Determinants of Business Fixed Investment: Evidence from German Firm-Level Data

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Abstract: This paper employs a novel firm-level dataset that combines financial accounts of German firms with data from a business survey to shed new light on the demand for capital. The empirical analysis employs firm-specific indicators in order to explore the effects of sales, the cost of capital and indicators of the business climate, which are used by the ifo Institute to provide a leading indicator for the German economy. The empirical results support a robust significant effect of a firm's cost of capital on the stock of capital with an elasticity not significantly different from -1. Controlling for sales, a good rather than normal business situation is found to be associated with about 8% higher investment.

Keywords: Investment; Business Climate; Cost of Capital; Capital Structure; Firm-Level Data; Survey Data; Neutrality of Taxation

JEL Classification: H25; E220; E320

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1 Introduction

The determinants of business fixed investment are an important issue in the debate on public policy. One strand of the empirical literature employs firm-level data to estimate dynamic models using reduced forms (for an overview see Bond and Van Reenen, 2007). Consistent with standard models of factor demand, this literature has focused on the effects of output and the cost of capital. While there are many empirical studies, results differ substantially, especially with regard to the strength of influence of the cost of capital. Somewhat surprisingly, studies often find only modest effects on investment (*e.g.*, Cummins, Hassett, and Hubbard, 1994). Since many important factors driving the cost of capital such as capital market conditions or key characteristics of tax systems are shared by all firms, the applied literature has found that it is important to exploit firm-specific variation in the tax burden on investment (*e.g.*, Hassett and Hubbard, 2002; Chirinko, Fazzari, and Meyer, 1999; Egger, Loretz, Pfaffermayr, and Winner, 2009; Dwenger and Steiner, 2012) or interest rates (Dwenger, 2014) in order to identify the effect of the cost of capital. Since information on individual firms' perceptions of business conditions are usually not available, the standard approach taken in the literature using firm-specific data is to rely on current and lagged sales.

Employing a new firm-level dataset of German firms that combines survey data with financial accounts, this paper reconsiders the determinants of the demand for capital. Using data from financial accounts we compute firm-specific indicators of the tax burden and using the survey information we augment the standard approach to the analysis of business fixed investment by firm-specific indicators of the business outlook. The data is taken from a business survey which is used by the ifo Institute to produce the influential monthly Business Climate Index, a leading indicator for the German and European economy (*e.g.*, Huefner and Schroeder, 2002; Camacho, and Perez-Quiros, 2010; Carstensen, Wohlrabe and Ziegler, 2011). More specifically, we use survey information and introduce firm-specific indicators that reflect a firm's assessment of the current business situation and the expected future business conditions. Thus our analysis contributes to the literature by exploring the determinants of investment at the firm-level using firm-specific indicators of business conditions, sales, and the cost-of-capital.

The empirical analysis employs panel data and utilizes instrumental variables to obtain consistent estimates for firm-specific determinants of business fixed investment. The empirical results point to a robust, significant effect of a firm's cost of capital on the stock of capital with an elasticity of about -0.8 and not significantly different from -1. This finding supports a recent study by Dwenger (2014), who reports a preferred elasticity of -0.9 using German data. Our results also support the predictive power of the business climate for investment decisions. With a business situation perceived as good rather than normal, investment is higher by about 8%. Changes in business expectations, however, are not found to exert significant effects.

The following section discusses the investigation approach, section 3 describes the data used in the analysis. Section 4 provides our results and section 5 concludes.

2 Empirical Model

Consider a simple factor-demand equation. Suppose that firm i has a production function with labor and capital and with a constant elasticity of substitution. If the optimal capital stock is defined as the amount of capital at which the value of the marginal product of capital is equal to the cost of capital, the optimal stock of capital in period t is determined by output and the cost of capital

$$K_{i,t}^{*} = \Gamma_{i,t} Y_{i,t} \left(coc_{i,t}\right)^{\sigma}, \tag{1}$$

where σ is the elasticity of substitution, $Y_{i,t}$ is output, $coc_{i,t}$ is the firm-specific cost of capital, and $\Gamma_{i,t}$ captures firm-specific factor shares and productivity. Abstracting from adjustment costs, equation (1) would suggest exploring a linear regression of the log of capital stock on the logs of output and cost of capital. With adjustment cost, the optimal capital stock will differ from the actual capital stock, and a dynamic approach is required to capture the adjustment path. Since incorporating adjustment cost into the decision model yields highly complex adjustment paths that critically depend on assumptions regarding the cost function, the empirical literature resorts to dynamic empirical models that capture the adjustment process of the capital stock in a reduced-form fashion (Bond and van Reenen, 2007). A standard approach would be to employ an autoregressive model that links the actual capital stock with current and lagged values of fundamental determinants of the capital stock. To remove firm-specific differences in the optimal capital stock, Chirinko et al. (1999) suggest using a specification in first differences

$$\Delta \log K_{i,t} = \delta_i + \sum_{s=0}^{P} \alpha_s \Delta \log Y_{i,t-s} + \sum_{s=0}^{P} \sigma_s \Delta \log coc_{i,t-s} + u_{i,t}, \tag{2}$$

where δ_i is the firm-specific depreciation rate, and α_s and σ_s are slope parameters for the effects of income and cost-of-capital. The error term $u_{i,t}$ captures firm- and period-specific shocks to productivity. P is some optimal lag length, which reflects the time of adjustment but also the expectation formation, as firms might extrapolate the development of the determinants of the optimal capital stock from their time paths. Note that the specification does not distinguish between different types of investment. The specification assumes that a firm-specific fraction of the capital stock depreciates in each period. If gross-investment is larger, the capital stock increases.

Given adjustment cost, uncertainty matters and, hence, sales might differ from actual output, as inventories are depleted or filled up. As a consequence, demand for capital will depend on expected rather than current market conditions. In lack of data on the business outlook, the empirical literature has mainly focused on current sales growth. We also use the current growth in sales of a firm $\Delta \log S_{i,t}$ but we add indicators from the survey data that capture the current business outlook as perceived by the individual firm and reported at firm level. Since current investment partly reflect investment decisions made in the past under adjustment cost, we include current values of the business outlook indicator $\mathsf{ifo}_{i,t}$ as well as lagged values corresponding to the other explanatory variables.

$$\Delta \log K_{i,t} = \delta_i + \sum_{s=0}^{P} \alpha_s \Delta \log S_{i,t-s} + \sum_{s=0}^{P} \beta_s \mathsf{ifo}_{i,t-s} + \sum_{s=0}^{P} \sigma_s \Delta \log coc_{i,t-s} + u_{i,t}. \quad (3)$$

Note that the business climate indicators are not entered in first differences, since they are defined as deviations from a normal state (see below).

As an alternative approach that helps to distinguish long and short-term effects, Bond and van Reenen (2007) as well as Dwenger (2014) suggest employing an error-correction model (ECM). In our setting, this would be equivalent to estimating

$$\begin{aligned}\log K_{i,t} &= \alpha_i + \sum_{s=0}^{P} \alpha_s \Delta \log S_{i,t-s} + \sum_{s=0}^{P} \beta_s \mathsf{ifo}_{i,t-s} + \sum_{s=0}^{P} \sigma_s \Delta \log coc_{i,t-s} \\ &+ (\phi + 1) \log K_{i,t-1} + \psi \log S_{i,t-1} + \omega \log coc_{i,t-1} + u_{i,t}.\end{aligned} \quad (4)$$

where α_i is a firm-specific effect. The effect of the pre-existing stock of capital on the right-hand side enables us to determine the speed of adjustment ϕ to the implied long-term relationship between capital, its cost and sales.

From an econometric point of view, the empirical estimation of specifications (3) and (4) poses some challenges. First of all, while unobserved heterogeneity among firms is controlled for by using firm-specific effects, dynamic panel data estimation with OLS is well known to yield inconsistent estimates. Since this is particularly relevant if the time dimension of the dataset is short (Nickell, 1981; Bond, 2002), this inconsistency cannot be expected to be small and negligible in our case (table A.2 in the appendix displays the number of yearly observations available for the firms contained in our sample.) Second, there may be problems of endogeneity with regard to the explanatory variables. While this may be obvious with regard to current sales, the difficulty with including the cost of capital variable comes from the inclusion of firms' financing preferences and asset structures. A similar concern arises with regard to the local variation in tax rates, since firms might respond to tax rate differences by sorting themselves into high- and low tax jurisdictions. A concern specifically with the error-correction model is whether the level-variables employed, *i.e.* the logs of capital, cost of capital and sales are stationary or cointegrated. Using financial accounts data similar to ours, but which has a longer time-series dimension, Dwenger (2014) shows that there is cointegration.

To obtain consistent estimates, we employ instrumental variable techniques. This allows us to approach both the dynamic panel biases and the problems of endogeneity. More specifically, we employ the Systems GMM estimator outlined by Arellano and Bover (1995) and refined by Blundell and Bond (1998), which includes not only a differenced equation but also the equation in levels.[1] Hence, instrumentation is done by including the contemporaneous first differences of the variables as instruments for the equations in levels and the lags of the variables in levels as instruments for the equations in first differences. In general, second or higher order lags of the variables in levels constitute a set of valid instruments for the differences if there is no serial correlation in the error terms. In a similar manner, the first differences of the corresponding variables are suitable instruments for the implied level equations.[2]

We employ the specification tests suggested by Arellano and Bond (1991) and Arellano and Bover (1995). The condition of zero second-order serial autocorrelation in the errors is tested by computing AR(2) autocorrelation statistics. While the AR(1) statistic should show significance due to first-differencing, a significant AR(2) statistic would indicate a misspecification of the model. In addition, Hansen-J statistics on the overidentifying restrictions are provided to test for the overall validity of the specification.[3] Since standard errors tend to be biased downward in small samples, we apply the correction proposed by Windmeijer (2005).

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[1] It has been shown that this additional information makes the Systems GMM estimator more efficient than the Difference GMM estimator (see Blundell and Bond, 1998).

[2] Arellano and Bover (1995) show that only the first lag of the difference is needed as an instrument since further lagged differences only result in redundant moment conditions.

[3] While the Sargan statistic would apply under the assumption of conditional homoskedasticity, in our case heteroskedasticity and autocorrelation are present, so the Hansen-J test is used to evaluate the suitability of the model.

3 Data

The empirical analysis employs an unbalanced panel dataset (EBDC Business Expectations Panel) of matched survey and financial statement data that mainly focuses on German manufacturing firms. The survey data stems from the ifo Business Survey, which is conducted monthly among firms located in Germany. It forms the basis for several indicators provided by the ifo Institute (*e.g.*, the monthly ifo Business Climate Index, BCI). This information allows us to control for a firm's own assessment of the current business situation and for the expected future business conditions. The yearly financial statement data comes from the firm databases Amadeus and Hoppenstedt. Both databases contain annual reports and also provide information on firm characteristics such as industry, location and legal form. Financial variables represent book values and are taken from unconsolidated statements.[4] Capital is measured by tangible fixed assets.[5]

We consider the observation period from 1994-2007 and take advantage of about 2700 firm-year observations that are based on almost 500 German firms. Most firms in the dataset are standalone, small or medium-sized firms, but there are also some larger corporations.[6] Descriptive statistics for the sample and covariates used in the estimations are provided in Table 1.

To capture the business climate perceived by a specific firm, we employ two related indicators: the

[4]Book and tax accounting differences are not observed. An overview on the construction and the information contained in the dataset can be found in Hoenig (2010). Specific information on the ifo Business Surveys is given in Becker and Wohlrabe (2008).

[5]Note that the dataset does not allow to distinguish different motives of investment. A new study by Buettner *et al.* (2015), uses ifo innovation survey data to explore different motives such as the enhancement of production and replacement investment.

[6]Due to different business regulations and specific tax rules we drop observations where the primary business activity is within the financial sector. Moreover, we restrict the sample of firms to corporations and ignore partnerships.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	Observations
Capital stock (Mill. EUR)	55.973	100.129	0.148	996.400	2722
Sales (Mill. EUR)	397.229	825.763	1.144	7033.828	2722
Cost of capital	0.055	0.023	0.016	0.123	2722
Business situation (ifo)	0.027	0.57	-1	1	2722
Business expectations(ifo-exp)	0.112	0.439	-1	1	2722

Inflation adjusted values included for the capital stock, which is measured by a firm's tangible fixed assets, and sales. Deflation is done using the yearly producer price index. All values represent unweighted sample averages, standard deviations are displayed in the third column. Variables business situation and business expectations are taken from the ifo survey.

firm's perception of its current business situation (ifo), and its business expectations (ifo-exp).[7] Note that these two indicators are used to construct the ifo Business Climate Index.[8] A closer inspection of the questionaire reveals some differences. While both indicators are defined relative to a standard level, the assessment of the current business situation refers the state of affairs. Respondents are asked to indicate whether the business situation is "*bad*", "*normal*" or "*good*" – coded as integers of -1, 0, and $+1$ in the data. The expectations are captured by a separate question that asks for the change of the conditions. Respondents can characterize their expectations by noting that business conditions are expected to be "*deteriorating*", "*unchanged*" or "*improving*" – again, coded as integers of -1, 0, and $+1$ in the data. Another difference between current and expected business situation is that the question on expectations is qualified in the survey. Under the headline *expectations for the next 6 months* respondents are asked for their assessment of the

[7] The ifo survey data include various further indicators that could help to predict firm investment decisions, such as the degree of capacity utilization (Smolny and Schneeweis, 1999) or credit constraints (Winker, 1993, Buettner and Fuest, 2010). However, since inclusion of further survey information would result in a substantial loss of observations, we focus only on the business climate indicators.

[8] The business climate index is computed as the geometric mean of scaled values of the two indicators (see http://www.ifo.de/w/45YCTv5Bp).

expected business conditions "with regard to the business cycle."[9] Consistent with the theoretical model, both indicators reflect the available information at the beginning of the current period. Since the survey asks for firms' business outlook on a monthly basis, while the financial accounts provide annual data, the indicators are computed as averages of monthly figures. Because the time-horizon of the survey is limited to the upcoming 6 months, we calculate the averages over the first six months of each year.

For the computation of the cost of capital we use detailed information about the German tax system and about each firm. As displayed in appendix A.1, the statutory tax rate includes the corporate income tax rate, the "solidarity surcharge", the firm-specific business tax rate and their interaction.[10] Moreover, we include annual data on nominal interest and inflation rates[11] and add information on depreciation rates. These parameters depend on the underlying assets and the respective allowance schemes. As in Devereux (2004), if financed with retained earnings the cost of capital is defined as

$$coc_{i,t} \equiv \frac{(1 - A_{i,t})}{(1 - \tau_{i,t})} \left(\frac{r_t + \delta_i}{1 + r_t} \right) \text{ and } A_{i,t} \equiv \frac{\tau_{i,t} \varphi_{i,t} (1 + r_t)}{\varphi_{i,t} + r_t}, \tag{5}$$

[9]In German, the questionnaire asks: "Unsere Geschftslage fr XY (business area) wird in konjunktureller Hinsicht eher gnstiger, eher gleich bleiben, eher ungnstiger."

[10]While the firm-specific tax rate is included, other features of local business taxation in Germany are not taken into account. First, although this tax is primarily levied on profits, there are several additions to and deductions from the business tax base. Moreover, multiregional corporations with sites or establishments in different locations are subject to formula apportionment based on the payroll (see 28 - 34 Trade Tax Act). Therefore, higher tax rates provide an incentive to substitute labor with other inputs such as capital (Riedel, 2010). While we experimented with the inclusion of an additional indicator in the regressions that captures the difference between the collection rate at the firm's location and the lowest possible collection rate, we did not find any significant effect of this "apportionment index". This may be caused by the difficulty of identifying firms with multiple locations in the dataset.

[11]Information on nominal interest rates for 10-year government bonds is taken from the Federal Statistical Office. Figures on tangible fixed assets and sales are deflated using the investment goods and producer price indices for Germany which are also provided by the Federal Statistical Office. 2005 is the base year.

where r_t is the interest rate, δ_i the rate of physical depreciation, $\tau_{i,t}$ is profit-tax rate which might vary not only over time, but also by firm location. $\varphi_{i,t}$ is the tax depreciation in the first year, $A_{i,t}$ represents the net present value of allowances in case of declining-balance depreciation.[12] With regard to the net present value of depreciation allowances, we follow the German tax law and use straight-line depreciation for buildings and the declining-balance method for machinery. Finally, we exploit the micro-level information of the financial statement data to proxy for a firm's capital and asset structures. Specifically, we compute firm-specific, time-varying weights using the respective firm-specific share of debt to total capital, where debt includes all interest-bearing liabilities but no pension reserves or trade accounts payable. Total capital is the sum of nominal capital, capital and profit reserves as well as total debt, *i.e.* it corresponds to total assets less contemporaneous profits or losses. Moreover, we also compute shares of plant/machinery and buildings in order to obtain firm-specific tax depreciation allowances.

Table 2 displays the unweighted annual averages of the variables employed. Like Table 1 it provides inflation adjusted figures.[13] As can be seen from Table 2, from 2004 onwards, there are more companies available in the database leading to a drop in mean values of the balance-sheet variables.[14]

[12]The present value of depreciation allowances depends on the type of asset, the respective depreciation rate and the allowance scheme. Neglecting time indices, in case of straight-line depreciation, $A \equiv \frac{\tau\varphi(1+r)}{r}(1 - \frac{1}{(1+r)^n})$ where n is the number of years for which depreciation allowances can be claimed. Following Devereux *et al.* (2002) and Yoo (2003), we assume a rate of economic depreciation for machinery of $\delta^M = 12.25\%$, while $\delta^{IB} = 3.61\%$ is assumed for buildings. Depreciation rates for tax purposes, *i.e.* capital allowances for industrial buildings and machinery are taken from the national tax code, from Yoo (2003) and the study of Devereux *et al.* (2008, section A, A-13, table A-5 pp).

[13]We drop observations of firms with a negative value for subscribed equity. Also extreme observations of sales and capital are dropped.

[14]When the dataset was established, most of the balance-sheets for the year 2007 were not yet available such that the number of observations in our sample drops again in 2007. For a discussion of the availability of the dataset and possible updates see Hoenig (2010).

Considering average sales, some large companies drive up the mean values. The annual median value of sales makes up some 20 % of the annual mean. This points at a skewed distribution, which is also reflected in the large standard deviations. With regard to the level of the cost of capital, the figures clearly emphasize the consequences of the 2001 tax reform, which lowered statutory tax rates substantially. Moreover, considering cross-sectional differences, the cost of capital displays substantial variation among firms. Obviously, this is due to the fact that they are firm-specific in three dimensions: First, there is variation in each firm's business tax rate, since we include municipality-specific multipliers. Second, we account for the firm-specific financial structure and, third, we also capture the asset structure of a firm (see appendix A.2).

4 Estimation Results

As a preliminary step, results for an OLS specification in first differences with fixed firm-effects are presented in table 3. Column (1) provides results including sales and the cost of capital and finds significant effects. While sales are positively associated with investment, the cost of capital exerts a strong negative effect. The time effects are positive, which reflects the choice of 2001 as the base year, during which the German economy experienced a slump. Column (2) includes the business situation, which shows a highly significant positive effect. Columns (3) and (4) show that business expectations do not exert significant effects regardless of whether they are included jointly with or independently of the business situation.

Since current values of sales and cost of capital might be correlated with the error term and due to the likely presence of autocorrelation, more reliable estimates can be expected from using a Systems

Table 2: Descriptive Statistics by Year

	1994	1995	1996	1997	1998	1999	2000
Capital stock (Mill. EUR)	65.46	62.54	72.76	62.25	66.01	59.43	63.50
	(98.290)	(97.80)	(122.31)	(95.02)	(98.83)	(95.95)	(98.33)
Sales (Mill. EUR)	411.5	443.3	513.4	500.3	499.2	408.9	422.9
	(813.24)	(873.00)	(1072.7)	(1083.7)	(964.54)	(825.86)	(764.16)
Cost of capital	0.074	0.092	0.085	0.069	0.071	0.070	0.071
	(.0165)	(.0177)	(.0152)	(.0136)	(.0117)	(.0108)	(.0121)
ifo business situation	-0.199	0.092	-0.246	-0.072	0.139	-0.094	0.235
	(.5832)	(.5674)	(.5261)	(.5376)	(.5297)	(.4825)	(.5414)
ifo business expectation	0.125	0.150	-0.064	0.104	0.146	-0.024	0.257
	(.4609)	(.4570)	(.4690)	(.4311)	(.3776)	(.4398)	(.4098)
Obervations	189	174	166	156	176	178	165
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Capital stock (Mill. EUR)	72.71	56.07	49.61	42.70	42.90	41.24	53.86
	(122.77)	(82.44)	(88.20)	(95.87)	(96.92)	(92.84)	(115.05)
Sales (Mill. EUR)	454.0	424.3	363.0	291.7	305.5	304.3	406.9
	(783.10)	(800.92)	(755.89)	(670.84)	(703.31)	(718.07)	(821.16)
Cost of capital	0.046	0.049	0.045	0.034	0.031	0.035	0.035
	(.0064)	(.0070)	(.0065)	(.0057)	(.0053)	(.0056)	(.0056)
ifo business situation	0.145	-0.167	-0.206	0.020	0.024	0.203	0.422
	(.5536)	(.4991)	(.5490)	(.5292)	(.5824)	(.5718)	(.5179)
ifo business expectation	-0.025	0.065	0.025	0.238	0.101	0.182	0.179
	(.4027)	(.4591)	(.4363)	(.4450	(.4096)	(.4369)	(.3809)
Obervations	148	172	198	246	282	286	186

Inflation adjusted figures for the capital stock and sales. Deflation is done using the yearly producer price index. All values represent unweighted sample averages, standard deviations are displayed in parentheses. Variables business situation and business expectations are taken from the ifo survey.

Table 3: Estimates of OLS Specification in First Differences (with P=0)

		(1)	(2)	(3)	(4)
Sales	$\Delta \log S_{i,t}$	0.182 ***	0.168 **	0.182 ***	0.168 **
		(0.067)	(0.067)	(0.067)	(0.067)
Cost of capital	$\Delta \log coc_{i,t}$	-0.561 ***	-0.574 ***	-0.561 ***	-0.574 ***
		(0.193)	(0.192)	(0.193)	(0.192)
Bus. situation	$\mathsf{ifo}_{i,t}$		0.057 ***		0.057 ***
			(0.015)		(0.015)
Bus. expectations	$\mathsf{ifo\text{-}exp}_{i,t}$			0.004	-0.003
				(0.018)	(0.018)
t=1995		0.384 ***	0.397 ***	0.383 ***	0.397 ***
t=1996		0.187 **	0.213 ***	0.187 **	0.213 ***
t=1997		0.124 **	0.139 **	0.124 **	0.140 **
t=1998		0.247 **	0.252 **	0.246 **	0.253 **
t=1999		0.264 ***	0.281 ***	0.264 ***	0.281 ***
t=2000		0.301 ***	0.304 ***	0.300 ***	0.304 ***
t=2002		0.275 **	0.300 ***	0.275 **	0.301 ***
t=2003		0.187 **	0.215 **	0.187 **	0.215 **
t=2004		0.054	0.071	0.054	0.072
t=2005		0.181 **	0.197 ***	0.180 **	0.198 ***
t=2006		0.284 **	0.297 **	0.284 **	0.297 **
t=2007		0.184 *	0.182 *	0.183 *	0.182 *
Constant		-0.243 ***	-0.259 ***	-0.243 ***	-0.259 ***
Observations		2084	2084	2084	2084
Firms		490	490	490	490
R^2 (total)		0.351	0.356	0.351	0.356
R^2 (within)		0.074	0.082	0.074	0.082

The dependent variable is the log of the capital stock. OLS estimates with firm-specific fixed effects. Robust standard errors are given in parentheses. * denotes significance at 10%; ** significance at 5%; *** significance at 1%.

GMM estimator. Note that we consider the current business climate and business expectations as exogenous. This may seem to be overly restrictive, since large investment decisions might be associated with some positive bias in the assessment of future developments. However, the issue of defining instruments for the survey responses is beyond the scope of the current analysis.

Table 4 provides corresponding results along with Windmeijer-corrected standard errors and test statistics robust to heteroskedasticity. The p-values of the Hansen statistic do not indicate any misspecification, while the tests on first and second-order autocorrelation suggest that the models are correctly specified as the null of no second-order serial correlation in the residuals cannot be rejected. The results are qualitatively similar to those obtained by a simple OLS regression. However, in all specifications, the cost of capital shows stronger effects, indicating that if the cost of capital increases by 10 % the capital stock decreases by about 10%. Significant effects are confirmed also for sales. The point estimates show that the effects are less than proportional. Columns (2) and (4) support strong effects of the business climate. The coefficient estimates indicate that an improvement of the business situation from "normal" to "good" is associated with an increase in investment by about 6 percent.

Table 5 shows results including lags of the explanatory variables. Columns (1) and (2) report results with one lag. In both specifications we find that current as well as lagged sales exert a significant positive effect. Although the magnitude of the coefficient for lagged sales is small, the sum of the current and lagged sales shows a larger effect than in the specification without lags. This points to the role of fluctuation in sales. If sales increase over a longer period, the effect on the capital stock gets larger. A similar effect is found for the business situation: If the business situation is currently good and has been good in the previous period, the capital stock increases by about 8%.

Table 4: Estimates of IV-GMM Specification in First Differences (with P=0,1)

		(1)	(2)	(3)	(4)
Sales	$\Delta \log S_{i,t}$	0.124 **	0.142 **	0.161 **	0.143 **
		(0.059)	(0.067)	(0.068)	(0.068)
Cost of capital	$\Delta \log coc_{i,t}$	-0.941 ***	-1.042 ***	-1.059 ***	-1.045 ***
		(0.278)	(0.306)	(0.308)	(0.303)
Bus. situation	$\mathsf{ifo}_{i,t}$		0.064 ***		0.064 ***
			(0.013)		(0.013)
Bus. expectations	$\mathsf{ifo}\text{-exp}_{i,t}$			0.012	-0.003
				(0.014)	(0.016)
t=1995		0.594 ***	0.665 ***	0.669 ***	0.666 ***
t=1996		0.286 ***	0.350 ***	0.332 ***	0.351 ***
t=1997		0.175 ***	0.215 ***	0.203 **	0.216 ***
t=1998		0.406 ***	0.450 ***	0.457 ***	0.451 ***
t=1999		0.408 ***	0.472 ***	0.466 ***	0.473 ***
t=2000		0.478 ***	0.527 ***	0.536 ***	0.528 ***
t=2002		0.474 ***	0.551 ***	0.540 ***	0.552 ***
t=2003		0.321 ***	0.390 ***	0.376 ***	0.391 ***
t=2004		0.121 **	0.148 ***	0.140 **	0.148 ***
t=2005		0.315 ***	0.357 ***	0.356 ***	0.358 ***
t=2006		0.550 ***	0.606 ***	0.617 ***	0.607 ***
t=2007		0.359 ***	0.384 ***	0.407 ***	0.385 ***
Constant		-0.403 ***	-0.460 ***	-0.460 ***	-0.461 ***
Observations		2084	2084	2084	2084
Firms		490	490	490	490
AR(1) (p-value)		0.000	0.000	0.000	0.000
AR(2) (p-value)		0.470	0.401	0.395	0.401
Hansen test (p-value)		0.279	0.473	0.431	0.473
No. of oid.restrictions		268	268	268	268
No. of instruments		283	284	284	285

The dependent variable is the log difference of the capital stock. GMM estimates from the Blundell-Bond System estimator. Sales and cost of capital are treated as endogenous and are instrumented as explained in the text. Robust standard errors are given in parentheses. * denotes significant at 10%; ** significant at 5%; *** significant at 1%.

As above, the business expectation does not show a significant effect. Since each of the indicators are given equal weights in the business climate indicator published by the ifo Institute, this would suggest that investment increases by about 4 percent if a firm's business climate improves by a full unit. The estimated effect of the capital cost points to an elasticity of about -0.8. Columns (3) and (4) report results with two lags ($P = 2$). Though the patterns found are similar, the number of observations declines and effects are estimated less precisely.

Table 6 reports the effects of an ECM specification following equation (4). Columns (1) and (2) report results with current changes in explanatory variables as well as lagged levels. Results presented in columns (3) and (4) have been obtained including first lags of the changes. Since the number of observations declines substantially due to the inclusion of lags, we do not report results with inclusion of higher-order lags.

Throughout the specifications, business expectations have no significant effects while business conditions exert significant effects on investment. This may seem surprising given the fact that the business expectations are a key indicator for the German economy. However, the expectations are captured in a dynamic fashion, *i.e.* they reflect expected changes in the business conditions and thus might be less informative for investment decisions. We should note also that the survey data are monthly data and are aggregated for the purpose of our study to annual data – the dependent variable is reported only annually. If expectations tend to fluctuate, monthly aggregation might take away important parts of the variation. We experimented with using specific dates for expectations and current conditions, but did not obtain qualitatively different results. Moreover, the survey qualifies the question on the expectation. As noted above, respondents are asked to assess the expected business conditions "with regard to the business cycle". As the specification

Table 5: Estimates of IV-GMM Specification in First Differences (with P=1,2)

		(1)	(2)	(3)	(4)
Sales	$\Delta \log S_{i,t}$	0.124 ***	0.171 ***	0.140 **	0.142 *
		(0.046)	(0.058)	(0.061)	(0.074)
Sales, 1st.lag	$\Delta \log S_{i,t-1}$	0.091 ***	0.066 ***	0.155 ***	0.148 ***
		(0.024)	(0.023)	(0.042)	(0.046)
Sales, 2nd.lag	$\Delta \log S_{i,t-2}$			0.061 **	0.075 **
				(0.026)	(0.032)
	sum of effects	0.215 ***	0.237 ***	0.356 ***	0.365 ***
Cost of capital	$\Delta \log coc_{i,t}$	-0.700 ***	-0.847 ***	-0.826 **	-0.739 **
		(0.233)	(0.296)	(0.340)	(0.344)
Cost of capital, 1st.lag	$\Delta \log coc_{i,t-1}$	0.042	0.007	-0.014	-0.067
		(0.065)	(0.068)	(0.080)	(0.083)
Cost of capital, 2nd.lag	$\Delta \log coc_{i,t-2}$			0.041	0.060
				(0.164)	(0.172)
	sum of effects	-0.658 ***	-0.840 ***	-.798 **	-0.747 *
Bus. situation	$\mathsf{ifo}_{i,t}$		0.047 ***		0.053 **
			(0.016)		(0.022)
Bus. situation, 1st.lag	$\mathsf{ifo}_{i,t-1}$		0.036 **		0.025
			(0.014)		(0.015)
Bus. situation, 2nd.lag	$\mathsf{ifo}_{i,t-1}$				-0.010
					(0.018)
	sum of effects		0.083 ***		0.068 ***
t=1996		0.198 **	0.278 **		
t=1997		0.138 **	0.191 ***	0.157 *	0.142
t=1998		0.296 ***	0.359 ***	0.350 **	0.300 **
t=1999		0.310 ***	0.388 ***	0.377 **	0.355 **
t=2000		0.368 ***	0.439 ***	0.420 **	0.377 **
t=2002		0.367 ***	0.446 ***	0.394 **	0.345 *
t=2003		0.257 ***	0.345 ***	0.349 **	0.359 **
t=2004		0.123 ***	0.159 ***	0.160 **	0.166 **
t=2005		0.262 ***	0.313 ***	0.279 **	0.248 **
t=2006		0.411 ***	0.480 ***	0.483 **	0.404 **
t=2007		0.252 **	0.302 **	0.289 *	0.248
Constant		-0.312 ***	-0.387 ***	-0.373 **	-0.342 **
Observations		1600	1517	1243	1134
AR(1) (p-value)		0.000	0.000	0.001	0.001
AR(2) (p-value)		0.608	0.588	0.567	0.710
Hansen test (p-value)		0.194	0.523	0.761	0.989
No. of oid.restrictions		267	263	252	252
No. of instruments		279	281	269	272

The dependent variable is the log difference of the capital stock. GMM estimates from the Blundell-Bond System estimator. Sales and cost of capital are treated as endogenous and are instrumented as explained in the text. Robust standard errors are given in parentheses. * denotes significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: Estimates of IV-GMM ECM Specification (with P=0,1)

		(1)	(2)	(3)	(4)
Sales growth	$\Delta \log S_{i,t}$	0.199 ***	0.213 ***	0.115 **	0.166 ***
		(0.061)	(0.070)	(0.045)	(0.056)
Sales growth, lagged	$\Delta \log S_{i,t-1}$			0.087 ***	0.064 ***
				(0.022)	(0.023)
Cost of capital growth	$\Delta \log coc_{i,t}$	-1.025 ***	-1.143 ***	-0.617 ***	-0.779 **
		(0.327)	(0.313)	(0.235)	(0.312)
Cost of capital growth, lagged	$\Delta \log coc_{i,t-1}$			0.033	0.008
				(0.072)	(0.079)
Bus. situation,	$\mathsf{ifo}_{i,t}$		0.049 ***		0.044 **
			(0.015)		(0.018)
Bus. situation, lagged	$\mathsf{ifo}_{i,t-1}$				0.027 *
					(0.015)
Stock of capital, lagged	$\log K_{i,t-1}$	0.876 ***	0.887 ***	1.036 ***	1.040 ***
		(0.039)	(0.037)	(0.027)	(0.027)
Sales, lagged	$\log S_{i,t-1}$	0.129 ***	0.119 ***	-0.003	0.007
		(0.042)	(0.041)	(0.030)	(0.033)
Cost of capital, lagged	$\log coc_{i,t-1}$	-0.114	-0.155	0.071	0.031
		(0.131)	(0.133)	(0.103)	(0.119)
Constant		-1.023 *	-1.188 **	-0.421	-0.775
Adjustment speed	ρ	-0.124 ***	-0.113 ***	0.036	0.040
		(0.039)	(0.037)	(0.027)	(0.027)
Sales, long-term	ψ	1.038 ***	1.047 ***	0.092	-0.174
		(0.182)	(0.207)	(0.781)	(0.891)
Cost of capital, long-term	σ	-0.915	-1.370	-1.966	-0.777
		(0.994)	(1.125)	(2.841)	(2.894)
Observations		2084	2084	1600	1517
Firms		490	490	371	343
AR(1) (p-value)		0.000	0.000	0.000	0.000
AR(2) (p-value)		0.373	0.333	0.644	0.609
Hansen test (p-value)		0.460	0.345	0.300	0.451
No. of oid.restrictions		265	265	260	260
No. of instruments		283	284	279	281

The dependent variable is the log capital stock. Time effects are suppressed. GMM estimates from the Blundell-Bond System estimator. The lagged capital stock, as well as sales and cost of capital are treated as endogenous and are instrumented as explained in the text. Robust standard errors are given in parentheses. * denotes significant at 10%; ** significant at 5%; *** significant at 1%.

includes year-specific effects, it may well be that this information is partly captured by the time effects. Beyond measurement of expectations, our data captures a broad definition of investment through the capital stock and, hence, captures different forms of investment including replacement investment, which may respond differently to expectations. Finally, if firms suffered from restricted access to funds due to capital market imperfections, investment may be more responsive to the current business climate, since a good climate might be related to better funding opportunities.[15]

Another consistent finding across all specifications is that current changes in sales and cost of capital exert significant effects on current investment, and also that the positive effect of the business climate is confirmed. An advantage of the ECM approach is that it might enable us to distinguish more precisely between temporary and long-term effects. This is partly confirmed by our findings. In all specifications, the lagged stock of capital shows a highly significant and strong effect. As reported in the table, the implied adjustment speed is rather small. In columns (1) and (2) the point estimate for the speed of adjustment φ is around -0.1. Accordingly, if the actual capital stock deviates from its optimal long-term value by 1 Euro, investment spending would increase by 10 cents per year. Though small, the speed of adjustment is significantly different from zero in specifications (1) and (2). This enables us consider the long-term effects. The point estimate for lagged sales in the implied long-term relation ψ being around unity, proportionality between sales and the capital stock cannot be rejected. The lagged cost of capital also shows the expected negative effect. Given the large standard error, it does not prove significantly different from zero. However, the hypothesis that the implied long-term effect is equal to -1 cannot be rejected either.

Columns (3) and (4) report results from a specification that includes lags of changes in the deter-

[15]We are grateful to an anonymous referee for pointing out this last explanation.

Table 7: Estimates with Cost-of-Capital Computed using Sample Averages

		(1)	(2)	(3)
Sales	$\Delta \log S_{i,t}$	0.095	0.144 **	0.112 **
		(0.081)	(0.067)	(0.070)
Cost of capital	$\Delta \log coc_{i,t}$	-0.185	-1.058 ***	-0.455 ***
		(0.207)	(0.305)	(0.266)
Bus. situation	$\mathsf{ifo}_{i,t}$	0.063 ***	0.064 ***	0.050 ***
		(0.014)	(0.013)	(0.013)
Bus. expectations	$\mathsf{ifo}\text{-exp}_{i,t}$	-0.002	-0.004	-0.000
		(0.017)	(0.016)	(0.015)
Observations		2084	2084	2084
Firms		490	490	490
AR(1) (p-value)		0.000	0.000	0.000
AR(2) (p-value)		0.439	0.389	0.395
Hansen test (p-value)		0.279	0.504	0.388
No. of oid.restrictions		268	268	268
No. of instruments		285	285	285

The dependent variable is the log difference of the capital stock. GMM estimates from the Blundell-Bond System estimator. Sales and cost of capital are treated as endogenous and are instrumented as explained in the text. Time specific effects are suppressed. Robust standard errors are given in parentheses. * denotes significance at 10%; ** significance at 5%; *** significance at 1%. In column (1) the cost-of-capital rely on the sample average rather than the firm-specific share of debt finance. In column (2) the cost-of-capital are based on the sample average rather than the firm-specific local business tax rate. In column (3) cost-of-capital are based on the sample average of the asset structure.

minants of investment. As a consequence of the richer dynamics, the number of observations is substantially reduced and the estimation fails to detect any adjustment. In other words, the adjustment speed is not significantly different from zero. As a consequence, implied long-term effects cannot be derived. This points to the limits of distinguishing between long-term and short effects in a setting with richer dynamics.

Throughout the different specifications, the results point to a relatively strong effect of the cost of capital. Existing studies mostly report lower elasticities for the capital stock, such as -0.25 (Chirinko, Fazzari and Meyer, 1999), -0.42 (Harhoff and Ramb, 2001), or -0.4 (Chirinko, Fazzari, and Meyer, 2011). Using German data, Dwenger (2009) finds a relatively large cost of capital elasticity of -0.9. Dwenger and Walch (2011) use tax loss-carry forwards in order to identify tax incentives and obtain a lower elasticity for Germany. It is interesting to note, however, that their analysis focuses only on the corporation tax. Hence, the incentives associated with the business tax are not taken into account.

To shed light on the sources of variation in the cost of capital, Table 7 provides results for a simple specification where the cost of capital is computed using sample averages rather than firm-specific information. Column (1) reports results from a specification where the cost-of-capital is based on the sample average rather than the firm-specific share of debt finance. In column (2) the cost-of-capital relies on the sample average of the local business tax rate, and in column (3) the cost-of-capital is based on the sample average of the asset structure. Hence in column (1) the variation used to identify cost-of-capital effects does not come from the firms' capital structure. The fact that the cost-of-capital in this specification turns out to be insignificant suggests that the non-neutrality of the tax-system with regard to debt/equity finance drives the negative cost-of-capital effect. In contrast, since the results in column (2) are similar to those obtained above, the local business tax rate seems unimportant for the cost-of-capital effects. The results in specification (3) suggest that the firm's asset structure is also important for the cost-of-capital effect. Yet, the effect on investment seems to be less strong than in the case of the firms's share of debt finance.

5 Conclusions

Using an innovative dataset of combined financial statement and survey data which enables us to explicitly control for the firm-specific tax burden and the firm's perception of business conditions this paper has reconsidered the empirical determinants of a firm's capital stock. A log-linear model of the optimal capital stock is estimated using fixed effects as well as instrumental variables estimators suited to dynamic panel data. As common in the large literature on the empirics of investment, we focus on simplified models of investment that capture the adjustment process of the capital stock in a reduced-form fashion. Although some of our results point to the limits of fitting complex dynamic models to firm-level data with limited cross-sectional and time-series dimensions, the findings are broadly consistent across models. The basic relationships between the variables even show up, at least qualitatively, in a simple OLS fixed effects framework.

Our findings indicate a robust, significant effect of a firm's cost of capital and of sales on investment. Our results also confirm the predictive power of the ifo survey data as all specifications exhibit highly significant effects of the firm-specific perception of the business situation on investment. An error-correction specification confirms strong effects of the standard determinants of investment. Using a parsimonious specification, the estimated implied long-term effects are consistent with a proportionality between output, the stock of capital and the cost of capital. However, the identification of the long-term effects proved difficult as the implied adjustment speed to the optimal capital stock turned out to be rather small.

With regard to the empirical magnitude of the effects, the preferred specification in first differences, which employs instrumental variables to obtain consistent estimates, suggests that a good rather than normal business situation is associated with about 8% higher investment. Firm-specific expectations have not been found to exert significant effects. The failure might be caused by the fact that, while the survey data are monthly, our dependent variable is reported only annually. Given the way the expectations are captured by the ifo Institute, it could also be that the indicator of expectations is more useful to predict the business cycle which is captured already by year-specific effects in the empirical model. Another explanation could be that the financial accounts do not enable us to distinguish different forms of investment, that may respond differently to expectations. Finally, investment may be more responsive to the current business climate compared to expectations if firms face financing restrictions. The cost of capital is found to exert a significant negative effect on the stock of capital. The point estimate of the elasticity being -0.8, a unit-elasticity of the cost of capital cannot be rejected. Most existing studies report lower elasticities for the capital stock, such as -0.25 (Chirinko, Fazzari and Meyer, 1999), -0.42 (Harhoff and Ramb, 2001), or -0.4 (Chirinko, Fazzari, and Meyer, 2011). Using German data, Dwenger (2009) finds a relatively large cost of capital elasticity of -0.9.

Further analysis has shown that the strong effects of the cost-of-capital stem largely from the tax treatment of different ways to finance investment. In particular, the tax implications of debt finance seems to drive the empirical effects. This suggests that the lack of neutrality of the tax system is an obstacle to investment in Germany. While this study has focused on debt finance vs. financing through retained earnings, future research should consider also the lack of neutrality if financing takes places through new-share issues and to the effects of taxation at the level of the shareholder.

6 Appendix

A.1 Corporate tax parameters in Germany

During the period 1994-2007 corporations were subject to various income taxes, namely the corporate income tax (τ_c), the business tax on income and capital (τ_{GSt}), and the "solidarity surcharge", τ_{SS}. To calculate the statutory tax rate τ for equation (5), we include all three components and account for their interaction. The local business tax rate varies at the level of municipalities, whereas the corporate tax and the solidarity surcharge are the same for all firms and do only vary over time.[16]

Table A.1 displays the tax parameters for the cost of capital calculations. Besides the headline rates on retained earnings (and distributed profits until 2000 shown in brackets), we report the solidarity surcharge and the average business tax in our sample for each year. The latter is calculated as an unweighted average of the business tax rates of all municipalities in period t.

Tax rates on corporate income declined substantially during the period 1994-2007. Moreover, there was a major change in the tax law with the full imputation and split rate system being replaced in 2001 by the so-called half-income system (Tax Relief Act 2001). This implied the replacement of

[16] Accounting for the local collection rate cr_z ("Hebesatz"; in %) in each municipality z, for a basic federal rate of 5 % ("Steuermesszahl") and for the self-deductibility of the business tax, the effective business tax rate τ_{GSt} that is applied to each unit of business income in period t can be calculated according to

$$\tau_{GSt,z} = \frac{0.05\frac{cr_z}{100}}{1 + 0.05\frac{cr_z}{100}}.$$

Information on municipalities' collection rates is taken from the Federal Statistical Office. For the time span from $t = 1994$ to 2007, the business tax payment has been a deductible expense in both the corporate tax and the personal tax base (see 11, 16 Trade Tax Act - "Gewerbesteuergesetz"; 4 IV Income Tax Act - "Einkommensteuergesetz"). All variables and figures refer to period t.

Table A.1: Parameters used for Tax Indicators

Year	Corporate tax rate retained (distributed) profits in % (τ_c)	Solidarity surcharge in % (τ_{SS})	Business tax in %, average (τ_{GSt})
1994	45.0 (30.0)	0	15.94
1995	45.0 (30.0)	7.5	15.95
1996	45.0 (30.0)	7.5	16.17
1997	45.0 (30.0)	7.5	16.30
1998	45.0 (30.0)	5.5	16.41
1999	40.0 (30.0)	5.5	16.45
2000	40.0 (30.0)	5.5	16.17
2001	25.0	5.5	16.40
2002	25.0	5.5	16.20
2003	26.5	5.5	16.00
2004	25.0	5.5	15.91
2005	25.0	5.5	15.99
2006	25.0	5.5	16.01
2007	25.0	5.5	16.13

Column (1) presents the corporate income tax rates for retained earnings and distributed profits (until 2000, in brackets). After 2001, both rates are replaced by the uniform corporate tax rate τ_c. In 1994, there was no "solidarity surcharge". See also 23 Corporate Income Tax Act ("Koerperschaftsteuergesetz") and 4 Solidarity Surcharge Act ("Solidaritaetszuschlaggesetz").

two corporate tax rates - one on retained earnings ($\tau_{c,RE}$ which varied between 45% and 40%) and one on distributed profits ($\tau_{c,D}$, of 30%) - by a lower, uniform tax rate of $\tau_c = 25\%$.[17]

A.2 Cost of capital and the firms' capital and asset structures

Cost of capital and the firm's capital structure To account for the fact that firms not only use internal funds, but also external funds in the form of debt, we assume that each firm has a specific target value for the share of debt. This target value will presumably be based on incentive considerations, since debt payments constitute a business expense that shields revenues from taxes. Let us denote the target level with λ. Then, if deviating from this target value is costly, optimal investment finance will weight the tax-advantage from using more debt against the cost associated with distorting the capital structure (*e.g.*, Huizinga, Laeven, Nicodme, 2008). For simplicity, one might assume that the cost of deviating from the optimal mix of financing with debt and retained earnings is very high. With this assumption, an investment project will be financed usually with a ratio of debt to capital that is consistent with each firm's target level λ. If the cost of deviating from the preferred capital structure is less than prohibitive, the actual share of debt used to finance the investment is determined by a function $\Lambda(\lambda, \Theta)$ that is increasing in the firm's preferred debt-to-capital ratio λ as well as in the cost advantage of using debt, denoted with Θ (derived below). Obviously, this function will be time-varying since each firm's target level and cost advantage of debt will change over time.

Then, with a share Λ of investment being financed with debt and only a share $1 - \Lambda$ being financed

[17] In 2003, the corporate income tax rate was temporarily increased to 26.5%.

with retained earnings, the cost of capital will differ from the base case analyzed before. Following Devereux (2004), the derivation of the cost of capital with debt finance is the same, except that we consider an increase in revenues during the investment period and a respective decline in the subsequent period as debt is being repaid. Thus, with a share of debt finance Λ, we need to take account of an increase in revenues equal to $\Lambda\left(1-\tau\varphi\right)$, with $\left(1-\tau\varphi\right)$ being the effective price of a unit of investment. In the second period, debt obligations are served and repaid. Hence, profits are reduced by $\left(1+\left(1-\tau\right)r\right)\left(1-\tau\varphi\right)\Lambda$. Taking these additional effects into account, we can thus specify the cost of capital coc^{Λ} for a given share of debt finance as

$$coc^{\Lambda} \equiv coc - \Lambda \underbrace{\frac{\left(1-\tau\varphi\right)\left(r\tau\right)}{\left(1-\tau\right)}}_{\Theta}, \tag{6}$$

where Θ is the difference between the cost of capital using retained earnings and debt finance. This term simply captures the reduction in the cost of capital which arises from the deductibility of interest payments.

Cost of capital and the firm's asset structure To further determine the cost of capital for a specific firm, we calculate tax-depreciation allowances for each firm by considering firms' asset structures.[18] Taking two types of assets into account, namely industrial buildings (IB) and plant/ machinery (M) as part of a firm's fixed assets, we construct weights Ω for each firm, with $\Omega^{IB}=\frac{IB}{IB+M}$, $\Omega^{M}=\frac{M}{IB+M}$ and $\Omega^{IB}+\Omega^{M}=1$ (for simplification, the time indices are neglected here). According to these asset shares we calculate firm-specific depreciation rates δ, firm-specific

[18] The approach of calculating the cost of capital tax component according to different asset types is not new. Previous studies that form weighted averages are, *e.g.*, Egger *et al.* (2009) or Bond and Xing (2010).

Table A.2: Records per Firm

Number of years	Number of firms	Percentage
14	46	7.76
13	12	2.02
12	10	1.69
11	10	1.69
10	26	4.38
9	19	3.20
8	21	3.54
7	30	5.06
6	42	7.08
5	48	8.09
4	89	15.01
3	119	20.07
2	121	20.40
Total	593	100

Source: Number of firms with no missing values in the number of years indicated.

rates of capital allowances ψ and net present values of allowances, A. Specifically, the firm-specific depreciation and capital allowance rates, as well as the net present values of allowances, are calculated according to $\delta = \delta^{IB}\Omega^{IB} + \delta^{M}\Omega^{M}$, $\psi = \psi^{IB}\Omega^{IB} + \psi^{M}\Omega^{M}$ and $A = A^{IB}\Omega^{IB} + A^{M}\Omega^{M}$.

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