should be addressed in another paper.

5 Conclusion

This article has shown that a firm's financial situation matters. In particular, it has linked a firm's balance sheet position to realized fixed investment. The paper contributes to the literature on financial investment constraints which has gained some renewed interest during the recent financial crisis. Our investment function estimation results reveal a significant and positive effect of cash flow on fixed investment. We find for four out of seven threshold variables evidence that the cash-flow-investment sensitivity is up to three times higher for firms operating in the high-default-risk regime. Overall, the results suggest that firm-level fixed investments are indeed financially supply-side restricted, which confirms previous findings. However, our analysis questions the *a priori* classification scheme according to firm size. We do not find strong evidence for a negative correlation between firm size and the probability to operate in a low-premium regime.

The results have implications for explanations of the persistence of low investment growth in Germany over the past decade. Our results provide some direct evidence that highlights the role of financial frictions in restricting the availability of credit to firms (Hall, 2011; Stock and Watson, 2012). This channel may also explain the long-lasting weak labour market development in Germany as restricted access to credit may result in persistent insufficient aggregate demand and forces firms to purge excess labour. Chodorow-Reich (2013) has recently studied the link between the health of a firm's lenders to its employment outcomes and finds an economically important relationship. Additionally, our results may help to explain why the downturn accelerated in 2008 much stronger in some southern European economies as well as why the negative economics repercussions of the GFC were rather limited in Germany in the following. As statistical numbers show, German firms were on average less indebted (according to standard balance sheet measures) compared to firms e.g. in Spain, Greece or Portugal. Thus, the share of firms falling into the high-premium regime may be rather low in Germany, in comparison to other economies.

This explains why the "deleveraging-aggregate demand" channel (Mian and Sufi, 2010) is less important in Germany. As firms and households face high debt burdens and restricted access to external finance, they are forced to deleverage which has severe negative repercussions on aggregate demand (Biggs et al., 2010; Keen, 2010; Eggertsson and Krugman, 2012; Mian et al., 2013).

Finally, the result that the regime-belonging does not depend on firm size, taken as a proxy for the degree of asymmetric information, may highlight the importance of banking relationships. The literature suggests that relationship-banking still plays a dominant role in Germany (Mommel et al., 2008). SMEs typically have long-term relationships with a single or small number of banks which are mostly public non-profit maximizing institutions. Relationship-lending can be a helpful institutional device to mitigate the impact of unforeseen events and/or asymmetric information problems on credit lending (Gobbi and Sette, 2012). This explains why SMEs may have similar access to external funding and may face less often restrictive access to external funds over the business cycle. However data constraints limit further investigation on this but future research should look whether relationship-banking aspects may help to explain why firm-size and the degree of financial frictions are only weakly correlated.

Data Appendix

The list of industrial sectors considered is provided in table 1 below.

| Industrial sectors included |
|--|
| Mining and quarrying |
| Manufacturing |
| Electricity, gas, steam and air conditioning supply |
| Water supply, sewerage, waste management and remediation act |
| Construction |
| Wholesale and retail trade; repair; repair of motor vehicles and motorcycles |
| Transportation and storage |
| Accommodation and food service activities |
| Information and communication |

Table 1: Overview of industries considered in the dataset

All data are taken from the Creditreform DAFNE database, as long as not stated differently.

Investment to capital stock ratio, $ik_{i,t} = \frac{I_{i,t}}{K_{i,t-1}}$, is the ratio of the change in tangible fixed assets over tangible fixed assets of the previous period. Tangible fixed assets consists of land, property, plant and equipment.

Cash flow over tangible fixed assets, $cf_{i,t} = \frac{Cf_{i,t}}{K_{i,t-1}}$, is the ratio of profits after taxes and interest over tangible fixed assets of the previous period.

Depreciation on fixed assets over tangible fixed assets, $d_{i,t} = \frac{D_{i,t}}{K_{i,t-1}}$. The depreciation on fixed assets had to be imputed due to missing values for all units calculating it instead by: depreciation on total assets weighted by the ratio of tangible fixed assets to total assets (same procedure as in Engel and Middendorf (2007)).

Real return on investment $roi_{i,t}$ is the nominal return on investment minus GDP inflation rate (AMECO: PVGD).

Growth of real sales revenue, $gt_{i,t}$, where nominal sales revenue is deflated by GDP price level (AMECO: PVGD).

Log of the number of workers per firm, $w_{i,t}$.

Total total liabilities to total equity ratio, $lev_{i,t}$.

Total liabilities minus short-term liabilities (maturity up to one year) to total equity ratio, $lglev_{i,t}$.

Interest expenditures minus interest income to cash flow ratio, $icov_{i,t} = \frac{Int_{i,t}}{Cf_{i,t}}$

Cash flow to total liability ratio, $sol_{i,t}$.

Sum of total inventory stock, tangible assets plus cash available at hand or at bank, over total tangible assets, $col_{i,t}$.

GDP output gap, gdp_t , (AMECO: AVGDGP).

Great Financial Crisis, gfc_t , is dummy variable variable which is unit for observations $T \geq 2008$ and otherwise zero.

The following screening procedure has been applied to the data. These steps are common procedures applied in the literature.

- Drop the 5% and 95% percentiles of the accumulation rate, $ik_{i,t}$.
- For both leverage measures, $lev_{i,t}$ and $lglev_{i,t}$, all negative values as well as values exceeding 10 were dropped.
- For the measure of collateral, $col_{i,t}$, non-positive values and values exceeding 20 were dropped.
- The net-interest-coverage ratio, $icof_{i,t}$, is restricted to positive values, as we are interested in financially restricted firms only.
- Except for both variables $ik_{i,t}$ and gdp_t , for all remaining variables the 2.5% and 97.5% percentiles were dropped to avoid excessive outliers or further implausible values.

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| Size | <i>ik</i> | <i>w</i> | <i>gt</i> | <i>roi</i> | <i>d</i> |
|-------------|-----------|----------|-----------|------------|----------|
| micro | 0.009 | 2.350 | 0.026 | 0.077 | 0.013 |
| small | 0.016 | 3.434 | 0.029 | 0.072 | 0.017 |
| medium | 0.036 | 4.654 | 0.032 | 0.073 | 0.019 |
| big | 0.048 | 6.087 | 0.033 | 0.057 | 0.034 |
| large | 0.059 | 7.852 | 0.035 | 0.051 | 0.043 |

| | <i>lev</i> | <i>lglev</i> | <i>icov</i> | <i>sol</i> | <i>col</i> |
|--------|------------|--------------|-------------|------------|------------|
| micro | 1.689 | 1.031 | 0.093 | 0.159 | 2.365 |
| small | 1.695 | 0.960 | 0.129 | 0.148 | 2.318 |
| medium | 1.523 | 0.902 | 0.119 | 0.180 | 2.133 |
| big | 1.258 | 0.715 | 0.118 | 0.193 | 1.984 |
| large | 1.270 | 0.826 | 0.141 | 0.186 | 1.772 |

Note: Statistics are based on unbalanced panel.

Table 2: Median values according to firm size. Sample: 2006–2012

| Legal | <i>ik</i> | <i>w</i> | <i>gt</i> | <i>roi</i> | <i>d</i> |
|--------------------|-----------|----------|-----------|------------|----------|
| Stock comp. | 0.048 | 6.057 | 0.037 | 0.062 | 0.031 |
| Limit. liab. comp. | 0.032 | 4.554 | 0.031 | 0.071 | 0.021 |
| Others | 0.038 | 4.580 | 0.030 | 0.047 | 0.041 |

| | <i>lev</i> | <i>lglev</i> | <i>icov</i> | <i>sol</i> | <i>col</i> |
|--------------------|------------|--------------|-------------|------------|------------|
| Stock comp. | 1.140 | 0.598 | 0.117 | 0.186 | 1.918 |
| Limit. liab. comp. | 1.543 | 0.931 | 0.120 | 0.176 | 2.135 |
| Others | 1.434 | 0.800 | 0.098 | 0.139 | 1.964 |

Note: Statistics are based on unbalanced panel.

Table 3: Median values according to legal firm status. Sample: 2006–2012

| Threshold variable | P-value | γ_1 | γ_2^T |
|--------------------|---------|------------------------|----------------------|
| <i>icov</i> | | | |
| T0 vs. T1 | 0.084 | 0.25 [0.10 0.65] | |
| T1 vs. T2 | 0.399 | 0.11 [-0.10 0.65] | 0.25 [0.12 0.65] |
| <i>lev</i> | | | |
| T0 vs. T1 | 0.415 | 2.63 [0.22 5.52] | |
| T1 vs. T2 | 0.078 | 2.50 [2.50 2.68] | 2.63 [2.63 2.65] |
| <i>lglev</i> | | | |
| T0 vs. T1 | 0.389 | 1.12 [0.06 4.85] | |
| T1 vs. T2 | 0.509 | 0.59 [0.06 4.85] | 0.66 [0.64 4.85] |
| <i>sol</i> | | | |
| T0 vs. T1 | 0.038 | 0.09 [0.05 0.11] | |
| T1 vs. T2 | 0.106 | 0.08 [0.08 0.25] | 0.09 [0.09 0.09] |
| <i>col</i> | | | |
| T0 vs. T1 | 0.166 | 2.80 [1.24 2.91] | |
| T1 vs. T2 | 0.196 | 2.78 [1.41 2.83] | 2.80 [2.80 2.80] |
| <i>factor1</i> | | | |
| T0 vs. T1 | 0.068 | -0.16 [-2.39 0.15] | |
| T1 vs. T2 | 0.762 | -0.16 [-0.66 0.01] | 1.81 [-2.39 2.05] |
| <i>factor2</i> | | | |
| T0 vs. T1 | 0.014 | 0.30 [-0.67 0.35] | |
| T1 vs. T2 | 0.279 | -0.66 [-1.17 -0.32] | 0.30 [0.20 0.35] |

Note: The test results for multiple thresholds are provided. *T0 vs. T1* and *T1 vs. T2* refer to the null of no threshold against one threshold (2 regimes) and one threshold against two thresholds (3 regimes). We provide the bootstrapped p-values based on 399 replications. γ_1 and γ_2 refer to the estimated threshold values (in square brackets the 95 % CIs are provided). For the test on two thresholds, the refinement estimates are given. The number of quantiles checked is 300.

Table 4: Threshold test results

| <i>icov</i> | <i>N</i> | <i>N/Obs</i> | <i>n</i> for which <i>icov</i> < 0.25 |
|-------------|-------------|--------------|---------------------------------------|
| Micro | 100 | 0.03 | 0.75 |
| Small | 370 | 0.11 | 0.76 |
| Medium | 1401 | 0.42 | 0.75 |
| Big | 949 | 0.28 | 0.73 |
| Large | 554 | 0.16 | 0.69 |
| Obs. | 3374 | | |

| <i>sol</i> | <i>N</i> | <i>N/Obs</i> | <i>n</i> for which <i>sol</i> < 0.09 |
|------------|-------------|--------------|--------------------------------------|
| Micro | 98 | 0.03 | 0.28 |
| Small | 407 | 0.11 | 0.25 |
| Medium | 1512 | 0.42 | 0.21 |
| Big | 1011 | 0.28 | 0.20 |
| Large | 584 | 0.16 | 0.13 |
| Obs. | 3612 | | |

| <i>factor1</i> | <i>N</i> | <i>N/Obs</i> | <i>n</i> for which <i>factor1</i> < -0.16 |
|----------------|-------------|--------------|---|
| Micro | 21 | 0.02 | 0.10 |
| Small | 139 | 0.11 | 0.22 |
| Medium | 542 | 0.41 | 0.29 |
| Big | 329 | 0.25 | 0.25 |
| Large | 278 | 0.21 | 0.22 |
| Obs. | 1309 | | |

| <i>factor2</i> | <i>N</i> | <i>N/Obs</i> | <i>n</i> for which <i>factor2</i> < 0.30 |
|----------------|-------------|--------------|--|
| Micro | 21 | 0.02 | 0.71 |
| Small | 139 | 0.11 | 0.79 |
| Medium | 542 | 0.41 | 0.78 |
| Big | 329 | 0.25 | 0.74 |
| Large | 278 | 0.21 | 0.74 |
| Obs. | 1309 | | |

Table 5: Number of firms according to size and share of firms, *n*, below estimated threshold value

| Threshold Var. | <i>icov</i> | <i>lev</i> | <i>lglev</i> | <i>sol</i> | <i>col</i> | <i>factor1</i> | <i>factor2</i> |
|-------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Linear benchmark coefficients | | | | | | | |
| β_{Lin}^{cf} | 0.095*** (0.026) | 0.075*** (0.019) | 0.061*** (0.020) | 0.065*** (0.015) | 0.103*** (0.034) | 0.160*** (0.036) | 0.149*** (0.035) |
| Regime-dependent coefficients | | | | | | | |
| β_{Low}^{cf} | 0.104*** (0.022) | | | 0.216*** (0.059) | | 0.223** (0.093) | 0.164** (0.068) |
| β_{High}^{cf} | 0.213*** (0.044) | | | 0.071*** (0.010) | | 0.051 (0.061) | 0.014 (0.058) |

Note: The β_{Lin} coefficient is based on the corresponding linear FE panel model. In the case more than one significant threshold is estimated, the refinement coefficients are reported. ***, ** and * indicate significance at the 1%, 5% and 10% level. White standard errors are given in parentheses.

Table 6: Regime-dependent coefficient estimates

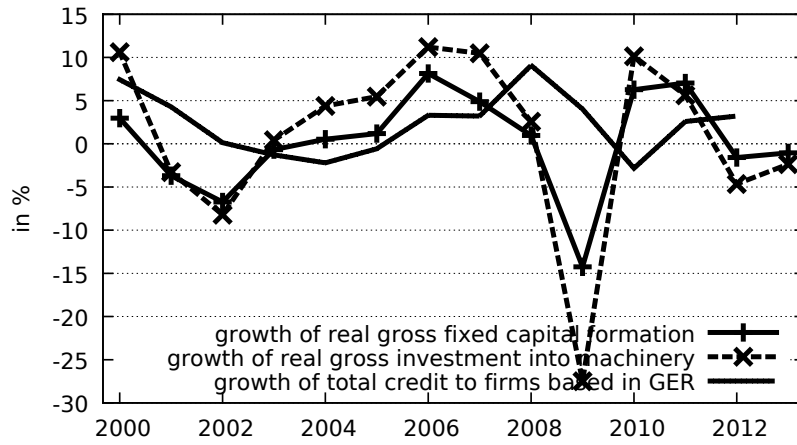


Figure 1: Growth of real private gross investment in GER, and bank lending to German non-financial firms. Source: Destatis and Bundesbank, own calculation.

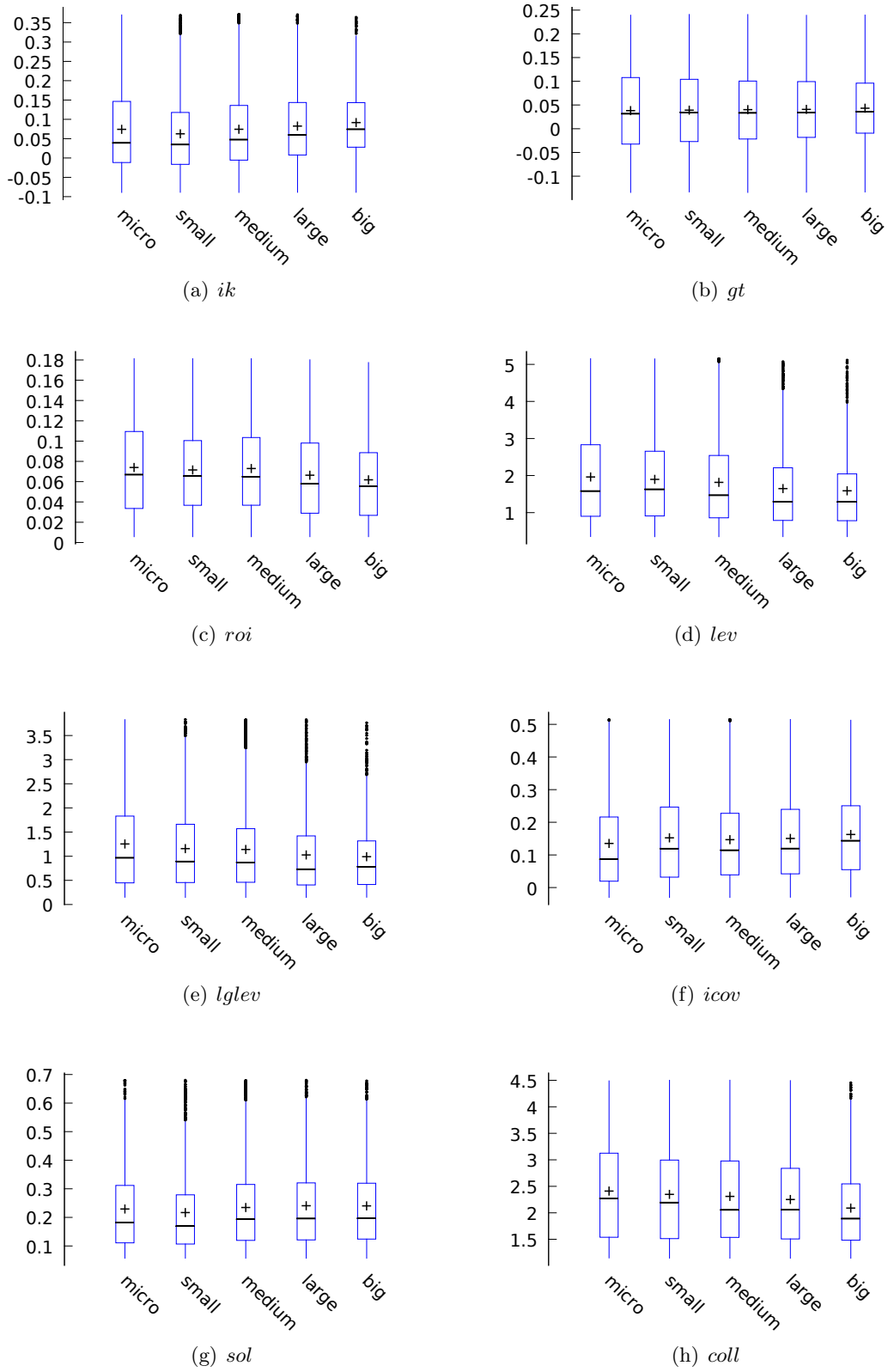
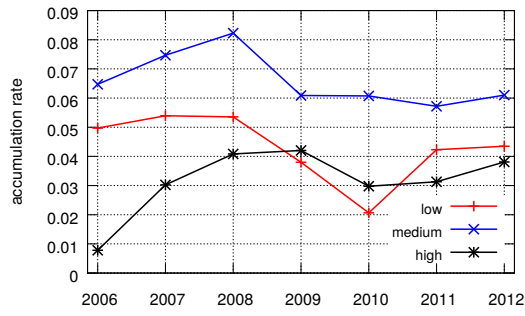
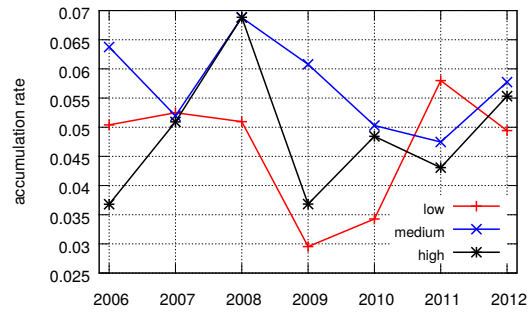


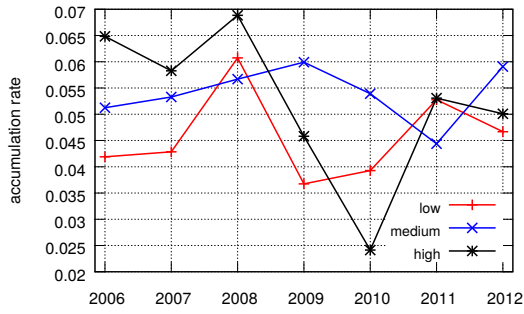
Figure 2: Unconditional distribution of key variables by firm size. Sample: 2006–2012



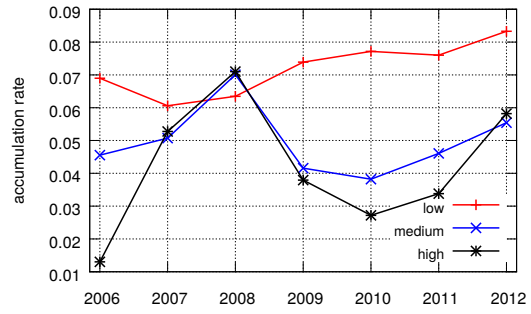
(a) *icov*



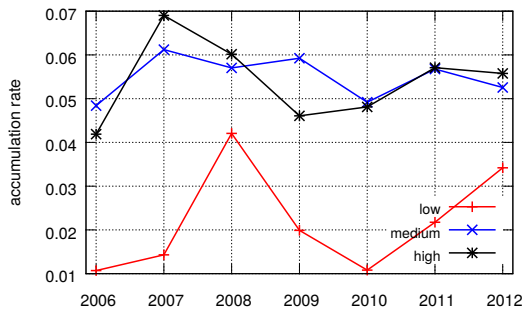
(b) *lev*



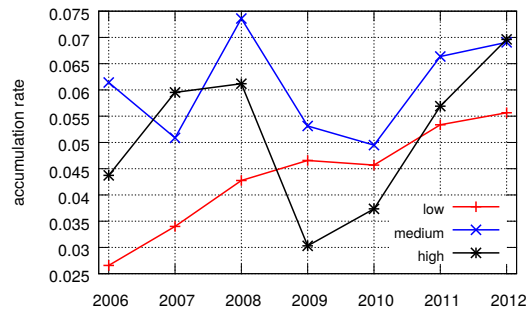
(c) *lglev*



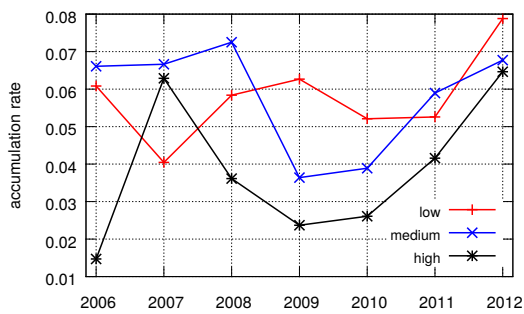
(d) *col*



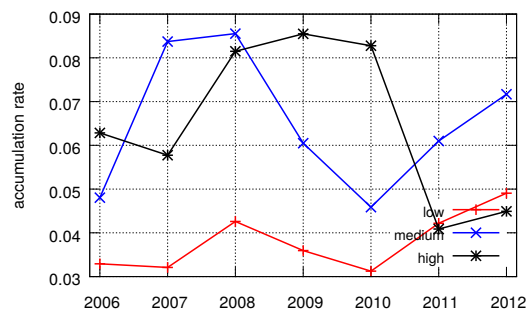
(e) *sol*



(f) *factor1*



(g) *factor2*



(h) *cf*

Notes: For each of the financial indicators considered, the charts show the current median accumulation rate (*ik*) for firms for which this (one-period lagged) indicator shows a high value (above the 85th percentile), an intermediate value (between the 40th and 60th percentiles) and a low value (below the 15th percentile).

Figure 3: Development of accumulation rate of fixed tangible investment according to financial position