

Tax Losses and Firm Investment: Evidence from Tax Statistics*

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Abstract

In the economic analysis of fiscal policies the elasticity of business capital with respect to changes in its user cost is of central interest. As a major component, the user cost of capital includes a firm's marginal tax rate, which for some firms can deviate strongly from the statutory tax rate due to the asymmetric treatment of tax losses and profits. In previous studies tax losses and loss carry-over have either been roughly approximated by accounting losses or, most of the time, fully been ignored. Disregarding taxable status of a firm, however, does not only result in a loss in efficiency but also leads to persistent measurement error in the firm-specific marginal tax rate and user cost of capital. This invalidates its lagged values as instrumental variables, as they have been used in previous research, and does not solve attenuation bias. We use a novel firm-level panel data set including official corporate income tax returns to overcome these problems. Our results show that accounting for tax losses yields a more precise point estimate for the user cost elasticity of investment, increasing in absolute value from -0.37 to -0.52 .

Keywords: Taxation; corporate investment; tax loss; asymmetric treatment of profits and losses; user cost of capital; measurement error

JEL classification: D22; G31; H25; H32

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1 Introduction

Governments all over the world frequently enact tax incentives to spur domestic business investment. The economic reasoning behind cutting tax rates and granting tax credits is to reduce the user cost of capital, i.e. the minimal rate of return before taxes that a project must earn to break even. Lower taxes and hence lower user cost of capital induce firms to realise investment projects that they would otherwise have regarded unprofitable. Considering the popularity of tax cuts as fiscal policy tool to buffer an economic downturn or to spur innovation, the empirical evidence on the effectiveness of such measures is surprisingly weak or inconclusive.

In general, what matters for a firm's forward-looking investment decision is the marginal tax rate on an additional unit of capital. This firm-specific marginal tax rate as one determinant of the user cost of capital often strongly differs from the statutory rate for various reasons, most importantly losses. A tax loss can reduce a firm's marginal tax rate to zero in the year the loss is incurred and, potentially, future years. Figures for the volume of losses in the corporate sectors of the United States and Germany show that loss deduction plays a crucial role in determining firms' tax rates. In the United States, the ratio of tax losses to net income of firms in 2003 averaged at 0.47 (Edgerton, 2010). For Germany, the 2004 Corporate Income Tax Statistics indicate that roughly 60% of corporations faced a marginal tax rate below the statutory tax rate by either suffering a loss (40%) or using a tax loss carry-forward or carry-back to offset current profits (20%).

So far, most of the literature on taxes and investment has ignored the prominence of tax losses in lowering marginal tax rates. This approach not only neglects an important source of variation in the user cost of capital across firms but also clearly leads to the mismeasurement of firms' marginal tax rate. While a small literature (Devereux, 1989; Devereux, Keen, & Schiantarelli, 1994; Cummins, Hassett, & Hubbard, 1995; Edgerton, 2010; Dreßler & Overesch, 2010) has addressed the asymmetric treatment of losses, all these studies are based on accounting data where true tax losses as well as tax loss carry-overs are unobservable. This shortcoming of accounting data is usually revamped by approximating tax losses with accounting losses. However, as Auerbach (1987) and Hanlon (2003) point out, the difference between tax and accounting data usually results in an under-representation of tax losses; on average, approximated marginal tax rates and user cost of capital exceed the unobservable, true ones. This mismeasurement leads to an attenuation bias of the estimated user cost elasticity of capital that previous studies have tried to overcome by instrumenting the user cost variable with its lags. This study argues that such an instrumental variable continues to suffer from measurement error: As loss carry-forwards are highly persistent, lags of the user cost variable are correlated with the measurement error in the current user cost of capital. This violates an important condition of instrumental variable estimation.

We make a twofold contribution to the literature by addressing methodological issues and using a new data set. First, we measure the marginal tax rate at the corporate level taking into account present tax losses as well as tax loss carry-forward and carry-back. This solves the measurement problem in the user cost variable and allows us to find valid instruments needed to

address endogeneity. Second, we use a so far unique data set that combines comprehensive corporate income tax return data with investment and cost structure variables, based on a full record of firms in the manufacturing sector with more than 20 employees in Germany during the period 1995-2004. This data set offers two advantages: broad coverage, including small firms, and detailed tax information that we use to construct a marginal tax rate, which differs from the statutory tax rate and varies across firms and over time. Our preferred estimation reveals that a 1% increase in the user cost of capital reduces capital by 0.52% in the long run. We contrast this figure to an estimate in which we disregard tax loss carry-over, yielding a less precise point estimate of the user cost elasticity of -0.37 . This finding is in line with our hypothesis that the neglect of measurement problems in the user cost variable attenuates the estimated coefficients.

In the following section, we provide a concise overview of previous results in the literature related to tax losses and investment. We further document the importance of tax losses and the implications of mismeasured marginal tax rates in earlier studies. Section 3 illustrates the data sources, the construction of the firm-specific marginal tax rate depending on tax status, the user cost of capital, and some descriptive statistics. The theoretical modelling and our estimation methodology are introduced in Section 4. In Section 5 we present our estimation results. Section 6 summarises our main results and draws conclusions.

2 Motivation

2.1. Facts on corporate tax losses

2.1.1. Tax treatment of corporate losses

In most tax systems, firms are subject to asymmetric treatment of profits and losses. While profitable companies immediately owe a tax liability, unprofitable firms only receive a tax refund if they are able to offset their loss against past or future profits. Companies that have paid corporate income tax in the year(s) before are refunded by carrying back the loss. If the loss exceeds previous profits or a legally defined maximum carry-back, the remaining loss must be carried forward in time; the resulting tax loss carry-forward is deductible against future positive profits. The refund for such a loss carry-forward occurs, at best, with delay. This reduces a company's effective marginal tax rate on an additional unit of return on capital below the statutory tax rate.¹

The impact of loss carry-overs on a firm's taxable status differs considerably across national corporate tax code regulations. Loss carry-back is, for example, granted in the United States, France, Germany, United Kingdom, Ireland, Netherlands, Canada, and Japan. The carry-back volume is unlimited with the exception of Germany and carry-back periods range from 1 to 3 years. All EU countries, Canada, Japan, and the United States offer schemes for loss carry-

¹ The effective marginal tax rate is given by $\frac{\tau}{(1+r)^k}$, where τ equals the statutory marginal tax rate, r the firm's discount rate, and k the number of periods until the company resumes a tax-paying position (Devereux, 1989).

forward. However, Austria, Germany, and Poland limit the carry-forward volume. Periods, in which tax losses carried forward are valid, range from 5 years to infinity.²

2.1.2. Recent surge of tax loss carry-forward

Relatively tight tax loss offset provisions may have been a political reaction to the surge in loss carry-forward that has been observed in several countries in recent time. For the United States, several authors (Cooper & Knittel, 2006; Auerbach, 2007; Altshuler, Auerbach, Cooper, & Knittel, 2008) report an increase in corporate losses in the 1990s and early 2000s that began to recede after 2002. The ratio of losses to positive income was much higher during the economic downturn of 2001/2002 than in earlier recessions, even in recessions of greater severity (Auerbach, 2007). Moreover, corporate losses were large relative to positive profits at the turn of the century; the ratio of losses to net income averaged 0.12 from 1973 to 1977, while it increased by 280% to an average loss ratio of 0.47 from 1999 to 2003 (Edgerton, 2010).

Table 1: Distribution of aggregate loss carry-forward in the corporate manufacturing sector of Germany (in million EUR)

Industry	1998	2001	2004
Manufacture of food products, beverages, tobacco	5,170	5,437	24,886
Manufacture of coke, refined petroleum products, and nuclear fuel; manufacture of chemicals, chemical products, and man-made fibres	7,711	5,871	11,601
Manufacture of basic metals and fabricated metal products	17,917	16,318	15,574
Manufacture of machinery and equipment	17,997	17,195	18,484
Manufacture of transport equipment	8,322	10,247	11,438
Total manufacturing sector	91,459	96,247	121,757
<i>For comparison: Total all industries</i>	295,484	388,160	520,328

Notes: Tax loss carry-forward on 31 December 1998, 2001, and 2004 in million EUR. Selected sub-branches of the manufacturing sector do not sum to the total.

Source: Corporate income tax statistics 1998, 2001, and 2004; Dwenger (2009).

An equally pronounced and even longer lasting rise in corporate tax losses – in absolute figures and in comparison to taxable income – is observable in Germany, where corporations' tax losses carried forward have roughly doubled between 1995 and 2004 from less than EUR 250 billion to EUR 520 billion (Dwenger, 2009). Therewith, aggregate unused losses from the past were more than four times larger than taxable corporate profits in the economy. Manufacturing accounted for EUR 122 billion in 2004, or nearly a quarter of aggregate corporate losses. As Table 1 shows, within the manufacturing sector, tax losses carried forward have significantly risen for manufacturers of food products, beverages, and tobacco. For these corporations,

² The presented facts are based on Bundesverband der Deutschen Industrie and PriceWaterhouse Coopers (2006).

starting from a relatively low level, tax losses have virtually quintupled between 1998 and 2004. For manufacturers of coke and for manufacturers of chemicals tax loss carry-forward has increased by 50%. Tax loss carry-forward possessed by other manufacturers, by contrast, has slightly receded; for manufacturers of basic metals and fabricated metal products, tax losses carried forward have fallen from EUR 18 billion in 1998 to about EUR 16 billion in 2001 and 2004.

Together, these facts underline the quantitative relevance of tax losses carried forward. The figures presented also show substantial variation in the importance of tax losses and in their development over time. We therefore expect the impact of the asymmetric tax treatment of losses on firms' taxable status and hence on their effective marginal tax rate to be important for understanding tax effects on investment.³

2.2. Prior literature

Prior literature has successfully identified the user cost elasticity of capital as a key parameter of the impact of tax policy on capital formation. Until recently, however, the asymmetric tax treatment of profits and losses, an important feature of corporate income tax systems, had been neglected in the investment literature. In other words, firms had been assumed to permanently face a marginal tax rate equal to the statutory tax rate. In reality, however, a tax loss may substantially reduce a firm's marginal tax rate in the year the loss is incurred as well as, potentially, in future years.⁴ As it was pointed out early that imperfect tax loss provisions may substantially alter investment incentives (Auerbach, 1986; Auerbach & Poterba, 1987; Mintz, 1988), it is surprising that most of the vast literature on taxes and investment ignored the provisions on tax losses and assumed the treatment of losses and profits to be symmetric.

The importance of tax losses and their implications on investment have received more attention in only a few papers. In an early work, Devereux (1989) studies the effects of the British partial imputation system and asymmetric treatment of losses on investment. His measure of the cost of capital, a dynamic equivalent to the expression developed by King and Fullerton (1984), takes account of tax asymmetries and allows tax rates to change. A Generalised Method of Moments estimation of the investment equation with lagged explanatory variables as instruments leads to a user cost elasticity of investment of -0.66 to -0.87 . However, assuming each firm to have perfect foresight of its accounting and tax position exacerbates endogeneity of the tax rate. As we will argue below current tax exhaustion is underestimated with perfect foresight and might lead to persistent measurement error in the user cost of capital. This would invalidate lags of the user cost of capital as instrumental variables.

In a follow-up, Devereux et al. (1994) estimate tax-adjusted Q and Euler equations to understand whether tax asymmetries are important to explain observed investment behaviour. Even though taking into account tax asymmetries substantially increases marginal Q and the cost

³ This type of firm-specific uncertainty needs to be distinguished from investment uncertainties related to changes in the overall statutory tax rate, as studied in Böckem (2001).

⁴ There is empirical evidence showing that firms strongly react to tax loss offset provisions. For instance, Aarbu (2003) show that firms under-utilise depreciation to avoid tax losses expire.

of capital, they find that careful modelling of tax status does not noticeably improve the empirical performance of the investment equations. One explanation for the apparent irrelevance of tax considerations discussed in their paper is errors in the effective tax variables that they have constructed using accounting data, which is silent about tax losses and tax loss carry-over.⁵

In contrast to earlier literature, Gendron et al. (2003) show that the investment behaviour of Canadian firms crucially depends on whether they are taxpaying or not. To alleviate concerns about the endogeneity of the user cost of capital they use a switching regression model, where tax status probabilities are estimated in a first stage.⁶ Exploiting tax reforms as natural experiments, Cummins et al. (1995) estimate user cost coefficients for firms with and without unused loss carry-forwards. They find that in general tax incentives have an economically important effect on firms' equipment investment through the user cost of capital. However, point estimates differ between tax exhausted firms and firms that are in a taxpaying position.⁷ While the authors find no evidence that firms with tax loss carry-forwards respond to tax changes, tax effects are most pronounced for firms in tax paying positions, which are more likely to face statutory tax rates and binding tax incentives for investment.

Also distinguishing tax effects between taxable and non-taxable firms, Edgerton (2010) models firm investment decisions in a setting with tax loss carry-forwards and carry-backs. He finds that tax reactions vary with firms' taxable status. The estimations suggest that tax incentives such as bonus depreciation are at least 4% less effective than they would have been if all firms were fully taxable. Because the study is based on Compustat accounting data, Edgerton cannot rule out "the possibility that difficulties in measuring firms' taxable status drive the relative unimportance of taxable status observed" (p. 949).

International differences in tax loss offsetting rules influence how multinational groups distribute their investment activities across subsidiaries. Investment levels are significantly affected by the existence of a group taxation regime, while tax loss carry-back and carry-forward provisions in the host country of the subsidiary do not influence investment behaviour of the average firm (Dreßler & Overesch, 2010). In line with other results (Devereux, Keen, & Schiantarelli, 1994; Edgerton, 2010), Dreßler and Overesch (2010) further find that while high corporate tax rates negatively affect investment for firms without tax loss carry-over, tax exhausted firms seem not to react that much to high corporate tax rates.

All of the previous studies briefly reviewed above are ground-breaking in that they account for the asymmetric tax treatment of losses and profits but share the disadvantage that they use accounting data where tax losses and tax loss carry-over remain unobserved. The difficulty in inferring tax losses, tax loss carry-over, and hence a firm's tax status from accounting data has been discussed in the literature. Several authors (Auerbach & Poterba, 1987; Hanlon, 2003;

⁵ Devereux (1994) uses statutory tax rates as instruments. From a theoretical point of view, the asymmetric treatment of losses and gains can become irrelevant in an imputation system, if investment is assumed to be irreversible (Panteghini, 2001).

⁶ Effective tax rates and the user cost of capital are determined by the time period until a firm resumes its taxpaying status. Problems of reverse causality may arise because the amount of time which must elapse before the firm becomes tax-paying again also depends on current investment decisions.

⁷ Due to the very large standard error for tax exhausted firms, the authors cannot reject the hypothesis that the coefficients are the same for firms with and without tax loss carry-forwards.

Edgerton, 2010) mention a number of reasons why financial statement data may misrepresent tax losses. For instance, rules on interest deduction, consolidation, and profit distribution differ between financial statement and tax data. Most importantly, firms are not required to report tax-related loss carry-forward in financial statements and hence some may choose not to. This means that tax losses are severely under-represented. Finally, financial statement data such as the Compustat database usually include predominantly large firms, while tax return data also encompass smaller corporations that might present different loss and carry-forward patterns. These differences between tax and accounting data attenuate estimated effects, leading to an instrumental variable technique in previous research with lagged user cost of capital as instruments. In Section 2.3 we argue that this might not be the end of the story, as persistent measurement error in tax losses and hence in the user cost of capital invalidate the use of lagged user costs as instruments. We further add to the literature by also observing investment behaviour of small and medium-sized firms for which empirical estimates on the investment activity with respect to taxes remain scarce.

2.3. Measurement error in the user cost of capital due to tax loss carry-forward

Traditionally, measurement error in the user cost of capital variable has been considered a major issue in the investment literature (Caballero, 1994; Cummins, Hassett, & Hubbard, 1994; Goolsbee, 2000). Such measurement error arises in case of misreporting of economic agents, estimated figures in official records, and lack of data availability on disaggregated level. Errors in measurement also occur in the presence of tax losses carried forward if the associated reduction in effective marginal tax rate and user cost of capital is not taken into account. This kind of measurement error is the focus of our study.

In the following we will briefly review the classical error-in-variables problem it entails, the bias implied, and the instrumental variable technique as a way to overcome it. We will then argue that even though lags of the user cost of capital are commonly used as instrumental variables, they are very unlikely to be valid instruments. The persistence in tax loss carry-forwards implies that user cost of capital subject to measurement error in one period is also very likely mismeasured in previous years. This violates the necessary assumption of no correlation between measurement error and instrumental variable. Unlike earlier literature, which we briefly reviewed in Section 2.2, the data set used in this study allows us to observe and take into account tax loss carry-forward avoiding the problem of persistent mismeasurement if the user cost of capital.

2.3.1. Classical error-in-variables problem

For the reasons discussed above the true user cost UCC^* is unobserved. Instead, we have a measure for UCC^* called UCC . Then, the measurement error in the population is

$$e = UCC^* - UCC, \quad (1)$$

which can be positive, zero, or negative.⁸ If the measurement error in the user cost of capital variable is uncorrelated with the unobserved user cost of capital, the observed *UCC* variable and measurement error e must be correlated. This classical error-in-variables leads ordinary least squares regressions to be biased towards zero (attenuation bias) and to be inconsistent (Wooldridge, 2010). Unfortunately, the problem cannot be isolated to the user cost of capital coefficient; the other coefficients are all biased as well, although in unknown directions.

While without further assumptions the bias cannot be removed, instrumental variable techniques can help to overcome this problem. To this end an instrumental variable is needed that is correlated with the user cost of capital observed but uncorrelated with the measurement error of the explanatory variable e and hence uncorrelated with the regression error ε . In previous studies, lags of the user cost of capital have been relied on as instruments. Whether lags of the mismeasured explanatory variables are valid instrumental variables, however, crucially depends on the absence of correlation between lagged user cost of capital and measurement error. If tax loss carry-forwards are one-time events, it is very unlikely that a firm also had unused losses from the past in previous periods leading to measurement error in the user cost of capital. Then past user costs of capital are uncorrelated with measurement error in the current user cost of capital and can be used as valid instruments. By contrast, if tax loss carry-forwards are highly persistent, this leads to repeated measurement error in the user cost of capital variable. In this case the use of lagged user cost of capital as instrument is highly questionable because it necessarily would correlate with the measurement error e and, as a consequence, with the regression error ε .

2.3.2. Persistence in tax loss carry-forward

Empirical data supports the latter argument, confirming that loss carry-forwards are highly persistent. Closer inspection of the German Corporate Income Tax Statistics reveals that the total volume of losses carried forward exceeds the volume of aggregated profits (before loss offset) by factor 2.33 in 1998, 3.35 in 2001, and 4.68 in 2004.⁹ This suggests that in all three years a limited share of carry-forwards can be set off against profits, in fact only 20% of all firms are able to make use of their carry-over positions. These aggregate figures do, however, not entirely eliminate an – admittedly unlikely – scenario, in which composition effects hide firms making use of their losses. This would be true if firms with high carry-forwards suddenly ran large profits that would allow them to use their carry-forward while other firms would incur large losses that would enter their carry-forward, i.e., with highly fluctuating profits. The amount of profits offset against tax loss carry-back and carry-forward, however, shows that high persistence in aggregate tax loss carry-forwards cannot be explained by composition effects. Quite the contrary, companies cannot capitalise on their yet unused losses from the past. On average, the small amount of 9 percent (27 billion euro) of loss carry-forward was used in 1998. With about 5% in 2001 (20 billion euro) and 3% in 2004 (17 billion euro), the rate of loss carry-forward offset against profits has even declined over time. Tax loss carry-back was negligible in all years.

⁸ We assume that the average measurement error in the population is zero, $E(e) = 0$; since we include a constant in our investment equation this assumption is without loss of generality.

⁹ Calculations are based on Dwenger (2009).

Auerbach (1987) present further evidence against composition effects relying on U.S. data. He estimates transition probabilities between the states of “loss carry-forward” and “no loss carry-forward” in a simple Markov model and finds that a firm with a loss carry-forward in period t has a probability of remaining in loss carry-forward in $t + 1$ of 0.913. Firms with loss carry-forward in $t - 1$ and t present a similar probability of remaining in loss carry-forward in $t + 1$ of 0.917.¹⁰ On basis of this evidence we conclude that it is very unlikely that lags of the user cost variable are valid instruments for their contemporary counterparts because the measurement error persists to be correlated with the error term. The measurement error in the user cost variable can thus only be overcome by obtaining either another, valid instrument or – as it is done in this study – by accounting for tax losses and loss offset provisions in the user cost of capital with tax data.

We contribute to the literature by employing a rich record of official tax return data to calculate firms’ marginal tax rates. Our data set contains detailed tax information for all German incorporated firms that are liable for corporate taxation. Stemming from the Corporate Income Tax Statistics, the information is very reliable because each firm’s tax statement is reviewed by the fiscal authorities. As a consequence, we can greatly improve the precision of the tax variable. For 2004, the statistics show that roughly 60% of corporations either suffer a loss (40%) or use a tax loss carry-forward or carry-back to offset current profits (20%) per year. The majority of corporations do not pay any corporate income taxes, and hence, their marginal tax rate does not equal the statutory corporate tax rate as has been predominantly presumed in the literature so far. Mismeasuring the firm-specific marginal tax rate by the neglect of tax losses, loss carry-forwards, and carry-backs might have thus largely biased the user cost of capital variable and estimation results in earlier studies. In the attempt to attain the “true” marginal tax rate faced by a firm, we consider both losses and tax loss carry-forward/carry-back provisions. Thereby, we also expect the efficiency of user cost elasticity estimates to increase.

3 Data

Estimations in this study rely on a new data set stretching over the period 1995 to 2004 which combines – at the firm level – tax data with investment and cost structure survey information from manufacturing industries.¹¹ Two features make the data set particularly interesting: First, the inclusion of tax return data that provides detailed information on tax losses and loss carry-over, and second, detailed information on investment (divestment) decisions for small and medium-sized firms. Below, we briefly introduce the data set’s three main components, which are linked via tax and survey numbers on firm-level in all years available.

For calculation of the user cost of capital we enrich the data base with the following industry-level information, all for the years 1995 to 2004: economic depreciation rates of structures and fixed assets, the producer price index as well as the gross and the net capital stock.

¹⁰ The authors also use more complex models and additional data. Although the probabilities of carry-forward persistence are lower in some specifications, they are still high enough to raise doubts about instrument validity.

¹¹ Tax data and survey data are provided to researchers by the German Statistical Offices, www.forschungsdatenzentrum.de/en/index.asp.

At the level of the economy, we use interest rates, the investment goods index, and the consumer price index. References for these additional sources are given in the data appendix.

3.1. Corporate income tax return data

The corporate income tax (CIT) statistics contain micro data on corporate tax returns by all corporations liable to the German CIT, i.e. about 860,000 firms in 2004. Thereof about 114,000 corporations belong to the manufacturing industries, i.e. 13% of the total of corporations. The data are constructed from all tax returns filed in a given year and have been published every three years since 1992. They provide information on more than 100 items that are relevant for calculating the CIT. Information on the assessed CIT, on tax loss carry-back, as well as on tax loss carry-forwards at the beginning and end of the year is part of the data set. Furthermore, the data set contains firm characteristics such as industry, region, and legal form.¹²

Tax return data offer several distinct advantages over accounting data. First, the data provide broad coverage of the corporate sector, including small and medium-sized firms. Second, they record the CIT actually assessed, together with taxable corporate profits. Third, they contain components important for calculating the marginal tax rate, such as the actual and potential amount of loss carry-forward and carry-backward. In our analysis we can therefore exclude that there are “many differences between accounting rules for book and tax purposes that may lead to mismeasurement of taxable status and attenuate its importance in the results” (Edgerton, 2010, p. 949), a caveat also mentioned by Auerbach (1987) and Hanlon (2003).

3.2. Investment and Cost Structure Surveys

The Investment Survey is a yearly survey on investment and divestment decisions in the mining, quarrying, and manufacturing industries in Germany.¹³ The survey is conducted at the plant and firm level and is a full record of plants and firms employing more than 20 employees.¹⁴ Participation in the survey is compulsory and unit non-response is sconced. The survey disaggregates investment and divestment activities in the respective calendar year into three categories (land, structures, and fixed assets); it covers own produced assets, acquired assets, and leased equipment as well as investment goods under lease. By virtue of its detailed questions, the statistics provide important insight into firms’ investment decisions.

The Cost Structure Survey is a yearly survey at firm-level, which contains information on the number of employees (full and part-time, along sex), sales (produced and trade goods), stocks of materials and goods, costs (broken down into materials, employees, rents, taxes, depreciation,

¹² Detailed information on the CIT statistics can be found in Gräß (2006). English-language information about the data is available at <http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Navigation/Statistics/Finanzen/Steuern/Koerperschaftsteuer/Koerperschaftsteuer.psmi>. Even though tax return data is also available for 1995 and 1998, we could not use those waves because firm identifiers were deleted in waves prior to 2001. It was thus impossible to exactly match tax and survey data using a firm identifier.

¹³ This corresponds to NACE classification B and C, German Industry Classification C and D (DESTATIS, 2003).

¹⁴ See DESTATIS (2006) for further information on the Investment Survey. Some English-language information about the statistics is available at <http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Content/Statistics/IndustrieVerarbGewerbe/Strukturdaten/Aktuell.templateId=renderPrint.psmi>

interest payment, etc.), subsidies as well as expenditures for research and development. Unlike the Investment Survey it is not a full record with cut-off but a stratified 45%-subsample thereof. The sample is stratified along industry and size (classification according to number of employees) and redrawn every few years; firms with more than 500 employees and firms in sparsely filled industries are always part of the sample.¹⁵ As for the Investment Survey, participation in the Cost Structure Survey is compulsory, and the number of non-response units of about 2% is negligible.

3.3. Firm-specific marginal tax rate depending on tax status

As discussed in Section 2.2 only few studies have accounted for tax status in their calculation of the marginal tax rate and the estimation of investment equation so far; results on whether tax status matters for firms' investment behaviour were inconclusive, which might be due to the fact that prior literature had to rely on accounting data where tax losses and loss carry-over are unobserved.

We contribute to this literature by, for the first-time, calculating firms' marginal tax rates on the basis of a full record of official CIT return data. In the definition of the marginal tax rate, which is the tax rate that applies to the last euro of taxable income, we adapt the approach of Edgerton (2010). Thus, the marginal tax rate equals the statutory rate except for two cases when it falls to zero: In the first case, net profit before loss carry-over (NPBL) is both negative and larger in absolute value than a positive profit in the previous year.¹⁶ The reasoning behind this case is that firms whose taxable loss is large in absolute value compared with positive profits in the previous year cannot fully carry back their tax loss, but must carry forward their residual tax loss. As the firm receives no tax refund on the loss remaining after carry-back, the tax on an extra euro of (negative) income equals zero. By contrast, if taxable loss is small in absolute value relative to positive profits in the previous year, the firm can carry back its marginal unit of loss and receives a tax refund, the refund in per cent being equivalent to the statutory tax rate. The second case occurs when NPBL is positive (after deduction of allowances) but smaller than losses (in absolute value) carried forward from past years. An extra euro of income is thus "absorbed" by the carry-forward and remains tax free.

In both cases the marginal tax rate falls to zero. This reasoning departs from a more dynamic perspective employed in Devereux (1989), where perfect foresight of firms calls to include an opportunity cost of using a loss carry-forward today because this inhibits its use in future years. Under this assumption the advantage of carry-forward use in the present is reduced to interest gains. In this study, we abstain from including this opportunity cost for two reasons. First, under the CIT code firms have no choice whether to use their loss carry-forward or not: unused tax loss carry-forward must be set off in full amount against current profits. Second and more importantly, in our view the assumption of perfect foresight of firms concerning their carry-forward is questionable. For many firms it is highly uncertain whether and when they will

¹⁵ To account for stratified sampling we first included the strata variables in our regressions (Wooldridge, 2010). As coefficients of the strata variables did not change results and were always insignificant on any common significance level we again excluded them from our estimations. We conclude that the inclusion of strata variables remains without effect because the investment equation is estimated in first-differences, which largely purges heterogeneity in composition.

¹⁶ A stylised calculation of NPBL and taxable income is provided in the appendix (Section 0).

be able to use their entire loss carry-forward. Either a firm never resumes a taxpaying position¹⁷ or sees its tax losses carried forward devalued. The tendency of devaluating tax losses arises for many reasons. First, tax competition has led to a significant reduction in CIT rates; in Germany, for instance, they were lowered from 45% on retained earnings and 30% on distributed earnings in the 1990s to a uniform CIT rate of 15% in 2008. This implies that the worth of a tax loss carry-forward has been more than halved over the last fifteen years. Second, recent CIT reforms in Germany, as in other European countries have been accompanied by a simultaneous broadening of the tax base by lowering depreciation allowances, introducing a requirement to reinstate original values, and cutting the use of tax loss carry-overs.¹⁸

The two cases in which the marginal tax rate equals zero can be summarized into one condition when writing the firm-specific marginal tax rate $\tau_{i,t}$ in a more formal way:

$$\tau_{i,t} = \begin{cases} 0, & (\widehat{NPBL}_{i,t} - CF_{i,t}^{sim} - A_{i,t}) < -\widehat{CB}_{i,t-1}^p \\ \tau_t^{CIT}(1 + \tau_t^s), & otherwise \end{cases} \quad (2)$$

where

$\widehat{NPBL}_{i,t}$ = predicted net profit before loss carry-over of firm i in year t ,

$CF_{i,t}^{sim}$ = simulated loss carry-forward of firm i from year $t - 1$ to year t ,

$\widehat{CB}_{i,t-1}^p$ = predicted potential loss carry-back of firm i from year t to year $t - 1$,

$A_{i,t}$ = allowance of firm i in year t ,

τ_t^{CIT} = statutory corporate income tax rate in year t , and

τ_t^s = statutory solidarity surcharge in year t .

Because CIT returns are published every three years only (see Section 3.1), information on net profit before loss carry-over, loss carry-forward and carry-back is not available for all years.¹⁹

¹⁷ As in many other countries, tax authorities have restricted the use of losses acquired with the purchase of a corporate shell in Germany in recent years. From 1997 to 2007 losses could be still used if less than 50% of shares were transmitted and if the company continually ran business operations with the same working capital (§ 8 (4) Corporate Income Tax Law 1997). Since 2008 tax losses perish on a pro rata basis if more than 25% of shares are transmitted within five years; tax losses are completely lost if more than 50% of shares change hands (§ 8c Corporate Income Tax Law).

¹⁸ Until 1998, profits could be carried back two years up to a value of EUR 5.1 million. The tax loss carry-forward was unrestricted in time and volume. In 1999, tax loss carry-back was restricted to one year. Further, tax loss carry-back was gradually reduced in volume; in 1999 and 2000 it was limited to EUR 1 million and since 2001 it has been capped to EUR 0.5 million. In 2004, the so-called “minimum taxation” was additionally introduced, restricting the use of tax loss carry-forward in volume: Only up to EUR 1 million are profits fully deductible against a tax loss carry-forward; exceeding profits can be offset up to 60%.

¹⁹ Information on NPBL is available for 2001 and 2004. Tax statistics offer information on stock of unused losses carried forward at the beginning and at the end of the year; loss carry-back is recorded for both the present and following year. Loss deductions are therefore perfectly known in 2001, 2002, and 2004.

We impute the missing values of $\widehat{NPBL}_{i,t}$ and $\widehat{CB}_{i,t-1}^p$ for intermediate years by regression imputation using explanatory variables from the cost structure survey. Then we calculate the intermediate values for $CF_{i,t}^{sim}$ with a mini-microsimulation.²⁰ With the predicted and simulated variables at hand, we can finally determine the firm-specific marginal tax rate depending on a firm's tax status that is necessary for calculating the user cost of capital as described next.

3.4. User cost of capital

Building on the work by Jorgenson (1963), Hall and Jorgenson (1967) and King and Fullerton (1984), the user cost of capital can be interpreted as the minimal rate of return before taxes a project must yield to break even. The user cost of capital for firm i in industry j with asset type a at time t is given by

$$UCC_{i,j,a,t} = \frac{P_t^I (1 - z_{a,t})(r_t + \delta_{j,a,t}^e)}{P_{j,t}^S (1 - \tau_{i,t})}, \quad (3)$$

where $\tau_{i,t}$ represents the firm-specific marginal tax rate of firm i in year t as derived in the previous section. In the Investment Survey we can distinguish three types of assets a : land, structures, and fixed assets. The investment goods price deflator P_t^I is identical for all industries and asset types in year t , $P_{j,t}^S$ stands for the producer price index specific to industry j in a given year, and $z_{a,t}$ are asset-specific depreciation allowances in the tax system.²¹ r_t equals the financial cost of the investment project and $\delta_{j,a,t}^e$ is the rate of economic depreciation specific to industry j , asset type a , and year t .

Often, a firm simultaneously invests in several types of assets a . We calculate the overall user cost of capital $UCC_{i,j,t}$ for firm i in industry j at time t as a weighted average of its asset type-specific user costs $UCC_{i,j,a,t}$:

$$UCC_{i,j,t} = \sum_a UCC_{i,j,a,t} \kappa_{i,t}^a, \quad (4)$$

where $\kappa_{i,t}^a$ is the firm-specific share of asset type a in total assets.²² The user cost of capital varies across individual firms mostly due to differences in tax status and capital structure. Additional variation over time and industries stems from changes in prices, statutory tax, interest, and economic depreciation rates.

²⁰ Please refer to the data appendix for greater detail on the imputation and microsimulation.

²¹ In Germany, a specific investment tax credit is granted only for an initial investment in Eastern Germany (*Investitionszulage*). There is no investment tax credit for a replacement investment or investment in Western Germany.

²² Of course, these asset shares are prone to endogeneity; endogeneity should be purged from our regression as we run an instrumental variable regression.

3.5. Descriptive evidence

In the panel resulting from linking the three main statistics, we drop all corporations without information from the Cost Structure Survey. Since the Cost Structure Survey is a stratified sample of the universe of corporations in manufacturing, this does not influence results. As a sensitivity check we also controlled for the sample structure in our regression equations by including the strata variables (Wooldridge, 2010); results remained unchanged. All observations that lie in the top or bottom percentile of the distribution of the investment-to-capital ratio and/or the cash flow-to-capital ratio are censored. We thereby avoid large outliers of the ratios that occur when the capital stock variable in the denominator contains very small values. The resulting panel used for estimation is unbalanced and contains 362,175 observations for 61,914 corporations during 10 years.

Table 2: Descriptive statistics for estimation variables

Variable	Mean	Median	Within-firm stand. deviat. ^{a)}	Firm-specific time variation ^{b)}
$K_{i,t}$ (in 1000 EUR)	16,800	1,858	23,400	0.999
$I_{i,t}/K_{i,t-1}$	0.132	0.061	0.188	0.979
$S_{i,t}$ (in 1000 EUR)	66,700	10,200	14,900	0.999
$\Delta S_{i,t}/S_{i,t-1}$	0.025	0.012	0.121	0.972
$Cash_{i,t}/K_{i,t-1}$	0.343	0.139	0.679	0.996
$UCC_{i,t}$	0.138	0.138	0.010	0.618
$\Delta UCC_{i,t}/UCC_{i,t-1}$	0.0001	-0.007	0.084	0.602
$UCC^{simple\ c)}$	0.141	0.140	0.010	0.544
Number of observations	362,175			

a) Using mean-differenced variables, the within-firm standard deviation measures variation in the time dimension of the panel only.

b) This measure is computed as 1 minus the R^2 statistic from a regression of each mean-differenced variable on a set of time dummies (Chirinko, Fazzari, & Meyer, 1999).

c) This measure of the UCC uses the statutory CIT rate rather than the firm-specific marginal tax rate and hence disregards tax loss carry-overs.

Notes: $I_{i,t}/K_{i,t-1}$ is the ratio of investment to the end-of-period capital stock, $S_{i,t}$ are firms' real sales in 1,000 EUR, $\Delta S_{i,t}/S_{i,t-1}$ is firm sales growth, $Cash_{i,t}/K_{i,t}$ is the ratio of firm cash flow to the end-of-period capital stock, $UCC_{i,t}$ is the user cost of capital, and $UCC_{i,t}/UCC_{i,t-1}$ is the percentage change in this variable.

Source: Research Data Center (FDZ) of the Statistical Offices of the Federation and the Länder, Investment and Cost Structure Surveys, 1995-2004, Corporate Income Tax Statistics 2001 and 2004, own calculations.

The descriptive statistics pictured in

Table 2 reflect the specificities of the data set. The investment-to-capital ratio has a mean of 0.13 and a value of 0.06 at the median. The cash flow-to-capital ratio amounts to 0.34 at the mean and 0.14 at the median. Both distributions are strongly skewed as usual for firm data. The

capital and sales figures reflect the presence of smaller firms in our data set. The user cost of capital variable is somewhat smaller in size by mean and median than in comparable studies (Harhoff & Ramb, 2001; Dwenger, 2014). This observation can be attributed to the inclusion of tax losses and loss carry-overs that reduce the marginal tax rate and hence the user cost of capital for some firms. As the account of asymmetric treatment of losses also introduces additional variation we also expect higher firm-specific time variation. Our argument is supported by the descriptive statistics for $UCC_{i,j,a,t}^{simple}$. This measure of the UCC is calculated with the statutory tax rate, disregarding loss carry-overs. It is somewhat higher by mean and median than our preferred measure $UCC_{i,t}$ and its firm-specific time variation is lower.

4 Theoretical modelling and estimation methodology

This study employs a distributed lag (DL) model with implicit dynamics based on the neoclassical approach. It is less clearly derived from theory than Q or Euler equation models, but offers the advantage of imposing less structure (Bond, Elston, Mairesse, & Mulkay, 2003). In particular, it does not require quadratic adjustment costs.²³ The DL model has frequently been used in the literature, which facilitates the comparison of our results derived from tax data with information on tax losses to prior estimations based on accounting data that disregard the incentive effects of tax loss carry-overs. Before briefly describing the model, we introduce the relationship among capital, the user cost of capital, and output. In the following, we estimate the model using both OLS and System Generalised Method of Moments (GMM) techniques.

4.1. Modelling optimal capital stock

The demand for capital and, in a dynamic perspective, for investment can be derived from the first-order conditions of profit-maximizing behaviour with static expectations (Eisner & Strotz, 1963). Using a production function with constant elasticity of substitution (σ) between capital and labour,²⁴ the optimal capital stock $K_{i,t}^*$ for firm i at time t can be written as (Arrow, Chenery, Minhas, & Solow, 1961)

$$K_{i,t}^* = A_i T_t S_{i,t}^\beta UCC_{i,t}^{-\sigma}, \quad (5)$$

where $\beta = \sigma + \frac{1-\sigma}{\nu}$.

The optimal level of capital depends on a firm's level of output or sales $S_{i,t}$, a firm-specific distribution parameter A_i that explains firm-specific relative factor shares of labour and capital, technology T_t , and the firm's user cost of capital UCC as defined in equations (3) and (4). In this partial analysis, the optimal capital stock is independent of the wage rate, such that companies

²³ Quadratic adjustment costs have been criticised as empirically implausible (Doms & Dunne, 1998) and too strict in the context of investment under (partial) irreversibility (Dixit & Pindyck, 1994).

²⁴ A production function with constant elasticity of substitution nests Leontief ($\sigma = 0$) and Cobb-Douglas ($\sigma = 1$) production functions.

are assumed to be price-takers on perfectly competitive product and factor markets.²⁵ The parameter of interest is the long-term elasticity of capital with respect to user cost of capital, $-\sigma$.

In a frictionless world, the log of the current optimal capital stock $k_{i,t}^*$ is simply a log-linear function of current sales in log ($s_{i,t}$), the logarithmised current user cost of capital ($ucc_{i,t}$), a firm-specific effect a_i , and a deterministic time trend d_t that captures technological progress. If costs of adjustment and uncertainty are introduced though, the current capital stock depends on both current and past values of sales and user cost of capital in logs, as well as on past values of the capital stock.²⁶ Appending a stochastic error term $\varepsilon_{i,t}$, the current capital stock can be expressed as follows:

$$k_{i,t} = c + a_i + \sum_{h=1}^H \phi_h k_{i,t-h} + \sum_{h=0}^H \beta_h s_{i,t-h} - \sum_{h=0}^H \sigma_h ucc_{i,t-h} + \sum_{t=1}^{T-1} \tau d_t + u_{i,t}. \quad (6)$$

4.2. Distributed lag model

In the specification proposed by Chirinko et al. (1999), investment I_t comprises replacement components and net components. Replacement investment is proportional to the capital stock available at the beginning of the year, because capital is assumed to depreciate geometrically at a firm-specific constant rate (δ_i). Net investment is the change in capital between years t and $t - 1$. The change in capital stock scaled by the existing stock thus equals

$$\frac{K_{i,t} - K_{i,t-1}}{K_{i,t-1}} = \frac{I_{i,t}}{K_{i,t-1}} - \delta_i. \quad (7)$$

Because firm-level data are usually right skewed and exhibit large differences in firm size, Chirinko et al. propose specifying the equation for capital with all variables as ratios or rates. Differencing equation (6) and omitting its auto-regressive part, with the log approximation ($\log(K_t) - \log(K_{t-1}) \approx \Delta K_t / K_{t-1}$) for the change in capital expressed in equation (7), and including cash flow relative to the existing capital stock as a measure of liquidity (Fazzari, Hubbard, & Petersen, 1988; Fazzari, Hubbard, & Petersen, 2000; Chirinko, Fazzari, & Meyer, 1999), they attain their DL investment equation:

$$\frac{I_{i,t}}{K_{i,t-1}} = \delta_i + \sum_{h=0}^H \beta_h \Delta s_{i,t-h} - \sum_{h=0}^H \sigma_h \Delta ucc_{i,t-h} + \sum_{h=0}^H \gamma_h \frac{Cash_{i,t-h}}{K_{i,t-h-1}} + \varepsilon_{i,t}, \quad (8)$$

²⁵ In the econometric analysis, differences in the wage rate over time and across firms are captured in the deterministic time trend and firm-specific effects.

²⁶ Adjustment costs are assumed to be a function of either the rate of gross or net investment and rationalised in reference to the costs of disruption, training of workers, management problems, and the like (Eisner & Nadiri, 1968; Lucas, 1967; Gould, 1968; Treadway, 1969). They also may be justified by supply side factors, assuming the supply curve of capital goods to the firm is upward sloping (Foley & Sidrauski, 1970; Foley & Sidrauski, 1971), Nickell (1977) rationalises lags by combining delivery lags and uncertainty. Harvey (1990) neatly distinguishes both effects: In a world with adaptive expectations, the optimal capital stock depends on lagged sales and the user cost of capital, whereas the currently optimal capital stock depends on lagged capital stock if the capital is only partially adjusted.

with $\varepsilon_{i,t} = \Delta u_{i,t}$. In the estimation equation, the long-term user cost elasticity of capital is captured by the sum of the σ_h s.

4.3. Estimation strategy

In a first step, we take first differences of the model equation (8) and estimate the resulting equation with ordinary least squares (OLS). The specification accounts for firm and time-fixed effects and reduces potential omitted variable bias. It also deals well with potential serial correlation of $\varepsilon_{i,t}$. However, the OLS estimation suffers from three substantial problems that call for an instrumental variable (IV) methodology.

First, in spite of using tax data measurement error is likely to be present in the user cost of capital due to the usage of aggregate information on, e.g., firms' financing cost. Second, firm-specific asset structures and firm-specific marginal tax rates are likely correlated with investment, making the user cost of capital endogenous. Third, with an upward sloping supply curve for capital, a reduction in tax rates drives up prices in the short run, which might inhibit an expected increase in investment (Goolsbee, 1998; Goolsbee, 2004). This simultaneity introduces a correlation between the user cost of capital and investment shocks that distorts the user cost elasticity towards zero. A similar argument suggests that simultaneity between investment shocks and interest rates biases the coefficient of the user cost of capital (Chirinko, Fazzari, & Meyer, 1999). Furthermore, investment shocks may be contemporaneously correlated with sales and cash flow. Both measurement error and simultaneity bias require an IV technique for the estimates to be consistent and unbiased.

In a second step, we therefore estimate the DL model using the heteroscedasticity-robust two-step System-GMM. This estimator uses the lagged levels of independent variables as instruments for the difference equation and the lagged difference of independent variables as instruments for the level equation (Blundell & Bond, 1998).²⁷ As standard errors in the usual two-step GMM estimator are downward biased in finite samples, we also apply the Windmeijer (2005) correction. We abstain from implementing a tobit estimation because the fraction of firms without investment is small while the challenge of endogeneity can be most effectively overcome by using the System-GMM estimator.

Only in the absence of higher-order serial correlation in the error term $\varepsilon_{i,t}$, does the GMM estimator provide consistent estimates of the parameters in the investment equation. To test for second-order serial correlation in the differenced residuals, we use the Arellano-Bond (1991) test.²⁸ We also report Sargan tests of overidentifying restrictions.

²⁷ We do not report results estimated with Difference-GMM (Arellano & Bond, 1991) or Forward-GMM (Arellano & Bover, 1995). These estimators can be subject to large finite-sample biases because the correlation between the explanatory variables in differences and their lagged levels grows weak in highly persistent series (Blundell & Bond, 1998). An indication of whether these biases are likely to be serious can be obtained from OLS levels and within-group estimates that are biased upward and downward, respectively.

²⁸ For consistent estimations, the error term $\varepsilon_{i,t}$ must be serially uncorrelated. If $\varepsilon_{i,t}$ are serially uncorrelated, then $\Delta\varepsilon_{i,t}$ are correlated with $\Delta\varepsilon_{i,t-1}$, but $\Delta\varepsilon_{i,t}$ will not be correlated with $\Delta\varepsilon_{i,t-k}$ for $k \geq 2$. If the estimation requirements are fulfilled,

5 Estimation results

Our baseline results yield user cost elasticities that are at the lower bound of results found in prior literature, which can be attributed to our sample which mainly consists of small and medium sized firms that have not been studied before. We show that the estimated user cost elasticity is larger in absolute size when taking into account tax loss carry-overs in comparison to estimates that ignore tax loss information. Even though this difference is not statistically well determined in our sample, the point estimates confirm our claim that mismeasurement of the marginal tax rate and user cost of capital have led to an underestimation of firms' response to user cost in previous studies which relied on accounting data to approximate tax losses or which ignored the asymmetric treatment of losses altogether.

5.1. Baseline results

Table 3 shows the results for the distributed lag model in our baseline specification, where the long-term user cost elasticity is given by the sum of σ_s .²⁹ The results are directly comparable with elasticities reported in prior studies. As a benchmark, column (1) shows estimates carried out with OLS after taking first differences of the estimation equation (8). The size of the user cost elasticity of -0.427 , which is statistically different from zero at the 1-percent level (two-sided test, t -value -5.77), is relatively small in absolute terms; as we noted previously, we did not expect an OLS regression of the change in user cost of capital on the change of investment to identify the user cost elasticity. We rather suspected the OLS estimate to suffer from attenuation bias towards zero due to mismeasurement of the user cost of capital by partly using aggregate information for, e.g., firm's financing cost. This bias might also carry over to other coefficients, in particular to the long-term coefficient of sales, which in this specification is 0.116 (t -value 2.97). It is clearly smaller than one and implies increasing returns to scale, as commonly found in the investment literature.

The results in column (2) are estimated using System-GMM. As expected, the long-term user cost elasticity increases in absolute size to -0.521 (t -value -2.50), giving a clear indication that the instrumentation strategy resolves the attenuation bias. This is our preferred estimate. As same instruments in all estimations we used lags two to seven of the explanatory variables, which allows for contemporaneous correlation between user cost of capital, sales, and shocks to the investment equation, as well as correlation with unobserved firm-specific effects. That is, both current sales and current user cost of capital are treated as potentially endogenous variables in the investment equation. The Sargan test supports the validity of the instruments we use, as the null hypothesis of instrument exogeneity cannot be rejected at any conventional level of statistical significance. In addition to the Sargan test, we also report direct tests for first-order (m1) and second-order (m2) serial correlation in the differenced residuals. These are asymptotically standard normal under the null of no serial correlation; our Arellano-Bond test of

we expect to reject the Arellano-Bond test for zero autocorrelation in the first-differenced errors at order 1 but not at order 2.

²⁹ Standard errors for the long-term effect are calculated using the delta method.

order 2 fails to reject the absence of higher-order serial correlation and indicates that the GMM estimates are consistent.

Table 3: Estimates for the DL model

$I_{i,t}/K_{i,t}$	(1) OLS FD	(2) System GMM	(3) System GMM
$\Delta ucc_{i,t}$			
σ_0	-0.180*** (0.025)	-0.294*** (0.112)	-0.237** (0.109)
σ_1	-0.130*** (0.025)	-0.116** (0.051)	-0.112** (0.050)
σ_2	-0.084*** (0.023)	-0.072* (0.039)	-0.074* (0.039)
σ_3	-0.034* (0.017)	-0.038* (0.022)	-0.036 (0.022)
SUM (σ)	-0.427*** (0.074)	-0.521** (0.208)	-0.495** (0.204)
$\Delta s_{i,t}$			
β_0	0.031*** (0.012)	0.134** (0.058)	0.120** (0.058)
β_1	0.045*** (0.012)	0.066*** (0.016)	0.061*** (0.015)
β_2	0.028** (0.013)	0.051*** (0.014)	0.040*** (0.014)
β_3	0.012 (0.011)	0.028*** (0.011)	0.027*** (0.010)
SUM (β)	0.116*** (0.039)	0.279*** (0.078)	0.248*** (0.077)
$C_{i,t}/K_{i,t-1}$			
γ_0			0.040** (0.018)
γ_1			0.001 (0.010)
γ_2			0.007 (0.006)
SUM (γ)			0.046*** (0.018)
Number of firms	3,982	3,982	3,982
Number of observations	7,605	8,462	8,462
<i>UCC</i> with carry-over	Yes	Yes	Yes
Sargan (<i>p</i> -value)		0.951	0.948
Arellano-Bond m1		-4.755	-4.983
Arellano-Bond m2		-1.867	-1.487

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Lags two to seven of the explanatory variables are used as instruments.

Source: Research Data Center (*FDZ*) of the Statistical Offices of the Federation and the Länder, Investment and Cost Structure Surveys, 1995-2004, Corporate Income Tax Statistics 2001 and 2004, own calculations.

In column (3) we add the cash flow-to-capital ratio to our baseline regression model in order to control for firm liquidity effects and finance constraints. We find that mainly current cash flow plays a role in the investment decision of a firm; the long-term effect is 0.046 and statistically different from zero at the 1-percent level (two-sided test, t -value 2.56). This economically small but statistically significant effect of cash flow can indicate the presence of financing constraints on investment. However, it is well known that financial constraints are not the only possible interpretation. If investment depends on expected future sales and cash flow acts as a proxy for the omitted expected future profitability variables, cash flow coefficients would be significant even in the absence of financing constraints (Kaplan & Zingales, 1997; Kaplan & Zingales, 2000). Irrespective of using cash flow as a proxy for future profitability or as an indicator of financial constraints, the coefficients of sales and user cost of capital remain very stable. These findings are in line with previous studies and can additionally be regarded as robustness check of our results.

Compared to other estimates of the user cost elasticity ranging between -0.66 and -0.40 for Germany (Harhoff & Ramb, 2001; von Kalckreuth, 2001; Chatelain, Hernando, Generale, Kalckreuth, & Vermeulen, 2003; Chateleain, Hernando, Generale, Kalckreuth, & Vermeulen, 2003; Dwenger, 2014) our preferred estimate of -0.427 is at the lower bound but comparable in size. This is surprising given that all these studies relied on accounting data and assumed the marginal tax rate to equal the statutory tax rate for all firms while we use tax data and firm-specific marginal tax rates. We argue that this happens because our estimation of the average user cost elasticity disguises two effects: On the one hand, taking into account tax losses and calculating firm-specific marginal tax rates increases the number of firms with non-taxable status in the estimation; we clearly expect this to increase the estimate of the user cost elasticity in absolute terms. On the other hand, our sample also includes small and medium-sized firms that have not been studied before. The following section aims at disentangling the two effects by comparing our preferred estimate to estimation results from a regression with “simple” user cost of capital, in which tax losses are fully ignored.

5.2. Tax loss carry-forward and user cost elasticity

For this purpose we alter our preferred specification from column (2) of Table 3. Instead of using our user cost of capital measure with firm-specific taxable status and marginal tax rates, we employ an alternative definition of the user cost of capital. The alternative, termed “simple” user cost of capital, is calculated with the statutory tax rate, hence disregarding tax losses and tax loss carry-forward as it has been done in many previous studies. This puts us in the position to contrast our preferred specification with the usual approach in the literature. We do this with the help of Table 4, where our preferred estimate is reprinted in column (1) and the alternative using “simple” user cost is reported in column (2). In the model discarding tax losses, both short and long term coefficients of the user cost of capital are smaller in absolute values and of weaker statistical significance. Yet the difference in the two point estimates is not statistically significant. This insignificance probably reflects the limitations of our relatively small data set, in which IV estimators tend to yield fairly large standard errors of estimated coefficients.

Table 4: Comparing UCE with and without tax loss carry-over

$I_{i,t}/K_{i,t}$	(1) System GMM	(2) System GMM
$\Delta ucc_{i,t}$		
σ_0	-0.294*** (0.112)	
σ_1	-0.116** (0.051)	
σ_2	-0.072* (0.039)	
σ_3	-0.038* (0.022)	
SUM (σ)	-0.521*** (0.208)	
$\Delta ucc_{i,t}^{simple}$		
σ_0^{simple}		-0.200** (0.080)
σ_1^{simple}		-0.082* (0.044)
σ_2^{simple}		-0.051 (0.036)
σ_3^{simple}		-0.040 (0.027)
SUM (σ^{simple})		-0.374** (0.165)
$\Delta s_{i,t}$		
β_0	0.134** (0.058)	0.124** (0.054)
β_1	0.066*** (0.016)	0.059*** (0.016)
β_2	0.051*** (0.014)	0.041*** (0.014)
β_3	0.028*** (0.011)	0.024** (0.011)
SUM (β)	0.279*** (0.078)	0.247*** (0.075)
Number of firms	3,982	3,982
Number of observations	8,462	8,462
<i>UCC</i> with carry-over	Yes	No
Sargan (<i>p</i> -value)	0.951	0.863
Arellano-Bond m1	-4.755	-4.601
Arellano-Bond m2	-1.867	-1.728

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Lags two to seven of the explanatory variables are used as instruments.

Source: Research Data Center (*FDZ*) of the Statistical Offices of the Federation and the Länder, Investment and Cost Structure Surveys, 1995-2004, Corporate Income Tax Statistics 2001 and 2004, own calculations.

The point estimates nevertheless support our claim that the IV estimation in column (2) cannot entirely overcome the attenuation bias in the user cost elasticity due to persistent measurement error in the user cost of capital variable. With persistent loss carry-forward and measurement error in the user cost of capital, lagged values of the user cost of capital are no longer uncorrelated with the measurement error of the explanatory variable. That is, one of the preconditions for using an IV regression to eliminate attenuation bias is violated. As our results show the problem can be solved if tax data are used, in which tax losses and loss carry-over are

perfectly observed. Additionally we can confirm our expectation that including tax loss information increases the efficiency of the estimation. The coefficient of the simple user cost of capital measure is estimated with a t -value of -2.27 , the more precise measure achieves a t -value of -2.50 . We have tested our findings in various other specifications, for example by including the cash flow-to-capital ratio and by using output instead of sales;³⁰ the conclusion proves to be robust.

6 Conclusion

When analysing the effects of tax incentives on corporate investment, most of the vast theoretical and empirical literature on taxes and investment has neglected the prominence of tax losses in lowering firm-specific marginal tax rates and have assumed the marginal tax rate to equal the statutory tax rate. Only a very limited number of studies have addressed the asymmetric treatment of losses and the relevance of loss carry-forward and carry-back. However, even this advanced literature relies on financial statements that lack precise information on tax losses. Due to data limitations these studies have approximated tax losses with accounting losses.

The neglect of tax losses in much of the investment literature does not only ignore an important source of variation in the user cost of capital but also leads to a classical error-in-variables problem, which attenuates the estimate of the user cost elasticity. Previous literature has applied an instrumental variable approach to overcome this problem, with lags of the user cost of capital as instrumental variables. This chapter provides evidence, however, that the measurement error in the user cost of capital arising from the neglect of tax losses and loss carry-overs cannot be remedied in this way. The reason for this is that carry-forwards are very persistent over time, distorting current and past measures of the user cost of capital. Hence, past user cost of capital as instrumental variables suffers from the same measurement error as their present-time equivalent, leading to correlation between instruments and regression error.

We argue that the attenuation bias resulting from the neglect or approximation of loss carry-forward can be overcome by using tax return data that offer precise information on tax losses, as it is done in this study. Our preferred baseline estimate for the elasticity of capital with respect to its user cost, estimated with System-Generalised Method of Moments, is -0.52 . That is, an increase in the user cost of capital of 1% reduces corporate investment by 0.52%. The estimate is at the lower end but within the range of results previously reported for Germany. The fact that the estimate is relatively small in absolute size is surprising but is partially due to our sample which also includes small and medium-sized firms which have not been studied before. Disentangling the composition effect of the sample and the effect of tax losses on the user cost elasticity shows that the user cost estimate is attenuated if tax losses are ignored. We find that the user cost elasticity estimate is underestimated at -0.37 with a user cost variable that does not include losses and loss carry-overs. Although the difference in the two point estimates is not well defined in our relatively small sample, the estimates support our claim that an instrumental

³⁰ Results are available upon request.

variable regression with lagged user costs as instruments still suffers from attenuation bias if tax losses are ignored.

Our results suggest that, on average, tax incentives geared to encourage firms' investment are more effective than found in previous literature. More research is needed, however, in order to better understand potential heterogeneity in firms' responses to tax incentives, in particular what concerns firms' tax paying status and the role of tax losses carried forward.

Annexes

Tax code provisions

Table 5: Derivation of taxable income according to the German CIT Code

	<i>Turnover</i>
-	Deductions such as interest payments and depreciation allowances
±	(...)
=	<i>Profit as shown in tax balance sheet</i>
±	Correcting entry concerning valuation (adjustment of values of balance sheet items, non-tax deductible losses, and non-tax relevant gains, etc.)
+	Correction of activities that are related to shareholders (declared profit distributions and constructive dividends, repayment of capital or capital increase, hidden contribution and other deposits under company law)
+	Non-deductible operating expenses (especially taxes paid, 50% of payment to members of the supervisory board, penalties)
±	Non-tax relevant domestic increases and decreases in net worth (inter-company dividends, investment subsidies, etc.)
±	Corrections related to double taxation agreements, tax legislation relating to non-residents, and fiscal units
=	<i>Total revenue</i>
-	Allowable deductions for agriculture and forestry
-	Deductible donations and contributions
±	Income generated by fiscal subsidiaries
=	<i>Net profit before loss carry-over (NPBL)</i>
-	Loss carry-forward and loss carry-back
=	<i>Net income</i>
-	Allowable deductions for non-incorporated firms and for commercial cooperatives
=	<i>Taxable income (TI)</i>
×	Statutory tax rate
-	Tax credits for foreign-source income
=	<i>Corporate income tax assessed (TA)</i>

Source: Own presentation.

Table 6: Statutory CIT rates in Germany 1995-2004

Year	Corporate income tax on retained profits	Corporate income tax on distributed profits	Solidarity surcharge
1995	45%	30%	7.5%
1996	45%	30%	7.5%
1997	45%	30%	7.5%
1998	45%	30%	5.5%
1999	40%	30%	5.5%
2000	40%	30%	5.5%
2001	25%	25%	5.5%
2002	25%	25%	5.5%
2003	26.5%	25%	5.5%
2004	25%	25%	5.5%

Source: Own presentation.

Data

Investment and divestment

Nominal gross investment is given in the Investment Survey; it is defined as an acquired or produced fixed tangible asset whose lifetime exceeds one year and which is usually activated in the firm's balance sheet (DESTATIS, 2006). In the statistical source, nominal gross investment $I_{p,i,a,t}^{(n)}$ (I22) is reported on plant-level p of firm i in year t , and it is classified into three investment categories a , land (without structures, I20), structures (including the land they stand on, I19), or fixed assets (I21). For our purpose, we aggregate plant level information to obtain nominal gross investment on firm-level, $I_{i,a,t}^{(n)} = \sum_p I_{p,i,a,t}^{(n)}$. If applicable, we deflate firm-specific investment streams to the base year 2000 using the investment good price index and derive real gross investment $I_{i,t,a}$.

Nominal divestment $J_{p,i,a,t}^{(n)}$ is also available on plant-level p , however, only for the asset category land (I32) and as sum over all asset categories a (I31). After aggregation on firm level ($J_{i,a,t}^{(n)} = \sum_p J_{p,i,a,t}^{(n)}$), divestment of structures is approximated as

$$J_{i,t,structures}^{(n)} = J_{i,t,land}^{(n)} \cdot \frac{I_{i,t,structures}^{(n)}}{I_{i,t,land}^{(n)}}$$

Divestment of fixed assets is then calculated by deducting divestment of land and structures from total divestment:

$$J_{i,t,fixed\ assets}^{(n)} = J_{i,t}^{(n)} - J_{i,t,land}^{(n)} - J_{i,t,structures}^{(n)}$$

As for gross investment, nominal divestment for each asset category a is deflated to real divestment $J_{i,a,t}$ using the investment good price index with base year 2000.

Sales

Nominal sales $S_{i,t}^{(n)}$ is retrieved from the Cost Structure Survey on firm-level. Nominal sales (EF40) is the sum of sales of produced goods (EF35), sales of trade goods (EF37), commission earnings for trade negotiation (EF38), and turnover of other activities (EF39); it contains the revenue or turnover net of taxes (DESTATIS, 2006). We derive real sales $S_{i,t}$ by deflating nominal sales with the industry-specific producer price index on NACE four-digit level.

Cash flow

Nominal cash flow $C_{i,t}^{(n)}$ can be retrieved as sum of several variables in the Cost Structure Survey (DESTATIS, 2006)

$$\begin{aligned}
 & \text{Total sales } S_{i,t}^{(n)} \text{ (EF40)} \\
 - & \text{ costs without costs for material/traded goods of firm } i \text{ at time } t \text{ (EF78)} \\
 - & \text{ materials consumption of firm } i \text{ at time } t \text{ (EF53, EF59)} \\
 + & \text{ total depreciation of firm } i \text{ at time } t \text{ (EF74)} \\
 + & \text{ subsidies to firm } i \text{ at time } t \text{ (EF80)} \\
 \hline
 = & \quad \mathbf{Cash}_{i,t}^{(n)}
 \end{aligned}$$

We use the investment good price index to convert nominal cash flow $Cash_{i,t}^{(n)}$ into real cash flow $Cash_{i,t}$ taking the year 2000 as base.

Capital stock

The data set includes investment variables but no information on corporations' accrued fixed tangible assets and their real replacement value. Capital stock on firm level is computed via the perpetual inventory method (PIM) that is recommended in the European System of Accounts (ESA95, 1.09.b). It relies on an assumed initial value of capital stock as well as on data on investment, divestment, inflation, and economic depreciation, for all of which Schmalwasser and Schidlowski (2006) provide exact definitions in the context of German statistics. The authors also exhibit the PIM in detail. In this chapter, a simplified formula adapted from Harhoff (1994) is used that builds on the variables previously described. We use investment series in constant prices which facilitates the calculation of the replacement value of capital stock in a given year:

$$K_{i,a,t+1} = (1 - \delta_{j,a,t})K_{i,a,t} + I_{i,a,t} - J_{i,a,t}, \quad (9)$$

where

- t = 1996, ..., 2004,
- $K_{i,a,t}$ = real capital stock of asset a of firm i at the beginning of year t ,
- $I_{i,a,t}$ = real gross investment of asset a by firm i during year t ,
- $J_{i,a,t}$ = real gross divestment of asset a by firm i during year t , and
- $\delta_{j,a,t}$ = economic depreciation rate of asset a in industry j in year t .

The capital stock is computed separately for land, structures, and fixed assets. The critical assumption of the PIM is the initial value of capital stock in the first year a firm is observed, usually in 1995. The literature suggests a variety of methods to approximate a plausible starting value. In our approach, we distribute the aggregate net capital stock of each NACE two-digit industry of manufacturing over all businesses within that industry according to their share in aggregated gross investment volume of the respective industry in that year:

$$K_{i,j,t,a} = K_{j,a,t} \cdot \frac{I_{i,j,t,a}}{\sum_i I_{i,j,t,a}} \quad (10)$$

where

- t = 1996, ..., 2004,
- $K_{i,j,a,t}$ = real capital stock of asset a of firm i in industry j at the beginning of year t ,
- $K_{j,a,t}$ = $\sum_i K_{i,j,a,t}^{(r)}$, aggregate real capital stock of asset a in industry j at the beginning of year t , and
- $I_{i,a,t}$ = real gross investment of asset a by firm i during year t .

The aggregate real capital stock of type a in industry j (NACE two-digit level), $K_{j,a,t}$, is retrieved from the national accounts (DESTATIS, 2009). As the Investment Survey only contains businesses larger than 20 employees we adjust $K_{j,a,t}$ downwards and follow an indication by the statistical authorities that roughly 5% of total capital stock is held by small firms with at most 20 employees.

We conducted two robustness checks: First, we calculated the starting value using the permanent growth method as suggested by Harhoff (1994). Second we followed the procedure described above but on aggregate level without using industry-level information. A comparison of the investment-to-capital ratios obtained with the different methods shows that results do not

vary much. We conclude that our approach delivers reliable capital figures. After finalizing the PIM, we aggregate asset-specific capital to total capital stock on firm level, $K_{i,t} = \sum_a K_{i,a,t}$.

Firm-specific marginal tax rate

The marginal tax rate $\tau_{i,t}$ for firm i in year t takes into account the statutory CIT rate, the solidarity surcharge as well as potential loss carry-forwards and carry-backs. The local business tax is disregarded because the data set does not allow the necessary allocation of its tax base to the respective municipalities.

The CIT statistics are available every three years only. As firms' tax identifiers were deleted by the statistical authorities for years prior to 2001, we can only integrate the years 2001 and 2004 into our data set. Thus, the tax variable "net profit before loss carry-over" (NPBL) is missing for years 1995-2001 and 2002-2003. The volume of loss carry-back and carry-forward is reported at the beginning and at the end of each tax year. Hence we observe the beginning-of-year tax loss carry-forward in 2001 and 2004, and we can use the end-of-year information of 2001 as the beginning-of-year observation in 2002. For the derivation of the firm-specific marginal tax rate, we impute missing observations for the tax variables as follows:

To derive NPBL for years without tax information, we regress the values observed in 2001 and 2004 on variables from the Cost Structure Survey. The specification with the best explanatory power yields an R^2 of 64.2%; estimated coefficients are used to predict the values for $\widehat{NPBL}_{i,t}$ in the tax missing years.

$$NPBL_{i,t} = \alpha + \beta ROS_{i,t} + \sum_{l=1}^2 \gamma_l^I P_{i,t-l} + \sum_{l=1}^2 \gamma_l^{II} P_{i,t-l}^2 + \sum_{l=1}^2 \gamma_l^{III} P_{i,t-l}^3 + \delta S_{i,t} + \eta X_{i,t} + \lambda D_{i,(t)} + \varepsilon_{i,t} \quad (11)$$

where

t = 2001, 2004,

$P_{i,t}$ = profit constructed from Cost Structure Survey,

$S_{i,t}$ = total of sales,

$X_{i,t}$ = total of costs, sum of wages, number of owner managers, number of employees, and,

$D_{i,(t)}$ = legal form, industry and federal state.

As loss carry-back has been restricted to the preceding year after 1998 (and to only two years preceding the loss year until 1998), the predictive power of a regression with flows as explanatory variables is satisfactory. We therefore use a regression similar to the one above, but have one additional year available for estimation:

$$CB_{i,t} = \alpha + \sum_{l=-1}^0 \beta_l ROS_{i,t-l} + \sum_{l=-1}^1 \gamma_l^I P_{i,t-l} + \sum_{l=-1}^1 \gamma_l^{II} P_{i,t-l}^2 + \sum_{l=-1}^1 \gamma_l^{III} P_{i,t-l}^3 + \delta S_{i,t+1} + \eta X_{i,t+1} + \lambda D_{i,(t)} + \varepsilon_{i,t} \quad (12)$$

We achieve an R^2 of 87.9% in our preferred specification and again use the estimated coefficients to predict $\widehat{CB}_{i,t}$.

The procedure we rely on to impute loss carry-forward is somewhat more complicated because losses can accumulate over longer time. Loss carry-forward should be treated as stock variable and level predictions based on regressions with flows as explanatory variables cannot convince. Therefore, we use a microsimulation to derive the missing values of loss carry-forward. As a first step, we assume the carry-forward to equal zero as starting value in year 1995. We then simulate the stock values of tax loss carry-forward using yearly information on tax losses/profits to meet its stock value in 2001, 2002, and 2004. The syntax of the simulation for years 1996 to 2001 is as follows:

$$CF_{i,t}^{sim} = \begin{cases} CF_{i,t-1}^{sim} - \widehat{NPBL}_{i,t-1} - \widehat{CB}_{i,t-2}^p, & \widehat{NPBL}_{i,t-1} < 0 \\ CF_{i,t-1}^{sim} - (\widehat{NPBL}_{i,t} - \widehat{CB}_{i,t-2}^p - A_{i,t-1}), & \widehat{NPBL}_{i,t-1} \geq \widehat{CB}_{i,t-1}^p + A_{i,t-1} \\ CF_{i,t-1}^{sim}, & 0 \leq \widehat{NPBL}_{i,t-1} < \widehat{CB}_{i,t-1}^p + A_{i,t-1} \\ 0, & CF_{i,t-1}^{sim} - (\widehat{NPBL}_{i,t-1} - \widehat{CB}_{i,t-1}^p - A_{i,t-1}) < 0 \end{cases}$$

where

- $CF_{i,t}^{sim}$ = simulated stock of losses carried forward of firm i in the beginning of year t ,
- $\widehat{NPBL}_{i,t}$ = predicted net profit before loss carry-over of firm i in year t ,
- $\widehat{CB}_{i,t-1}^p$ = predicted potential loss carry-back of firm i from year $t + 1$ to year t , and
- $A_{i,t}$ = allowance of firm i in year t .

In 2001, $CF_{i,t}^{sim}$ is compared to $CF_{i,t}$, the observed value. If $CF_{i,t}^{sim}$ is smaller than $CF_{i,t}$, the difference is added to $CF_{i,t}^{sim}$ in 1995 and the simulation starts again with the new starting value. This procedure is iterated a few times. For the missing values in 2003, we proceed analogously with the observed values in 2002 or 2004 as benchmarks.

As a robustness check, we predict loss carry-forward via a regression approach similar to the one used for net profit before loss carry-over and correct the predicted values for the time trend observed in aggregate loss carry-forward by Dwenger (2009). The distributions of the values obtained via the two methodologies differ little and we choose to employ the simulated variable.

Once we obtained values for $\widehat{NPBL}_{i,t}$, $\widehat{CB}_{i,t-1}^p$ and $CF_{i,t}^{sim}$ for all years, we calculate taxable income for each firm. Section 0 provides an overview of the legal definition of taxable income. We also take into account allowances $A_{i,t}$ according to § 24 and § 25 of the German CIT Code. Finally we assign the firm-specific marginal tax rate according to equation (2) on page 12. For comparison, statutory tax rates are presented in Section 0.

Price indices

The yearly producer price index (*Erzeugerpreisindex*) $P_{j,t}^S$ is available on NACE four-digit level for industry j . It measures the development of prices for products sold by the manufacturing, mining, energy, and water industries in Germany. The index is based on data of 5,000 businesses and 9,000 price time series of single goods (DESTATIS, 2008).³¹

The investment good price index (*Investitionsgüterpreisindex*) $P_{j,t}^I$ is available for all years t on level of the economy. It is a subindex of the producer price index reflecting the price development of investment goods only.

Economic depreciation

We calculate the rate of economic depreciation $\delta_{j,a,t}^e$ on NACE two-digit level for industry j , asset type a , and year t as

$$\delta_{j,a,t}^e = \frac{\text{depreciation}_{j,a,t}}{K_{j,a,t}}$$

where $\text{depreciation}_{j,a,t}$ equals economic depreciation of asset a in industry j at time t (in prices of 2000) and $K_{j,a,t}$ is real gross capital stock of asset a in industry j at time t (in prices of 2000). Both variables are obtained from national accounts (DESTATIS, 2009).

Depreciation allowances

(Regular) depreciation allowances $z_{a,t}$ follow different methods in Germany, depending on asset a and year t : Structures are depreciated on a straight-line basis, whereas fixed assets could be depreciated according to the declining-balance method until 2007. At that time, firms could also change from the declining-balance to the straight-line method once the latter was beneficial. The rates of depreciation are set by the German income tax law and industry-specific tables are issued by the Federal Ministry of Finance. When calculating the discounted value, we took the different methods and changes in rates into account and also corrected for inflation because historical cost depreciation increases taxes with inflation. Due to data restrictions, we can only consider regular depreciation allowances. Accelerated depreciation allowances for investment in Eastern

³¹ Some English-language information on the producer price index for industrial products is available at: <http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/press/abisz/Erzeugerpreise.templateId=renderPrint.psm>.

Germany, introduced after reunification,³² extraordinary depreciation allowances for some industries (e.g. agriculture), and additional depreciation allowances for small and medium-sized businesses cannot be taken into account.

Structures: Until 2000, the taxation-relevant lifetime of structures was 25 years. Since 2001, this lifetime has been prolonged to $33\frac{1}{3}$ years.

Fixed assets: Until 2000, the yearly rate for the declining-balance method was 0.3 (since 2001: 0.2) for fixed assets. Unfortunately, there is no information about the relevant lifetime for different fixed assets, which vary considerably. We therefore assumed a relevant lifetime of 10 years (year 1997) on average. An investigation of depreciation allowances in Germany concludes that reforms in 1998 and 2001 worsened depreciation allowances by approximately 30% (Oestereicher & Spengel, 2002). Hence we scaled the average lifetime accordingly (1998 to 2000: 13 years, 2001 to 2008: 16.9 years).

Financial cost

We assume the firm to have access to financial capital at interest rate r_t , which is the interest rate of bonds issued by non-financial institutions within Germany in year t (Deutsche Bundesbank, 2010). We calculate annual averages of the monthly figures provided by the central bank for the years 1995 to 2004.

³² See *Fördergebietsgesetz*.

Bibliography

- Aarbu, K. O., & MacKie-Mason, J. K. (2003). Explaining underutilisation of tax depreciation deductions: empirical evidence from Norway. *International Tax and Public Finance*, 10, 229-257.
- Altshuler, R., Auerbach, A. J., Cooper, M., & Knittel, M. (2008). Understanding U.S. Corporate Tax Losses. *NBER Working Paper No. 14405*. Cambridge: The National Bureau of Economic Research.
- Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277-297.
- Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68(1), 29-51.
- Arrow, K. J., Chenery, H. B., Minhas, B. S., & Solow, R. M. (1961). Capital-Labor Substitution and Economic Efficiency. *The Review of Economics and Statistics*, 43(3), 225-250.
- Auerbach, A. J. (1986). The Dynamic Effects of Tax Law Asymmetries. *The Review of Economic Studies*, 53(2), 205-225.
- Auerbach, A. J. (2007). Why have Corporate Tax Revenues declined? Another Look. *CESifo Economic Studies*, 53(2), 153-171.
- Auerbach, A. J., & Poterba, J. (1987). Tax loss carry-forwards and corporate tax incentives. In M. Feldstein, *The Effects of Taxation on Capital Accumulation*. Chicago: University of Chicago Press.
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115-143.
- Böckern, S. (2001). Investment and Politics - Does Tax Fear Delay Investment? *FinanzArchiv*, 58(1), 60-77.
- Bond, S., Elston, J. A., Mairesse, J., & Mulkay, B. (2003). Financial factors and investment in Belgium, France, Germany, and the United Kingdom: a comparison using company panel data. *The Review of Economics and Statistics*, 85, 153-165.
- Bundesverband der Deutschen Industrie, & Price Waterhouse Coopers. (2006). *Verlustberücksichtigung über Grenzen hinweg*. Freiburg: Haufe.
- Caballero, R. J. (1994). Small Sample Bias and Adjustment Costs. *The Review of Economics and Statistics*, 76(1), 52-58.
- Chatelain, J.-B., Hernando, I., Generale, A., Kalckreuth, U., & Vermeulen, P. (2003). New findings on firm investment and monetary transmission in the euro area. In I. Angeloni, A. K. Kashyap, & B. Mojon, *Monetary policy transmission in the euro area*. Cambridge: Cambridge University Press.
- Chateleain, J.-B., Hernando, I., Generale, A., Kalckreuth, U., & Vermeulen, P. (2003). New findings on firm investment and monetary transmission in the euro area. *Oxford Review of Economic Policy*, 19(1), 1-11.

- Chirinko, R. S., Fazzari, S. M., & Meyer, A. P. (1999). How responsive is business capital formation to its user cost? *Journal of Public Economics*(74), 53-80.
- Cooper, M., & Knittel, M. (2006). Partial Loss Refundability. *National Tax Journal*, 59(3), 651-663.
- Cummins, J. G., Hassett, K. A., & Hubbard, R. G. (1994). A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments. *Brookings Papers on Economic Activity* 1994/2, 1-74.
- Cummins, J., Hassett, K. A., & Hubbard, R. G. (1995). Have Tax Reforms Affected Investment? In J. Poterba, *Tax Policy and the Economy, Volume 9*. Cambridge: MIT Press.
- DESTATIS. (2003). *Klassifikation der wirtschaftszweige 2003 mit Erläuterungen*. Wiesbaden: Statistisches Bundesamt.
- DESTATIS. (2006). Beschäftigte, Umsatz und Investitionen der Unternehmen und Betriebe des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden 2004. *Fachserie 4 Reihe 43*. Wiesbaden: Statistisches Bundesamt.
- DESTATIS. (2006). Kostenstruktur der Unternehmen des Verarbeitendes Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden 2004. *Fachserie 4 Reihe 4.2.1*. Wiesbaden: Statistisches Bundesamt.
- DESTATIS. (2008). *GENESIS-Tabelle: Erzeugerpreisindizes gewerblicher Produkte*. Wiesbaden: Statistisches Bundesamt.
- DESTATIS. (2009). Inlandsproduktberechnung 2008: Lange Reihen ab 1970. *Fachserie 18 Reihe 1.5*. Wiesbaden: Statistisches Bundesamt.
- Deutsche Bundesbank. (2010). Umlaufrenditen inländischer Inhaberschuldverschreibungen / Anleihen von Unternehmen (Nicht-MFIs) (Zeitreihe WU0022).
- Devereux, M. P. (1989). Tax asymmetries, the cost of capital and investment: Some evidence from United Kingdom panel data. *The Economic Journal*, 99(395), 103-112.
- Devereux, M. P., Keen, M., & Schiantarelli, F. (1994). Corporation tax asymmetries and investment: Evidence from UK panel data. *Journal of Public Economics*, 53(3), 395-418.
- Dixit, A., & Pindyck, R. (1994). *Investment under Uncertainty*. Princeton: Princeton University Press.
- Doms, M., & Dunne, T. (1998). Capital Adjustment Patterns in Manufacturing Plants. *Review of Economic Dynamics*, 1(2), 409-429.
- Dreßler, D., & Overesch, M. (2010). Investment Impact of Tax Loss Treatment: Empirical Insights from a Panel of Multinationals. *ZEW Discussion Paper No. 10-097*. Mannheim: Centre for European Economic Research (ZEW).
- Dwenger, N. (2009). *Corporate income taxation and firms' investment and financing decisions. Doctoral dissertation*. Berlin: Freie Universität Berlin.
- Dwenger, N. (2014). User cost elasticity of capital revisited. *Economica*, 81, 161-186.
- Edgerton, J. (2010). Investment incentives and corporate tax asymmetries. *Journal of Public Economics*, 94(11-12), 936-952.

- Eisner, R., & Nadiri, M. I. (1968). Investment Behavior and Neo-Classical Theory. *The Review of Economics and Statistics*, 50(3), 369-382.
- Eisner, R., & Strotz, R. (1963). Determinants of Business Investment. In Commission on Money and Credit, *Impacts of Monetary Policy*. Englewood Cliffs: Prentice Hall.
- Fazzari, S. M., Hubbard, R. G., & Petersen, B. C. (1988). Investment, Financing Decisions, and Tax Policy. *The American Economic Review*, 78(2), 200-205.
- Fazzari, S. M., Hubbard, R. G., & Petersen, B. C. (2000). Investment Cash flow Sensitivities are Useful: A Comment on Kaplan and Zingales. *Quarterly Journal of Economics*, 115(2), 695-705.
- Foley, D. K., & Sidrauski, M. (1970). Portfolio Choice, Investment, and Growth. *The American Economic Review*, 60(1), 44-63.
- Foley, D. K., & Sidrauski, M. (1971). *Monetary and Fiscal Policy in a Growing Economy*. New York City: Macmillan.
- Gendron, P. P., Anderson, G., & Minth, J. (2003). Corporation tax asymmetries and firm-level investment in Canada. *International Tax Program Paper No. 0303*. Toronto: Rotman School of Management, University of Toronto.
- Goolsbee, A. (1998). Investment Tax Incentives, Prices and the Supply of Capital Goods. *Quarterly Journal of Economics*, 113(1), 121-148.
- Goolsbee, A. (2000). The importance of measurement error in the cost of capital. *National Tax Journal*, 53(2), 215-228.
- Goolsbee, A. (2004). Taxes and the quality of capital. *Journal of Public Economics*, 88(3-4), 519-543.
- Gould, J. P. (1968). Adjustment Costs in the Theory of Investment of the Firm. *The Review of Economic Studies*, 35(1), 47-55.
- Gräß, C. (2006). Körperschaftsteuerstatistik 2001. *Wirtschaft und Statistik 1/2006* (pp. 66-70). Wiesbaden: Statistisches Bundesamt.
- Hall, R. E., & Jorgenson, D. W. (1967). Tax Policy and Investment Behavior. *The American Economic Review*, 57(3), 391-414.
- Hanlon, M. (2003). What can we infer about a firm's taxable income from its financial statements? *National Tax Journal*, 56(4), 831-863.
- Harhoff, D. (1994). R&D productivity in German manufacturing firms. *ZEW Discussion Paper No. 94-01*. Mannheim: Centre for European Economic Research (ZEW).
- Harhoff, D., & Ramb, F. (2001). Investment and Taxation in Germany - Evidence from Firm-Level Panel Data. In Deutsche Bundesbank, *Investing Today for the World of Tomorrow: Studies on the Investment Process in Europe*. Berlin and Heidelberg: Springer.
- Harvey, A. C. (1990). *The Econometric Analysis of Time Series - 2nd Edition*. Cambridge: MIT Press.
- Jorgenson, D. W. (1963). Capital Theory and Investment Behavior. *The American Economic Review*, 53(2), 247-259.

- Kaplan, S. N., & Zingales, L. (1997). Do Investment Cash Flow Sensitivities Provide Useful Measures of Financing Constraints? *The Quarterly Journal of Economics*, 112(1), 169-215.
- Kaplan, S. N., & Zingales, L. (2000). Investment Cash Flow Sensitivities are not Valid Measures of Financing Constraints. *The Quarterly Journal of Economics*, 115(2), 707-712.
- King, M. A., & Fullerton, D. (1984). *The taxation of income from capital: a comparative study of the United States, the United Kingdom, Sweden, and West Germany*. Chicago: University of Chicago Press.
- Lucas, R. E. (1967). Optimal Investment Policy and the Flexible Accelerator. *International Economic Review*, 8(1), 78-85.
- Mintz, J. M. (1988). An empirical estimate of corporate tax refundability and effective tax rates. *the Quarterly Journal of Economics*, 103(1), 225-231.
- Nickell, S. (1977). Uncertainty and Lags in the Investment Decisions of Firms. *The Review of Economic Studies*, 44(2), 249-263.
- Oestereicher, A., & Spengel, C. (2002). *Analyse handels- und steuerrechtlicher Abschreibungsregeln - anforderungen an Abschreibungsvorschriften im modernen Wirtschaftsleben, Internationaler Vergleich. Gutachten für das Bundesministerium der Finanzen*. Göttingen and Mannheim.
- Panteghini, P. M. (2001). Corporate Tax Asymmetries under Investment Irreversibility. *FinanzArchiv*, 58(3), 207-226.
- Schmalwasser, O., & Schidlowski, M. (2006). Kapitalstockrechnung in Deutschland. *Wirtschaft und Statistik* 11/2006. Wiesbaden: Statistisches Bundesamt.
- Treadway, A. B. (1969). On Rational Entrepreneurial Behaviour and the Demand for Investment. *The Review of Economic Studies*, 36(2), 227-239.
- von Kalckreuth, U. (2001). Monetary transmission in Germany: New perspectives on financial constraints and investment spending. *Economic Research Centre of the Deutsche Bundesbank, Discussion Paper No. 19/01*. Frankfurt am Main: Deutsche Bundesbank.
- Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, 126(1), 25-51.
- Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press.