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Conference Paper

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Beiträge zur Jahrestagung des Vereins für Socialpolitik 2011: Die Ordnung der Weltwirtschaft: Lektionen aus der Krise - Session: Fiscal Policy, No. G11-V4

Provided in Cooperation with:
Verein für Socialpolitik / German Economic Association

Suggested Citation: Walch, Florian; Dwenger, Nadja (2011) : Tax Losses and Firm Investment: Evidence from Tax Statistics, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2011: Die Ordnung der Weltwirtschaft: Lektionen aus der Krise - Session: Fiscal Policy, No. G11-V4, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft

This Version is available at:
https://hdl.handle.net/10419/48699

Tax Losses and Firm Investment: Evidence from Tax Statistics

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February 23, 2011

Abstract

The elasticity of business capital to changes in its user cost is central to the economic analysis of fiscal policies. As a major component, the user cost of capital includes a firm's marginal tax rate. Due to the asymmetric treatment of tax losses and profits, the marginal tax rate can depart strongly from the statutory tax rate; it thus differs across firms. Previous studies have mis-measured the firm-specific marginal tax rate because of data limitations. This leads to a systematic mis-representation of the user cost of capital and neglects an important source of variation. 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 reduces the estimated user cost elasticity of investment. Small and medium sized enterprises seem to be more responsive to tax incentives than larger firms.

Keywords: Taxation; Business investment; Tax loss; Asymmetric treatment of profits and losses; User cost of capital
JEL Classification: D22; G31; H25; H32

Acknowledgement: This paper greatly benefited from valuable discussions with Martin Simmler and from helpful comments by Viktor Steiner and seminar participants at the Free University of Berlin. We also want to thank the Research Data Centre of the Statistical Offices of the German Länder for providing data and Julia Höninger for executing countless computations. The usual disclaimer applies.

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1 Introduction

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

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, the foremost one being firms incurring losses. A tax loss can reduce a firm's marginal tax rate to zero in the year the loss is incurred and, potentially, in past and future years. Figures for the overall volume of losses in the corporate sectors of the US and Germany show that loss deduction plays a crucial role in determining firms' individual tax rates. In the US, the ratio of tax losses to net income in 2003 averaged at 0.47. For Germany, the 2004 corporate income tax (CIT) statistic indicates that roughly 60% of corporations either suffered a loss (40%) or used a tax loss carry-forward or carry-back to offset current profits (20%).

Most of the vast theoretical and empirical literature on taxes and investment has ignored the prominence of tax losses in lowering marginal tax rates but instead has assumed symmetric tax treatment of profits and losses. This approach not only neglects an important source of variation in the user cost of capital across firms but also clearly leads the approximation of firms' marginal tax rate to be upward biased; further, if the determinants of tax losses (e.g., profitability, growth opportunities) also drive a firm's decision to invest, this biases non-instrumental variable estimates. While a small literature (Devereux et al. 1994, Cummins et al. 1995, Edgerton 2010, Dreßler and Overesch 2010) has addressed the asymmetric treatment of losses, all studies are based on accounting data where true tax losses, as well as tax loss carry-forward and carry-back are unobservable. This shortcom-

ing of accounting data is usually revamped by approximating tax losses with accounting losses. However, as Auerbach and Poterba (1987) and Hanlon (2003) show the difference between tax and accounting data usually leads to an under-representation of tax losses; on average, approximated marginal tax rate and user cost of capital exceed the unobservable, true ones. In an estimation, which determines the "average" investment response on "average" user cost of capital, the systematic mis-measurement of the marginal tax rate causes the estimated user cost elasticity of capital to be biased. We expect such a regression to overestimate firms' investment response to tax incentives.

We make a twofold contribution to literature by addressing both methodological issues and the data set used. 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. Second, we use a rich data set that combines comprehensive corporate income tax return data with investment and cost structure variables, based on the full record of firms in the manufacturing sector with more than 20 employees in Germany during the period 1995-2004. This unique data set offers two advantages: broad coverage 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 instrumental variable (IV) estimation reveals that a one percent increase in the user cost of capital reduces capital by 0.6% in the long run. Our estimate represents the lower bound of results found in prior literature; we argue that this divergence reflects the neglect of the asymmetric treatment of tax losses and profits in earlier literature. Accounting for tax losses reduces the estimated user cost elasticity. Small and medium sized enterprises seem to be more responsive to tax incentives than larger firms are.

In the next 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 mis-measurement of 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. In Section 5, we present our estimation results, for manufacturers in general and differentiated along subgroups. Section 6 summarizes our main results and concludes.

2 Motivation

2.1 Prior literature

The response of long-run capital stock to its user cost is pivotal to any economic analysis of tax reforms and monetary policy. 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, an important feature of corporate income tax systems, the asymmetric tax treatment of profits and losses, has been neglected. In other words, firms have been assumed to permanently face a marginal tax rate equal to the statutory tax rate. In reality, however, a tax loss can reduce a firm's marginal tax rate to zero in the year the loss is incurred as well as, potentially, in past and future years.

Lately, the importance of tax losses, tax loss carry-forward and carry-back, and their economic implications have received more attention (Edgerton 2010, Cummins et al. 1995, Devereux et al. 1994, Auerbach and Poterba 1987). Two questions, however, have remained open that we will address in the following. First, earlier studies have to a large extent relied on accounting data such as Compustat to approximate carry-forward and carry-back provisions in the lack of firms' true tax returns.[1] As we argue in the following, this probably led the user cost of capital to be systematically mis-measured and tax responses to be overestimated in earlier literature.

Second, the financial statement data employed in most of the empirical literature on taxes and investment predominantly covers large, publicly traded firms. Empirical evidence on the investment activity of small and medium-sized entreprises (SMEs) with respect to taxes remains scarce. User cost shocks driven by changes in taxation or by tax losses might affect SMEs' behavior differently from larger firms, especially when liquidity constraints play a role.

[1] E.g., Auerbach and Poterba (1987), Devereux et al. (1994), Cummins et al. (1995), Desai and Goolsbee (2004), House and Shapiro (2008).

2.2 Surge of tax loss carry-forward

For the US, Cooper and Knittel (2006), Auerbach (2007), and Altshuler et al. (2008) observe a surge 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). Corporate losses were quite 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).

An equally pronounced and even longer lasting rise in corporate tax losses - on aggregate 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 250 bn euro to 520 bn euro (Dwenger 2008). Therewith, aggregate unused losses from the past were more than four times larger than taxable corporate profits in the economy. Manufacturing accounted for 122 bn euro in 2004, or nearly a quarter of aggregate corporate losses.

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

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**
For comparison: **Total all industries**	**295,484**	**388,160**	**520,328**

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

Source: Dwenger (2009).

In most tax systems, firms are subject to asymmetric treatment of profits and losses. While profitable enterprises immediately owe a tax liability, unprofitable firms only receive

a refund if they are able to offset their loss against past or future profits. The refund for a loss carried into the future occurs, at best, with delay. Potentially, tax losses decrease firms' marginal tax rates to zero, switching a firm from taxable to non-taxable status as will be exhibited in more detail in section 3.3. The impact of loss provisions on a firm's taxable status differs considerably across national corporate tax code regulations. Loss carry-back is, for example, granted in the US, France, Germany, UK, Ireland, Netherlands, Canada, and Japan. The carry-back volume is unlimited with the exception of Germany while carry-back periods range from 1 to 3 years. All EU countries, Canada, Japan, and the US offer schemes for loss carry-forward. However, Austria, Germany, and Poland limit its volume. Periods range from 5 years to infinity.[2]

2.3 Avoid systematic mis-measurement of the marginal tax rate

A few studies have addressed the asymmetric treatment of losses (Devereux et al. 1994, Cummins et al. 1995, Edgerton 2010, Dreßler and Overesch 2010). However, all of them are based on accounting data where true tax losses, as well as tax loss carry-forward and carry-back are unobservable. We regard the approximation of tax variables via financial statement data as insufficient. As Auerbach and Poterba (1987) and Hanlon (2003) show, the difference between tax and accounting data usually leads to a severe underrepresentation of tax losses; on average, approximated marginal tax rate and user cost of capital exceed the unobservable, true ones. Hence, the negligence of tax losses leads to a systematic upward bias of the marginal tax rate assumed and to a biased estimation of tax effects on investment.

In an early work, 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 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

[2]The presented facts are based on Bundesverband der Deutschen Industrie e.V. and PriceWaterhouseCoopers (2006) and subject to frequent legislative adaptations.

tax variables that they have constructed using accounting data; accounting data is silent about tax losses and tax loss carry-over. Estimating separate user cost coefficients for firms with and without unused loss carry-forwards, Cummins et al. (1995) find that tax incentives have an economically important effect on firms' equipment investment through the user cost of capital; tax effects are most pronounced for firms not in tax loss positions, which are more likely to face statutory tax rates and investment incentives. Neither of the two studies can rely on tax information to determine taxable status but infer taxable status from accounting data.

In a recent paper, Edgerton (2010) models firm investment decisions in a setting with tax loss carry-forwards and carry-backs. Tax incentives vary with firms' taxable status and his 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. As his study is based on Compustat accounting data, he cannot rule out "the possibility that difficulties in measuring firms' taxable status drive the relative unimportance of taxable status observed" (p. 949).

Auerbach and Poterba (1987), Hanlon (2003), and Edgerton (2010) mention a number of reasons why financial statement data may misrepresent tax loss provisions. Most importantly, firms are not required to report tax-related loss carry-forward in financial statements and hence some may choose not to. Furthermore, rules on interest deduction, consolidation, and profit distribution differ between financial statement and tax data. Finally, financial statement data sets such as Compustat usually include predominantly large firms, while tax return data also includes smaller businesses that might suffer losses more frequently although they do not necessarily result in very high carry-forward volumes. Even if these differences between tax and accounting data were random, the measurement error would attenuate estimated effects.

We contribute to this literature by, for the first-time, calculating firms' marginal tax rates on the basis of a rich record of official tax return data. Our data set contains detailed tax information for all German incorporated firms that are liable to corporate taxation. Stemming from the Corporate Income Tax Statistic, 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. The statistic shows that roughly 60% of corporations per year either suffer a loss (40%) or use a tax loss carry-forward or carry-back to offset current profits (20%). Thus, the majority of corporations does not pay any CIT and has a marginal tax rate of zero; their marginal tax rate does not equal the statutory corporate tax rates mainly employed in the literature so far. The figures presented above underline the quantitative importance of tax losses and intertemporal loss provisions. Mis-measuring the firm-specific marginal tax rate by the neglect of tax losses, loss carry-forwards, and carry-back might have largely biased the user cost of capital and estimation results in earlier studies. In the attempt to attain the "true" marginal tax rate faced by a firm, we consider both losses as well as tax loss carry-forward and carry-back provisions.

3 The Data

Estimations in this study rely on a new data set for the period 1995 to 2004 that combines - on firm level - tax data with investment and cost structure survey information in manufacturing industries.[3] Two features make the data set particularly interesting: First, the inclusion of tax return data and second, detailed information on investment (divestment) decisions for small and medium-sized firms. In the following, 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, producer price index, as well as gross and net capital stock. On the level of the economy, we use interest rates, the investment good index, and the consumer price index. References for these additional sources are given in the data appendix (A.1).

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

3.1 Corporate Income Tax Return Data

The Corporate Income Tax (CIT) Statistic contains micro data on corporate tax returns by all corporations liable to the German CIT. This means a little more than 800 000 firms in 2001 and about 860 000 in 2004. Thereof, about 114 000 corporations in both years fall upon manufacturing industries, i.e., 14% of the total of corporations. The data are constructed from all tax returns filed in a given year and are published every three years since 1992. They provide information on more than 100 items that are relevant for calculating the CIT. Information on the CIT assessed, on tax loss carry-back, as well as on tax loss carry-forwards at the beginning and end of the year is also part of the data set. Furthermore, the data set contains firm characteristics such as industry, region, and legal form.[4] Even though tax return data are also available for 1995 and 1998, we could not use these waves, because firm identifiers were deleted in waves prior to 2001. This renders the record-linkage of tax and survey data on firm-level impossible.

Tax return data offer several distinct advantages compared to accounting data. First, they provide broad coverage of the corporate sector. 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 it is "many differences between accounting rules for book and tax purposes that may lead to mis-measurement of taxable status and attenuate its importance in the results" (Edgerton 2010, p. 949) also mentioned by Auerbach and Poterba (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.[5] The survey is conducted on the plant

[4]Detailed information on the CIT statistics can be found in Gräb (2006). English-language information about these data is available at http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Navigation/Statistics/FinanzenSteuern/Steuern/Koerperschaftsteuer/Koerperschaftsteuer.psml.

[5]This corresponds to NACE classification B and C, German Industry Classification C and D (Federal Statistical Office 2003).

and firm-level, and is a full record of plants and firms employing more than 20 employees.[6] Participation in the survey is compulsory, and unit non-response is sconced. The survey disaggregates investment and divestment activities in the respective calender 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 statistic provides important insight into firms' investment decisions.

The Cost Structure Survey is a yearly survey on firm-level, which contains information on 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, interest payments 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.[7] 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 2.1 many earlier studies have assumed the individual marginal tax rate to equal the statutory rate; this led to mis-measurement of the marginal tax rate for tax-exhausted firms (Edgerton 2010). Only few studies have accounted for tax status in their calculation of the marginal tax rate and the estimation of investment equation so far (Devereux et al. 1994, Cummins et al. 1995, Edgerton 2010); results on whether tax status matters for firms' investment behaviour were inconclusive. As pointed out by Edgerton "One cannot rule out, however, the possibility that difficulties in measuring firms' taxable

[6] Cf. Federal Statistical Office (2006a) for further information on the Investment Survey *(Investitionserhebung)*. Some English-language information about the statistic is available at http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Content/Statistics/IndustrieVerarbGewerbe/Strukturdaten/Aktuell,templateId=renderPrint.psml

[7] To account for stratified sampling we include the strata variables in our regressions, see Wooldridge (2010).

status drive the relative unimportance of taxable status observed in the Compustat data" (p.949).

We contribute to this literature by, for the first-time, calculating firms' marginal tax rates on the basis of the 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 follow Edgerton (2010). Thus, the marginal tax rate equals the statutory rate except for two cases when it falls to zero: In the first case, adjusted gross income is both negative and larger in absolute value than a positive profit in the previous year. 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 the marginal tax loss. Because the firm receives no tax refund on marginal tax loss, the tax on this last euro of 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 tax loss and receives a tax refund; the tax refund for marginal tax loss in percent being equivalent to the statutory tax rate. The second case the marginal tax rate falls to zero is when adjusted gross income is positive (after deduction of allowances and loss carry-back from future years) but smaller than losses (in absolute value) carried forward from past years. The two cases for the marginal tax rate equal to zero can be summarized into one condition when writing the firm-specific marginal tax rate $\tau_{i,t}$ in a more formal way:

$$\tau_{i,t} = \begin{cases} 0, & (\widehat{AGI}_{i,t} - CF^{sim}_{i,t} - \widehat{CB}_{i,t} - A_{i,t}) < -\widehat{CB}^{p}_{i,t-1} \\ \tau^{CIT}_{t}(1+\tau^{s}_{t}), & otherwise \end{cases} \tag{1}$$

where

$\widehat{AGI}_{i,t}$ = predicted adjusted gross income of firm i in year t,
$CF^{sim}_{i,t}$ = simulated loss carry-forward of firm i from year $t-1$ to year t,
$\widehat{CB}_{i,t}$ = predicted loss carry-back of firm i from year $t+1$ to year t,
$\widehat{CB}^{p}_{i,t-1}$ = predicted potential loss carry-back of firm i from year t to year $t-1$,
$A_{i,t}$ = allowance for 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 adjusted gross income, loss carry-forward and carry-back is not available for all years.[8] We impute the missing values of $\widehat{AGI}_{i,t}$, $\widehat{CB}_{i,t}$ and $\widehat{CB}^p_{i,t-1}$ for intermediate years by regression imputation using explanatory variables from the cost structure survey. Then we calculate the intermediate values for $CF^{sim}_{i,t}$ with a mini-microsimulation. Please refer to the data appendix (Section A.1.5) for greater detail on the imputation and microsimulation. 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.

While further information on the legal provisions concerning adjusted gross income, taxable income and the corporate income tax rate can be found in Appendix A.2, we now briefly describe the development of the tax code regulations concerning loss carry-forward and carry-back in Germany. Provisions on the use of tax losses have been tightened in recent years (cf. Table A.1). Until 1998, profits could be carried back two years up to a value of 5.1 million euro. The tax loss carry-forward was unrestricted in time and volume. The use of tax loss carry-forward is not at the corporation's discretion though, because unused tax loss carry-forward must be set off in the full amount against current profits. 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 1 million euro and since 2001 it has been capped to 0.5 million euro. In 2004, the so-called "minimum taxation" was additionally introduced, restricting the use of tax loss carry-forward in volume: Only up to 1 million euro are profits fully deductible against a tax loss carry-forward; exceeding profits can be offset up to 60 percent.

This tightening in the provisions of loss carry-forward and carry-back has certainly further impeded the use of tax losses. In fact, tax statistics show that only a small fraction

[8]Information on adjusted gross income 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 known in 2001, 2002, and 2004.

of losses can be offset against profits. This implies that an important fraction of unprofitable firms remain tax-exhausted for many years or even cease to exist before they can offset their losses against profits. These figures again underline the quantitative importance of tax losses and intertemporal loss provisions. Mis-measuring the marginal tax rate by the neglect of tax losses, loss carry-forward, and carry-back might have largely biased the user cost of capital and estimation results in earlier studies.

3.4 User Cost of Capital

Building on the work by Jorgenson (1963), Hall and Jorgenson (1967), and King and Fullerton (1984), the UCC 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

$$UCC_{i,j,a,t} = \frac{P_t^I}{P_{j,t}^S} \frac{(1 - z_{a,t}) \left(r_t + \delta_{j,a,t}^e\right)}{1 - \tau_{i,t}}, \tag{2}$$

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.[9] r_t stands for 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 $UCC_{i,j,a,t}$:

$$UCC_{i,j,t} = \sum_a UCC_{i,j,a,t} \kappa_{i,t}^a, \tag{3}$$

[9] 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.

where $\kappa_{i,t}^{a}$ is the firm-specific share of asset type a in total assets.[10] The user cost of capital varies across individual firms mostly due to differences in tax status and investment activities. Additional variation over time and industries stems from changes in prices, statutory tax, interest, and economic depreciation rates.

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 because tax variables cannot be predicted in the years without cost structure information. Since the Cost Structure Survey is a stratified sample of the universe of corporations in manufacturing, this does not influence results. We control for the sample structure in our regression equations by including the strata variables (see Wooldridge (2010)). All observations that lie in either the top or bottom percentile of the investment to capital ratio or in the top or bottom percentile of the cash flow to capital ratio or both are censored. We thereby avoid large outliers of the quotient that occur when the capital stock variable in the denominator contains very small values. The resulting panel used for estimation is unbalanced and contains 67 534 observations for 27 112 corporations during 10 years.

The descriptive statistics pictured in the table reflect the specificities of the data set. The investment-to-capital ratio has a mean of 0.13 and a value of 0.071 at the median. The cash-flow-to-capital ratio amounts to 0.317 at the mean and 0.138 at the median. Both distributions are strongly skewed as usual for firm data. The capital and sales figures reflect that the data set also contains a considerable number of smaller firms. The user cost of capital variable is of similar size by mean and median as in comparable studies, but varies less as the financial structure does not contribute to the variation in the UCC.

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

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 euro)	44,000	5,642	32,200	0.998
$I_{i,t}/K_{i,t-1}$	0.130	0.071	0.126	0.980
$S_{i,t}$ (in 1000 euro)	96,700	14,600	11,600	0.998
$\Delta S_{i,t}/S_{i,t-1}$	0.030	0.017	0.117	0.966
$Cash_{i,t}/K_{i,t-1}$	0.317	0.138	0.521	0.994
$UCC_{i,t}$	0.139	0.139	0.008	0.780
$\Delta UCC_{i,t}/UCC_{i,t-1}$	0.009	0.002	0.080	0.572
Number of observations			67,534	

a Using mean-differenced variables, the within-firm standard deviation measures variation in the time dimension of the panel only.
b Following Chirinko et al. (1999), 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.
Notes: 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 euro, $\Delta S_{i,t}/S_{i,t-1}$ is firm sales growth, $Cash_{i,t}/K_{i,t-1}$ 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 Statistic, 2001 and 2004, own calculations.

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 et al. 2003b). In particular, it does not require quadratic adjustment costs.[11] The DL model has frequently been used in the literature, which facilitates the comparison of our results produced with tax data to prior estimations based on accounting data. 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-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

[11] Quadratic adjustment costs have been criticized as empirically implausible (Doms and Dunne 1998) and too strict in the context of investment under (partial) irreversibility (Dixit and Pindyck 1994).

and Nadiri 1968). Using a production function with constant elasticity of substitution (σ) between capital and labour,[12] the optimal capital stock $K^*_{i,t}$ for firm i at time t can be written as (Arrow et al. 1961)

$$K^*_{i,t} = A_i T_t {S_{i,t}}^{\beta} UCC^{-\sigma}_{i,t}, \tag{4}$$

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,[13] technology T_t, and the firm's user cost of capital UCC as defined in equations (2) and (3). In this partial analysis, the optimal capital stock is independent of the wage, such that companies are assumed to be price-takers on the labour market.[14] The parameter of interest is the long-term elasticity of capital with respect to UCC, $-\sigma$.

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 logarithmized 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.[15] Appending a stochastic error term $\varepsilon_{i,t}$, the current capital stock can be expressed as:

$$k_{i,t} = c + a_i + \sum_{h=1}^{H} \phi_h k_{i,t-h} + \sum_{h=0}^{H} \beta_h s_{i,t-h} - \sum_{h=0}^{H} \sigma_h ucc_{i,t-h} + \sum_{t=1}^{T-1} \tau d_t + \varepsilon_{i,t}. \tag{5}$$

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

[13] Beyond firm-specific relative factor shares, the parameter might capture a firm-specific price markup in monopolistic markets.

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

[15] Adjustment costs are assumed to be a function of either the rate of gross or net investment and rationalized in reference to the costs of disruption, training of workers, management problems, and the like (e.g., Eisner and Strotz 1963, 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 (e.g., Foley and Sidrauski 1970, 1971). Nickell (1977) rationalizes 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.

Furthermore, expectational variables in the data generating process imply potential problems in the estimation of short-run effects and long-term solutions. The equation cannot be identified without knowledge of the series underlying the expectation formation process, because in that case, the explanatory variables are not contemporaneously uncorrelated with the error term for the parameters of interest, and short-run and long-term effects might not be estimated consistently.

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

$$\frac{K_{i,t} - K_{i,t-1}}{K_{i,t-1}} = \frac{I_{i,t}}{K_{i,t-1}} - \delta_i. \tag{6}$$

Because firm-level data are usually right skewed and exhibit large differences in firm size, Chirinko et al. (1999) propose specifying the equation for capital with all variables as ratios or rates. Differencing equation (5) 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 (6), and including cash flow relative to the existing capital stock as a measure of liquidity (cf. Fazzari et al. 1988, 2000), Chirinko et al. (1999) attain their DL investment equation:

$$\begin{aligned} \frac{I_{i,t}}{K_{i,t-1}} = \delta_i &+ \sum_{h=0}^{H} \beta_h \Delta s_{i,t-h} - \sum_{h=0}^{H} \sigma_h \Delta ucc_{i,t-h} \\ &+ \sum_{h=0}^{H} \gamma_h \frac{Cash_{i,t-h}}{K_{i,t-h-1}} + \Delta \varepsilon_{i,t}. \end{aligned} \tag{7}$$

A significant cash flow effect in this model can indicate the presence of financing constraints on investment. However, it is well known that financial constraints are not the only possible interpretation of significant coefficients for the cash flow variables. 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 (e.g., Kaplan and Zingales 1997, 2000). In the estimation equation, the long-term user cost elasticity of capital is captured by the sum of the σs.

4.3 Estimation strategy

In a first step, we take first differences of the model equation (7) 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, Goolsbee (2000) shows that the coefficient of the user cost of capital in an OLS regression is considerably biased towards zero because of measurement error in the UCC (attenuation bias). This is especially true in our case, because we abstract from the financial structure of firms. Second, the firm-specific asset structure as well as 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, 2004). This simultaneity introduces a bias between the UCC 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 et al. 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 generalized method of moments (GMM); we report results for the heteroscedasticity-robust two-step System-GMM. This estimator uses the lagged levels of dependent and independent variables as instruments for the difference equation and the lagged difference of dependent and independent variables as instruments for the level equation (Blundell and Bond 1998).[16]

[16]We do not report results estimated with Difference-GMM (Arellano and Bond 1991) or Forward-GMM (Arellano and 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

Because standard errors in the usual two-step GMM estimator are downward biased in finite samples, we also apply the Windmeijer (2005) correction.

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.[17] We also report robust Sargan tests of overidentifying restrictions.

5 Estimation results

Our baseline results yield similar user cost elasticities as previously reported by studies on Germany. Furthermore, we show that firms with a tax loss carry-forward have a lower user cost elasticity than firms that are fully taxable. This confirms our claim that the upward bias in the firm-specific marginal tax rate in previous studies relying on accounting data leads to an overestimation of firms' response to the user cost. Additionally, we present results indicating that small firms react differently to changes in their user cost than larger firms.

5.1 Baseline results

Table 3 shows the results for the distributed lag model in the baseline specification. The results of the estimation are easily comparable with elasticities reported in prior studies. The long-term user cost elasticities in both estimations is given by the sum of σs. Standard errors for the long-term effect are calculated using the delta method. In all estimations we control for stratified sampling in the Cost Structure Survey by including the stratification variables into the regression (Wooldridge 2010).

The first column shows estimates carried out with OLS after taking first differences of

highly persistent series (Blundell and 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.

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

the estimation equation (7). The size of the user cost elasticity of -0.362 seems reasonable but small in comparison with other studies. This amplifies our concern about measurement error in the user cost variable. We suspect the OLS estimate to suffer from attenuation bias towards zero.

The results in the second column are produced using the System GMM estimator suggested by Blundell and Bond (1998). As expected, the long-term user cost elasticity increases to -0.601, giving an clear indication that the instrumentation strategy resolves the attenuation bias. As instruments we used at least twice-lagged values of the explanatory variables, which allows for contemporaneous correlation between them and shocks to the investment equation, as well as correlation with unobserved firm-specific effects.

Estimates found in the DL-model by Dwenger (2009), Chatelain et al. (2003a), Chatelain et al. (2003b), von Kalckreuth (2001), and Harhoff and Ramb (2001) range between -0.66 and -0.40. Surprisingly, our preferred estimate for the UCE of -0.601 is similar to what was found for Germany in these earlier studies – even though they 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 infer firm-specific marginal tax rates. We argue that this happens because our estimation of the average user cost elasticity confounds two effects operating in opposite directions: 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 and hence decreases the estimated coefficient. On the other hand, including small and medium-sized enterprises in the estimation raises the elasticity estimate, as anecdotal evidence suggests that SMEs are more responsive to tax incentives (Coyne 1995, Chen et al. 2002). The following section thus aims at disentangling both effects, the universal influence of tax loss treatment on investment and the implications of including SMEs in the analysis.

5.2 Tax loss carry-forward and user cost elasticity

In order to further investigate the effects of a tax loss carry-forward on the user cost elasticity of capital, we repeat our preferred specification (column two) but split our sample. We mark all firm-year observations containing a tax loss carry-forward greater than zero with an indicator and estimate the model separately for both groups. Tax losses carried

Table 3: Estimates for the distributed lag model

$I_{i,t}/K_{i,t-1}$	**OLS FD**		**System GMM**	
$\Delta ucc_{i,t}$				
σ_0	-0.163^{**}	(0.028)	-0.271^{**}	(0.125)
σ_1	-0.115^{***}	(0.027)	-0.153^{***}	(0.051)
σ_2	-0.061^{**}	(0.025)	-0.113^{**}	(0.048)
σ_3	-0.023	(0.024)	-0.026	(0.032)
σ_4			-0.041	(0.032)
SUM(σ)	**-0.362**		**-0.601**	
$\Delta s_{i,t}$				
β_0	0.027^{**}	(0.012)	0.045	(0.072)
β_1	0.039^{***}	(0.013)	0.076^{***}	(0.026)
β_2	0.027^{*}	(0.014)	0.052^{**}	(0.025)
β_3	0.010	(0.012)	0.007	(0.018)
SUM(β)	**0.103**		**0.177**	
Number of firms	3,886		3,886	
Number of observations	7,678		7,678	
Sargan[a]	-		0.312	
Arellano-Bond order 1[a]	-		0.009	
Arellano-Bond order 2[a]	-		-	

a p-value
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 Statistic, 2001 and 2004, own calculations.

forward are measured at the start of our observation period in order to avoid the potential endogeneity of changes in investment and tax losses in the observation period.

Unfortunately, we cannot report the results of this regression because they were not yet cleared by the statistical authorities at the time of submission. The Research Data Centres of the Statistical Offices are required to inspect all our analyses for infringements of data protection and tax confidentiality, which is the downside of our valuable data set. We expect the UCE for firms with loss carry-forward to be lower than for firms without it.

Furthermore, we enquire the effect of firm size on the UCE in another sample split. Given the relatively small size of our data set, we simply differentiate between "small" and "large" corporation size defined by the median of sales. In a robustness check we also split the sample according to number of employees.

We cannot report any results at this point for the reasons mentioned above. We anticipate that the regression for the firms below the median size of companies, representing small and medium enterprises, should yield larger elasticities of investment with respect to changes in user cost of capital.

6 Conclusion

When analysing the effects of tax incentives on firms' 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. This procedure does not only ignore an important source of variation in the user cost of capital but also causes previous estimates of firm's marginal tax rate to be upward biased. Only a very limited number of studies has addressed the asymmetric treatment of losses and the relevance of loss carry-forward and carry-back. However, even this advanced literature relies on financial statement data where tax losses, tax loss carry-forward and carry-back are not reported precisely, if at all.

We have provided evidence that the approximation of tax variables via financial statement data under-represents the volume of tax losses as well as carry-forward and carry-back. We claim that studies ignoring the true and lower size of the marginal tax rate overestimate firms' response to tax incentives. Our preferred baseline estimate for the elasticity of capital with respect to its user cost yields -0.6, which is at the lower end but within the range of results previously reported for Germany. We claim that this occurs because our estimation of the average user cost elasticity confounds two effects operating in opposite directions: Taking into account tax losses should decreases the estimated coefficient, while including small and medium-sized enterprises in the estimation should raise the elasticity estimate. Consequently, we have implemented a sample split in order to estimate separate user cost elasticities for firms with and without tax loss carry-forward. We expect the estimates for firms without carry-forward to be smaller in absolute value in comparison to fully taxable firms. These results provide evidence that the effectiveness of tax incentives to spur investment in times of economic distress could fall short of widely shared expectations.

From a methodological perspective, we have shown that the estimation approaches aiming to determine the "average" investment response on "average" user cost of capital

changes are not always sensible. When economic agents under scrutiny find themselves in fundamentally different regimes, such as taxable versus non-taxable, an average effect cannot sufficiently reflect the heterogeneity of effects on the agent level. Hence, average effects provide a rather unreliable reference point for decisions in the policy world.

A Appendix

A.1 Data

This appendix describes the calculation of the principle variables and data sources used.

A.1.1 Investment and divestment

Nominal gross investment is given in the Investment Survey; it is defined as acquired or produced fixed tangible asset whose lifetime exceeds one year and which is usually activated in the firm's balance sheet (Federal Statistical Office 2006a). In the statistical source, nominal gross investment $I^{(n)}_{p,i,a,t}$ (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, $I^{(n)}_{i,a,t} = \sum_p I^{(n)}_{p,i,a,t}$. 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 $J^{(n)}_{p,i,a,t}$ 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 ($J^{(n)}_{i,t,a} = \sum_p J^{(n)}_{p,i,a,t}$), divestment of structures is approximated as

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

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

$$J^{(n)}_{i,t,fixedassets} = J^{(n)}_{i,t} - J^{(n)}_{i,t,land} - J^{(n)}_{i,t,structures}.$$

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.

A.1.2 Sales

Nominal sales $S^{(n)}_{i,t}$ 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 (Federal Statistical Office 2006b). We derive real sales $S_{i,t}$ by deflating nominal sales with the industry-specific producer price index on NACE four-digit level.

A.1.3 Cash flow

Nominal cash flow $Cash_{i,t}^{(n)}$ can be retrieved as sum of several variables in the Cost Structure Survey (Federal Statistical Office 2006b):

	Total sales $S_{i,t}^{(n)}$ (EF40)
-	costs without costs for material/traded goods of firm i at time t (EF78)
-	materials consumption of firm i at time t (EF53, EF59)
+	total depreciation of firm i at time t (EF74)
+	subsidies to firm i at time t (EF80)
=	$Cash_{i,t}^{(n)}$

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 a base.

A.1.4 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 paper, a simplified formula adapted from Harhoff (1994) is used that builds on the variables previously described. We use investment series in constant prices (real values) which facilitates the calculation of the replacement value of capital stock in a given year:

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

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 divestment of asset a by firm i during year t, and
$\delta_{j,a,t}$ = economic depreciation rate of asset type a in industry j in year t.

The capital stock is computed separately for land, structures, and fixed assets. The streams of investment $I_{i,a,t}$ and divestment $J_{i,a,t}$ are taken from the Investment Survey for the years 1995 through 2004. The critical assumption of the PIM is the initial value of capital stock in the first year a firm is observed, usually 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:

$$K_{i,j,t,a} = K_{j,a,t} \cdot \frac{I_{i,j,a,t}}{\sum_i I_{i,j,a,t}}$$

where $t = 1995, ..., 2004$,

$K_{i,j,a,t}$ = real capital stock of asset a of firm i in industry j at the beginning of year t,
$K_{j,a,t}$ = $\sum_i K^{(r)}_{i,j,a,t}$, aggregate real capital stock of asset a of industry j at the beginning of year t, and
$I_{i,a,t}$ = real gross investment of asset a by firm i in industry j 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 (Federal Statistical Office 2009a). 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 for our approach: 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, $K_{i,t} = \sum_a K_{i,a,t}$.

A.1.5 Firm-specific marginal tax rate

The marginal tax rate $\tau_{i,t}$ for firm i in year t takes into account the statutory corporate income tax 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 statistic is 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 "adjusted gross income" (AGI, *Gesamtbetrag der Einkünfte*) is missing for years 1995-2001 and 2002-2003. The volume of loss carry-bank 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 AGI for years without tax information, we regress the observed values in 2001 and 2004 on variables from the Cost Structure Survey. The specification with the best explanatory power yields a R^2 of 64.2%; estimated coefficients are used to predict the values for $\widehat{AGI}_{i,t}$ in the tax missing years.

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

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, # owner managers, # employees, and
$D_{i,(t)}$ = legal form, industry, 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.

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

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:

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

where

$CF_{i,t}^{sim}$ = simulated stock of losses carried forward of firm i in the beginning of year t,
$\widehat{AGI}_{i,t}$ = predicted gross adjusted income of firm i in year t,
$\widehat{CB}_{i,t}$ = predicted loss carry-back of firm i from year $t+1$ to year t, and
$A_{i,t}$ = allowance for 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 over 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 adjusted gross income and adjust 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 obtain values for adjusted gross income ($\widehat{AGI}_{i,t}$) and loss provisions ($\widehat{CB}_{i,t}$, $CF^{sim}_{i,t}$) for all years, we calculate taxable income for each firm. Appendix A.2.1 provides an overview of the legal definition of taxable income. We also take into account allowances $A_{i,t}$ according to §24 and §25 German CIT Code. Finally, we assign the firm-specific marginal tax rate according to Equation 2.1 in Section 3.3 of the paper. For comparison, statutory tax rates are presented in appendix A.2.3.

A.1.6 Price indices

The yearly producer price index *(Erzeugerpreisindex)* $P^S_{j,t}$ 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 (Federal Statistical Office 2008). Some English-language information on the the producer price index for industrial products is available at: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/press/abisz/Erzeugerpreise_e,templateId=renderPrint.psml.

The investment good price index *(Investitionsgüterpreisindex)* P^I_t 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.

A.1.7 Economic depreciation

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

$$\delta^e_{j,a,t} = \frac{depreciation_{j,a,t}}{K_{j,a,t}},$$

where $depreciation_{j,a,t}$ 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 the national accounts (Federal Statistical Office 2009b).

A.1.8 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 Germany, introduced after reunification,[18] 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 $33^1/_3$ 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 percent (Oestereicher and Spengel 2002). Hence we scaled the average lifetime accordingly (1998 to 2000: 13 years, 2001 to 2008: 16.9 years).

[18] See *Fördergebietsgesetz*

A.1.9 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 (Deutsche Bundesbank 2010). We calculate annual averages of the monthly figures provided by the Central Bank for the years 1995 to 2004.

A.2 Tax code provisions

A.2.1 Derivation of taxable income

	Turnover
-	Deductions such as interest payments and depreciation allowances
+/-	(...)
=	***Profit as shown in tax balance sheet***
+/-	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
=	***Total Revenue***
-	Allowable deductions for agriculture and forestry
-	Deductible donations and contributions
+/-	Income generated by fiscal subsidiaries
=	***Adjusted Gross Income (AGI, Gesamtbetrag der Einkünfte)***
-	Loss carry-forward and loss carry-back
=	***Net Income, Einkommen***
-	Allowable deductions for non-incorporated firms and for commercial cooperatives
=	***Taxable Income (TI, zu versteuerndes Einkommen)***
×	Statutory tax rate
-	Tax credits for foreign-source income
=	***Corporate income Tax Assessed (TA, festzusetzende Körperschaftsteuer)***

Source: Own presentation.

A.2.2 Provisions on loss carry-forward and carry-back

In parallel to the tightening-up of loss carry-back and carry-forward, tax authorities have also restricted the use of losses acquired with the purchase of a corporate shell. Until 1996, losses could be still used if less than 75 percent of shares were transmitted and if the company has not ceased business operations (§8 (4) German Corporate Income Tax Law 1996). From 1997 to 2007 the threshold was reduced to 50 percent; additionally, a tax loss carry-forward could only be used if the company continually ran business operations with the same working capital (§8 (4) German Corporate Income Tax Law 1997). Since

Table A.1: Rules for the inter-year use of tax losses since 1984

	Volume (upper limit)	Time
Tax loss carry-back		
1984 - 1998	5.1 million euro (10 million DM)	2 years
1999 / 2000	1 million euro (2 million DM)	1 year
Since 2001	0.5 million euro (1 million DM)	1 year
Tax loss carry-forward		
1984 - 2003	unlimited	unlimited
Since 2004	1 million euro + 60% of the profit exceeding this threshold	unlimited

Sources: Own depiction. §8(1) German Corporate Income Tax Law in conjunction with §10d Income Tax Law for the years 1984 to 2004.

2008 tax losses perish on a *pro rata* basis if more than 25 percent of shares are transmitted within five years; tax losses are completely lost if more than 50 percent of shares change hands (§8c German Corporate Income Tax Law). Through 2005, tax losses carried over in mergers and spin-offs if business operations continued for at least five years (§12 (3) 2nd sentence German Tax Reorganization Law 2004). Nowadays, mergers and spin-offs are put on a par with the purchase of a corporate shell, i.e., tax losses cannot be (fully) transmitted if more than (25 percent) 50 percent of the corporation are transferred.

A.2.3 Statutory corporate tax rates

Table A.2: Statutory corporate tax rates 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%

Sources: Own presentation, corporate income tax law, 1987 to 2008, solidarity surcharge law, 1991 to 2008.

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