Business taxation
and its factor market distortions

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List of selected abbreviations

2SLS	Two-stage least squares
ABS	Asset-backed security
CB	(Loss) carry-back
CF	(Loss) carry-forward
CIT	Corporate income tax
DL	Distributed lag
ECB	European Central Bank
FD	First differences
FDZ	Forschungsdatenzentrum (Research Data Centre)
FE	Fixed effects
FTT	Financial transaction tax
GMM	Generalised method of moments
IMF	International Monetary Fund
ISIN	International securities identification number
IV	Instrumental variable
NACE	*Nomenclature statistique des acitivités économiques* (Statistical Slassification of Economic activities in the European Community)
NPBL	Net profit before loss carry-over
OLS	Ordinary least squares
PIM	Perpetual inventory method
OTC	Over-the counter
UCC	User cost of capital

Chapter 1:
GENERAL INTRODUCTION

1.1. Motivation and research objective

Direct taxation of businesses generates sizeable income streams for governments' budgets despite a general tendency of declining corporate tax revenues. In the United States, the corporate income tax accounted for 9.9% of total receipts at federal level and for 1.3% of gross domestic product (GDP) in the fiscal year of 2012[1]. In Germany, the corporate income tax and the federal share in the business tax stood at 3.3 % of total federal receipts at the federal level and at 0.4% of GDP[2]. Besides profit taxation, businesses are sometimes also taxed for their use of production factors through payroll or capital taxation. All in all, business taxation is an important source of public revenues.

In addition to fulfilling a revenue objective, taxation of businesses is also believed to contribute to society's equality. On average, individuals at the top of the income distribution earn a larger share of their income from business activity and capital income (Bach, Corneo, & Steiner, 2009) and are hence held to bear the main burden of business taxation. This popular wisdom has repeatedly become apparent in public outcries about tax avoidance strategies of international corporations[3]. More recently, expectations have been raised that even indirect business taxation can contribute to societal equity or limit excessive business activity. One example is the discussion of a possible financial transaction tax in the European Union. However, economic literature finds that it is difficult to make general statements about which parts of society and which production factors bear the burden of business taxation. Minor details in the design of a specific tax can fundamentally influence its incidence. Contrary to the popular wisdom mentioned above, the burden of business taxation may in some settings even mostly be borne by labour rather than capital owners. Hence, each tax must be analysed individually in order to obtain robust results that can serve as advice to policy makers.

1 See Budget Results for Fiscal Year 2012 under http://www.treasury.gov/press-center/press-releases/Pages/tg1734.aspx
2 See *Haushaltsrechnung des Bundes für das Haushaltsjahr 2012* under http://www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Oeffentliche_Finanzen/Bundeshaushalt/Haushalts_und_Vermoegensrechnungen_des_Bundes/2013-06-13-haushaltsrechnung-des-bundes-2012.pdf
3 See, for example, Rigby (2013), Waters (2013), Neville and Malik (2012) or Lindner (2011) as well as the controversy around "Lux-Leaks".

In this regard, this dissertation seeks to show empirically how the specific design of a business tax causes particular factor market distortions and how such distortions determine the incidence of that tax on the various production factors. For this, three different applications with three very different results are analysed empirically in chapters 2 to 4. The concrete contributions of this dissertation and the individual chapters are summarised in section 1.3 just below.

1.2. Literature

In economic research, the view that taxation of businesses is paid for by capital owners has prominent support, in particular in the field of corporate income taxation. Most notably, Arnold C. Harberger stated in what is regarded as the founding article of the corporate tax incidence literature that "it is hard to avoid the conclusion that plausible alternative sets of assumptions about the relevant elasticities [of substitution between production factors] all yield results in which capital bears very close to 100% of the tax burden" (Harberger, 1962, S. 234). Harberger derived his findings from a general-equilibrium model inspired by the field of international trade and by researchers such as Heckscher, Ohlin, Stolper, Samuelson, Metzler or Meade. The model assumes an economy with two competitive sectors, the corporate and the non-corporate sector, in which both sectors have the same two production factors. Incidence of the corporate income tax in the model is analysed through the changes in factor and product prices in both industries. Most importantly, Harberger finds that all capital – not just capital in the corporate sector – bears the burden of the tax and that the allocation of capital is distorted towards the untaxed non-corporate sector.

Harberger's findings sparked the emergence of a new field of literature that thoroughly examined his results and their sensitivity to the underlying assumptions. The literature is summarised, for example, in a review of tax incidence in general (Fullteron & Metcalf, 2002) and of corporate tax incidence specifically (Auerbach, 2005). In particular, the assumptions about mobility or immobility of production factors across borders are crucial as Harberger himself shows in a variant of this study (Harberger, 1995).

Many studies in the field and adjacent literature share the result that the distortions in factor markets caused by business taxation determine the distribution of incidence. The variety of findings concerning incidence is hence driven by the variety of different factor market distortions. In theoretical studies, results are driven by assumptions on the factor markets. In empirical studies, the results are driven by the actual design of the tax under analysis and its rules regarding tax base, tax rate, profit allocation to local subsidiaries, market size, available substitutes, etc. In this regard, it should be noted that the variety of taxes on businesses in the real world is much broader than the simple national corporate income tax in Harberger's seminal paper. In many cases, the definition of the tax base goes beyond taxation of capital income and also includes elements such as payroll or even turnover. Alternatively, the tax base sometimes includes capital income only but then profits are allocated to sub-national jurisdictions via apportionment formulas that make use of turnover or factor variables.

1.3. Contribution

Each of the three chapters of this dissertation is devoted to one empirical application. However, all chapters have three elements in common. First, they all analyse taxes that have recently been at the centre of the policy debate in Europe. Second, all chapters rely on micro data at firm or community level. Third, they employ micro-econometric methodology that allows to control for unobserved heterogeneity or to simulate firm and asset heterogeneity. Chapter 2 estimates the effect of a change in the user cost of capital on firms' investment. Chapter 3 assesses the impact of changes in transaction costs in financial markets on the value of collateral pledged to the Eurosystem by financial institutions. Chapter 4 is devoted to the effects of municipal business taxation on the local level of employment. Finally, chapter 5 summarises the results and outlines possible areas of further research work as well as policy conclusion.

Chapter 2 – which is based on joint work with Nadja Dwenger[4] – explores factor market distortions in the capital market related to corporate income taxation in Germany. More specifically, it assesses how a change in the corporate income tax rate, modelled as variation in the user cost of capital of firms, influences the investment activity of the corporate sector. 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 it incurs the loss and, potentially, in future years. So far, most of the literature on taxes and investment has ignored the prominence of tax losses in lowering marginal tax rates or has approximated tax losses through accounting data. This approach not only neglects an important source of variation in the user cost of capital across firms but also leads to mismeasurement of firms' marginal tax rate. The chapter addresses those shortcomings in a twofold manner. First, the chapter measures 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, it employs a so far unique data set that is used to construct a marginal tax rate, which differs from the statutory tax rate and varies

[4] This chapter is based on joint work with Nadja Dwenger (Dwenger & Walch, mimeo).

across firms and over time. The estimation relies on a distributed lag model and uses the heteroscedasticity-robust two-step system general method of moments (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. The preferred estimation reveals that a one per cent increase in the user cost of capital reduces investment by 0.52% in the long run. Just like other studies this finding confirms that the neglect of measurement problems in the user cost variable attenuates the estimated coefficients.

Chapter 3 – which is based on joint work with Rudolf Alvise Lennkh[5] – looks at capital markets again and focusses on distortions caused by an indirect tax on financial transactions that changes the transaction costs of selling or buying a financial instrument. The empirical setting is a financial transaction tax that has recently been proposed by the European Commission. The fundamental question is how such a tax on the sale or purchase of a financial instrument may affect the value of assets. Specifically, the focus lies on assets that financial institutions pledge as collateral to the Eurosystem when they access central bank credit operations. A change in the transaction costs for financial instruments can affect the collateral value through various channels, most importantly asset prices but also liquidity and credit risk considerations. As the collateral submitted to the Eurosystem is re-valued based on market prices on every business day, a change in market prices immediately affects the overall value of a counterparty's collateral pool and hence its ability to access monetary policy operations. In particular, the chapter analyses how assets will be affected heterogeneously by the tax, depending on their turnover, maturity, coupon definition and other characteristics. As a consequence, Eurosystem counterparties will also be affected heterogeneously, conditional on the composition of their collateral pool. For the analysis, the chapter develops a microsimulation model of the Eurosystem collateral framework on an asset-by-asset basis in order to capture heterogeneous effects due to composition effects and asset as well as counterparty characteristics. The analysis develops a set of scenarios for possible asset price changes and their respective effect on the value of the collateral submitted to the Eurosystem.

Chapter 4 shifts the focus to tax-induced distortions in labour markets and examines the relationship between municipal taxation of businesses and the local level of employment in Germany. In a number of countries such as the US or Switzerland sub-national entities have the legal competence to levy a tax on businesses that are located in their jurisdiction. In such an environment, jurisdictions intensively compete for enterprises when setting their rate of business taxation. As a consequence, sub-national taxation of business profits causes various externalities and a potential relocation of production factors between jurisdictions. However,

[5] This chapter is based on joint work with Rudolf Alvise Lennkh (Lennkh & Walch, 2015).

only few studies analyse labour incidence of business taxation at the state level and even fewer at the municipal level. This is surprising given that taxation at sub-federal level follows its own economic theories, may cause a considerable tax-burden and offers a promising research ground. Based on the theoretical work by McLure (1977), this chapter makes two contributions: First, it estimates the effect of a change in the local business tax rate on the total level of employment in a municipal district. In this context, employment is defined as the number of persons employed by all firms that are based in the respective municipal district. Second, it expands on previous studies of local employment effects which have relied on ordinary least squares estimations by using instrumental variable estimation. The local business tax rate is instrumented with the lagged average tax rate of the most probable competitors. For small municipalities these are neighbouring jurisdictions. For larger municipalities, non-neighbouring jurisdictions of the same size within the same state or elsewhere in the nation are taken as the competitors. The results show that an increase in the local business tax rate affects the local level of employment negatively. This finding is significant and robust across a number of different specifications, in which the local tax rate is instrumented. The preferred estimate yields that a 1%-increase in the local business tax rate entails a 1.3%-decrease in the level of local employment. As many fiscal transfers in federal nation states are linked to population size there are reasons to believe that an increase in the local business tax rate may have a negative feedback effect on the local budget. These results confirm that municipal business taxation entails a number of distortions of high scientific and practical relevance.

Chapter 2:

TAX LOSSES AND FIRM INVESTMENT: EVIDENCE FROM TAX STATISTICS[1]

2.1. 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 a mismeasurement of firms' marginal tax rates. While a small literature (Devereux, 1989; Devereux, Keen, & Schiantarelli, 1994; Cummins, Hassett, & Hubbard, 1995; Edgerton, 2010; Dreßler & Overesch, 2010; Dwenger N. , 2009) has addressed the asymmetric treatment of losses, all

1 This chapter is based on joint work with Nadja Dwenger (Dwenger & Walch, mimeo).

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 stock variables, 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 one per cent increase in the user cost of capital reduces investment 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 confirms 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 2.3 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. Then, the theoretical modelling and our estimation methodology are briefly introduced. In section 2.5 we present our estimation results and section 2.6 summarises our main results and draws conclusions.

2.2. Motivation

2.2.1. Facts on corporate tax losses

2.2.1.1. 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 below the statutory tax rate.[2]

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-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.[3]

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

[2] 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).

[3] The presented facts are based on Bundesverband der Deutschen Industrie and PriceWaterhouse Coopers (2006) and subject to frequent legislative adaptations.

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**
For comparison: **Total all industries**	**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 as in 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, 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.[4]

2.2.2. 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. 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 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

[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.

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 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.

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[5] Devereux (1994) use statutory tax rates as instruments.

[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.

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; 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 2.2.3 we argue that this might not be the end of the story, as persistent measurement error in tax losses and hence the user cost of capital invalidate the use of its lags 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.

2.2.3. 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 reduction in effective marginal tax rate and user cost of capital due to unused losses from the past 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, the bias it implies, 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 probably not 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, that we briefly reviewed in section 2.2.2, the data set used in this study allows us to observe and take into account tax loss carry-forward avoiding persistent mismeasurement.

2.2.3.1. 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[8]. Then, the measurement error in the population is

$$e = UCC^* - UCC \,, \tag{1}$$

which can be positive, zero, or negative.[9] 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 observed user cost of capital 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 the lagged user cost of capital and the measurement error. If tax losses are transitory events and if hence no stock of tax loss carry-forward accumulates, 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. That means that past user costs of capital are uncorrelated with measurement error in the current user cost of capital. By contrast, if tax losses are persistent and a stock of tax loss carry-forward accumulates, 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. The definition of the firm-specific marginal tax rate including possible tax loss carry-overs will be given in section 2.3.3, the resulting definition of the firm-specific UCC in section 2.3.4.

2.2.3.2. Persistence in tax loss carry-forward

Empirical data confirms that large stocks of loss carry-forward exist, making loss deduction a highly persistent phenomenon. Closer inspection of the German Corporate Income Tax

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[8] The precise UCC definition used in this study is given in section 2.3.4.

[9] 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.

Statistics reveals that the stock of losses carried forward exceeds the flow of aggregated profits (before loss offset) by factor 2.33 in 1998, 3.35 in 2001, and 4.68 in 2004.[10] 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. However, what really matters are not aggregates but the persistence of firm-specific variables as aggregate figures do 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 simultaneously incur large losses that would enter their carry-forward. The amount of profits offset against tax loss 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.

Auerbach (1987) present further evidence against composition effects. While their results rely on U.S. data there is no reason to believe that firms' tax losses should be more volatile (i.e. less persistent) in Germany than in the U.S. but given the flexibility of structures in the U.S. economy rather the opposite. They estimate transition probabilities between the states of "loss carry-forward" and "no loss carry-forward" in a simple Markov model. They find 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.[11]

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 stemming from the tax variable persists to be correlated with the error term. The measurement error in the user cost variable originating from the tax 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.

For completeness, it needs to be mentioned that there are also other reasons for measurement error in the user cost variable than the tax variable. First, it could be argued that the user costs of a given period will only be reduced by the use of tax loss carry-forward to the extent that this results in an interest rate or tax gain as the carry-forward will not be

[10] Calculations are based on Dwenger (2009).

[11] 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.

available any longer in the future. The true user costs would hence have to include the opportunity cost of running down the stock of loss carry-forward and hence be lower. Second, the financing cost of a company may not be measured correctly by the user cost variable because it does not appropriately reflect the funding structure of the company at the margin. However, the use of weighted averages also suffers from disadvantages as a comparison of financial costs or the UCC over time (or across countries) may be blurred, since changes in taxation interact with changes in firms' financial structure (Weichenrieder, 2008). We follow the approach of simplifying firm- or industry-specific weighted averages to the overall cost of debt finance. Dwenger (2009) sees results unchanged in a robustness check comparing both approaches. Third, the use of industry-averages for UCC components such as price deflators, price indices and depreciation rates could cause additional measurement error. In order to overcome the various sources of measurement error, we rely on instrumental variable estimation which results in consistent and unbiased estimates.

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 to 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 does 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. The figures presented above underline the quantitative importance of tax losses and intertemporal loss carry-overs. Mismeasuring the firm-specific marginal tax rate by the neglect of tax losses, loss carry-forwards, and carry-backs 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. Thereby, we also expect to increase the efficiency of user cost elasticity estimates.

2.3. Data

Estimations in this study rely on a new data set stretching over the period 1995 to 2004 which combines – on firm level – tax data with investment and cost structure survey information from manufacturing industries.[12] Two features make the data set particularly interesting: First, the inclusion of tax return data that provides detailed information on tax

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

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 at firm level[13] 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. On level of the economy, we use interest rates, the investment price goods index, and the consumer price index. References for these additional sources are given in the data appendix (section 2.7.2).

2.3.1. Corporate income tax return data

The corporate income tax (CIT) statistics contain firm-level 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.[14] Even though tax return data are 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.

Tax return data offer several distinct advantages compared to accounting data. First, they 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).

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13 The unit of observation leaves the firm level in cases where the corporate tax statistic reports at a higher level of aggregation ("Organschaft").

14 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/Finanzen/Steuern/Koerperschaftsteuer/Koerperschaftsteuer.psml.

2.3.2. Investment and Cost Structure Surveys

The Investment Survey is a yearly survey on investment and divestment decisions in the mining, quarrying, and manufacturing industries.[15] The survey is conducted both at the plant and firm level and is a full record of plants and firms employing more than 20 employees.[16] 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, 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.[17] 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.

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

As discussed in section 2.2.2 only few studies have accounted for tax status[18] 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 the literature about the effects of taxes on investment by, for the first-time, calculating firms' marginal tax rates on the basis of a full record of official CIT return data. In this, we build on Dwenger and Steiner (2014). In the definition of the marginal tax

15 This corresponds to NACE classification B and C, German Industry Classification C and D (DESTATIS, 2003).
16 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.psml
17 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.
18 Tax status is a binary concept describing whether a firm has taxable profits. A taxable firm has positive taxable profits and its marginal tax rate equals the statutory rate. A non-taxable firm has zero taxable profits and its marginal tax rate is zero. See also equation (2).

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.[19] 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.

According to the reasoning of this chapter, the marginal tax rate in these two cases 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 they will ever be able to use their entire loss carry-forward. Either a firm never resumes a taxpaying position[20] 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

[19] A stylised calculation of NPBL and taxable income is provided in the appendix (section 2.7.1).

[20] 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).

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.[21]

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:

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

where

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

$CF_{i,t}^{sim}$ = stock of losses carried 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 2.3.1), information on net profit before loss carry-over, loss carry-forward and carry-back is not available for all years.[22] 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[23]. 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.

[21] 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. 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 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 EUR 1 million are profits fully deductible against a tax loss carry-forward; exceeding profits can be offset up to 60%.

[22] 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 known in 2001, 2002, and 2004.

[23] Please refer to the data appendix (section 2.7.2) for greater detail on the imputation and microsimulation.

2.3.4. 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

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

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.[24] r_t equals the financial cost of the investment project[25] 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 $UCC_{i,j,a,t}$:

$$UCC_{i,j,a,t} = \sum_a UCC_{i,j,a,t} \kappa_{i,t}^a, \tag{4}$$

where $\kappa_{i,t}^a$ is the firm-specific share of asset type a in total assets.[26] 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.

The above rests on the assumption that investment decisions are made at the level of the firm where the user cost is observed. In reality, investment decisions are regularly taken at company level, i.e. at a level encompassing several firms. In that case, investment decisions observed in the data of this study will also reflect company-wide considerations based on information that is not observed in this data set. For example, a company may decide to

[24] 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.
[25] We abstract from distinguishing debt and equity-financed financial cost as we have no empirical information about the financing structure of the companies in our sample.
[26] Of course, these asset shares are prone to endogeneity; endogeneity should be purged from our regression as we run an instrumental variable regression.

invest at firm level although the rate of return of a project is below the user cost of capital of that firm. This could still be rational because sufficient profits are generated elsewhere in the company. However, this does not call in doubt the results of our study. What matters is the question how the *change* of the user cost affects investment decisions. There is no reason to believe that company-wide investment decisions do not react to firm-specific changes in the user cost.

2.3.5. 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. 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.

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. 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.

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
$I_{i,t}/K_{it-1}$	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.

2.4. Model 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.[27] The DL model has frequently been used in the literature, which facilitates the comparison of our results derived from tax data, including 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 (System-GMM) techniques.

[27] 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).

2.4.1. 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,[28] 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 $\beta = \sigma + \frac{1-\sigma}{\nu}$.

Under the assumption that a firm is constrained on product markets, 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 are assumed to be price-takers on perfectly competitive product and factor markets following Dwenger (2009).[29] 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.[30] Following Dwenger (2009) the current capital stock can be expressed as follows by appending a stochastic error term $\varepsilon_{i,t}$:

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

[29] 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.

[30] 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.

$$k_{i,t} = c + a_i + \sum_{h=1}^{H} \phi_h k_{i,t-h} + \sum_{h=0}^{H} \beta_h s_{i,t-h} - \sum_{h=0}^{H} \sigma_h ucc_{i,t-h} + \sum_{t=1}^{T-1} \tau d_t' + u_{i,t}. \quad (6)$$

2.4.2. 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

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

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), we attain the following DL investment equation:

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

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_hs. Equation (8) is also the basis for the analysis by Dwenger (2009).

2.4.3. 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. 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, 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 goods, a reduction in tax rates spurs investment demand and drives up capital good 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).[31] 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 $\varepsilon_{i,t}$ and if choosing the appropriate lag structure, the GMM estimator provides 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.[32] We also report Sargan tests of overidentifying restrictions.

2.5. 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 also including 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

31 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.

32 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.

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 relying on accounting data or ignoring the asymmetric treatment of losses altogether.

2.5.1. 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 σs.[33] As a benchmark, the first column shows estimates carried out with OLS after taking first differences of the estimation equation (23). 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 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 literature.

The results in the second column are produced using the System-GMM estimator. 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 order 2 fails to reject the absence of higher-order serial correlation and indicates that the GMM estimates are consistent.

[33] Standard errors for the long-term effect are calculated using the delta method.

Table 3: Estimates for the DL model

$I_{i,t}/K_{i,t}$	(1) OLS FD	(2) System-GMM	(3) System-GMM
$\boldsymbol{\Delta ucc_{i,t}}$			
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 ($\boldsymbol{\sigma}$)	**−0.427*** (0.074)**	**−0.521** (0.208)**	**−0.495** (0.204)**
$\boldsymbol{\Delta s_{i,t}}$			
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 ($\boldsymbol{\beta}$)	**0.116*** (0.039)**	**0.279*** (0.078)**	**0.248*** (0.077)**
$\boldsymbol{C_{i,t}/K_{i,t-1}}$			
γ_0			0.040** (0.018)
γ_1			0.001 (0.010)
γ_2			0.007 (0.006)
SUM ($\boldsymbol{\gamma}$)			**0.046*** (0.018)**
Number of firms	3,982	3,982	3,982
Number of observations	7,605	8,462	8,462
UCC with carry-over	Yes	Yes	Yes
Sargan (p-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. As noted, the interpretation of the coefficients refers to equation (8), i.e. $I_{i,t}/K_{i,t}$ etc. However, all estimations were carried out in first differences in line with the column heads.

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 three we add the cash flow-to-capital ratio to our baseline regression model in order to control for firm liquidity effects and finance constraints (Fazzari, Hubbard, &

Petersen, 1988; Fazzari, Hubbard, & Petersen, 2000; Chirinko, Fazzari, & Meyer, 1999). 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 N. , 2009) our preferred estimate of −0.427 is at the lower bound but comparable in size. This is partially driven by different estimation methodologies or data sets. For example, as regards methodology, our effects are similar but somewhat smaller than those obtained by Dwenger (2009) also using a distributed lag model. When using a dynamic specification in an error-correction model she obtains significantly larger effects. As regards, data sets, all the other above 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. There are two ways in which our different data set could yield different results: 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. Comparing estimation results from a regression with "simple" user cost of capital, i.e., disregarding tax losses, to our preferred estimate, the following section thus aims at disentangling the two effects.

2.5.2. Tax loss carry-forward and user cost elasticity

For this purpose we alter our preferred specification from column two 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.

Table 4: Comparing user cost elasticity with and without tax loss carry-over

$I_{i,t}/K_{i,t}$	(1) System-GMM		(2) System-GMM	
$\boldsymbol{\Delta ucc_{i,t}}$				
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 ($\boldsymbol{\sigma}$)	$\mathbf{-0.521^{***}}$	**(0.208)**		
$\boldsymbol{\Delta ucc_{i,t}^{simple}}$				
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 ($\boldsymbol{\sigma^{simple}}$)			$\mathbf{-0.374^{**}}$	**(0.165)**
$\boldsymbol{\Delta s_{i,t}}$				
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 ($\boldsymbol{\beta}$)	$\mathbf{0.279^{***}}$	**(0.078)**	$\mathbf{0.247^{***}}$	**(0.075)**
Number of firms	3,982		3,982	
Number of observations	8,462		8,462	
UCC with carry-over	Yes		No	
Sargan (p-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. As noted, the interpretation of the coefficients refers to equation (8), i.e. $I_{i,t}/K_{i,t}$ etc. However, all estimations were carried out in first differences in line with the column heads.

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.

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 one and the alternative using ”simple” user cost is reported in column two. 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.

The point estimates nevertheless support our hypothesis that the IV estimation in column two 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, i.e., 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, where tax losses and loss carry-over are 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;[34] the conclusion proves to be robust.

2.6. 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

[34] Results are available upon request.

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, yields −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. This is surprising but is partially due to our sample which also includes small and medium-sized firms that have not been studied before. We therefore disentangle the composition effect of the sample and the effect of tax losses on the user cost elasticity and show that the user cost elasticity is reduced to −0.37 when employing a user cost variable that does not include losses and loss carry-overs. Although the difference in the two point estimates is not statistically significant, they support our hypothesis that instrumenting the user cost with its lags as in earlier studies cannot entirely overcome the attenuation bias. Additionally, the use of more precise tax data helps to increase the efficiency of the estimation. We have successfully subjected our findings to various robustness checks, for example by including the cash flow-to-capital ratio and by using output instead of sales.

Our results suggest that, on average, tax incentives geared to encourage firms' investment might be more effective than previous literature has claimed. At the same time it is clear that an individual firm's reaction to changes in the user cost of capital can strongly deviate from the average effect. This study has emphasised that firms' individual marginal tax rates depend crucially on the size of its loss carry-overs. When economic agents under scrutiny find themselves in fundamentally different legal and economic 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. Nevertheless, this study clearly shows that although some firms may be immune to tax incentives due to tax losses and loss carry-overs, the average firm in the economy reacts significantly to a tax-induced change in its user cost of capital.

2.7. Appendix

2.7.1. Tax code provisions

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

	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
=	***Net profit before loss carry-over (NPBL)***
−	Loss carry-forward and loss carry-back
=	***Net income***
−	Allowable deductions for non-incorporated firms and for commercial cooperatives
=	***Taxable income (TI)***
×	Statutory tax rate
−	Tax credits for foreign-source income
=	***Corporate income tax assessed (TA)***

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.

2.7.2. Data

2.7.2.1. 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.

2.7.2.2. 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.

2.7.2.3. Cash flow

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

	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)
=	$\boldsymbol{Cash_{i,t}^{(n)}}$

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 base.

2.7.2.4. 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 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:

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

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:

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

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, $K_{i,t} = \sum_a K_{i,a,t}$.

2.7.2.5. 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.

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

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:

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

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:

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

where

$CF_{i,t}^{sim}$ = simulated stock of losses carried forward of firm i in the beginning of year t,

$\widehat{NPBL}_{\mathrm{i,t}}$ = 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 $\widehat{NPBL}_{\mathrm{i,t}}$, $\widehat{CB_{i,t-1}^{p}}$ and $CF_{i,t}^{sim}$ for all years, we calculate taxable income for each firm. Section 2.7.1 provides an overview of the legal definition of taxable income. We also take into account allowances $A_{i,t}$ according to § 24 and § 25 of the German CIT Code. Finally we assign the firm-specific marginal tax rate according to equation (2) on page 29. For comparison, statutory tax rates are presented in section 2.7.1.

2.7.2.6. 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).

The investment good price index (*Investitionsgüterpreisindex*) $P^I_{j,t}$ 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.

2.7.2.7. 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 national accounts (DESTATIS, 2009).

2.7.2.8. 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,[35] 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

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35 See *Fördergebietsgesetz*.

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).

2.7.2.9. 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 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.

Chapter 3:

MICRO-SIMULATION OF TRANSACTION COST SHOCKS ON THE VALUE OF CENTRAL BANK COLLATERAL[1]

3.1. Introduction

This chapter analyses the consequences of a transaction cost shock in financial markets on the value of collateral assets that banking institutions submit to the central bank in order to obtain liquidity in monetary policy credit operations. Amidst the revolving discussions about introducing some form of a financial transaction tax – be it EU-wide or in any other combination of European jurisdictions – this question is of interest to policymakers and central bankers in particular. While a change in transaction costs for trades among financial market participants may not necessarily require the central bank to adjust the implementation of its monetary policy, it cannot be excluded that some selected counterparties may suffer relatively large collateral losses. This could lead to collateral constraints for individual counterparties. Also other recent legislative proposals may affect transaction costs in financial markets. For example, the initiative for banking structural reform in the EU that follows up to the Liikanen report could have an impact on the cost of intermediation in the banking system as it could limit certain forms of market-making, depending on the outcome of the legislative process.

In its theoretical analysis, this work disentangles the various channels through which transaction cost shocks may affect the value of the assets pledged by banks in their credit operations with the central bank. It explains how different assets will be affected by a transaction cost shock, depending on their turnover, maturity, coupon structure and other characteristics. As a consequence, central bank counterparties will also be affected heterogeneously, conditional on the composition of the collateral they dispose of. The theoretical findings are then translated into an asset-by-asset model of the Eurosystem collateral framework. We note that for confidentiality reasons we do not make use of the data on the actual collateral positions of euro area banks and instead construct a dataset of Eurosystem collateral, the most granular unit of observation of which are 12,000 assets drawn from the actual list of eligible assets which are allocated to 1,800 hypothetical counterparties.

1 This chapter is based on joint work with Rudolf Alvise Lennkh (Lennkh & Walch, 2015).

Micro-simulation is the methodology of choice to capture heterogeneous effects due to composition effects and characteristics on the micro level. More specifically, the model calculates how a transaction cost shock influences the required rate of return and consequently the market price for different assets. The calculation encompasses several scenarios resting on assumptions about the transaction cost shock and the size of second round effects through trading volume. In our model, the first round effect refers to the direct impact of the introduction of a transaction cost shock on the asset price, as determined by the sum of its discounted future cash flows, which declines by the present value of the transaction cost shock payable on all future transactions of a specific security. Second round effects relate to the likely reduction in trading volume, which in turn reduces the negative impact of the first round effect as the asset is less frequently traded. The model does not take into account general equilibrium effects beyond changes in trading volume.

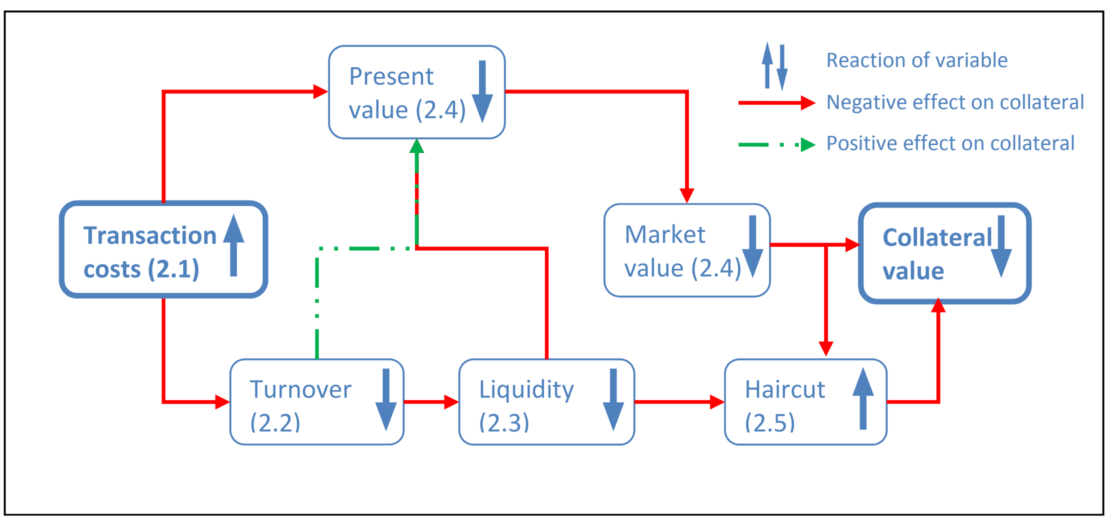
The results of our simulations show that a 10 basis point increase in transactions costs entails a -0.30% decrease in collateral value without second-round effects. When including second-round effects on asset turnover of 25% or 75% the decrease in collateral value falls to -0.22% and -0.07% respectively. The disaggregation of the results by asset characteristics shows that uncovered bank bonds, central government debt instruments and bonds of non-financial corporates experience the largest decreases with -0.96%, -0.91% and -0.34% respectively (without second-round effects). We also find that residual maturities of 3 to 5 years and 1 to 3 years are more affected (-0.49% and -0.38%) than shorter and longer residual maturities. When differentiating between haircut buckets, the results show that the haircut category from 5% to 15% is affected the most with -0.77%. On the counterparty level, our study shows that counterparties with small and large collateral pools are similarly affected.

Overall, we find that the effect on the aggregate level is very small with limited implications for the monetary policy stance. The vast majority of counterparties only experiences a small collateral loss due to a positive transaction cost shock. This conclusion does not rule out that some selected counterparties may suffer larger collateral losses. A counterparty with a low collateral buffer that is furthermore collateral-constrained may either tolerate the increased risk of affording a smaller collateral buffer, post additional collateral if available or reduce its outstanding liquidity position vis a vis the Eurosystem. From a policy perspective, assuming counterparties hit their collateral constraint as a result of the transaction cost shock, a small increase in the list of eligible securities for monetary policy operations could be enough to compensate the shock. Thus, even if on average the counterparties' collateral buffer is large enough to absorb a transaction cost shock this does not mean that the shock is costless.

3.2. Theory and prior literature

In order to implement their monetary policy stance central banks conduct monetary policy operations that can be carried out as outright purchases and sales or as credit operations. For outright purchases central banks acquire assets to hold them for an indeterminate period of time. Examples of such outright purchases or sales are the securities and market programme (SMP), the outright monetary transactions (OMTs), the covered bond purchase programmes (CBPPs), the asset-backed securities purchase programme (ABSPP) and the public sector purchase programme (PSPP) of the Eurosystem as well as the permanent open market operations conducted by the US Federal Reserve System (US Fed). In credit operations, by contrast, central banks lend (or borrow) funds to (from) a specified set of counterparties in exchange for eligible collateral assets based on (reverse) repurchase agreements or collateralised loans. Examples of such credit operations are the main refinancing operations or the long-term operations of the Eurosystem as well as the temporary open market operations and the discount window lending programme of the US Fed. Typically, the assets submitted as collateral are marked to market on a daily basis to ensure that the central bank is appropriately covered against financial risk. In addition, the actual central bank liquidity provided is less than the collateral that is pledged by counterparties, given the application of haircuts, the size of which reflect the liquidity, credit, interest rate and valuation risk of the asset.

Figure 1: Channels from an increase in transaction costs to collateral value



Notes: Liquidity and market value developments may induce downward rating adjustments and require the application of higher haircuts under the Eurosystem Credit Assessment Framework (ECAF). The numbers in brackets denote the section, in which the respective variable is discussed.

In times of regular market functioning, the amount of funds that banks obtain in central bank credit operations is usually determined by market forces. In the case of the

Eurosystem's main refinancing operations under variable rates and fixed allotment[2], the allotted liquidity depended on the interest rate that a counterparty was willing to pay. However, when central banks provide ample liquidity – as in the Eurosystem's marginal lending facility and the Fed discount window or under temporary procedures in crisis times[3]– the liquidity that counterparties can obtain is mainly limited by the collateral they have available. A financial institution with limited access to funding markets or in an otherwise stressed environment may have difficulties submitting a sufficient amount of collateral to obtain the amount of liquidity it needs to run its operations. Changes in the market value of collateral assets therefore may affect banks' ability to access central bank funding in spite of ample central bank liquidity provision. The vast majority of counterparties may only suffer a small collateral loss due to a transaction cost shock and the aggregate effect for the monetary policy stance may be limited. This finding at the average would, however, not exclude that some selected counterparties suffer larger collateral losses which they may not be able to compensate if they are collateral-constrained. It could be argued that a change in market value could be remedied by the central bank by lowering the haircuts it applies. However, haircuts are a risk control measures and are determined by the risk characteristic of the respective asset. The central bank could rather increase availability of eligible instruments.

Various channels of causal relationships have been identified by the literature that describes in general terms how transaction cost shocks could affect collateral value. They are schematically summarised in Figure 1. The arrows in the graph indicate how an increase in transaction costs triggers up- or downward adjustments in other market variables according to the findings in prior research.

3.2.1. Transaction costs in financial markets

Transaction costs for trades among market participants in financial markets are composed of bid-ask spreads, commission, fees, taxes, delay cost, price appreciation, market impact, timing risk and opportunity cost (Wagner & Edwards, 1993; Kissell, 2006). A transaction cost shock hence alters the wedge between the price of the seller and the buyer and influences trading behaviour. In their summary of the transaction costs literature, Pollin et al. (2003) conclude that transaction costs vary strongly across markets and within markets, depending on market and asset characteristics as well as trading behaviour. This is confirmed by Keim and Madhavan (1998) who find that the transaction costs of trading vary significantly with the size of the trade, the size of the corporation being traded and the trading infrastructure. For small firms, trading costs are high, likely driven by low trading

2 This procedure was standard for main refinancing operations that settled prior to 15 October 2008.
3 As from the operation settled on 15 October 2008, the weekly main refinancing operations of the Eurosystem were carried out through a fixed rate tender procedure with full allotment at the interest rate on the main refinancing operation for as long as needed.

volumes. Reiss and Werner (1996) confirm high transaction costs for small firms and show that a spread measure they develop is 0.71 of trading volume for large firms and 2.28 for small firms. In this context, Pollin et al. (2003) make the important observation that a uniform transaction cost shock on asset prices, e.g. a tax, can be highly distortive as the asset price as reference base is not comparable across assets. They show how bonds of different maturities can be affected very heterogeneously.

The decline of transaction costs over time is a general trend across markets observed by several authors Hong and Warga (2000) demonstrate that corporate bond spreads have declined over time and that trades in U.S. government bonds have even become a zero-profit business for dealers. Driessen et al. (2005) work with a dataset of US Treasury Bills prices and show that the average bid-ask spread for 1, 3, 6 and 9 month maturities has fallen by roughly 75% when comparing the 1972-1997 and 1987-1997 period. More generally, it is argued that a transaction cost shock would be felt most (least) in market segments where transaction costs are already low (high). Constantinides (1986) also concludes that a general increase in transaction costs across markets affects more strongly those segments where the transaction costs were low initially.

Overall, the presence of transaction costs among financial market participants and their size and development in different market segments is well documented in the literature. Transaction cost shocks affect assets heterogeneously.

3.2.2. Transaction costs and asset prices

The market value or price of an asset is determined by the sum of its discounted future cash flows. Hence, the price of an asset declines by the present value of the transaction cost shock payable on all future transactions of this specific security (Hawkins & McCrae, 2002). Importantly, a transaction cost shock affects all investors that value their assets at market prices, not only those that engage in trading activity. This becomes clearer when looking at the case analytically. Matheson (2011) presents a model of the impact of a transactions tax on security valuation and cost of capital for share prices. Based on this we derive a simple framework for exploring the same for fixed-income securities, drawing on a simple present value calculation. The price of a fixed-income security – a typical asset class for central bank collateral – under presence of transaction costs can be given as

$$p = \left(\sum_{t=1}^{T} \frac{cf - \Delta\tau \frac{\sum_{j=1}^{N_t} p_j q_j}{S_t^a}}{(1+i)^t} \right) + f(1+i)^{-T}$$
$$= \left(cf - \Delta\tau \frac{V_t}{S_t^a} \right) \left(\frac{1-(1-i)^{-T}}{i} \right) + f(1+i)^{-T} \tag{13}$$

where c is the coupon rate, f is the nominal, redemption or face value of a bond, N_t designates the number of transactions j within period t (typically a year), $p_j$and $q_j$stand for the price and quantity of transaction j, $\Delta\tau$ is the transaction cost shock, i is the yield to maturity observed in the market prior to the transaction cost shock, V_t stands for the total trading volume over all transactions observed for the security in period t and S_t^a is the number of outstanding titles per security that are held for trade or available for sale and not held to maturity[4]. The ratio of V_t and S_t^a hence describes the turnover per individual title of a security.

In this equation the transaction cost shock is modelled as a negative cash flow that is deducted from the positive cash flow resulting from the coupon payment c. This modelling ensures an appropriate discounting of the cash flows caused by the costs on future transactions. We also assume a market populated by homogenous traders. The representative trader buys an asset with the intention to possibly re-sell it at a later stage. Hence, the trader does not only take into account the transaction costs paid on the purchase of the asset but also factors in that the next purchaser in the future will do the same. Hence, the trader expects that the next purchaser will slightly decrease its offering price and thus the buyer in the present will do the same. In this way, transaction costs accumulate over the residual maturity of the asset and imply negative cash flows that lower the return of the asset. On the contrary, if the marginal investor were to buy and hold the asset, then the price would not depend on the turnover and an increase in transaction costs by $\Delta\tau$ would just imply a decrease in the price by $\Delta\tau$.

The change rather than the level of the transaction cost, $\Delta\tau$, enters the model because the absolute level of transaction costs is already priced in by market participants and hence contained in the yield to maturity i that is observed in the market prior to the credible announcement of the introduction of a transaction cost shock. This does not mean that the initial transaction costs are zero. Multiplying the $\Delta\tau$ with the total trading volume over all

[4] This assumes that assets in held-for-trading or available-for-sail portfolios are valued at fair value while assets in held-to-maturity portfolios would be valued at amortised cost and therefore not be affected by market price changes.

transactions observed for the security in period t, V_t, gives the tax due for the security as a whole. This figure is then scaled by the number of outstanding titles of the security that are available for trade and not held to maturity in period t, S_t^a. This figure is a theoretical concept and cannot be empirically observed in a reliable manner. The scaled net cash flow per period t and title, i.e. the coupon minus the transaction cost, is discounted over the time to maturity. This naturally assumes that the transaction volume is the same in all future years. This assumption can be relaxed to take into account second-round effects as we will show in section 3.3.4.3. The overall effect on the asset price is negative. Kupiec (1996) comes to the same conclusion when analysing the effects of a transaction cost shock on asset prices in a general equilibrium model.

In addition to the direct effect of transaction costs on the asset price, the specification in equation (13) also reveals that the turnover volume V_t influences the asset price. As turnover can be expected to decline in reaction to an upward transaction cost shock, the negative cash flow in each period would actually be reduced. Hence, a decline in turnover dampens the decline of the asset price. This second round effect is reflected by the dotted green arrow in Figure 1.

Furthermore, the price of an asset in the market is also influenced by the liquidity of its market because investors – in particular those that do not plan to hold the asset until maturity – are interested in being able to re-sell the asset at any time without affecting the asset's price. Their willingness to hold and pay for that asset would decline in comparison to assets not affected by a transaction cost shock. This demand shock would lead to a further decline of asset prices (see Block (2007) and Acharya and Pedersen (2005)). The liquidity premium is implicitly contained in the yield in the above price that reflects the return that investors in the market demand for more or less liquidity. More liquid assets will *ceteris paribus* trade at a lower yield.

The downward effect of transaction cost shocks on asset prices has been documented empirically by several authors, in particular for transaction taxes. Umlauf (1993) finds that the introduction of a transaction tax on equities of one per cent in Sweden in 1984 resulted in a decline of market prices at the Stockholm stock exchange of about 5.3 per cent for the 10-day period up to and including the announcement. On the day of announcement, the index decreased 2.2 per cent. However, we note that the findings for Sweden may not be representative due to the peculiar design of the tax. Saporta and Kan (1997) analyse the price developments of UK equity shares in the surroundings of changes in the UK stamp duty, both through announcement effects on the index and by comparing price developments of American Depository Receipts and their underlying shares. They find evidence that the stamp duty is capitalised in prices. However, both Umlauf as well as Saporta and Kan cannot control for other possible influences, in particular policy announcements made on the same day. Abstracting from second-round effects on turnover and assuming a dividend yield of 4%, Hawkins and McCrae (2002) expect a 3.1% increase in share prices upon halving the UK stamp duty. Further evidence is presented by Hu (1998), Schwert und Senguin (1993), Bond et al. (2004) and Oxera (2007). Several authors find elasticities of share prices with respect to transaction costs to be around -0.2% for the UK stamp duty.

3.3. A micro model of the Eurosystem collateral framework

The previous section has established the theoretical links between a change in transaction costs of an asset and its value as central bank collateral. In addition, empirical estimates for the market price effects of a transaction cost shock were collected from prior literature. However, these estimates can only serve as rough guidance for the degree to which a transaction cost shock may impact the value of central bank collateral. To obtain more refined estimates of that impact, this study needs to take into account more specific information on the micro level, in particular asset and counterparty heterogeneity. Asset heterogeneity means that asset values react heterogeneously to a transaction cost shock, depending on an asset's individual characteristics. For example, the price of a bond that is traded more often within a given period of time than another bond is expected, *ceteris paribus*, to be relatively more affected by such a shock. Counterparty heterogeneity refers to the fact that the composition of a counterparty's collateral pool depends on the counterparty's individual characteristics such as size, business model or geographical location. As a result, some counterparties are expected to be more affected by a transaction cost shock than others. In an extreme case, a counterparty that is collateral-constrained may be forced to either repay liquidity obtained from the central bank or submit additional collateral in order to remedy a situation of under-collateralisation.

Asset and counterparty heterogeneity call for a methodological approach that can take into account the micro level characteristics of assets and counterparties when determining changes in collateral value. Therefore, we have opted to develop a micro-simulation model that quantifies the effects of a transaction cost shock on collateral value on an asset-by-asset and counterparty-by-counterparty basis. The empirical setting of our analysis is the collateral framework of the Eurosystem, which is described in section 3.3.1 before turning to the description of the dataset and the construction of the micro-simulation model in the sections thereafter.

3.3.1. The Eurosystem collateral framework

According to Article 18.1 of the Statute of the European System of Central Banks and of the European Central Bank[5], Eurosystem credit operations must be "based on adequate collateral". This way the Eurosystem ensures that it is protected against losses arising from monetary policy operations, while enabling access to central bank operations for a wide range of counterparties. To implement this operationally the Eurosystem developed a catalogue of eligibility criteria for marketable as well as non-marketable assets[6]. For marketable assets the ECB maintains a public list of eligible assets that counterparties may choose to pledge as collateral. Marketable assets are further grouped into central government securities, regional government securities, uncovered bank bonds, covered bank bonds, corporate bonds, asset-backed securities and other marketable assets. Non-marketable assets comprise credit claims, cash deposits, retail mortgage-backed debt instruments and fixed-term deposits.

Collateral that is mobilised by a counterparty towards a Eurosystem central bank is marked to market prices on a daily basis. The most representative market price is maintained by the Common Eurosystem Pricing Hub. If no representative market price is available, assets are valued theoretically. Importantly, market price developments – caused, for example, by a change of transaction costs – immediately affect the lendable collateral value. In addition, the Eurosystem mitigates the risks of financial loss related to an asset by applying valuation haircuts, variation margins, concentration limits, initial margins and other measures[7]. Standard valuation haircuts range from 0.5 to 65 per cent. The haircuts reflect the liquidity, credit and interest rate risk of the asset. In some cases additional valuation mark-downs are applied for collateral in foreign denominations.

During quarter 3 of 2012 the average nominal amount of eligible marketable assets amounted to EUR 13,644 billion, among which central government securities and uncovered bank bonds were the two largest asset groups with EUR 5,998 billion and EUR 2,429 billion respectively[8]. However, the average outstanding credit of the Eurosystem amounted to EUR 1,216 billion while the peak outstanding credit in the same period was EUR 1,282 billion. This volume of outstanding credit was collateralised with assets of an average value after valuation and haircuts during quarter 3 of 2012 of EUR 2,520 billion. The use of collateral is summarised in Table 7. In quarter 3 of 2012, non-marketable assets were the largest collateral asset type with EUR 668 billion, followed by covered bonds, asset backed securities and central government debt instruments.

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5 Available under http://www.ecb.europa.eu/ecb/legal/pdf/en_statute_from_c_11520080509en02010328.pdf.

6 The eligibility criteria for all assets are codified in Annex I to the ECB Guideline ECB/2011/14, the General Documentation, which is available under http://www.ecb.europa.eu/ecb/legal/pdf/l_33120111214en000100951.pdf.

7 See Box 7 of the General Documentation, ibid.

8 Available under http://www.ecb.europa.eu/paym/pdf/collateral/collateral_data.pdf.

Table 7: Use of collateral by Eurosystem counterparties

Asset type	2004	2005	2006	2007	2008	2009	2010	2011	2012 Q1	2012 Q2	2012 Q3	2012 Q4	2014 Q1
Central government securities	252.4	233.5	205.5	176.9	158.2	224.9	261.5	255.0	336.4	358.2	368.4	374.3	320.5
Regional government securities	57.7	64.8	61.3	53.4	62.2	70.5	71.0	82.1	99.8	98.5	97.7	100.6	96.5
Uncovered bank bonds	169.3	226.5	294.1	370.6	439.6	562.1	430.2	269.2	369.3	374.2	341.8	328.8	260.6
Covered bank bonds	213.3	190.1	172.5	162.8	173.9	272.8	264.5	287.8	404.1	423.1	488.8	498.8	377.7
Corporate bonds	26.9	44.2	60.0	76.5	95.8	115.2	101.7	95.7	95.6	95.4	88.3	85.3	106.7
Asset-backed securities	45.0	83.5	109.3	182.1	443.6	473.6	490.0	358.0	407.5	407.3	371.7	352.7	306.6
Other marketable assets	18.9	22.0	19.9	16.2	15.8	21.0	32.7	57.8	73.8	77.9	95.1	81.2	117.5
Non-marketable assets	33.5	35.4	36.3	109.3	190.1	294.8	358.5	418.7	587.6	621.0	668.4	656.5	527.3
Total	**817**	**900**	**959**	**1,148**	**1,579**	**2,035**	**2,010**	**1,824**	**2,374**	**2,456**	**2,520**	**2,478**	**2,113**

Notes: EUR billion, after valuation and haircuts, averages of end of month data over each time period shown.
Source: ECB, for a full and current time series see http://www.ecb.europa.eu/paym/pdf/collateral/collateral_data.pdf

3.3.2. The construction of the dataset

In this section we explain the construction of our dataset of Eurosystem collateral. We select 12,000 assets that were registered on the Eurosystem's single list of eligible marketable assets at a point in time during the third quarter 2012 and randomly assign these assets to 1,800 hypothetical counterparties. In addition, each counterparty is assigned a random volume of non-marketable collateral. We obtain a many-to-many relationship, more precisely an n:m relationship, between counterparty identifiers and asset identification numbers. The resulting dataset contains 221,100 observations. For each counterparty-ISIN combination the dataset contains the hypothetical nominal amount of the asset that the counterparty has pledged as collateral. In a final step, the volume of the collateral after haircuts is scaled to the amounts observed per asset class at the end of the third quarter 2012. The sum of collateral value after haircuts per asset class in our dataset hence matches the figures pictured in the respective column of Table 7.

Besides the nominal amount submitted as collateral the dataset contains a series of other asset characteristics, such as asset type, price, coupon frequency, coupon structure, residual maturity, issuance date, maturity date, redemption value, liquidity category (as defined by the Eurosystem) and the Eurosystem valuation haircut. The majority of variables are obtained from the list of eligible marketable assets published by the ECB. Prices are obtained from the

Common Eurosystem Pricing Hub[9]. We use asset characteristics to compute the yield to maturity. The resulting value is verified against the yield to maturity reported by Bloomberg. All variables and their sources are explained in detail in section 3.6.1.

The dataset is further enriched with information on asset turnover. The data covers 1,161,629 transactions in the secondary market of 50 European exchanges or trading platforms between 1 December 2012 and 1 March 2013. Altogether, we observe zero or a positive number of transactions for 9,031 of the 12,000 securities in our sample. For the remaining 2,969 securities trading information is missing and could either be zero or positive.

3.3.3. Descriptive statistics

In the following we present some descriptive statistics of our simulated dataset on asset and counterparty level. Table 8 summarises the characteristics of the marketable assets in our dataset. We disregard the non-marketable assets in the table because they display very different characteristics. The residual maturity of marketable assets ranges from two days to almost 100 years, with the mean at around six years and the median at close to three years. The predominant coupon frequency is one annual payment but also other patterns occur. The average coupon rate is at 2.6 per cent, ranging from zero-coupon bonds to a maximum of 16.7 per cent. Asset prices average at EUR 98.03. Although the minimum and maximum are far from the standard par value of EUR 100, the standard deviation is at only EUR 12.61, which confirms that the majority of assets trade within a reasonable corridor around par. The predominant redemption value in the dataset is EUR 100. The yield ranges from 0 to 22 per cent, with the mean and median both around 1.9 per cent. The yield figures reasonably reflect the maturity profile of the assets in the dataset as well as the interest rate level prevailing at the time of observation. Overall, the table confirms that outliers can be justified and do not distort the aggregate characteristics of the dataset. Haircuts range from 0.5 to 68 per cent in line with the Eurosystem haircut schedule valid at the time.

[9] The CEPH collects market prices from various sources and defines the most reliable one on a given business day. See also http://www.ecb.europa.eu/mopo/assets/risk/valuation/html/index.en.html.

Table 8: Descriptive statistics for marketable assets

Variable	Mean	Min	10th percentile	Median	90th percentile	Max	Standard deviation
Residual maturity [days]	2,172	2	166	1,034	4,301	35,929	3,803
Coupon frequency	1.83	-	1.00	1.00	4.00	4.00	1.32
Coupon rate [%]	2.6	0.0	0.4	2.5	4.9	16.7	1.8
Price [EUR]	98.03	13.59	88.43	99.80	108.63	499.93	12.61
Redemption value [EUR]	100.58	35.00	100.00	100.00	100.00	1,000.00	15.21
Yield [%]	1.912	0.000	0.523	1.879	3.298	22.199	1.138
Haircut [%]	8.0	0.5	1.5	6.5	16.0	68.0	7.0

Table 9 shows the value of submitted collateral by asset type in the simulated dataset. The figures in the first column are identical with the column for Q3 2012 in Table 7 as the collateral values in the simulated dataset are scaled to that point in time. The second column displays the share of the respective asset type of the total collateral value.

Table 9: Simulated collateral value by asset type

Asset type	Collateral value [EUR million]	Share [%]
Central government securities	368,400	14.6
Regional government securities	97,700	3.9
Uncovered bank bonds	341,800	13.6
Covered bank bonds	488,800	19.4
Corporate bonds	88,300	3.5
Asset-backed securities	371,700	14.7
Other marketable assets	95,100	3.8
Non-marketable assets	668,400	26.5
Total	**2,520,200**	**100.0**

Notes: Collateral values after valuation and haircuts, averages of end of month data over each time period shown.

Table 10 shows the counterparty characteristics in our simulated dataset. The number of different securities submitted by counterparties ranges from one at the lower end to over

2,000 at the upper end. On average, counterparties post 212 different securities in their collateral pool. The value of counterparties' collateral pools ranges from close to EUR 600,000 at the 1st percentile to roughly EUR 34 billion at the 99th percentile. The collateral pool at the median is worth EUR 58 million for lending. The value of central government securities as per cent of the total value of the collateral pool ranges from 0 to 100 per cent, with 13 per cent at the mean. All numbers refer to the simulated dataset described above. Overall, the table reflects the typical skewedness of firm-level data where many small and few large entities cause the mean and median to differ significantly from each other.

Table 10: Descriptive statistics for counterparties

Variable	Mean	1st percentile	10th percentile	Median	90th percentile	99th percentile	Standard deviation
Number of different submitted securities	212	1	2	10	80	2,168	897
Value of collateral pool [EUR million]	1,398.6	0.6	5.1	57.8	1,929.5	34,212.4	5,993.5
Value of central government securities against total pool [%]	12.8	0.0	0.0	0.0	57.7	100.0	27.6

3.3.4. The structure of the micro model

In this section we develop the micro model that is used to simulate the effects of a transaction cost shock on central bank collateral. The model builds on the theory developed in section 3.2. The simulations are carried out in various scenarios with different parameters as pictured in Table 11. Scenarios I-III all foresee a positive transaction cost shock. The transaction cost shock could of course also be negative but we stick to positive shocks for simplicity only. Scenarios II and III introduce, in addition, second round effects in the turnover of securities. A change in transaction costs has a considerable effect on trading turnover. These additional scenarios take into account this important effect. We call this a second-round effect because it is not necessarily intended by a policy action and results by behavioural adaptations of market participants to a change in the transaction cost. Beyond the second-round effects on turnover, the model does not take into account any other dynamics over time, nor does it deal with indirect effects running through liquidity or haircuts. Hence, any changes in liquidity premia or credit risk ratings caused by a transaction cost shock remain outside the model we develop here.

Table 11: Overview of scenario parameters

	Transaction cost shock ($\Delta\tau$)	Second-round effect on turnover $\left(\frac{\Delta V_t}{V_t}\right)$
Base scenario	0	-
Scenario I	0.1%	0
Scenario II	0.1%	-25%
Scenario III	0.1%	-75%

3.3.4.1. Base scenario

In the base scenario, the asset characteristics observed in the dataset are used to compute the base line price of each security based on a standard price function for fixed-income securities

$$p = \left(\sum_{t=1}^{T} \frac{cf}{(1+i)^t}\right) + f(1+i)^{-T} \tag{14}$$

where c is the coupon rate, f is the nominal or face value, T stands for the years until maturity and i is the yield to maturity. The price obtained in this computation is validated against the price observed in the dataset to ensure that the simulation functions appropriately.

In a further step, the model applies haircuts on the simulated market price of the collateral assets in line with risk control measures of the Eurosystem. The haircut is determined by the credit quality, the residual maturity, the coupon structure and the liquidity category on an asset-by-asset basis. Additional haircuts are applicable for certain foreign currency denominations, theoretical pricing and some asset groups (e.g. asset-backed securities). The collateral value after haircuts is the lendable value of the assets that determines the volume of liquidity that counterparties can be allotted in a central bank operation.

3.3.4.2. Simulation of first-round effect

The simulation of first-round effects in scenario I extends equation (14) by inserting a transaction cost shock.

$$
\begin{aligned}
p &= \left(\sum_{t=1}^{T} \frac{cf - \Delta\tau \frac{V^o}{S_o}}{(1+i)^t} \right) + f(1+i)^{-T} \\
&= \left(\sum_{t=1}^{T} \frac{\left(c - \Delta\tau \frac{V^o}{S_o f}\right) f}{(1+i)^t} \right) + f(1+i)^{-T} \\
&= \left(\sum_{t=1}^{T} \frac{(c - \Delta\tau \nu^o) f}{(1+i)^t} \right) + f(1+i)^{-T}
\end{aligned}
\qquad (15)
$$

In fact, this formula is based on equation (13) that was derived and explained in the theoretical section. To recall, the coupon rate c multiplied by the face value f yields the positive annual cash flow of the bond. From this we deduct the negative cash flow caused by the transaction cost. For the scenarios we assume a transaction cost shock $\Delta\tau$ of +0.1%. We note that one important characteristic of our model is that we assume that initial transaction costs are zero while in practice, many of the assets in our sample have large transaction costs, that already drive prices down, which would imply that the impact of any additional shock would be lower than our estimates suggest.

The shock size is realistic compared with the transaction costs that prevail across the wide range of different markets in which collateral assets are traded. For sovereign bond markets with tight spreads of around 0.05% the shock is relatively large. However, other debt instruments trade with much higher spreads of above 0.1%. Another approach would be to compare the assumed shock to securities transaction tax rates. The regular UK Stamp Duty Reserve Tax is charged at a rate of 0.5%. The transaction tax proposed by the European Commission in 2011 has a standard rate of 0.1%. The transaction cost shock is multiplied with a measure of annual secondary market turnover, V^o[10]. The resulting aggregate negative cash flow caused by the transaction cost shock is obtained on the security level. It is therefore scaled by the number of outstanding titles per security, S_o. For further illustration, section 3.6.2 applies the first line of equation (15) to three exemplary bonds with different maturities and coupon rates. For the model, we transform the equation in two steps. The cash flow then reads $(c - \Delta\tau\nu^o)$ where ν^o is the turnover ratio of a certain security (the whole issue or ISIN).

In the model, the formula is applied to all 12,000 marketable assets that are used as central bank collateral by the 1,800 counterparties in the simulated dataset. For non-marketable assets it is assumed for simplicity under all scenarios that a transaction cost shock

---

[10] We use V^o (S_o) in equation (15) rather than $V_t(S_t^a)$ that was used in equation (13) in order to express that $V^o(S_o)$ is a specific measure of V_t (S_t^a). The computation of the specific measure is explained in section 3.3.5.

does not cause any change in their value[11]. The application of haircuts is identical to the base scenario in all alternative scenarios as we assume haircut sizes not to be affected by the transaction cost shock in our model.

3.3.4.3. Simulation of second-round turnover effects

However, reality is more complex because turnover itself also depends on the transaction cost shock and equation (15) needs to be augmented as follows:

$$p = \left(\sum_{t=1}^{T} \frac{\big(c - \Delta\tau \nu^{o}(\Delta\tau)\big) f}{(1+i)^{t}} \right) + f(1+i)^{-T} \tag{16}$$

The simulation of second-round effects of a transaction cost shock on turnover is operationalised in a simplified manner as the parameters of thefunction $\nu^{o}(\Delta\tau)$ are unknown. Equation (15) is hence amended as follows.

$$p = \left(\sum_{t=1}^{T} \frac{(c - \varphi \Delta\tau \nu^{o}) f}{(1+i)^{t}} \right) + f(1+i)^{-T}$$

where (17)

$$\varphi = 1 + \frac{\Delta\nu^{o}}{\nu^{o}} = 1 + \frac{\Delta V^{o}}{V^{o}}$$

The second-round effect φ depends on the percentage change in turnover $\frac{\Delta V^{o}}{V^{o}}$. The equation is again applied to the three exemplary bonds in section 3.6.2 for further illustration. In scenario II a turnover decrease of 25% is assumed in the case of a positive transaction cost shock. In scenario III the decrease is assumed to be 75%. The assumptions for second-round effects in the model are fully hypothetical and apply to all assets in the same way. In reality, second-round effects are likely to differ across maturity, asset types, market liquidity, etc. In addition, second round effects are likely to lead to further changes in other variables. Specifically, we analyse how an increase in transaction costs decreases volume, so that transaction costs are paid less often, thus attenuating the negative impact of transaction costs on the asset value. However, it could be expected that an increase in transaction costs (negatively affecting the asset price), decreases the trading volume (positively affecting the asset price), which in turn complicates dealers' ability to find counterparties, thus reducing liquidity (again, negatively affecting the asset price). In our analysis we assume that the positive 'volume' effect dominates the resulting negative 'liquidity' effect though we

[11] It could be argued that the demand for non-marketable assets rises (falls) with the increase (decrease) of transaction costs.

acknowledge that we do not have any information on the magnitude of either of these effects. Section 3.6.3 illustrates what the scenarios we assume here imply in terms of elasticities of turnover with respect to transaction costs. A comparison of the implied elasticities with those observed by the literature we have cited in section 3.2.2 shows that they lie within the range observed empirically.

3.3.5. Computing the turnover ratio

This section explains how we use the information on trading volume in the dataset to compute the turnover ratio that is used in line with equation (17). The data on trading volume suffers from two shortcomings, which are typical of trading data. First, for some assets no trading data is available at all. Second, the data only covers a segment of the overall market turnover because over-the-counter (OTC) transactions are likely to be underrepresented. In order to deal with these shortcomings we adopt a dual approach. On the one hand, we propose a workaround for the shortcomings that allows us to still use the trading data as a source of variance. On the other hand, we conduct a robustness check which fully abstracts from the trading data at the asset level. In the following we explain both approaches – baseline and robustness check – one by one.

For the baseline approach, we aggregate the transaction-level information in the dataset over time by asset and obtain quarterly transaction volumes. For the assets in our sample for which no transaction information is available we impute transaction volumes. We opt for a cell-mean imputation using the geographical residence of the issuer and the asset type as the two categorical variables defining the cells. This method has the disadvantage that the variance of the underlying population is underestimated by the sample variance after imputation, even when assuming that the observations are missing at random. However, cell-mean imputation still serves the purpose of the study because we do not aim at making inferences in a multivariate analysis where coefficients would be biased. The main objective of our imputation is to avoid selection bias in transaction volumes.

The underrepresentation of OTC transactions implies that even for the securities for which we do observe transactions our figures very likely understate the true size of the secondary market. This is a common challenge of transactions data that cannot be easily overcome because OTC transaction data are not centrally collected. As workaround we obtain turnover data for the three biggest secondary debt markets in the euro area. Based on this information we scale up the turnover volume for all assets in the dataset. Finally we scale by the average nominal value outstanding to obtain the turnover ratio ν^{o} used in equations (15) and (17). We explain our method in more detail in section 3.6.4. The disadvantage of this workaround is that the missing observations are likely not missing at random. Rather, the availability of data may be thinner for some specific asset types, trading venues or countries. Extrapolating our information on turnover in sovereign debt markets into other asset categories may be imprecise but given the unavailability of better data it is a second best solution. As we scale up turnover conservatively, the transaction data we obtain for the micro-simulation should be interpreted as a lower-bound figure when drawing empirical conclusions about the effects of transaction cost shocks.

In order to enhance the credibility of these assumptions regarding the scaling factor coupled with the underlying trading data, we carry out a robustness check. The robustness check does not rely on any trading data at the micro level. It rather assumes a turnover ratio ν^{o} of 5 for all assets. For comparison, the turnover ratio for German government securities in 2012 amounted to 4.7[12]. The results of the robustness check are summarised in section 3.4.3.

Table 12: Descriptive statistics for asset turnover ratio

Variable	Mean	1st percentile	10th percentile	Median	90th percentile	99th percentile	Standard deviation
Baseline	28.08	0.00	0.00	0.00	11.15	735.38	297.90
Robustness check	5	5	5	5	5	5	0

3.4. Micro-simulation results

The simulation results from the three scenarios discussed above are presented in two sets. First, we show results on an asset level that reflect how the impact of a transaction cost shock on collateral value varies by different asset characteristics. Second, we move on to the counterparty level and demonstrate how different types of counterparties are affected in our simulation. Towards the end of the section we point out some caveats regarding the results of the study and their interpretation.

12 See Deutsche Finanzagentur (2013), Bund Fact Sheet.

3.4.1. Assets

Table 13: Simulation results by asset type

Asset type	**Base**	**S I**	**S II**	**S III**
$\Delta\tau$	**0%**	**0.1%**	**0.1%**	**0.1%**
ΔV^0	**0%**	**0%**	**-25%**	**-75%**
Central government securities	368,400	365,055	365,891	367,564
		-0.91%	*-0.68%*	*-0.23%*
Regional government securities	97,700	97,654	97,666	97,689
		-0.05%	*-0.04%*	*-0.01%*
Uncovered bank bonds	341,800	338,512	339,334	340,978
		-0.96%	*-0.72%*	*-0.24%*
Covered bank bonds	488,800	488,434	488,525	488,708
		-0.07%	*-0.06%*	*-0.02%*
Corporate bonds	88,300	88,002	88,076	88,225
		-0.34%	*-0.25%*	*-0.08%*
Asset-backed securities	371,700	371,700	371,700	371,700
		0.00%	*0.00%*	*0.00%*
Other marketable assets	95,100	94,935	94,976	95,059
		-0.17%	*-0.13%*	*-0.04%*
Non-marketable assets	668,400	668,400	668,400	668,400
		0.00%	*0.00%*	*0.00%*
Total	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against the base scenario.

In section 3.2 this study demonstrated theoretically why a transaction cost shock is expected to affect the value of an asset heterogeneously depending on the asset's micro characteristics. This section corroborates that finding empirically and shows simulation results for a number of selected asset characteristics across the three scenarios introduced previously. The first asset characteristic we look at is the asset type. Table 13 summarises the results in absolute levels of collateral value as well as percentage changes. The amounts in the column of the base scenario are naturally equal to the values presented in Table 7. Turning to the scenarios, scenario I presents the strongest change in collateral value (-0.30%) of the three scenarios simulating an upward transaction cost shock. This is entirely intuitive as scenario I disregards any second-round effects of a transaction cost shock on turnover. The effect is considerably weaker for scenarios II and III with -0.22% and -0.07% respectively, for which second-round effects are taken into account.

In order to put the size of these estimates into perspective we compare them with existing literature. As the results vary considerably across studies in terms of ex-ante transaction cost level, transaction cost shock size and resulting price change, elasticity is the most useful measure to compare the various estimates. As summarised in section 3.2.2, several authors find elasticities of share prices with respect to transaction costs to lie at around -0.2% for the UK stamp duty.

Table 14: Implied elasticities at a transaction cost shock of 0.1%

Change of collateral value	Initial transaction cost level		
	0.05%	**0.50%**	**2.00%**
Scenario II (-25%): -0.22%	-0.001	-0.011	-0.044
Scenario III (-75%): -0.07%	-0.0004	-0.004	-0.014

Notes: For comparison, the average of the bid-ask spread within the approximately 60 outstanding German Bunds is at 0.048 at the lower end. At the higher end, bid-ask spreads are as high as 2 for less liquid markets.

We compute the implied elasticities for scenarios II and III at three different initial transaction cost levels in Table 14. At the transaction cost level of 0.5%, we obtain elasticities ranging from -0.011 for scenario II to -0.004 for scenario III. This means that a transaction cost increase of 0.1% results in a price decline of between 20 and 5 times lower than the estimates for the UK stamp duty. The apparently large difference between the UK results can be explained as follows: First, equities are very different assets from those in our dataset and their markets behave fundamentally different. Price-elasticity in equity markets could generally be higher than in fixed-income markets that dominate our study. Second, the empirical estimates that some of the other studies are based on do not control for other possible influences on the price change and therefore likely suffer from an upward bias as also Hawkins and McCrae (2002) point out. Third, the estimates were obtained in the context of the UK stamp duty which is a very small market with many substitutes in other countries and other financial instruments. Traditionally, markets with close substitutes have a much higher elasticity. Taking these three reasons into account, the elasticities we obtain seem realistic from an empirical point of view. Our results are further supported by the percentage price changes that we obtain in our stylised mini-model in section 3.6.2.

It should also be noted that the size of effects in our study varies considerably across different asset types. As explained previously, we assume that the value of non-marketable collateral is not affected by transaction cost shocks. Uncovered bank bonds, central government assets and corporate bonds experience relatively large changes in their collateral values. We note that ABSs are not affected in our model given that our dataset does not capture any turnover for this asset class, thus completely negating the adverse impact of a transaction cost shock as simulated by our model.

Table 15: Simulation results by residual maturity

Residual maturity	Base	S I	S II	S III
$\Delta\tau$	0%	0.1%	0.1%	0.1%
ΔV^0	0%	0%	-25%	-75%
Below 1 year	444,657	444,596	444,612	444,642
		-0.01%	*-0.01%*	*0.00%*
1 – 3 years	620,715	618,385	618,967	620,132
		-0.38%	*-0.28%*	*-0.09%*
3 – 5 years	398,527	396,593	397,076	398,043
		-0.49%	*-0.36%*	*-0.12%*
5 – 7 years	151,730	151,225	151,351	151,603
		-0.33%	*-0.25%*	*-0.08%*
7 – 10 years	207,707	207,178	207,310	207,575
		-0.25%	*-0.19%*	*-0.06%*
More than 10 years	696,866	694,714	695,252	696,328
		-0.31%	*-0.23%*	*-0.08%*
Total	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against base scenario.

As second group of results, we look at the effect of a transaction cost shock differentiated by residual maturity. Table 15 pictures the results broken down into the six maturity buckets that are differentiated by the Eurosystem. Naturally, we recognise the same pattern across scenarios, with the absolute size of the effect decreasing from scenario I to III. The largest effects can be found in the maturity buckets from 3 to 5 years and 1 to 3 years. A closer inspection of the simulation on the micro level suggests that these results are driven by the asset types and transaction volumes that dominate the maturity buckets. Furthermore, we also recognise increasing effects from the first to the third maturity bucket. This reflects a pattern that is also visible in the exemplary bond simulations in section 3.6.2 that shows that bonds with a longer residual maturity show stronger percentage price changes. The reason for this finding is that the bond values of shorter residual maturities are dominated by the principal repayment amount, which is not affected by a transaction cost shock. Coupon payments and costs for transactions play a relatively minor role. For longer maturities, however, the value of the principal repayment is discounted more strongly. Hence, annual payments such as coupons and transaction costs affect the asset's pricing more strongly.

We furthermore disaggregate the simulation results by five haircut categories. The results are pictured in Table 16. The distribution across haircut categories is driven by the random simulation of the dataset. A transaction cost shock entails the highest effects on collateral value for assets in the 5%-15% haircut category, followed by the 2.5%-5% category. For assets with haircuts between 15% and 50% the effects are minimal because these haircut categories are dominated by marketable assets with lower market liquidity or non-marketable assets, for which we assume a zero effect in this study.

Table 16: Simulation results by haircuts

Haircut		**Base**	**S I**	**S II**	**S III**
	$\Delta\tau$	**0%**	**0.1%**	**0.1%**	**0.1%**
	ΔV^0	**0%**	**0%**	**-25%**	**-75%**
Below 2.5%		840,234	838,950	839,271	839,913
			-0.15%	*-0.11%*	*-0.04%*
2.5% – 5%		232,816	232,253	232,393	232,675
			-0.24%	*-0.18%*	*-0.06%*
5% – 15%		712,799	707,317	708,688	711,429
			-0.77%	*-0.58%*	*-0.19%*
15% – 50%		34,354	34,354	34,354	34,354
			0.00%	*0.00%*	*0.00%*
Above 50%		699,997	699,818	699,863	699,952
			-0.03%	*-0.02%*	*-0.01%*
Total		**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
			-0.30%	***-0.22%***	***-0.07%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against base scenario. The observations at the category cut-off values (2.5%, 5%, 15%, 50%) are contained in the lower bracket respectively.

Finally, we disaggregate the results by credit quality step as defined by the Eurosystem. The credit quality steps reflect the credit quality as assessed by accepted external credit rating agencies. The results show that assets with a higher credit quality suffer a greater collateral value contraction following a transaction cost shock.

Table 17: Simulation results by credit quality

Credit quality	**Base**	**S I**	**S II**	**S III**
$\Delta\tau$	**0%**	**0.1%**	**0.1%**	**0.1%**
ΔV^0	**0%**	**0%**	**-25%**	**-75%**
Credit quality step 1 and 2	1,686,857	1,679,824	1,681,582	1,685,099
		-0.42%	*-0.31%*	*-0.10%*
Credit quality step 3	164,943	164,468	164,587	164,824
		-0.29%	*-0.22%*	*-0.07%*
Non-marketable assets	668,400	668,400	668,400	668,400
		0.00%	*0.00%*	*0.00%*
Total	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against base scenario. The credit quality steps 1 and 2 correspond to the "A" range of ratings by major agencies, credit quality step three to the "BBB" range. Non-marketable assets are pictured separately.

Overall, the effects across different scenarios and asset characteristics can be explained intuitively. As expected, the effects seem to be mainly driven by the turnover in the respective market segment and by the assumed second-round effects of a transaction cost shock on turnover. Compared with the exemplary calculations presented in section 3.6.2 the results are realistic and within the expected range.

The size of the effects can be put into perspective in a variety of ways. Given the large amount of used collateral, roughly EUR 2.5 trillion in the base scenario, the percentage changes stand for amounts in the order of billions of euro. This magnitude simply underlines the strong effect of transaction costs on the price of financial assets in general. Another way to look at the effects of the study is to translate them into changes in the implied yield. For this the new market value before haircuts resulting in the simulation is used to calculate back the implied yield. Of course, this is an entirely theoretical exercise as the implied yields would never be observed in markets due to second-round price and substitution effects brought about by arbitrage. In section 3.6.2 we show that the effect of a transaction cost shock on the profitability of a certain instrument in terms of its implied yield can be huge in spite of relatively small percentage changes in prices. For example, assuming a positive transaction cost shock of 0.1% for bond B with one year residual maturity results in the yield to maturity increasing from 0.5% observed in the base scenario to an implied yield of 1.0% in scenario I and still 0.62% in scenario III after taking into account second-round effects on turnover. This effect is very large and clearly underlines that relatively small transaction cost changes can cause strong effects on market activity.

3.4.2. Counterparties

Yet another way to interpret the effects observed in the previous section is to analyse their implications for Eurosystem counterparties. For this we have aggregated the collateral on counterparty level and ranked the counterparties according to the size of their collateral pool in the base scenario. Collateral pool size is a – naturally imperfect – proxy of counterparty size. Table 18 shows the simulation results by counterparties in quintiles. The first quintile contains the counterparties with the smallest collateral pools and therefore stands for roughly EUR 1.7 billion of collateral only. At the other end of the distribution, the fifth quintile contains the largest collateral pools corresponding to an aggregate value of roughly EUR 2.4 trillion. In spite of the strongly skewed distribution of the collateral pool size, the effects of a transaction cost shock on collateral value is relatively balanced across pool size classes. This could, for example, be explained by the fact that the collateral pools across the five quintiles are well diversified in terms of asset classes. While this should not be misinterpreted as a proof of diversification on the micro level, it is a clear sign that small collateral pools are on average not more or less affected by a transaction cost shock than larger ones. This is overall good news for the hypothetical banking system in our dataset.

Table 18: Simulation results by counterparty quintiles

Collateral quintile	**Base**	**S I**	**S II**	**S III**
$\Delta\tau$	**0%**	**0.1%**	**0.1%**	**0.1%**
ΔV^0	**0%**	**0%**	**-25%**	**-75%**
1st quintile	1,754	1,748	1,750	1,752
		-0.31%	*-0.23%*	*-0.08%*
2nd quintile	7,694	7,672	7,677	7,688
		-0.29%	*-0.21%*	*-0.07%*
3rd quintile	22,890	22,832	22,846	22,875
		-0.25%	*-0.19%*	*-0.06%*
4th quintile	83,909	83,495	83,599	83,805
		-0.49%	*-0.37%*	*-0.12%*
5th quintile	2,403,954	2,396,945	2,398,697	2,402,202
		-0.29%	*-0.22%*	*-0.07%*
Total	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against base scenario.

The percentage changes of collateral value should also be evaluated against the background of the figures for over-collateralisation of counterparties that the Eurosystem publishes on a quarterly basis. These figures show that counterparties are on average strongly over-collateralised for a variety of reasons. This allows for the conclusion that the vast majority of counterparties will not suffer a very significant collateral loss due to a transaction cost shock. At the same time, this general statement does not preclude the possibility that single counterparties facing collateral scarceness may experience constraints in their access to central bank liquidity due to a limited collateral pool. This is further highlighted in section 3.6.5, where we show the impact of transaction costs on two stylised banks with a differing composition of their collateral pools.

3.4.3. Robustness checks

In order to explore the sensitivity of our results with respect to various assumptions, we conduct two robustness checks. The first robustness check, which was already explained in section 3.3.5, explores the sensitivity of the results to the way in which we compute the turnover ratio in our dataset. In this first robustness check, we do not rely on any trading data but rather assume a turnover ratio of 5 for all assets.

Table 19: Results of the robustness check 1 (size of second round effects)

Asset type $\Delta\tau$ ΔV^0	**Base** **0%** **0%**	**S I** **0.1%** **0%**	**S II** **0.1%** **-25%**	**S III** **0.1%** **-75%**
Central government securities	368,400	365,055	365,891	367,564
		-0.91%	*-0.68%*	*-0.23%*
Regional government securities	97,700	97,656	97,667	97,689
		-0.04%	*-0.03%*	*-0.01%*
Uncovered bank bonds	341,800	338,172	339,079	340,893
		-1.06%	*-0.80%*	*-0.27%*
Covered bank bonds	488,800	488,421	488,516	488,705
		-0.08%	*-0.06%*	*-0.02%*
Corporate bonds	88,300	88,052	88,114	88,238
		-0.28%	*-0.21%*	*-0.07%*
Asset-backed securities	371,700	371,700	371,700	371,700
		0.00%	*0.00%*	*0.00%*
Other marketable assets	95,100	94,930	94,973	95,058
		-0.18%	*-0.13%*	*-0.04%*

Non-marketable assets	668,400	668,400	668,400	668,400
		0.00%	*0.00%*	*0.00%*
Total	**2,520,200**	**2,512,387**	**2,514,340**	**2,518,247**
		-0.31%	***-0.23%***	***-0.08%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against the base scenario.

Table 19 reproduces Table 13 of the baseline computations for the robustness check. Table 20 directly compares the results of the two computations. The overall effects are very similar, the percentage changes remain constant to the first decimal but there are differences in the absolute values. This underlines that the way in which we use the trading data in our dataset does not lead to disproportionate results.

Table 20: Comparison of baseline and robustness check 1

Asset type	**Base**	**S I**	**S II**	**S III**
$\Delta\tau$	**0%**	**0.1%**	**0.1%**	**0.1%**
ΔV^0	**0%**	**0%**	**-25%**	**-75%**
Total baseline	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***
Total robustness check 1	**2,520,200**	**2,512,387**	**2,514,340**	**2,518,247**
		-0.31%	***-0.23%***	***-0.08%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against the base scenario.

As second robustness check, we present the results for a different size of the transaction cost shock. Table 21 shows the results for a transaction cost shock of + 0.5%.

Table 21: Results of the robustness check 2 (size of transaction cost shock)

Asset type	Base	S I	S II	S III
$\Delta\tau$	0%	0.5%	0.5%	0.5%
ΔV^0	0%	0%	-25%	-75%
Central government securities	368,400	354,612	358,059	364,953
		-3.74%	*-2.81%*	*-0.94%*
Regional government securities	97,700	97,544	97,583	97,661
		-0.16%	*-0.12%*	*-0.04%*
Uncovered bank bonds	341,800	334,129	336,047	339,882
		-2.24%	*-1.68%*	*-0.56%*
Covered bank bonds	488,800	487,198	487,599	488,400
		-0.33%	*-0.25%*	*-0.08%*
Corporate bonds	88,300	87,541	87,731	88,110
		-0.86%	*-0.64%*	*-0.21%*
Asset-backed securities	371,700	371,700	371,700	371,700
		0.00%	*0.00%*	*0.00%*
Other marketable assets	95,100	94,618	94,739	94,980
		-0.51%	*-0.38%*	*-0.13%*
Non-marketable assets	668,400	668,400	668,400	668,400
		0.00%	*0.00%*	*0.00%*
Total	**2,520,200**	**2,495,743**	**2,501,857**	**2,514,086**
		-0.97%	***-0.73%***	***-0.24%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against the base scenario.

Table 22 compares the totals in the baseline and the robustness check. As expected, the effects are higher when the transaction cost shock is increased to +0.5%. However, the relationship is not proportional as the effect only increases by roughly three times, while the shock increases five times. The main reason for this is that some collateral assets are assumed not to change their value at all (non-marketable assets and ABS). Therefore, the overall change in collateral value is less than proportional to the transaction cost shock.

Table 22: Comparison of baseline and robustness check 2

Asset type ΔV^0	**Base** 0%	**S I** 0%	**S II** -25%	**S III** -75%
Total baseline ($\Delta\tau$ +/-0.1%)	**2,520,200**	**2,512,692**	**2,514,569**	**2,518,323**
		-0.30%	***-0.22%***	***-0.07%***
Total robustness check 2 ($\Delta\tau$ +/-0.5%)	**2,520,200**	**2,495,743**	**2,501,857**	**2,514,086**
		-0.97%	***-0.73%***	***-0.24%***

Notes: Collateral values after valuation and haircuts. Figures in italics denote changes in per cent against the base scenario.

3.4.4. Caveats

This section points out a series of methodological specificities of the study that the reader should keep in mind when interpreting the results that were suggested above. Most importantly one should recall that the dataset reflects a hypothetical banking system. Although the securities are selected from the actual list of eligible assets, the extent of their use by counterparties is based on hypothetical assumptions. This selection procedure could lead to systematic over- or underrepresentation of assets that are most affected by a transaction cost shock due to their turnover or other asset characteristic. This in turn could also bias the aggregate results to either direction.

Another caveat is the incompleteness of the transaction data that we circumvent by cell-mean imputation and scaling up transaction volumes. We have explained previously that the conservative rescaling of transaction volumes implies that the overall simulation results should be interpreted as a lower-bound estimate. For assets, for which we significantly underestimate turnover (for instance ABSs, for which we assume a turnover of zero), the effects may be considerably higher. However, underestimating first-round effects due to missing turnover data also means underestimating the second-round effects on turnover which could partially neutralise the bias.

Another important limitation is our assumption that initial transaction costs are zero, while in practice, many of the assets in our sample have large transaction costs, already driving prices down. This implies that, depending on the current transaction costs for each asset, the impact of any additional shock would be lower than our estimates suggest.

Furthermore, it should be recalled that the scenarios we use to reflect second-round effects cover a very wide range. The precise estimation of second-round effects on turnover depends on a variety of other variables and a precise estimation goes far beyond the scope of this study. In particular, for short maturities the rise in the yield implied by the price change simulated here suggests that arbitrage trades between short-term debt instruments and other short-term investments such as loans could entail an even higher reduction in turnover. Nevertheless, the scenarios are useful to trace out the range of possible second effects and the robustness of the results. At the same time, the reader should keep in mind that the scenarios only reflect second-round effects on turnover. Other second-round effects could also affect the price level. For example, a decrease in turnover would also reduce liquidity in certain market segments and hence liquidity premia that investors are willing to pay for such assets. Similarly, it is conceivable that under certain circumstances counterparties optimise their collateral strategies by shifting their pools away from marketable towards more non-marketable assets. This also suggests that the estimates presented in this study are, from this angle, likely at the lower end of true effects.

3.5. Concluding remarks and wider implications

In this study we have shown theoretically and empirically how a transaction cost shock can affect the value of assets that financial institutions use as collateral with their central bank. In the theoretical analysis, we disentangled the various channels through which transaction cost shocks may affect the collateral value and explained how different assets are affected by a transaction cost shock, depending on their turnover, maturity, coupon structure and other characteristics. We also pointed out why financial institutions are affected heterogeneously, conditional on the composition of the collateral they use with the central bank. The theoretical findings were then translated into an asset-by-asset micro-simulation model of the Eurosystem collateral framework. Micro-simulation was chosen because it captures micro heterogeneity at the asset and counterparty level. For this we simulate a dataset with 12,000 assets and 1,800 counterparties and scale the aggregate collateral amounts to the end of quarter 3 of 2012.

We find that a 0.1 percentage point increase in transactions costs entails a -0.30% decrease in the value of aggregate collateral when disregarding any second-round effects. At the aggregate level, the collateral losses are in the order of billions of euro. When taking into account second-round effects on the turnover of debt instruments in the order of 25% or 75% the decrease in collateral value comes in lower at -0.22% and -0.07% respectively. When breaking down the results along asset characteristics we find that uncovered bank bonds, central government assets and corporate bonds are affected the most with a decrease of collateral value by -0.96%, -0.91% and -0.34% respectively in a scenario without second-round effects. Furthermore, maturity buckets with a residual maturity of 3 to 5 years and 1 to 3 years are more affected (-0.49% and -0.38%) than shorter and longer residual maturities. When disentangling the effect for different risk mitigation haircut categories, the results show that the haircut category 5%-15% is affected the most with a -0.77% decrease in collateral value.

In a further step we take the analysis from the asset to the counterparty level. Our simulations show that small and large counterparties measured in terms of the value of their collateral pool are similarly affected. There is no clear tendency to whether smaller or larger counterparties would be more exposed to a shock in transaction costs.

Overall, the simulation results allow for the conclusion that the vast majority of counterparties will only suffer a small collateral loss due to a transaction cost shock. However, this finding at the average does not exclude that some selected counterparties suffer larger collateral losses which they may not be able to compensate if they are collateral-constrained. Thus, while on the aggregate level the economic relevance of such an effect is close to zero, or at least a minor concern compared to other potential side effects of the introduction of a transaction cost shock – including intermediation financing costs of companies etc. – it could lead to collateral constraints for individual counterparties.

In this scenario, if counterparties prefer to maintain the size of their collateral buffer after the shock they would have to submit additional collateral. Alternatively, counterparties could tolerate the increased risk of affording a smaller collateral buffer, or reduce their outstanding liquidity position vis a vis the Eurosystem. From a policy perspective, assuming counterparties hit their collateral constraint as a result of the transaction cost shock, a small increase in the list of eligible securities for monetary policy operations, or alternatively, a small reduction in the applied haircuts on certain affected assets, would probably be enough to compensate the shock.

3.6. Appendix

3.6.1. Dataset description

Variable	Description	Source
Asset type	Asset type can take on one of the following specifications: central government security, regional government security, uncovered bank bond, government-guaranteed bank bond, covered bank bond, corporate bond, asset-backed security, other marketable asset, credit claim, cash deposit, retail mortgage-backed debt instrument and fixed-term deposit. These are all asset types eligible as Eurosystem collateral.	ECB list of eligible marketable assets
Residual maturity	Residual maturity assigns the asset to a certain maturity bucket based on issuance date and maturity date.	ECB list of eligible marketable assets
Coupon frequency	Coupon frequency states whether a coupon is paid annually, semi-annually	ECB list of eligible marketable assets

	or quarterly	
Coupon structure	Coupon structure distinguishes zero, variable, fixed and inverse floater coupons structures.	ECB list of eligible marketable assets
Coupon rate	Coupon rate is the interest the coupon pays at the defined frequency.	ECB list of eligible marketable assets
Liquidity category	Liquidity category distinguishes assets according to their liquidity profiles, using the Eurosystem's classification for risk management purposes. According to this classification, each marketable asset is allocated to one of five categories depending on its issuer and asset type. Category I contains the most liquid assets, such as central government and central bank debt instruments, and category V encompasses asset-backed securities (ABS).	ECB list of eligible marketable assets
Price	Price contains the market price of the asset as it is used by the Eurosystem to calculate the value after haircut on the date of observation.	Common Eurosystem Pricing Hub
Redemption value	Redemption value refers to the face value of the asset.	ECB list of eligible marketable assets
Haircut	Haircut contains the variable that is applied by the Eurosystem when calculating the collateral value after haircut. [13]	ECB list of eligible marketable assets
Turnover	Transactions in the secondary market of 50 European exchanges or trading platforms	ECB centralised securities database

3.6.2. Illustration of asset price model

This section illustrates our simple asset price model based on three exemplary hypothetical bonds. The three bonds A, B and C and their characteristics are pictured in the table. The bonds have a residual maturity of 3 months, 1 year and 10 years respectively. They also differ in their coupon rate. The assumed yield curve is increasing with a moderate slope. The prices in this base scenario are EUR 100.20, EUR 101.00 and EUR 106.75 respectively.

Now suppose the simulation of a transaction cost shock of +0.1% with a turnover of the bonds of 5 transactions per year as scenario I. The annual cash flows of the bonds are hence calculated as the difference of the coupon payments and the transaction costs. The transaction costs are the product of the shock times the number of transactions times the average of the price in the base scenario and the redemption value. This average reflects in a very simplified way that the price of the bond converges towards the face value over time. As a consequence of the transaction cost shock, the prices of bonds A, B and C decrease to

[13] See Table 7 of the General Documentation, ibid.

EUR 100.17, EUR 100.50 and EUR 102.28 respectively. Inversely, the yield to maturity implied by the new price increases for all three securities. What may at first seem counter-intuitive, in reality reflects the higher yield demanded by investors in order to compensate for the lower revenue stream over the life time of the security. The implied yield increases strongly for the short maturities because price changes are hardly discounted over time. No second-round effects are assumed in this scenario.

By contrast, in scenarios II and III we assume a decrease of the number of transactions by 25% and 75% as a second-round effect. Hence, the negative cash flow for transaction costs decreases and the respective price and yield shocks become small in comparison to scenario I. In a more complex model, one may want to differentiate the second-round effect across residual maturities with shorter maturities suffering a bigger second round effect. This would, however, reduce the comparability of the effects across maturities what is the main intention of this example.

		Bond A	Bond B	Bond C
Base scenario	Settlement	18-Jan-14	18-Jan-14	18-Jan-14
	Maturity	18-Apr-14	18-Jan-15	18-Jan-24
	Rate	1.0%	1.5%	3.5%
	Redemption	€100	€100	€100
	Frequency	1	1	1
	Transaction cost shock	0%	0%	0%
	No. of trades per annum	5	5	5
	Effective annual trades	1.23	5	5
	Yield to maturity	0.20%	0.50%	2.72%
	Price	**€100.20**	**€101.00**	**€106.75**
Scenario I (first-round effect only)	Transaction cost shock	0.1%	0.1%	0.1%
	Effective annual trades	1.23	5	5
	Annual cash flow	€0.88	€1.00	€2.98
	Coupon payments	€1.00	€1.50	€3.50
	Transaction costs	-€0.12	-€0.50	-€0.52
	Price	**€100.17**	**€100.50**	**€102.28**
	change in price over base	*-0.03%*	*-0.50%*	*-4.19%*
	Implied yield to maturity	0.32%	1.00%	3.23%
	change in implied yield over base	*61%*	*100%*	*19%*
Scenario II (first and second-round effect: reduction of trade by 25%)	Transaction cost shock	0.1%	0.1%	0.1%
	Effective annual trades	0.92	3.75	3.75
	Annual cash flow	€0.91	€1.12	€3.11
	Coupon payments	€1.00	€1.50	€3.50
	Transaction costs	-€0.09	-€0.38	-€0.39
	Price	**€100.18**	**€100.62**	**€103.40**
	change in price over base	*-0.02%*	*-0.37%*	*-3.14%*
	Implied yield to maturity	0.29%	0.87%	3.10%

	change in implied yield over base	*46%*	*75%*	*14%*
Scenario III (first and second-round effect: reduction of trade by 75%)	Transaction cost shock	0.1%	0.1%	0.1%
	Effective annual trades	0.31	1.25	1.25
	Annual cash flow	€0.97	€1.37	€3.37
	Coupon payments	€1.00	€1.50	€3.50
	Transaction costs	-€0.03	-€0.13	-€0.13
	Price	**€100.19**	**€100.87**	**€105.63**
	change in price over base	*-0.01%*	*-0.12%*	*-1.05%*
	Implied yield to maturity	0.23%	0.62%	2.85%
	change in implied yield over base	*15%*	*25%*	*5%*

3.6.3. Elasticities of second-round effects

	Transaction cost shock -0.1%		
Transaction cost level	0.05%	0.10%	0.50%
Scenario II (-25%)	-0.13	-0.25	-1.25
Scenario III (-75%)	-0.38	-0.75	-3.75

3.6.4. Scaling of market turnover

Even for the securities in our dataset for which we do observe transactions this data covers a subset of the overall secondary market of these instruments only. In particular, over-the-counter (OTC) transactions are likely to be unobserved in the dataset. While this is a common challenge of transactions data we intend to remedy the resulting bias by scaling up the transaction volumes across the whole dataset by using information from prominent markets for which reliable information on turnover is available. We choose the three biggest secondary debt markets in the euro area (Italy, France and Germany) as reference. The public debt agencies of the three countries regularly publish the outstanding amounts as well as information on secondary market turnover. Based on this information we compute the turnover ratios for the three markets

$$v_{i,t}^{*} = \frac{V_{i,t}^{*}}{F_{i,t}^{*}},$$

where $v_{i,t}^{*}$ is the turnover ratio of the debt market of country i in period t, $V_{i,t}^{*}$ denotes turnover of the debt market of country i in period t and F_t is the nominal debt outstanding of country i in period t, where t is the year 2012. We then compute the turnover ratio based on the trading volume $V_{i,\frac{t}{4}}$ that we observe in our dataset for the period from 1 December 2012 to 1 March 2013 and the nominal debt outstanding of country i that we observe in our dataset at a point in time in the fourth quarter of 2012 $F_{i,t}$, We multiply the quarterly transaction volume $V_{i,\frac{t}{4}}$ by four to obtain annual turnover.

$$\nu_{i,t} = \frac{4 \times V_{i,\frac{t}{4}}}{F_{i,t}}.$$

Based on these variables we derive a scaling factor for each of the three countries

$$\sigma_i = \frac{\nu_i^*}{\nu_i}.$$

The average scaling factor across all three markets is defined as follows

$$\bar{\sigma} = \frac{\sum_i^{DE,\ FR,\ IT} \sigma_i}{3}.$$

The turnover observed for each single asset in our dataset is then scaled up by $\bar{\sigma}$.

3.6.5. Illustration of counterparty effects

For better illustration of the effects of a transaction cost change, we show the implications for the collateral pools of two stylised banks A and B. Both banks have a collateral pool of 100 million. Bank A is overweight on central government securities and uncovered bank bonds. Bank B is overweight on non-marketable assets and asset-backed securities. As a result, the impact for bank A is seven times bigger than for bank B.

	Eurosystem (EUR bn)			**Bank A (EUR mn)**			**Bank B (EUR mn)**		
	Base	After	*Difference*	Base	After	*Difference*	Base	After	*Difference*
Central government securities	368,400	365,055		46.4	45.9		14.6	14.5	
Regional government securities	97,700	97,654							
Uncovered bank bonds	341,800	338,512		27.1	26.9				
Covered bank bonds	488,800	488,434							
Corporate bonds	88,300	88,002							
Asset-backed securities	371,700	371,700					32.3	32.3	
Other marketable assets	95,100	94,935							
Non-marketable assets	668,400	668,400		26.5	26.5		53.0	53.0	
Difference			*-7,508*			*-0.7*			*-0.1*
Total	**2,520,200**	**2,512,692**		**100**	**99.3**		**100**	**99.9**	

Chapter 4:

A CENTRAL SIDE-EFFECT OF MUNICIPAL BUSINESS TAXATION: THE IMPACT ON LOCAL EMPLOYMENT

4.1. Introduction

This chapter aims to quantify the effect of municipal business taxation on local employment, i.e. the number of persons employed by all firms that are based in a given municipal district. The impact of local business taxation on employment has high policy relevance. First, municipal business taxation exists in many countries. Second, municipal politicians care a lot about firms creating jobs in their district to increase their chance to be re-elected. In addition, people follow jobs and hence local policy-makers care about jobs to attract residents who make their municipality prosper and grow. And third, the effects of municipal business taxation on local employment are sizable as this study will show.

The existing literature on the incidence of business taxation mainly focuses on the national level (Hassett & Mathur, 2015; Dwenger, Rattenhuber, & Steiner, 2011). Much of the newer literature in the field deals with the incidence on wages, while Dwenger, Rattenhuber and Steiner (2011) also take into account employment effects. Only few studies analyse labour incidence at the state level and even fewer at the municipal level. This is surprising given the strong policy relevance of local business taxation. Riedel (2010) finds that an increase in the local business tax rate leads to a variety of distortions and externalities, among others a reduction in payroll of enterprises. Goolsbee (2004) shows for the U.S. how the corporate tax design of different states has affected their manufacturing employment. These and other studies underline the specificities of local or regional business taxation in a remarkable way, but they fall short of quantifying the effect that a business tax at local level may have on employment in a municipal district. Section 4.2.2 provides a more detailed review of prior studies.

This chapter makes a twofold contribution. First, it estimates the effect of a change in the local business tax rate on the level of employment in a municipal district. Second, it makes a methodological contribution. Previous works on local employment effects have relied on ordinary least squares estimations that suffer from potential endogeneity. This chapter surmounts that shortcoming by using instrumental variable estimation. It instruments the local business tax rate with the lagged average tax rate of the most probable competitors. For small municipalities these are neighbouring jurisdictions, for larger municipalities, non-neighbouring jurisdictions of the same size within the same state or elsewhere in the nation.

The empirical analysis in this study is carried out for German municipalities. The data set comprises a complete panel of German municipalities between 1998 and 2008 with a total of 136,142 observations. The panel is broadly balanced and contains information on local business tax rates, employment, population, public finances and other socio-demographic and economic characteristics. The database is a compilation of a large variety of different administrative records.

The study finds that an increase in the local business tax rate affects the local level of employment negatively. The result is significant and robust across a number of different specifications, in which the local tax rate is instrumented. The preferred estimate yields that a 1%-increase in the local business tax rate entails a 1.3%-decrease in the level of local employment. Furthermore, the study argues that a change in the local business tax rate also indirectly affects the size of the population of the same municipality. As many fiscal transfers in federal nation states are linked to population size there are reasons to believe that an increase in the local business tax rate may have a negative feedback effect on the local budget. These results confirm that municipal business taxation entails a number of distortions of strong scientific and practical relevance.

The following section exhibits the motivation for this chapter and the prior literature it draws on. Section 4.3 develops a theoretical model of local employment with respect to local business taxation. Section 4.4 introduces the data set used for the econometric analysis whose methodology is explained in section 4.5. Finally, section 4.6 presents the results, while section 4.7 discusses wider implications of the findings.

4.2. Motivation

While taxes on business profits are formally levied on the return to capital, economic theory suggests that the other main production factor – labour – may also bear a considerable part of the tax burden. Hence, an ample body of literature is dedicated to analysing the effects of business taxation on labour. In this literature, two broad fields can be distinguished. Studies in the first field examine the effects of taxation on wages. Studies in the second field focus on the level of employment independent of its remuneration. This chapter forms part of the latter field and analyses the effects of municipal business taxation on the local level of employment.

4.2.1. Policy relevance

The effects of local business taxation on employment deserve attention for three reasons: (i) Local business taxation exists in many countries, (ii) municipal politicians care a lot about jobs in their district, and (iii) the effects of local business taxation on local employment are sizable and significant as this study will show. Reasons (i) and (ii) will be substantiated in the following paragraphs, reason (iii) is further substantiated in the results section of this chapter.

In many countries – most prominently in those that are organised as a federation – not only states, provinces or cantons but also municipalities enjoy the competence to levy taxes on business income. Local taxation is usually implemented by setting a common tax base at national level and leaving rate decisions to local policy makers. In Europe, several countries allow taxation of business profits at local level. In Austria, a communal tax on business profits existed until 1993 and was then replaced by the community tax (*Kommunalsteuer*), a tax on payroll. German municipalities universally levy the business tax (*Gewerbesteuer*) on profits and interest payments of resident companies. In Switzerland, municipalities in some cantons have a direct tax on business profits in place as for example the community tax (*Gemeindesteuer*) in the canton of Zurich. In the United States many localities tax the income of partnerships or even corporations.[1] In some countries, the share of the local business tax in the overall income tax burden of a company can exceed 50%. For example, some large German cities with high municipal business tax rates impose a rate of 17% while the statutory national corporate income tax rate reaches 15% only, with both rates being levied on a comparable tax base.

In countries with local business taxation, municipal politicians care about local tax levels because they are very concerned about the number of persons employed by the firms in their municipal district. They do this for three main reasons: First, politicians care about jobs in their district to increase their chance to be re-elected. Second, they care about jobs to attract residents to their municipal district. And third, as a consequence of one and two, municipalities care about jobs and inhabitants for fiscal reasons. The following sub-sections will briefly present these reasons one by one, building on evidence for German municipalities which are the empirical research ground for this study. All of these reasons can be generalised to a large degree to municipalities in other countries.

4.2.1.1. Competition for jobs

Most importantly, local employment matters for municipal politicians for political economy considerations. The shut-down of an important firm in the community and the ensuing loss

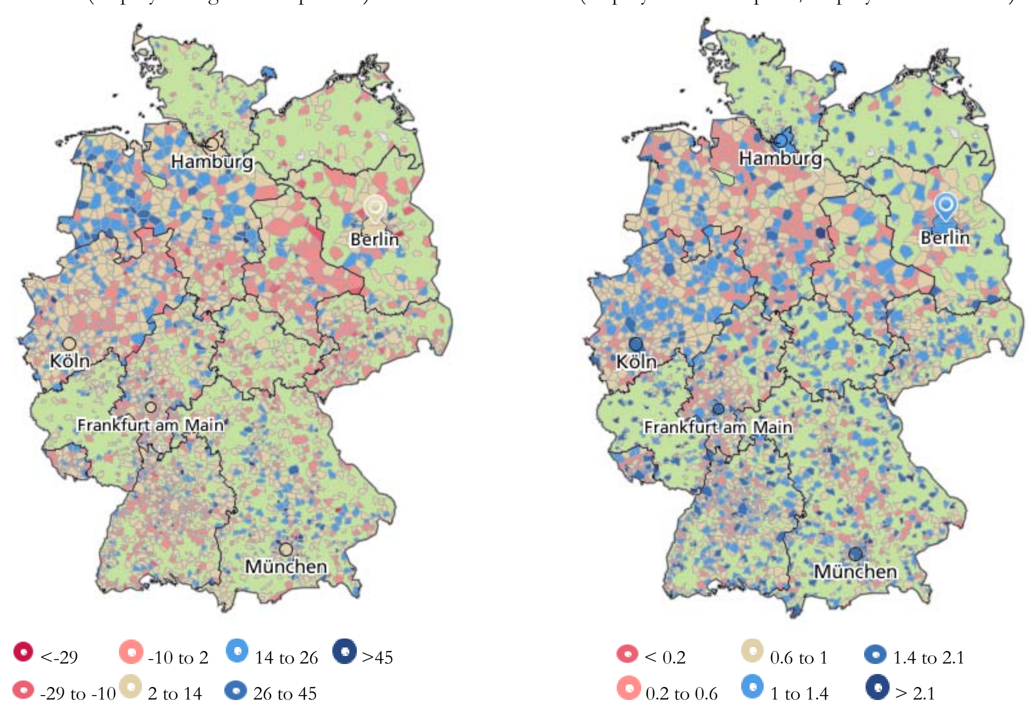
1 For more information on sub-national business taxation see European Commission (2012), OECD (2011) and International Bureau of Fiscal Documentation (2012).

of jobs will undoubtedly exert political pressure on the town hall. Vice versa, mayors and members of local councils can be sure to improve their approval rates when an employer decides to set up a plant or outlet in the community. Hence, policy makers are commonly very conscious of making policy choices that affect local employment in a positive manner. However, they are well aware of the fact that policy makers in other municipalities are trying to achieve exactly the same. Jobs are often scarce and municipalities compete fiercely for firms to create or maintain jobs in their district. For a number of reasons firms can be expected to react strongly to a change in taxation in their local municipality. The relocation of a plant or outlet is less costly in inter-municipal than in international competition. The relative geographic proximity of municipalities limits transport and travel costs as well as other distance-related costs that occur upon relocation. Furthermore, companies do not have to overcome national barriers such as language, culture or legal system when relocating to another municipality. In some cases they may even maintain their workforce upon relocation if employees are willing to accept a longer commute to a neighbouring municipality. In other words, competition for firms between municipalities is strong and the number of persons employed by firms in a given municipal district can change quite considerably.

Figure 2: Local employment dynamics in Germany

Employment growth in municipal districts 2008-2013
(employment growth in percent)

Employment centrality 2013
(employees at work place/employees at residence)



Source: Federal Employment Agency (BA), ZEFIR
Notes: Figures are given for municipalities with more than 5,000 inhabitants. Municipalities with less than 5,000 inhabitants are shaded in green.

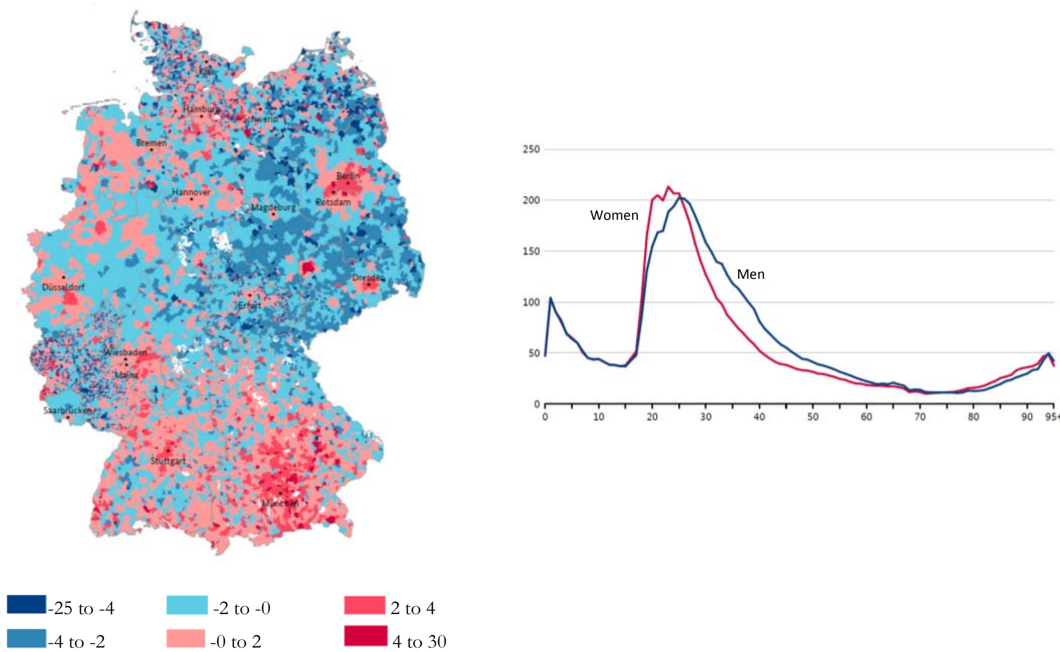
In Figure 2 the left panel shows employment growth in German municipalities in a five-year time period starting in 2008. Over this relatively short time-period, employment developments diverged strongly across municipal districts with more than 5,000 inhabitants, ranging from −29% to +45%. While these divergences are partially driven by factors that local policy makers can only influence very indirectly, e. g. fertility rates, there are other factors that policy makers can influence quite directly, such as local business tax rates. In addition to firms and jobs, people are quite flexible to work in one municipal district and live in another. This is reflected in the indicator of employment centrality which is pictured in the right panel of Figure 2. For some municipal districts the number of employees at their work place is twice as high as the number of employees at their residence.

4.2.1.2. Competition for inhabitants

Figure 3: Local population dynamics in Germany

Population growth in municipal districts 2011-2013
(population growth in percent)

Migration across age and gender 2013
(Immigration from other municipalities per 1,000 inhabitants)



Source: Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), Federal Institute for Population Research (BiB), Federal Statistical Office

Municipalities do not only want to attract jobs but also inhabitants. Inhabitants of working age and with offspring are scarce in times of ageing societies. Pressure on local policy-makers is strong not to be on the losing side of demographic change and having to close down municipal infrastructure due to a lack of funding. As "people follow jobs" (Schmidt & Große Starmann, 2006) municipal politicians have a strong interest in attracting inhabitants through job opportunities.

In Germany, competition for inhabitants is intensified by two specific demographic dynamics. First, population growth differs quite dramatically across municipalities. The left-hand panel of Figure 3 shows that population growth in 2011-2013 varied between −25% and 30%. Second, inhabitants are very mobile across municipalities. The right-hand panel of Figure 3 shows that as much as 200 women and 200 men per 1000 inhabitants at the age of around 25 years have immigrated to a municipality in Germany in 2013. In particular in this age group when young adults are mobile, jobs can be a key determinant of their relocation choice. In absolute terms, more than 3.8 million people out of roughly 80 million Germans have migrated to a different municipality in 2013.

4.2.1.3. Competition for fiscal resources

Depending on the design of the tax system, municipal policy makers may also care about jobs in their district because this increases their revenue streams from income taxation. But this is not all: When analysing local taxation it should never be neglected that tax rates are usually set in a context of fiscal equalisation mechanisms among sub-national jurisdictions. The variety of equalisation mechanisms can be organised along two dimensions: horizontal versus vertical transfers and cost versus revenue sharing[2]. These mechanisms are based on rather complex distribution formulas that often refer to two critical variables: the local tax base as measure of the municipality's fiscal capacity and the local population as measure of fiscal need. As a consequence, a decline of the local tax base may be partially compensated by an increase of equalisation transfers and vice versa. This set-up raises the question how a change in the local business tax rate affects the revenue stream of fiscal equalisation schemes. According to economic theory and empirical evidence, an increase of the municipal tax rate causes a decline of the local tax base. Depending on the equalisation scheme this may entail a decrease of the measure of fiscal capacity of the respective municipality, which could then expect a partial compensation for the shrinking of its tax base. However, this is not the only way in which a rate increase may feed through the equalisation system. A second one runs through the employment channel: In line with the results of this study, a rate increase lowers the number of employees in the municipal district. This could also have an effect on the size of the local population. Some employees may lose their jobs and decide to move somewhere else in search for a new occupation. Open positions may not be filled again and less opportunities arise for workers in search for a job to move to the municipality. Taking

[2] For more information about fiscal equalisation consult Blöchliger et al. (2007).

furthermore into account that an employee may also have dependent family members, the population decrease following a business tax rate increase may be rather pronounced. Under many fiscal equalisation schemes this would eventually result in lower horizontal or vertical transfers. In summary, the effect of a rate increase on the tax base may be compensated while the effect on the local population may contrarily be punished by lower transfers. This underlines again the importance of the empirical effects of a change in the local business tax rate on employment – and possibly the population as a whole.

All the above underlines that local policy makers need to carefully balance the budgetary objectives of taxation with possible distortions in local factor markets and possible relocations of firms. For this, they need precise knowledge, for example, about the effects of a rate change on local employment. While small municipalities may be able to anticipate those effects through bilateral exchanges with important local employers, larger municipalities have to complement this information with scientific evidence as it is produced in this study.

4.2.2. Prior literature

It is surprising how little empirical literature exists on employment effects of local business taxation in spite of their strong policy relevance. Nevertheless, a few studies have found interesting evidence on which this analysis can build. Gordon and Wilson (1986) analyse the corporate income tax in the U.S. and find incentives for firms to merge operations from different states and for states to set inefficiently low corporate tax rates. Weiner (1994) presents cross-sectional evidence suggesting that business taxation does not affect capital-labour ratios and that capital spending is hardly affected. Klassen and Shackelford (1998) find evidence for North America that sub-national taxation affects the location of sales. However, employment and property seem to be unaffected. Goolsbee (2000) makes a twofold contribution to the empirical literature by using panel data and analysing employment effects in a detailed way. He uses state-level data from the U.S. manufacturing sector between 1978 and 1994 and finds that reducing the weight of payroll in the apportionment formula from one third to one quarter increases manufacturing employment around 1.1%. Büttner (2003) analyses tax base effects of local business taxation using a panel of German municipalities. The results show a very strong impact of the local tax rate on its base. Büttner presumes that profit-shifting activities are responsible for these effects and calls for further research. Another study on this aspect was presented by Riedel (2010). She uses very valuable micro data from the German municipal business tax statistic and finds that businesses distort their payroll cost in favour of low-tax locations. Unfortunately, the data set is not sufficient to examine aggregate employment effects at municipal level because it contains a subset of businesses only. Furthermore, the study focuses on the sum of payrolls that cannot be extrapolated to employment figures that this analysis is interested in[3]. Dwenger, Rattenhuber and Steiner (2011) even show that it is necessary to take into account employment effects when analysing tax effects on the wage level. Fuest, Peichl and Siegloch (2013) produce results for German municipalities according to which a 1 EUR increase in tax liabilities yields a 0.77 EUR decrease in the wage bill.

4.2.3. Contribution

To my knowledge, no empirical evidence on aggregate employment effects of business taxation neither at state nor municipal level has so far been presented although the theoretical analysis presents pressing arguments for significant effects. As most important contribution, this study intends to close this gap and analyses employment effects in the empirical context of the German municipal business tax. The research is based on a full panel data set of all German municipalities between 1998 and 2008. Additionally, the study relies on empirical methodology that has not yet been used to examine sub-national employment effects. It uses an instrumental variable approach to dispel endogeneity concerns that are particularly dogged for local profit taxation. It implements a novel instrument derived from theory by computing a references tax rate of competing municipalities for each municipality individually.

4.3. Modelling

This section will exhibit the theoretical considerations behind the analysis of this study. It is dedicated to the construction of a theoretical model that can then be estimated with conventional econometric methods.

Basic economic theory provides all necessary tools to analyse both wage and employment-level effects of business taxation. Auerbach (2005) and Gentry (2007) have not only comprehensively summarised the relevant theory but also reviewed the classics and latest pieces in the empirical business tax incidence literature. In what is often regarded as the founding article of the field, Harberger (1962) relies on a model of an economy with two sectors, the corporate and non-corporate sectors. In this economy corporate tax is levied on the return to capital in the corporate sector only. Harberger concludes that "plausible alternative sets of assumptions about the relevant elasticities all yield results in which capital bears very close to 100% of the tax burden" (Harberger, 1962, p. 234). In this, he refers to all

[3] The sum of payroll may stay constant while the number of employees changes due to a shift in salary structure, and vice versa. Furthermore, the payroll measure used in the German context is capped at 50,000 EUR per employee and does not include profit-related bonuses (§31 Business Tax Law).

capital, not just capital in the corporate sector. Auerbach (2005) discusses the assumptions of Harberger's model, for example (1) a closed economy, (2) fixed capital and labour supply in the model economy, (3) full factor mobility between sectors and (4) competitive markets. It should also be noted that in addition to the assumptions above, Harberger's model is purely static while it would appear more realistic if, for example, factor mobility between sectors was low in the short run, but high in the long run. Hence, the more mobile a production factor, the better it can avoid the sector-specific burden of corporate taxation.

We now consider the case of municipal business taxation and translate Harberger's model to fit the objective of this study. A municipal district represents a small economy with its own tax rate on all business capital income. Assumptions (1) and (2) need to be relaxed because factors can roam freely between the open local economies. Capital and labour are instead assumed to be fixed at the national level[4]. Assumption (3), full factor mobility between sectors, does not matter any longer because municipal business taxation affects both the corporate and non-corporate sectors.[5] Assumption (4), competitive markets, is meanwhile maintained. Under the remaining assumptions, two factors determine to what degree labour shares the burden of municipal business taxation: relative labour mobility and the elasticity of factor substitution. Concerning the first factor, if capital enjoys higher mobility relatively to labour, ceteris paribus, the tax burden on labour is higher. With regard to the elasticity of substitution, the higher the substitutability between labour and capital, the lower the burden on labour because a higher output level can be maintained by substituting the fleeing capital by labour. Of course, this model simplifies reality strongly, but also more complicated general equilibrium models (Randolph, 2006; Harberger, 2008; Gravelle & Smetters, 2006) come to similar conclusions. In all models, the assumption about mobility of labour and capital is crucial: If capital is mobile and labour immobile or much less mobile, the return to labour, wages, bear a considerable part of the burden[6].

This study, in contrast to the aforementioned ones, examines the local employment level rather than wages. The reasoning, however, remains essentially the same. If capital is relocated in response to an increase in the municipal tax, the demand for labour falls, given a degree of complementarity of labour and capital and given that labour is less mobile than capital.[7] In order to test and substantiate this hypothesis, we consider an analytical model that reflects the employment choice of a firm in a multi-jurisdictional context. For simplicity we assume a single representative firm per municipal district. The firm requires input goods

4 Naturally, the analysis could be further expanded by adding additional production factors, such as land. As fixed production factor, land would bear a large part of the burden of corporate taxation. In this study, we are however focussing on the interactions between capital and labour as the two mobile production factors.

5 However, in Germany business tax essentially only applies to corporations because non-incorporated firms can deduct the business tax due from their taxable personal income.

6 Randolph (2006) finds that labour and capital bear the burden approximately according to their income shares.

7 Even if assumption (4) is relaxed and wages are sticky, firms lay off workers until a new equilibrium is reached at a lower employment level.

capital (K) and labour (L) as well as a public production factor G to produce its output good. The firm's technology is described by function F with aggregate input-output combinations for the firm as a whole. It is assumed that $\frac{\partial F}{\partial L}, \frac{\partial F}{\partial K} > 0$ and $\frac{\partial^2 F}{\partial L^2}, \frac{\partial^2 F}{\partial K^2}, \frac{\partial^2 F}{\partial L \partial K}, \frac{\partial^2 F}{\partial K \partial L} < 0$. The profit of the representative firm Π is subject to the respective municipal business tax rate τ_i where the subscript stands for municipality i. The profit function of the firm reads

$$\Pi = (1 - \tau_i)(F(K_i, L_i, G_i) - wL_i - \xi r K_i) - (1 - \xi) r K_i, \tag{18}$$

where r is the return to capital and ξ a parameter that determines the tax-deductible capital income and w is the wage level. L_i is the labour employed by the firm in municipality i and given that we assume one representative firm per municipality it also stands for the level of employment in municipal district i. The price of the output good is normalised at 1. In its production decision, the representative firm chooses the combination of L and K that maximises Π, i.e. the cost minimum. To obtain the optimal combination of L and K, Π is derived with respect to the input factors resulting in two first order conditions for local input choices.

$$\begin{aligned} \frac{\partial F}{\partial L_i} &= w \\ \frac{\partial F}{\partial K_i} &= \frac{(1 - \tau_i \xi) r}{(1 - \tau_i)} \end{aligned} \tag{19}$$

In line with common practice, a Cobb-Douglas production function is used to describe the firm's technology.

$$F(L_i, K_i, G_i) = L_i{}^{\alpha} K_i{}^{\beta} G_i{}^{1-\alpha-\beta} \tag{20}$$

Dividing the two first order conditions in equation (19) by each other, deriving the factor demand functions for L and K from (20) and plugging the latter into the quotient of the two first order conditions in equation (19) results in

$$\frac{L_i}{K_i} = \frac{\alpha r}{\beta w} \cdot \frac{1 - \tau_i \xi}{1 - \tau_i} \tag{21}$$

This expression can also be given in an additive form by taking the logarithm on both sides and bringing capital to the right-hand side.

$$\log L_i = \log \alpha - \log \beta + \log \frac{r}{w} + \log K_i + \log \left(\frac{1 - \tau_i \xi}{1 - \tau_i} \right) \tag{22}$$

Equation (22) shows a model in which the labour employed by the representative firm in municipality i is explained by α and β – the output elasticities of the production function with respect to the input factors L and K respectively – the capital employed by the firm, the relative return of the two production factors r and w as well as the local tax rate in municipality i.

We now turn to the empirical implementation of the model. Most importantly, we have assumed full factor mobility and factors can roam freely between the open municipal economies. Therefore, the return to the factors, r and w, interest rate and wages, is the same in all municipal districts at a given point in time. Hence, the term representing the relative return of the two production factors is constant across municipalities but varies over time. This assumption of full labour mobility can of course be challenged. At least in the short term, workers may not be mobile which could lead to wage differentials across municipalities. However, approximately 60% of employees are subject to some form of a collective bargaining agreement, most of which are negotiated at sector level[8]. The wage formation process of these agreements can be expected to dominate the wage formation process in most municipalities and hence the assumption of an exogenous wage rate that is the same for all municipalities is reasonably close to reality.

In the empirical specification (23) this time-fixed effect is caught by the time dummies d_t. The level of capital employed by the firm is not observed in the dataset and is hence not included in the empirical specification. The possibly resulting omitted variable bias will be overcome by the estimation methodology. Furthermore, a set of control variables is employed as well as unit and time-fixed effects. Thus, the empirical model reads

$$l_{i,t} = \alpha_i + \beta_1 \tau_{i,t} + \gamma c_{i,t} + \sum_{t=1}^{T-1} \zeta d_t + \varepsilon_{i,t}\ , \tag{23}$$

where

$l_{i,t}$ = measure of labour in municipal district i and year t,

$\tau_{i,t}$ = statutory tax rate[9] of the home municipality i in year t,

$c_{i,t}$ = vector of controls for municipality characteristics of municipality i and year t,

α_i = a unit-fixed effect,

d_t = a series of time dummies, and

$\varepsilon_{i,t}$ = the disturbance term.

[8] See DESTATIS (2010). The minimum wage was not yet applicable during the period of observation.

[9] As also argued in Chapter 2: firms' investment decisions are determined by the firm-specific marginal tax rate. However, as the firm-specific tax rate is not observed the estimation relies on the statutory tax rate.

4.4. Data

This section introduces the dataset employed for the empirical implementation of the model developed above. A detailed illustration of the variables and their sources is, however, relegated to the appendix. The dataset consists of a full panel of all German municipalities for the period from 1998 to 2008. The data is obtained through Local Statistics (*Statistik lokal*), a database provided by the Federal Statistical Office that contains information on county and municipality level originating from a variety of statistical sources. The variables used in this study are extracted from administrative records and therefore offer a high quality. The problem of missing data due to non-response hardly occurs. Nevertheless, the panel of municipalities is unbalanced. Since Reunification in 1990, several Länder, especially those in Eastern Germany, have undertaken fundamental administrative reforms, through which municipalities have been newly founded or – most commonly – merged into larger entities. In those mergers, either one municipality joins another one and ceases to exist as independent observation, or two municipalities merge into one and both disappear from the records en lieu of a new-born jurisdiction. This study follows exactly the coding of the administrative identification keys in the interpretation of these mergers. Unfortunately, the reforms in some cases reduce the number of periods over which a jurisdiction can be observed. This does, however, not fundamentally change the way in which tax rates affect business decisions. Arguments could be made that mergers reduce competition between municipalities since – from a spatial point of view – the closest location with a different local tax rate moves inherently farther away. Furthermore, a business that used to have two affiliates in two neighbouring municipalities and was able to shift profits according to developments in the tax rate now faces one and the same tax rate in both its affiliates after the merger of those municipalities. The weakening of inter-municipal competition over the sample period could dampen the effect of a rate increase on employment. This observation does, however, neither change nor invalidate the interpretation of the estimated effect that reflects an average over a wide variety of municipalities anyhow.

We now briefly review one by one the variables used in the empirical analysis and review their descriptive statistics. The number of employees at workplace (l) encompasses all persons who are employed by the affiliate of a firm located in municipality i and who are liable for social insurance contributions. It does not matter whether they are registered as resident of the respective municipality or not. In contrast to the overall workforce employed in a municipality, this figure does not include civil servants, soldiers and self-employed persons. In the context of this study, this comes in handy because government bodies are not liable for business taxation. Hence, this variable is well suited as dependent variable in this study. The descriptive statistics show that the number of local employees varies as strongly across municipalities as population. The smallest municipal districts have no employees, the municipal district with the largest work force is Berlin with 1.1 million employees. The distribution is strongly skewed.

The local statutory tax rate (τ) is levied on the tax base in each municipality[10]. It is determined by the municipal legislature and varies between 0 and 900 within the sample. Since 2004 the minimum tax rate has been universally set at 200. The pooled sample mean lies at 326. The tax-base weighted mean of the local tax base is close to, but below 400 in 2010. The simple mean increased from 321 in 1998 to 332 in 2008. These figures reflect the slow but steady upward trend in the local tax rate. The variance of the rate over time is quite low. Of the 119,600 first differences of the tax rate observed in the data set, 110,210 equal zero. This means that the tax rate remains unchanged in 92% of the observed occasions. Among the 9,390 rate changes in the entire sample, 8,566 were increases, 824 decreases. The biggest increase was 200 points, the biggest cut -300 points. These and other important control variables of the regression are reported in a table with further descriptive statistics.

Table 23: Descriptive statistics

Variable	Mean	Minimum	50th percentile	Maximum	Coefficient of variation
Number of employees	2,298	0	247	1,125,714	7.4
Business tax rate	326	0	330	900	0.1
Population	6,356	0	1,377	3,431,675	6.3
Income tax share	1,785,460	0	253,801	963,568,000	7.2
Credit expenditure	796,801	-878,553	71,943	713,088,947	10.0
Investment expenditure	1,936,231	-3,024,000	495,722	652,524,741	4.4

Notes: The coefficient of variation is defined as the ratio of the standard deviation over the mean.
Source: Statistics local, Federal Statistical Office; own calculations.

4.5. Empirical methodology

In a first step the empirical model is estimated with classical panel methods. Municipal data has the advantage over national data that it suffers less from unobserved heterogeneity. Many unobservable variables such as culture or legal framework can be captured by using estimations with fixed effects or first differences. This helps to avoid bias emanating from

[10] Tax base (*Gewerbesteuermessbetrag*) = business profit (*Gewerbeertrag*) × tax factor (*Steuermesszahl*). Until 2008 the tax factor ranged between 1% and 5% depending on business profit. Since 2009 the tax factor has lain at 3.5%. For a local tax rate of 390 the total marginal tax burden thus amounts to 13.65%.

omitted variables that do not vary across units or over time. Furthermore, additionally, the estimation in first differences can reduce bias stemming from serial correlation in the error term ε. Due to the high quality of the data, measurement error is not a predominant concern of this study. Illicit labour cannot systematically bias the results of the estimation because it does not affect the tax bill of a firm. Any random measurement error in the employment variable would be captured by the error term. Measurement error in the statutory local tax rate is unlikely.

Nevertheless, the econometric set-up suffers from two potential problems: The omission of variables that vary across unit and over time as well as reverse causation between the tax rate and the level of employment. As regards the first problem, unobserved heterogeneity is a concern in spite of the empirical setting of sub-national panel data. Most importantly, the capital employed by the representative firm as well as regional business cycles or structural impediments in the local economy may influence one of the explanatory variables, e.g. the local tax rate, as well as the level of employment and therefore cause omitted variable bias. Omitted variable bias can be dealt with by instrumenting the local tax rate $\tau_{i,t}$ with its own lags $\tau_{i,t-a}$. The second problem, reverse causation, however, is more severe. Assume a local business or affiliate decides to relocate parts of its production to another municipality in year $t-1$, thus lowering the local level of employment $l_{i,t-1}$. In response, the municipal legislature brings down the local business tax rate for the following year $\tau_{i,t}$. This in turn is likely to affect $l_{i,t}$. At the same time $l_{i,t-1}$ clearly influences $l_{i,t}$ directly and is hence an omitted variable in the regression equation for year t, causing a bias in the estimation of coefficient of $\tau_{i,t}$. This endogeneity bias cannot be solved by instrumenting the tax rate $\tau_{i,t}$ with its lag $\tau_{i,t-1}$ because $\tau_{i,t-1}$ is still correlated with $l_{i,t-1}$. Hence, either longer lags have to be chosen – raising concerns about instrument relevance – or another instrument needs to be found. This endeavour will be dealt with in section 4.5.1.

The structure of the endogeneity between l and τ also sheds doubts on the use of some more advanced estimation techniques. For example, the generalised method of moments (GMM) usually employs lags of the explanatory variable to avoid endogeneity. As a result, only lags of instruments with $t-3$ can be assumed to deliver a satisfying degree of exogeneity, while possibly suffering from weaker instrument relevance. Furthermore, GMM estimators require a large number of observations in the cross section to achieve consistency. In this study, large N can only be achieved for estimations with the whole sample, robustness checks based on sub-samples would not be possible.

4.5.1. Instrumental variable estimation

In principle, the municipal context offers a variety of possible variables that may serve as relevant instruments for the local tax rate. These are predominantly budgetary variables. Büttner (2003) analyses the effects of the local tax rate on the local tax base and argues that grants and other predetermined budget variables are very useful instruments for the tax rate. As the size of grants is largely outside the control of municipal policy makers, they can be regarded as exogenous shock to the local budget. This line of arguments, however, cannot be transferred to the present study because it uses local employment rather than the local tax base as dependent variable. Many grants are essentially per-capita payments that are sensible to shocks in the size of the municipal population. Unfortunately, the same is true for the local number of employees. It is quite likely that grants as instrument and the dependent variable are jointly driven by unobserved shocks to the size of population that cannot be sufficiently controlled for by including the local population as additional control variable. As a consequence predetermined budget variables such as grants should be regarded as inadequate instruments in an estimation including local employment.

Therefore, this study strives to exploit a different source of exogenous variation, which is found in the structure of the inter-municipal tax competition. An inspection of the dataset reveals two basic observations about the co-movement of tax rates in German municipalities. First, the tax rate increases with the population size of the municipality. The literature explains this with the market power of larger agglomerations which results in an urban business tax premium (Epple & Zelenitz, 1981; Hoyt, 1992; Seitz, 1995). Second, the tax rates of small municipalities located within the same county seem to respond to changes in their neighbours' tax rates. These or similar observations have been made by authors analysing municipal tax competition in Germany. For example, Büttner (2001) estimates the effect of a municipality's neighbouring tax rates on its own rate using an instrumental variable approach. Furthermore, Janeba and Osterloh (2013) explore the structure of tax rate competition in detail and find that the intensity of competition can mainly be explained by the size and location of the jurisdiction. Riedel (2010) underlines that "affiliates of a multi-jurisdictional group are usually not located in neighbouring communities but are settled around 100 kilometres apart on average".

The instrument used in this study is constructed based on the two above observations and the related literature. It should be underlined that the instrument does not need to fully reflect all aspects of inter-municipal tax competition in order to be an adequate instrument, fulfilling the criteria for a relevant and exogenous instrument. Section 4.6.2 will argue in more detail why the chosen instrument is both relevant and exogenous.

As a first step, municipalities of a similar population size are classified in six groups as indicated in Table 24. As a second step, a reference group is defined for each municipality.

For the municipalities in group 1 the reference group are all municipalities in the same county (*Landkreis*). For group 2, the reference group are all municipalities in the same administrative district (*Regierungsbezirk*) or the same state (*Land*) if the state is small and does not have districts. The cut-offs between size groups were chosen in order to ensure comparable size of the reference groups while deviating as little as possible from the administrative territories. As a result, it cannot be guaranteed that the cut-offs appropriately reflect the structure of inter-municipal competition. Several different cut-offs were used for robustness checks. Changing the cut-off can influence the significance of estimations results. However, as emphasised before, it does not matter whether the competitive structure is reflected precisely as long as the instrument is relevant and exogenous. As a third step, a reference tax rate is computed for each municipality, which is the average of the local tax rates of all municipalities within the reference group except its own tax rate.

$$\tau_i^r = \sum_{j \neq i} \frac{\tau_j}{N_{g,m}} \tag{24}$$

where

i, j = municipalities of group g in reference region m,

τ_i^r = reference tax rate for municipality i,

τ_j = tax rate of municipality j, and

$N_{g,m}$ = number of municipalities of group g in reference region m.

The municipality groups (g) and their respective reference regions (m) are defined as pictured in Table 24.

Table 24: Municipality size groups and reference regions

Group	Population size	Reference region
1	0 – 10,000	County
2	10,001 – 20,000	Administrative district (or state if state is small)
3	20,001 – 40,000	State
4	40,001 – 140,000	Five zones composed of one or several states each *(see notes section)*
5	140,001 – 200,000	Germany
6	200,001 – max	Germany

Notes: Zone 1: Schleswig-Holstein, Hamburg, Lower Saxony, Mecklenburg-Vorpommern; zone 2: North Rhine-Westphalia; zone 3: Hesse, Rhineland-Palatinate, Saarland; zone 4: Berlin, Brandenburg, Saxony, Saxony-Anhalt, Thuringia; zone 5: Baden-Württemberg, Bavaria
Source: Own grouping

4.6. Results

The results section is structured in a way that allows comparing the preferred estimate with conventional methods in size and quality. Therefore, sub-section one briefly presents a set of estimations produced with conventional techniques. Sub-section two describes the preferred estimate and sub-section three is devoted to a number of robustness checks.

4.6.1. Conventional fixed-effects and instrumental variable estimates

The results of the conventional estimations are pictured in Table 25. The dependent variable is the logarithm of the number of local employees. The fixed-effects estimation in column 1 shows no significant effect of the local tax rate on labour. This does not surprise because the validity of this estimate is subject to a variety of concerns as outlined in the empirical section. Columns (2) and (3) rely on instrumental variable methods and are produced with a two-stage least squares estimator. The twice-lagged local tax rate serves as instrument. The first-stage F-statistic is of satisfactory size to assume instrument relevance. Furthermore, all variables are used in first differences because this eliminates fixed effects and deals more efficiently with serial correlation in the error term. This is also the reason why the number of observations drops. The drop may seem very large in view of the long sample period, it must however be recalled that a considerable number of communities are not observed for the whole sample period due to administrative reforms, especially in Eastern Germany. Both estimations yield a similar effect of the local tax rate on employment. As both dependent and independent variables are measured in logarithms, the coefficient can be interpreted as elasticity. According to theses estimations, an increase in the tax rate by 1% results in a decrease of the number of employees by 0.8%. These estimates seem realistic in size and are statistically significant. Also the coefficient on the control variable population size seems realistic in view of the approximate rate of employment of roughly 50%. Hence, an increase in the population by 1% results in an employment increase of roughly 0.4 percent. For comparison, the table also reports results from a System-GMM estimation. The System-GMM estimator is designed to employ lags two to five of the local tax rate in the differenced equation and lag one in the level equation. The size of the coefficient remains quite stable, even when including the level of local credit and investment expenditure as further control variables. However, as elaborated earlier, even the use of the twice lagged local tax rate suffers from potential endogeneity. The instrument is not valid if the error term has any form of autocorrelation other than MA(1).

Table 25: Classic IV and FE estimation

	(1) FE	(2) 2SLS	(3) 2SLS	(4) System-GMM	(5) System-GMM
D.Local tax rate		-0.827^{***} (0.181)	-0.778^{***} (0.180)		
Local tax rate	−0.011 (0.039)			-0.828^{***} (0.244)	-0.768^{***} (0.181)
Population	0.940^{***} (0.044)			1.331^{***} (0.017)	1.573^{***} (0.042)
D.Population		0.433^{***} (0.050)	0.432^{***} (0.051)		
Local income tax share	0.011 (0.012)			−0.014 (0.010)	-0.204^{***} (0.032)
D.Local income tax share		0.010 (0.010)	0.010 (0.010)		
Time trend				0.000 (0.000)	0.000^{***} (0.000)
D.Time trend			0.000 (0.001)		
D.Credit expenditure					0.125^{***} (0.181)
D.Investment expenditure					0.100^{***} (0.181)
Constant	-1.278^{***} (0.434)	0.022^{***} (0.002)	0.014 (0.021)	0.500 (1.342)	0.761 (1.217)
Observations	119,652	78,141	78,011	119,652	68,044
R^2	0.069				
1st stage *F*-statistic		69.564	66.237		

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; instruments: 2SLS: twice-lagged local tax rate in levels; GMM: lags two to five of local tax rate for the differenced equation and lag 1 for the level equation.

Source: Statistics local, Federal Statistical Office; own calculations

4.6.2. Instrumentation with the reference tax rate

As a remedy to the disadvantages of instrumenting with lags of the local tax rate, the empirical section developed an alternative instrumental variable: a reference tax rate of competing municipalities. This new instrument is now used to expand the conventional estimations. The results are pictured in Table 26. In column one, the contemporaneous reference tax rate is employed. The poor and insignificant point estimate suggests that the instrument is not valid. This would be in line with expectations from economic theory because a municipality would very likely not be able to react to a change of their competitor's tax rate within the same year, taking into account the duration of the political and legislative process surrounding such a decision. From a theoretical perspective, using the reference tax rate instrument lagged once or twice is hence more appropriate. The relevance of the instrument is furthermore confirmed by the first-stage F statistic. In order to be not only relevant but also exogenous the instrument must also fulfil the exclusion restriction. This means that the reference tax rate of competing municipalities should not have a direct effect on the level of employment in the home municipality. And indeed it is very unlikely that a firm would reallocate employees to a competing municipality within the same or the following year for two reasons. First, the relocation of a firm that is so far only present in the home municipality to the competing municipality requires a significant amount of lead time for a thorough economic analysis, the purchase or rental of property, construction or remodelling of its new premises, a number of administrative procedures and possibly the shedding or recruiting of employees. Even for firms that are already present in both municipalities, the relocation of employees and their related tasks, functions and infrastructure will require time. Second, it is quite likely that a firm will not immediately react to the lowering of a tax rate in a competing municipality but would rather wait whether the home municipality may follow the decision by the competing municipality and also lower the home tax rate. For many firms lobbying their own town hall to lower tax rates would be much cheaper than actually relocating to another municipality. Therefore, the reference tax rate lagged once can be regarded as exogenous instrument that satisfies the exclusion restriction.

In columns (2) and (3), the reference tax rate is lagged once. Model (2) is estimated with a full set of control variables and yields a tax-elasticity of employment of -1.3%. The result in (3) yields a slightly lower estimate but omits the important control variable of the local income tax share which captures cyclical variation. In comparison with the estimates in Table 25, this estimate is considerably higher, suggesting that the true effect of the local tax rate on employment is somewhat disguised by endogeneity bias inherent in conventional models. Columns (4) and (5) of Table 26 confirm the size of column (2) when employing lags $t-2$

as well as $t-1$ and $t-2$ respectively. The estimate of the population coefficient maintains its size. The remaining control variables are reported for information, they do not affect the results. However, the use of the twice-lagged reference tax rate as instrument in columns (4) and (5) may be subject to exogeneity concerns. Subsequently, the results in column (2) are thus referred to as the preferred estimate.

Table 26: Instrumentation with reference tax rate

	(1) 2SLS	**(2) 2SLS L1**	**(3) 2SLS L1**	**(4) 2SLS L2**	**(5) 2SLS L1-L2**
D.Local tax rate	−0.063 (0.102)	−1.344*** (0.482)	−0.998** (0.423)	−1.238* (0.716)	−1.208*** (0.451)
D.Population	0.543*** (0.044)	0.526*** (0.053)	0.486*** (0.049)	0.528*** (0.058)	0.528*** (0.058)
D.Local income tax share	0.054*** (0.012)	0.035** (0.014)		0.007 (0.015)	0.008 (0.014)
D.Time trend	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
D.Credit expenditure	0.000 (0.000)	0.000 (0.000)		0.000 (0.001)	0.000 (0.001)
D.Investment expenditure	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.001** (0.001)	0.001** (0.001)
Constant	−0.001*** (0.021)	0.000* (0.021)	0.003 (0.021)	0.007 (0.021)	0.007 (0.021)
Observations	66,996	59,750	66,744	52,740	52,740
1st stage *F*-statistic	840.35	102.75	141.25	47.39	56.74

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; instruments: reference tax rate in first differences with the following lags: (1) L0, (2) and (3) L1, (4) L2, (5) L1 and L2.
Source: Statistics local, Federal Statistical Office; own calculations

4.6.3. Robustness checks

After the identification of a preferred estimate, this result is checked for robustness with respect to a variety of crucial assumptions. Column (1) of Table 27 repeats the preferred estimate. Column (2) shows the same estimate but for municipalities in zone 5 only, namely the states of Baden-Württemberg and Bavaria. The estimate remains rather stable. Column (3) again repeats the same estimation model but only for municipalities of group 6, i.e. smaller than 10,000 inhabitants. The estimate drops slightly but is broadly confirmed. For both columns (2) and (3) it must however be remarked that these are sub-samples with relatively good performance. Not all sub-groups can deliver credible results for various reasons. For example, the groups with larger municipalities suffer from a much smaller N which poses efficiency as well as consistency problems.

Table 27: Robustness checks

	(1) Base line	(2) Zone 5 only	(3) Small
D.Local tax rate	-1.344^{***} (0.482)	-1.142^{*} (0.688)	-1.270^{**} (0.502)
D.Population	0.526^{***} (0.053)	0.302^{***} (0.065)	0.524^{***} (0.054)
D.Local income tax share	0.035^{**} (0.014)	0.040^{**} (0.017)	0.036^{**} (0.014)
D.Time trend	0.001 (0.001)	0.002^{**} (0.001)	0.001 (0.001)
D.Credit expenditure	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)
D.Investment expenditure	0.002^{***} (0.001)	0.000 (0.001)	0.002^{***} (0.001)
Constant	0.000 (0.021)	−0.027 (0.023)	0.007 (0.023)
Observations	59,750	26,640	56,672
1st stage *F*-statistic	102.75	38.04	96.16

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; instruments: reference tax rate in first differences with the following lags: (1), (2) and (3): L1.

Source: Statistics local, Federal Statistical Office; own calculations

4.7. Local business taxation and fiscal federalism

In line with the discussion in section 4.2.1.3 there are two channels through which a change in the local tax rate may influence equalisation transfers between municipal districts. First, according to economic theory an increase of the municipal tax rate causes a decline of the local tax base, which in turn may lower the measure of fiscal capacity of the fiscal equalisation system. Hence, the transfer payments increase. The marginal cost of increasing the local business tax rate, meaning the downwards distortion of the local tax base, is therefore only partially internalised by the municipality. Theoretically, this feedback mechanism entails inefficiently high municipal business tax rates (Smart, 1998). Empirically, this first feedback channel is rather well documented, a recent and encompassing study for German municipalities has been presented by Büttner (2006).

The second suspect feedback loop from the tax rate to the revenue side of the local budget runs through the level of employment. As argued in the theoretical analysis above, there are strong arguments for an effect of a municipal business tax rate change on the number of local employees. Based on this, it is argued that a change in the local employment level also affects the size of the municipal population. When job opportunities within a town decrease, it is unlikely that workers and their families will move to this town in search for or holding a job offer. Additionally, employees who have lost their position may decide to move to another town if they do not find a new job nearby within an acceptable duration of time. Although overall local migration patterns can obviously only partially be explained through this reasoning, a pattern along this line becomes apparent. Assuming that an increase in the municipal tax rate causes the population to shrink, this would be reflected in a decrease of inflowing vertical and horizontal transfers. This observation about the second feedback channel is interesting because it partially contradicts the first channel developed by Smart, Büttner and others that fiscal equalisation leads to inefficiently high tax rates. Municipalities would partially internalise the costs of a rate increase through lower transfers. If the effect on population size is strong, for example because entire families move when the head of household is laid off, municipalities might even over-internalise the cost of taxation and consequently set inefficiently low municipal corporate tax rates. Goolsbee (2000) has detected a similar reaction for the North American corporate income tax on state level: they find evidence that a lowering of the state CIT rate entails revenue losses but generates additional employment at the same time, creating an indirect revenue source through the personal income tax. Even if the feedback of a tax rate change through employment to public finances is weak, municipalities cannot neglect potential population effects of local taxation in times of ageing societies[11]. Therefore, this second feedback channel of local taxation deserves closer empirical investigation.

4.8. Conclusion

The empirical investigation confirms the theoretical expectation that an increase in the local business tax rate affects the local level of employment negatively. The result is significant and robust across a number of different specifications, in which the local tax rate is instrumented. As instrument the study computes a reference tax rate for each municipality that is an average of competing municipalities' tax rates. The preferred estimate yields that a 1%-increase in the local business tax rate causes local employment to decrease by 1.3%. In addition, the study indicates that a change in the local business tax rate may also indirectly affect the size of the municipal population. As many fiscal transfers in federal nation states are linked to population size there are thus reasons to believe that an increase in the local business tax rate may have a negative feedback effect on the local budget.

These results underline in a very tangible way that municipal business taxation entails a number of distortions that go considerably beyond the well-known effects on the tax base. It

[11] Municipalities are expected to face considerable challenges in the context of demographic change over the next decades. Geys et al. (2008) assess local government's vulnerability to fiscal consequences of this development, especially with respect to the cost of public infrastructure.

shows that employment effects on municipal level are quantifiable and considerable in size. For instance, if a municipal district with 10,000 employees decided to increase its tax rate from 15 to 17% (a 13-percent increase) this would result in a loss of 1,690 local jobs. This finding establishes serious limitations to the viability of local profit taxation as an appropriate and effective instrument for local revenue raising. If local revenue autonomy strongly depends on business profit taxation, as it is currently the case in Germany, the concept of local fiscal autonomy is essentially revealed as an illusion because the hands of local politicians are tied by very large potential job losses and possible feedback effects through the fiscal equalisation system. The destiny of local public finances thus ultimately lies in the hands of superior layers of government.

4.9. Appendix

All variables in the dataset are extracted from Local Statistics (Statistik lokal). This collection is compiled by the Federal Statistical Office and makes use of a variety of administrative records. It contains roughly 330 attributes for more than 12,000 municipalities in Germany (Statistische Ämter des Bundes und der Länder, 2011).

Table 28: Employees at workplace

Characteristic	**Value**
Code in Statistik lokal	254-21
Original source	Employment Statistic
Original supplier	Federal Employment Agency
Date of observation	30 June of each year
Further information	Quality report: http://statistik.arbeitsagentur.de/Statischer-Content/Grundlagen/Qualitaetsberichte/Generische-Publikationen/Qualitaetsbericht-Statistik-Beschaeftigung.pdf (German only); Glossary: http://statistik.arbeitsagentur.de/Statischer-Content/Grundlagen/Glossare/Generische-Publikationen/BST-Glossar.pdf (German only)

Table 29: Employees at residence

Characteristic	**Value**
Code in Statistik lokal	254-13

Original source	Employment Statistic
Original supplier	Federal Employment Agency
Date of observation	30 June of each year
Further information	Quality report: http://statistik.arbeitsagentur.de/Statischer-Content/Grundlagen/Qualitaetsberichte/Generische-Publikationen/Qualitaetsbericht-Statistik-Beschaeftigung.pdf (German only); Glossary: http://statistik.arbeitsagentur.de/Statischer-Content/Grundlagen/Glossare/Generische-Publikationen/BST-Glossar.pdf (German only)

The difference between the previous variable and this one indicates whether the municipal district is a net-supplier or net-demander of labour. Net-suppliers are predominantly residential areas with large firms, net-demanders are communities with few residents or with one or several large employers.

Chapter 5:
CONCLUSION

5.1. Main results

This dissertation set out to show how the specific design of a business tax causes particular factor market distortions, which in turn determine the incidence of that tax on the various production factors. In this regard, a number of overarching results can be derived from this thesis as a whole. First, all three empirical analyses find that the effects of business taxation on factor markets are sizeable and in some occasions even bigger than those ensuing from previous empirical studies. Second, the analyses give rise to new evidence that confirms concerns about the applicability of estimated average effects of a tax on a factor market due to strong heterogeneity at the micro level. Finally, all chapters deal with empirical applications that display that minor details in the design of a specific tax can fundamentally influence the incidence of that tax through factor market distortions. The conclusions constitute yet another rejection of Harberger's hypothesis that the incidence of capital taxation falls predominantly on capital owners. Instead, labour may in some settings bear a significant share of the burden. The following paragraphs will relate each of these three overall results to the findings of the individual chapters one by one.

Chapter 2 of the study has argued that previous theoretical and empirical research has disregarded or underestimated the importance of tax losses in lowering firm-specific marginal tax rates. This leads to a classical error-in-variables problem, which attenuates the estimate of the user cost elasticity and cannot be remedied by instrumenting with lags of the user cost of capital. This attenuation bias is overcome by using tax return data that contains actual tax losses. The preferred baseline estimate for the elasticity of capital with respect to its user cost yields −0.52. In an additional step, it is shown that the user cost elasticity declines to −0.37 when employing a user cost variable that does not include losses and loss carry-overs. The difference in the two point estimates is not statistically significant but it suggests that, on average, the effect of CIT on factor markets is even bigger than previous literature has claimed. In a similar vein, chapter 3 shows that an increase in the cost of transaction for financial instruments does not stop at lowering the market value of debt instruments in capital markets. In addition, such asset price changes entail a decline in the value of collateral submitted by financial institutions to the central bank as well as other business partners. As a consequence, the access of financial institutions to central bank liquidity may be constrained, in particular in times of dysfunctional interbank money markets and a fixed-rate full allotment policy of the central bank. Ultimately, this leads to a further increase in the cost of capital: Beyond the asset price change itself, the funding cost of banks increases because more collateral has to be provided to the central bank. Chapter 4 of the thesis tackles yet another effect of business taxation on factor markets. It confirms the theoretical expectation that an increase in the local business tax rate affects the local level of employment negatively. The preferred estimate yields that a 1%-increase in the local business tax rate causes local employment to decrease by 1.3%. These results underline in a very tangible way that municipal business taxation entails a number of distortions not only in capital but also labour markets. In addition the thesis exhibits the quantitative importance of the effect on local labour markets. For instance, if a municipal district with 10,000 employees decided to increase its tax rate from 15% to 17% (a 13-percent increase) this would results in a loss of 1,690 local jobs. In summary, all three chapters underline that effects of business taxation on factor markets are strong and possibly even bigger than previously estimated.

In a second string of results, all three chapters of the thesis present evidence about the applicability of estimated average effects of a tax. Variation among economic agents at the micro level is very large and hence the average treatment effect can deviate significantly from the action of the individual agent. This issue presents itself as particularly intricate in the application of chapter 2. To recall, in Germany roughly 60% of corporations either suffered a loss (40%) or used a tax loss carry-forward or carry-back to offset current profits (20%) in 2004. The majority of corporations do not pay any corporate income tax at all. Moreover, it is shown that corporations' tax-exhaust status is very persistent over time. Hence, a significant amount of corporations are non-taxable for an extended period of years and cannot be expected to react to any incentives set by the tax systems as suggested by the estimated effects. On the other hand, the corporations that remain taxable could react more strongly. This must be taken into account when assessing the effects of a change in the tax rate on investment and capital markets. Chapter 3 also underlines that heterogeneity at the micro-level matters. The microsimulation exploits both financial asset and bank characteristics in order to show the possible effect of a change in transaction cost on the value of Eurosystem collateral. The change of the price of an asset in response to variation in the transaction cost for such an asset depends crucially on the characteristics of that asset. Furthermore, the pools of financial collateral that financial institutions maintain with the Eurosystem to secure their uptake in monetary policy operations are composed heterogeneously and also the level of over-collateralisation of banks varies. It cannot be excluded that single counterparties facing collateral scarceness may experience constraints in their access to central bank liquidity due to a tax-induced change in asset prices. In the application of chapter 4, heterogeneity at the micro level is less predominant as the units of observation are larger, i.e. municipalities rather than individuals, assets or corporations. In fact the dissertation shows that the effects for small municipalities with less than 10,000 inhabitants are not significantly different from the effects for the full sample. The financial situation of the municipality seems to be irrelevant as well because variables such as credit or investment expenditure are not significant or significant with very small effects in the estimations. Nevertheless, the effect of a business tax on local labour markets can be expected to depend on the characteristics of the local work force.

Finally, all three chapters show that minor details in the design of a specific tax can fundamentally influence the incidence or distortionary effects of that tax. In chapter 2 it became apparent how a relatively generous scheme that allows carrying forward losses into the future without size and time limits can fundamentally influence the taxability status of a large number of corporate tax payers. In response to this situation, policy makers introduced the so-called "minimum taxation" (*Mindestbesteuerung*), restricting the use of tax loss carry-forward in volume[1]. This seemingly minor amendment of the tax code leads to a change in the taxable status for many corporations and, hence, to possible implications for investment and capital markets. A general statement on the factor incidence of a corporate income tax can hence not be made. For chapter 3, it can also be illustrated that the specific design of a transaction tax can deal with possible market distortions. For example, the differential impact of a transaction tax on instruments with differing maturities can easily be compensated by scaling the tax rate with the duration of the taxed transaction. Thus instruments with short maturities need not bear a disproportionate burden of a flat tax on the transaction value.

Chapter 4 shows how the design of apportionment formula that is used to allocate the tax base to sub-national jurisdictions is pivotal in determining the tax effect on the local labour market. In the German application that is examined in that chapter the apportionment formula exclusively relies on the local sum of payroll. While apportionment only applies to the 135,274 multi-jurisdictional enterprises or 5% of all business tax payers, their taxable profits represent no less than 52% of the national tax base. Consequently, the effects on local employment are considerable.

5.2. Policy implications

The analyses of this dissertation allow deriving a variety of policy conclusions. The results imply that policy makers should engage in advanced empirical analysis of the effects and incidence of a tax policy on factor markets rather than trusting results generated for different empirical settings. If insufficient empirical data on a measure is available, microsimulation can help to assess the consequences of heterogeneity of taxed subjects at the micro level. The study also suggests that policy makers can actively steer the incidence of the tax on

[1] Under "minimum taxation" only up to EUR 1 million of profits are fully deductible against a tax loss carry-forward; exceeding profits can be offset up to 60%.

production factors by making specific design choices for the tax without altering the general policy objective.

More specifically, the results suggest that income tax incentives set by policy makers to encourage business investment might, on average, be more effective than some earlier studies have claimed. These effects hold in principle in either direction, i.e. raising and lowering the tax level. A lowering of the marginal tax rate should encourage a stronger boost of investment activities by firms than previously assumed. At the same time, however, policy makers have to expect a larger dampening of investment when taxes on business income increase. Moreover, tax payers may find themselves in fundamentally different legal and economic tax regimes, such as taxable versus non-taxable. As a consequence average effects provide a rather unreliable reference point for decisions in the policy world, especially if policy makers are interested in the investment effects for a specific group of businesses. In this regard, the dissertation underlines the results of earlier work (Dwenger N. , 2009) about the drawbacks of excessive tax losses carried forward. In essence, such large stocks reduce the amount of taxable business profits for years to come in a rather unpredictable way. Ex ante, fiscal authorities are uninformed whether future profits will fall on firms with or without carry-forward. In Germany, the legislator has decided to limit the use of carry-forward ex post at the stage of deductibility. Alternatively, limiting the carry-forward at the origin, either by volume or by duration, could be more effective from an economic perspective. Last but not least, all those considerations must be seen in an international context. In spite of the large mobility of corporate profits across borders, rules for loss deductibility vary strongly across countries. A further international harmonisation of the corporate income tax base, at least in Europe, may hence reduce uncertainty for policy makers and compliance costs for tax payers.

In addition, the results of this dissertation underline that indirect taxes in financial markets can be one among many factors contributing to the scarcity or decline of liquid, high quality collateral. A transaction cost shock by itself is unlikely to have a system-wide effect on the access to liquidity. However, an upward transaction cost shock that occurs simultaneously with a market or regulation-induced shortage in collateral assets could hamper the access of financial institutions to central bank liquidity. The central bank could then of course pre-empt a collateral shortage by making additional collateral eligible for monetary policy operations. As most of high-grade collateral is already central bank eligible, such a move could entail a shift to collateral assets with higher credit risk that would have to be compensated with appropriate haircuts. This in turn could increase asset encumbrance on banks' balance sheets. All these effects on central bank collateral policy and monetary policy implementation can however be mitigated by designing the tax in a way that reduces distortions across market segments and maturities.

Finally, this doctoral thesis underlines that local business taxation causes various distortions that go considerably beyond the well-known effects on the tax base and also affect local employment. While local tax practitioners have long been aware of these side-effects, the consequences for the set-up of local business tax as a whole have been understated. The considerable size of the effects of municipal business tax rate decisions on local employment in fact poses serious limitations to the practicability of local profit taxation as an appropriate and effective instrument for local revenue raising. If local revenue autonomy is strongly dependent on business profit taxation, as it is currently the case in Germany, the concept of local fiscal autonomy is essentially revealed as an illusion. Only cities with a very strong competitive advantage can maintain a satisfactory degree of fiscal autonomy (Janeba & Osterloh, 2013). The policy objectives of ensuring both fiscal equivalence and fiscal capacity at the local level seem to be strongly conflicting. In particular, a fiscal equalisation system can fully countervail fiscal equivalence ex post. Therefore, it could be considered to build communal finances on two incentive-compatible blocks. Basic unconditional per-capita grants from a higher level of government can ensure the provision of a certain minimum of public infrastructure. Beyond that, communities may have the competence to levy additional local taxes (Simmler & Walch, 2011). This shows that the destiny of local public finances ultimately lies in the hands of higher layers of government.

5.3. Future research

A fundamental observation of this dissertation is that tax policy requires empirical analyses of each and every policy undertaking that can take into account the specific circumstances of the case at hand. This of course relies heavily on the availability of relevant data. Very often, the research on tax policy is constrained by the unavailability of tax return data at the micro level. As chapter 2 has shown, the approximation by publicly available information does not suffice. In essence, the phenomenon of non-taxability of a business due to large stocks of losses carried forward continues to be understudied because of the unavailability of data. From a methodological perspective, it would be sensible to relax some of the constraints on the production function that chapter 2 relies on, in particular constant elasticity of substitution. This could yield different results because the optimal capital stock would no longer be independent of the wage rate.

The literature on the effects of transaction taxes and hence transaction cost changes on asset prices could benefit from further research in two particular areas: First, the literature has so far focused mainly on equity markets when estimating the price elasticities of securities to transaction cost shocks (see Hawkins and McCrae (2002), Hu (1998), Schwert und Senguin (1993), Bond and al. (2004) and Oxera (2007)). Hardly any studies are available for bond markets although they constitute the backbone of capital markets for debt instruments. Second, studies on turnover data as well as data for OTC trades remain scarce. Further research in both areas could also improve the first and second-round effect estimates that were provided in this dissertation respectively.

The study of local business taxes would in particular profit from a more refined analysis of local factor markets. This applies in particular to local labour markets that can be assumed to be geographically segmented, at least in the short term. Such a study could be further extended to the real estate market, which is another important production factor market for local businesses.

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ENGLISH SUMMARY

Taxation of businesses is an important source of public revenues in many countries. In the United States, the corporate income tax accounted for 9.9% of total receipts on federal level and for 1.3% of gross domestic product (GDP) in the fiscal year of 2012. In Germany, the corporate income tax and the federal share in the business tax stood at 3.3 % of total federal receipts at the federal level and at 0.4% of GDP. These figures underline that direct taxation of businesses continues to generate sizeable income streams to governments' budgets despite a general tendency of declining corporate tax revenues. In addition, businesses are sometimes taxed for their consumption of production factors.

Further to fulfilling a revenue objective, taxation of businesses is also widely believed to contribute to society's equity. On average, individuals at the top of the income distribution earn a larger share of their income from business activity and capital income (Bach, Corneo, & Steiner, 2009) and are hence held to bear the main burden of business taxation. This popular wisdom has repeatedly become apparent in public outcries about tax avoidance strategies of international corporations. More recently, expectations have been raised that even indirect business taxation can contribute to societal equity or limit excessive business activity. One example is the discussion of a possible financial transaction tax in the European Union.

In economic research, the view that taxation of businesses is paid for by capital owners also has prominent support, in particular in the field of corporate income taxation. Most notably, Arnold C. Harberger stated in what is regarded as the founding article of the corporate tax incidence literature that "it is hard to avoid the conclusion that plausible alternative sets of assumptions about the relevant elasticities [of substitution between production factors] all yield results in which capital bears very close to 100% of the tax burden" (Harberger, 1962, S. 234). Harberger derived his findings from a general-equilibrium model inspired by the field of international trade and by researchers such as Heckscher, Ohlin, Stolper, Samuelson, Metzler and Meade. The model assumes an economy with two competitive sectors, the corporate and the non-corporate sector, in which both sectors have the same two production factors. Incidence of the corporate income tax in the model is analysed through the changes in factor and product prices in both industries. Most importantly, Harberger finds that all capital – not just capital in the corporate sector – bears the burden of the tax and that the allocation of capital is distorted towards the untaxed non-corporate sector.

Harberger's findings sparked the emergence of a new field of literature that thoroughly examined his results and their sensitivity to the underlying assumptions. The literature is summarised, for example, in a review of tax incidence in general (Fullteron & Metcalf, 2002) and of corporate tax incidence specifically (Auerbach, 2005). In particular, the assumptions about mobility or immobility of production factors across borders are crucial as Harberger himself shows in a variant of this study (Harberger, 1995).

Many studies in the field and adjacent literature share the characteristic that the distortions in factor markets caused by business taxation determine the distribution of incidence. The variety of findings concerning incidence is hence driven by the variety of different factor market distortions. In theoretical studies, results are driven by assumptions on the factor markets. In empirical studies, the results are driven by the actual design of the tax that is under analysis and its provisions regarding tax base, rate, profit allocation to local subsidiaries, market size, available substitutes, etc. In this regard, it should be noted that the variety of taxes on business in the empirical world is much broader than the simple national corporate income tax in Harberger's seminal paper. In many cases, the definition of the tax base goes beyond taxation of capital income and also includes elements such as payroll or even turnover. Alternatively, the tax base sometimes includes capital income only but then profits are allocated to sub-national jurisdictions via apportionment formulas that make use of turnover or factor variables.

Naturally, all these tax characteristics alter the incidence structure immensely. Hence, each tax must be analysed individually against the background of theoretical findings and the empirical set-up in order to derive results that can serve as advice to policy makers. In this regard, this dissertation exhibits the variety of factor market distortions that are caused by different types of business taxation. Each of the following three chapters is devoted to an empirical application. However, all chapters have three elements in common. First, they all analyse taxes that have recently been at the centre of the policy debate in Europe. Second, all chapters rely on micro data on firm or community level. Third, they employ micro-econometric methodology that allows to control for unobserved heterogeneity or to simulate firm and asset heterogeneity. Chapter 2 estimates the effect of a change in the user cost of capital on firms' investment. Chapter 3 assesses the impact of changes in transaction costs in financial markets on the value of collateral pledged to the Eurosystem by financial institutions. Chapter 4 is devoted to the effects of municipal business taxation on the local level of employment. Finally, chapter 5 summarises the results and outlines possible fields of further research work as well as policy conclusion.

Chapter 2 explores factor market distortions in the capital market related to corporate income taxation. More specifically, it assesses how a change in the corporate income tax rate, modelled as variation in the user cost of capital of firms, influences the investment activity of the corporate sector. 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 it incurs the loss and, potentially, in future years. So far, most of the literature on taxes and investment has ignored the prominence of tax losses in lowering marginal tax rates or approximated tax losses through accounting data. This approach not only neglects an important source of variation in the user cost of capital across firms but also leads to mismeasurement of firms' marginal tax rate. These shortcomings are addressed in a twofold manner. First, the chapter measures 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, it employs a so far unique data set that is used to construct a marginal tax rate, which differs from the statutory tax rate and varies across firms and over time. The estimation relies on a distributed lag model using 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. The preferred estimation reveals that a one per cent increase in the user cost of capital reduces investment by 0.52% in the long run. Just like other studies this finding confirms the hypothesis that the neglect of measurement problems in the user cost variable attenuates the estimated coefficients.

Chapter 3 looks at capital markets again and focusses on distortions caused by indirect taxation that changes the costs of selling or buying a financial instrument. The fundamental question is how a change in the transaction costs related to a sale or purchase of a financial instrument may affect the value of assets. Specifically, the focus lies on assets that financial institutions pledge as collateral to the Eurosystem when they access central bank credit operations. A change in the transaction costs for financial instruments can affect the collateral value through various channels, most importantly asset prices but also liquidity and credit risk considerations. As the collateral submitted to the Eurosystem is re-valued based on market prices on every business day, a change in market prices immediately affects the overall value of a counterparty's collateral pool and hence its ability to access monetary policy operations. In particular, the chapter disentangles how assets will be affected heterogeneously by the tax, depending on their turnover, maturity, coupon definition and other characteristics. As a consequence, Eurosystem counterparties will also be affected heterogeneously, conditional on the composition of their collateral pool. For the analysis, the chapter develops a microsimulation model of the Eurosystem collateral framework on an asset-by-asset basis in order to capture heterogeneous effects due to composition effects and asset as well as counterparty characteristics. The analysis develops a set of scenarios for possible asset price changes and their respective effect on the value of the collateral submitted to the Eurosystem.

Chapter 4 shifts the focus to tax-induced distortions in labour markets and examines the relationship between municipal taxation of business and the local level of employment. In a number of countries sub-national entities have the legal competence to levy a tax on businesses that are located in their jurisdiction. In such an environment, jurisdictions intensively compete for enterprises when setting their rate of business taxation. As a consequence, sub-national taxation of business profits causes various externalities and a potential relocation of production factors between jurisdictions. However, only few studies analyse labour incidence of business taxation on the state level and even fewer on the municipal level. This is surprising as taxation on sub-federal levels follows its own economic theories, may cause a considerable tax-burden and offers a promising research ground. Based on the theoretical work by McLure (1977), this chapter makes two contributions: First, it estimates the effect of a change in the local business tax rate on the total level of employment in a municipality. In this context, employment is defined as the number of persons employed by all firms that are based in the respective municipality. Second, it expands on previous studies of local employment effects which have relied on ordinary least squares estimations by using instrumental variable estimation. The local business tax rate is instrumented with the lagged average tax rate of the most probable competitors. For small municipalities these are neighbouring jurisdictions. For larger municipalities, non-neighbouring jurisdictions of the same size within the same state or elsewhere in the nation are taken as the competitors. The results show that an increase in the local business tax rate affects the local level of employment negatively. This finding is significant and robust across a number of different specifications, in which the local tax rate is instrumented. The preferred estimate yields that a 1%-increase in the local business tax rate entails a 1.3%-decrease in the level of local employment. Furthermore, it can be argued that a change in the local business tax rate also indirectly affects the size of the population of the same municipality. As many fiscal transfers in federal nation states are linked to population size there are reasons to believe that an increase in the local business tax rate may have a negative feedback effect on the local budget. These results confirm that municipal business taxation entails a number of distortions of high scientific and practical relevance.

Each of the three empirical applications of business taxation exhibited in chapters two through four yields its individual methodological and economic results. Their innovation and relevance are discussed at the end of the respective chapter. Above and beyond those specific findings, three overarching results can be derived from this doctoral thesis as a whole. First, all three chapters confirm prior findings that effects of business taxation on factor markets are sizeable and – as an innovation – are even bigger than those ensuing from previous empirical studies where they exist. Second, the thesis gives rise to new evidence that confirms concerns about the applicability of estimated average effects of a tax on a factor market due to strong heterogeneity at the micro level. Finally, all chapters deal with empirical applications that display that minor details in the design of a specific tax can fundamentally influence the incidence of that tax through factor market distortions. At the least, the conclusions constitute yet another rejection of the hypothesis that the incidence of capital taxation is born by capital owners. The following paragraphs will relate each of these three results to the findings of the individual chapters one by one.

Chapter 2 of the study has argued that previous theoretical and empirical research has disregarded or underestimated the importance of tax losses in lowering firm-specific marginal tax rates. This leads to a classical error-in-variables problem, which attenuates the estimate of the user cost elasticity and cannot be remedied by instrumenting with lags of the user cost of capital. This attenuation bias is overcome by using tax return data that contains actual tax losses. The preferred baseline estimate for the elasticity of capital with respect to its user cost yields −0.52. In an additional step, it is shown that the user cost elasticity declines to −0.37 when employing a user cost variable that does not include losses and loss carry-overs. The difference in the two point estimates is not statistically significant but it suggests that, on average, the effect of CIT on factor markets is even bigger than previous literature has claimed. In a similar vein, chapter 3 shows that an increase in the cost of transaction for financial instruments does not stop at lowering the market value of debt instruments in capital markets. In addition, such asset price changes entail a decline in the value of collateral submitted by financial institutions to the central bank as well as other business partners. As a consequence, the access of financial institutions to central bank liquidity may be constrained, in particular in times of dysfunctional interbank money markets and a fixed-rate full allotment policy of the central bank. Ultimately, this leads to a further increase in the cost of capital: Beyond the asset price change itself, the funding cost of banks increases because more collateral has to be provided to the central bank. Chapter 4 of the thesis tackles yet another effect of business taxation on factor markets. It confirms the theoretical expectation that an increase in the local business tax rate affects the local level of employment negatively. The preferred estimate yields that a 1%-increase in the local business tax rate causes local employment to decrease by 1.3%. These results underline in a very tangible way that municipal business taxation entails a number of distortions not only in capital but also labour markets. In addition the thesis exhibits the quantitative importance of the effect on local labour markets. For instance, if a municipality with 10,000 employees decided to increase its tax rate from 15% to 17% (a 13-percent increase) this would results in a loss of 1,690 local jobs. As an extension, the study indicates that a change in the local business tax rate may furthermore indirectly affect the size of the municipal population. In summary, all three chapters underline that effects of business taxation on factor markets are strong and possibly even bigger than previously estimated.

In a second string of results, all three chapters of the thesis present unsettling evidence about the applicability of estimated average effects of a tax. Variation among economic agents at the micro level is very large and hence the average treatment effect can deviate significantly from the action of the individual agent. This issue presents itself as particularly intricate in the application of chapter 2. To recall, in Germany roughly 60% of corporations either suffered a loss (40%) or used a tax loss carry-forward or carry-back to offset current profits (20%) in 2004. The majority of corporations do not pay any corporate income tax at all. Moreover, it is shown that corporations' tax-exhaust status is very persistent over time. Hence, a significant amount of corporations are non-taxable for an extended period of years and cannot be expected to react to any incentives set by the tax systems as suggested by the estimated effects. On the other hand, the corporations that remain taxable could react more strongly. This must be taken into account when assessing the effects of a change in the tax rate on investment and capital markets. Chapter 3 also underlines that heterogeneity at the micro-level matters. The microsimulation exploits both financial asset and bank characteristics in order to show the possible effect of a change in transaction cost on the value of Eurosystem collateral. The change of the price of an asset in response to variation in the transaction cost for such an asset depends crucially on the characteristics of that asset. Furthermore, the pools of financial collateral that financial institutions maintain with the Eurosystem to secure their uptake in monetary policy operations are composed heterogeneously and also the level of over-collateralisation of banks varies. It cannot be excluded that single counterparties facing collateral scarceness may experience constraints in their access to central bank liquidity due to a tax-induced change in asset prices. In the application of chapter 4, heterogeneity at the micro level is less predominant as the units of observation are larger, i.e. municipalities rather than individuals, assets or corporations. In fact the dissertation shows that the effects for small municipalities with less than 10,000 inhabitants are not significantly different from the effects for the full sample. The financial situation of the municipality seems to be irrelevant as well because variables such as credit or investment expenditure are not significant or significant with very small effects in the estimations. Nevertheless, the effect of a business tax on local labour markets can be expected to depend on the characteristics of the local work force.

Finally, all three chapters show that minor details in the design of a specific tax can fundamentally influence the incidence or distortionary effects of that tax. In chapter 2 it became apparent how a relatively generous scheme that allows carrying forward losses into the future without size and time limits can fundamentally influence the taxability status of a large number of corporate tax payers. In response to this situation, policy makers introduced the so-called "minimum taxation" (*Mindestbesteuerung*), restricting the use of tax loss carry-forward in volume. This seemingly minor amendment of the tax code again leads to a change in the taxable status for many corporations and, hence, possible implications for investment and capital markets. A general statement on the factor incidence of a corporate income tax can hence not be made. Chapter 4 shows how the design of apportionment formula that is used to allocate the tax base to sub-national jurisdictions is pivotal in determining the tax effect on the local labour market. In the German application that is examined in that chapter the apportionment formula exclusively relies on the local sum of payroll. Consequently, the effects on local employment are considerable.

GERMAN SUMMARY

Unternehmensteuern dienen in vielen Ländern als eine wichtige Finanzierungsquelle des Staats. In den Vereinigten Staaten entfielen im Haushaltsjahr 2012 9,9% der Gesamteinnahmen der Bundesebene auf die Körperschaftsteuer. In Deutschland lagen das Aufkommen der Körperschaftsteuer und des Bundesanteils der Gewerbesteuer bei 3,3% der Gesamteinnahmen des Bundes. Diese Zahlen unterstreichen, dass direkte Unternehmensteuern entgegen der allgemeinen Tendenz sinkender Unternehmensteuern beträchtliche Einkommensströme generieren.

Neben der Erzielung von Steuereinnahmen wird der Unternehmenbesteurung häufig eine weitere Zielsetzung zugeschrieben: die Verteilungsgerechtigkeit. Im Durchschnitt verdienen Personen an der Spitze der Einkommensverteilung einen größeren Anteil ihres Einkommens aus Kapitaleinkünften (Bach, Corneo, & Steiner, 2009) und tragen somit vordergründig die Hauptlast der Unternehmensteuern. Zuletzt wurden im Rahmen der Diskussionen über eine mögliche Finanztransaktionssteuer in der Europäischen Union Erwartungen genährt, dass sogar indirekte Unternehmensbesteuerung zur gesellschaftlichen Verteilungsgerechtigkeit beitragen könne.

Auch in der Wirtschaftswissenschaft hat die Ansicht, dass die Besteuerung von Unternehmen von den Kapitaleignern getragen wird, prominente Unterstützung. Arnold C. Harberger erklärte in einem wegweisenden Beitrag, dass unter verschiedenen plausiblen Annahmen die Kapitaleigner nahezu 100% der Steuerlast tragen (Harberger, 1962). Harbergers Untersuchungen begründeten die Entstehung eines neuen Forschungsgebiets, das sich der Frage der Lastverteilung von Steuern verschrieben hat. Die Literatur über Steuerinzidenz wurde von Fullteron & Metcalf (2002) zusammengefasst, eine Übersicht über die Forschung zur Unternehmenssteuerinzidenz im Speziellen hat Auerbach (2005) vorgelegt. Viele Studien dieses Literaturzweigs kommen zu dem Ergebnis, dass die Verzerrungen, die von Unternehmensteuern in den Faktormärkten ausgelöst werden, die Steuerinzidenz maßgeblich beeinflussen. Diese Verzerrungen wiederum hängen von den theoretisch getroffenen Annahmen oder dem empirischen Umfeld der jeweiligen Studie ab. Die tatsächliche Lastenverteilung wird maßgeblich von den Elastizitäten von Angebot und Nachfrage bestimmt. Daraus muss geschlossen werden, dass jede Steuer als Einzelfall behandelt und untersucht werden muss, bevor belastbare Aussagen zu ihrer Inzidenz getroffen werden können, die wiederum als Entscheidungsgrundlage für die Politik dienen könnten.

Die drei Kapitel im Kern dieser Arbeit sind jeweils einer solchen Einzelfalluntersuchung im empirischen Kontext gewidmet. Die drei Kapitel verfügen über drei verbindende Elemente: Erstens behandeln sie alle konkrete Steuervorhaben oder Reformen, die kürzlich Gegenstand der politischen Debatte waren oder es noch immer sind. Zweitens nutzen und untersuchen alle Kapitel Mikrodaten auf Firmen- oder Gemeindeebene. Drittens verwenden alle Kapitel mikro-ökonometrische Methoden, die es erlauben unbeobachtete Heterogenität auszuschließen oder Mikro-Heterogenität zu simulieren. Über diese Gemeinsamkeiten hinaus leistet jedes Kapitel seinen eigenen Beitrag zur Forschung.

Zu den Kapiteln im Einzelnen: Kapitel 2 untersucht Verzerrungen auf Kapitalmärkten, die durch die Besteuerung von Unternehmenseinkünften hervorgerufen werden. Es wird analysiert, wie eine Änderung des Unternehmenssteuersatzes – modelliert als eine Änderung der Kapitalnutzungskosten – die Investitionstätigkeit von Unternehmen beeinflusst. Bei der Investitionsentscheidung eines Unternehmens ist der individuelle Grenzsteuersatz einer zusätzlichen Kapitaleinheit ausschlaggebend dafür, ob eine Investition betriebswirtschaftlich lohnend ist. Dieser firmenspezifische Grenzsteuersatz unterscheidet sich aus verschiedenen Gründen oft stark von der Höhe des gesetzlichen Steuersatzes. Ein steuerlicher Verlust kann dazu führen, dass der Grenzsteuersatz einer Firma im laufenden Jahr – und womöglich sogar im Jahr zuvor oder in den Folgejahren – auf Null sinkt. Bislang hat ein Großteil der Literatur über Steuern und Investitionen diese Auswirkung steuerlicher Verluste auf die Grenzsteuersätze ignoriert. Das liegt insbesondere daran, dass die Mehrzahl der Untersuchungen auf handelsrechtlichen Jahresabschlussdaten beruhen, die steuerliche Verlusts und Verlustvorträge unzureichend abbilden. Diese datenbedingte Vereinfachung vernachlässigt nicht nur eine wichtige Quelle mikro-ökonometrisch wertvoller Variation in den Kapitalnutzungskosten von Unternehmen. Sie führt auch zu Fehlern bei der Berechnung des Grenzsteuersatzes, die die Ergebnisse verfälschen können. Diese Mängel behebt diese Arbeit in zweifacher Hinsicht. Zum einen wird der Grenzsteuersatz auf Unternehmensebene unter Berücksichtigung der tatsächlichen steuerlichen Verluste sowie der steuerlichen Verlustvorträgen und Rückträgen berechnet. Aufgrund dieses Vorgehens kann der Messfehler in der Kapitalnutzungskosten-Variable behoben werden. Dies wiederum ermöglicht es, valide Instrumente zu finden und so eine mögliche Endogenität der Schätzungen zu überwinden. Zum anderen beruht die Arbeit auf einem neuartigen Datensatz, der auf die amtliche Steuerstatistik zurückgreift. So kann ein individueller Grenzsteuersatz berechnet werden, der sich vom gesetzlichen Steuersatz unterscheidet und zwischen Unternehmen und über die Zeit hin variiert. Die Schätzungen basieren auf einem rationalen Lag-Modell (*distributed lag model*) und verwenden einen Zwei-Schritt-System-GMM Schätzer (*generalised method of moments*) der gegen Heteroskedastizität robust ist. Die Schätzung zeigt, dass eine Zunahme der Kapitalnutzungskosten um ein Prozent das Kapital auf lange Sicht um 0,52% reduziert. Ein Vergleich mit anderen Studien bestätigt die Annahme, dass die Vernachlässigung von Messfehlern in der Kapitalnutzungskosten-Variable die geschätzten Koeffizienten verringert.

Kapitel 3 ist ebenfalls den Kapitalmärkten gewidmet und beschäftigt sich mit den Verzerrungen, die durch indirekte Steuern auf den Verkauf oder Kauf eines Finanzinstruments erzeugt werden. Die zentrale Frage lautet, wie die Änderung der Transaktionskosten für ein Finanzinstrument dessen Marktwert beeinflussen kann. Untersuchungsgegenstand sind dabei insbesondere Finanzinstrumente, die von Finanzinstituten gegenüber dem Eurosystem verpfändet werden können, um Zugang zu den Kreditgeschäften der Zentralbank zu erhalten. Eine Änderung der Transaktionskosten für Finanzinstrumente kann den Wert dieser Zentralbanksicherheiten über verschiedene Kanäle beeinflussen, vor allem über die Marktpreise, aber auch über die Liquidität und die Kreditrisikobewertung. Die an das Eurosystem verpfändeten Sicherheiten werden an jedem Geschäftstag gemessen an der Marktpreisentwicklung neu bewertet. Eine Änderung des Marktpreises beeinflusst also unmittelbar den Gesamtwert des Sicherheitenbeckens eines Geschäftspartners der Zentralbank und damit auch dessen Fähigkeit, auf geldpolitische Geschäfte zugreifen zu können. Das Kapitel arbeitet heraus, dass Finanzinstrumente sehr unterschiedlich von der Steuer betroffen sein können, abhängig von Umsatz, Laufzeit und Couponmerkmalen. Folglich sind auch die Geschäftspartner des Eurosystems je nach Zusammensetzung ihres Sicherheitenbeckens unterschiedlich betroffen. Für die quantitative Analyse dieser Effekte entwickelt das Kapitel ein Mikrosimulationsmodell der Sicherheitenvorgaben des Eurosystems auf Wertpapierebene, welches heterogene Effekte, die durch die Wertpapiermerkmale und die Zusammensetzung der Sicherheitenbecken bedingt sind, abbilden kann. Die Untersuchung wird anhand einer Reihe von verschiedenen Szenarien durchgeführt, deren Auswirkungen auf den Wert der verpfändeten Sicherheiten dargestellt werden kann.

Kapitel 4 richtet das Augenmerk auf steuerinduzierte Verzerrungen auf Arbeitsmärkten und untersucht den Zusammenhang zwischen kommunaler Unternehmensbesteuerung und der Beschäftigung in einer Kommune. In einer Reihe von Ländern verfügen sub-nationale Körperschaften über Kompetenzen, Unternehmen innerhalb ihres Zuständigkeitsbereichs zu besteuern. In einem solchen Umfeld stehen öffentliche Körperschaften bei der Festlegung ihrer lokalen Steuersätze in einem intensiven Wettbewerb um Unternehmen. Folglich versursacht die lokale oder regionale Besteuerung von Unternehmensgewinnen erhebliche externe Effekte und kann die Verlagerung von Produktionsfaktoren zwischen den Körperschaften nach sich ziehen. Allerdings haben bislang nur wenige Studien die Inzidenz von lokalen Unternehmensteuern für den Faktor Arbeit untersucht. Das ist insofern überraschend, als die Besteuerung auf den unteren Ebenen eines föderalen Systems ihren eigenen volkswirtschaftlichen Gesetzmäßigkeiten folgt und einen erheblichen Anteil der Gesamtsteuerlast ausmachen kann. Aufbauend auf den theoretischen Arbeiten von McLure

(1977) leistet dieses Kapitel zwei wissenschaftliche Beiträge: Zunächst schätzt es basierend auf einem Datensatz deutscher Kommunen den Effekt einer Änderung des Gewerbesteuersatzes auf das Niveau der Beschäftigung innerhalb der betroffenen Kommune. In diesem Zusammenhang ist Beschäftigung definiert als die Anzahl der Personen, die bei einem in der Kommune ansässigen Unternehmen angestellt sind. Zweitens geht das Kapitel über frühere Untersuchungen hinaus, indem es statt eines Schätzers mit der Methode der kleinsten Quadrate *(ordinary least squares*) eine Schätzung mit Hilfe einer Instrumentenvariable vornimmt. Der kommunale Steuersatz wird mit dem verzögerten Durchschnittssteuersatz der wahrscheinlichsten Wettbewerber instrumentiert. Für kleine Kommunen werden als die wahrscheinlichsten Wettbewerber die Nachbarkommunen angenommen. Für größere Kommunen werden nicht-benachbarte Kommunen im gleichen Bundesland oder anderswo herangezogen. Die Ergebnisse zeigen, dass sich eine Anhebung des Gewerbesteuersatzes negativ auf die lokale Beschäftigung auswirkt. Dieser Befund ist signifikant und robust in einer Reihe von verschiedenen Spezifikationen, in denen der lokale Steuersatz instrumentiert wird. Die bevorzugte Schätzung ergibt, dass eine 1%-Zunahme der Gewerbesteuer eine Abnahme der lokalen Beschäftigung in der Höhe von 1,3% nach sich zieht. Darüber hinaus kann argumentiert werden, dass eine Änderung des Gewerbesteuersatzes indirekt auch Auswirkungen auf die Größe der Bevölkerung der betroffenen Gemeinde hat. Da viele Transferzahlungen in einem Bundesstaat an die Größe der Bevölkerung geknüpft sind, darf man annehmen, dass eine Erhöhung des Gewerbesteuersatzes zudem einen negativen Rückkopplungseffekt auf den Kommunalhaushalt haben könnte. Das bestätigt, dass kommunale Unternehmensbesteuerung zu einer Reihe von wirtschaftlichen Verzerrungen von hoher wissenschaftlicher und politischer Relevanz führen kann.

Die drei Analysen der Unternehmensbesteuerung in den Kapiteln 2 bis 4 liefern jeweils eigenständige methodische und volkswirtschaftliche Beiträge und Lehren. Jenseits dieser spezifischen Ergebnisse lassen sich drei allgemeinere Ergebnisse aus dieser Doktorarbeit als Ganzes ableiten. Zunächst bestätigen alle drei Kapitel die Befunde vorheriger Studien, dass die Auswirkungen der Unternehmensbesteuerung auf Faktormärkte erheblich sind und – das ist neu – sogar noch größer als in vorherigen Untersuchungen. Zweitens liefert die Arbeit neue Belege dafür, dass die praktische Relevanz von geschätzten Durchschnittseffekten einer Steuer auf Faktormärkte aufgrund der starken Mikroheterogenität der Marktteilnehmer begrenzt ist. Und schließlich befassen sich alle Kapitel mit empirischen Anwendungen, die verdeutlichen, dass vermeintlich kleine Details in der Ausgestaltung einer spezifischen Steuer oder ihres wirtschaftlichen Umfelds starken Einfluss auf die Inzidenz dieser Steuer haben können. In diesem Sinne bekräftigen die Schlussfolgerungen dieser Arbeit auch die Ablehnung der Hypothese, dass Kapitaleigentümer die Hauptträger der Last von Unternehmensteuern sind.

Zunächst zu den Auswirkungen auf die Faktormärkte. Kapitel 2 dieser Arbeit argumentiert, dass die bisherige theoretische und empirische Forschung die Absenkung der firmenspezifischen Grenzsteuersätze durch steuerliche Verluste außer Acht gelassen oder unterschätzt hat. Dieses Vorgehen führt zu einem klassischen Messfehlerproblem, das die Schätzung des Koeffizienten der Kapitalnutzungskosten nach unten verzerrt. Ein solches Messfehlerproblem kann nicht durch die Instrumentierung mit den verzögerten Kapitalnutzungskosten beseitigt werden. Diese Arbeit überwindet die Verzerrung der Schätzung durch die Verwendung steuerstatistischer Daten, die die tatsächlichen Steuerverluste enthalten. Das bevorzugte Schätzergebnis für die Elastizität des Kapitals mit Bezug auf seine Nutzungskosten liegt bei −0.52. In einem zusätzlichen Schritt wird gezeigt, dass die Elastizität der Kapitalnutzungskosten auf −0,37 sinkt, wenn die Zusatzinformation aus der Steuerstatistik vernachlässigt wird. Der Unterschied zwischen den beiden Punktschätzungen ist statistisch nicht signifikant, aber er deutet darauf hin, dass die Auswirkungen der Unternehmensbesteuerung auf den Faktormarkt für Kapital im Durchschnitt noch größer ist als die bisherigen Literatur vermuten lässt. In ähnlicher Weise zeigt Kapitel 3, dass eine Erhöhung der Transaktionskosten für Finanzinstrumente durch eine Steuer nicht nur den Marktwert der Schuldtitel auf den Kapitalmärkten nach sich zieht. Darüber hinaus verursacht eine solche Vermögenswertänderung auch einen Rückgang des Werts der Sicherheiten von Finanzinstituten bei der Zentralbank. Als Folge kann der Zugang von Finanzinstituten zu Zentralbankliquidität in Zeiten dysfunktionaler Interbankengeldmärkte und einer Vollzuteilungspolitik der Zentralbank eingeschränkt werden. Auch dies führt letztendlich zu einer Erhöhung der Kapitalnutzungskosten. Kapitel 4 der Arbeit befasst sich mit noch einem weiteren Effekt der Unternehmensbesteuerung auf den Faktormärkten. Es bestätigt die theoretische Erwartung, dass eine Erhöhung des Gewerbesteuersatzes sich negativ auf die lokale Beschäftigung auswirkt. Die bevorzugte Schätzung ergibt, dass eine Zunahme des Gewerbesteuersatzes um 1% bewirkt, dass die Beschäftigung in der betroffenen Kommune um 1,3% sinkt. Diese Ergebnisse unterstreichen in einer sehr konkreten Weise, dass kommunale Unternehmensbesteuerung zu einer Reihe von Verzerrungen nicht nur auf den Kapitalmärkten, sondern auch auf den Arbeitsmärkten führt. Darüber hinaus zeigt diese Arbeit die quantitative Bedeutung der Wirkung auf den lokalen Arbeitsmärkten. Wenn zum Beispiel eine Gemeinde, in der 10.000 Beschäftigte tätig sind, beschließt ihren Steuersatz von 15% auf 17% anzuheben (ein Anstieg von 13 Prozent), dann würde dies im Schnitt zu einem Verlust von 1.690 Arbeitsplätzen in dieser Kommune führen. Zusammenfassend zeigen alle drei Kapitel, dass die Auswirkungen der Unternehmensbesteuerung auf Faktormärkte stark sind und möglicherweise sogar noch größer als bisher angenommen.

Darüber hinaus präsentieren alle drei Kapitel der Arbeit beunruhigende Erkenntnisse über die praktische Anwendbarkeit der geschätzten durchschnittlichen Auswirkungen einer Steuer. Die Unterschiede zwischen den Wirtschaftsakteuren auf der Mikroebene sind sehr groß. Dieses Problem stellt sich besonders in der Anwendung von Kapitel 2. Zur Erinnerung. In Deutschland erlitten im Jahr 2004 rund 60% der Unternehmen entweder einen Verlust (40%) oder verrechneten einen Steuerverlustvortrag oder Rücktrag mit aktuellen Gewinnen (20%). Die Mehrheit der Unternehmen zahlte überhaupt keine Körperschaftssteuer. Darüber hinaus wurde gezeigt, dass der Besteuerungsstatus einzelner Unternehmen sehr stark über die Zeit korreliert. Daraus kann geschlossen werden, dass eine erhebliche Menge an Kapitalgesellschaften über einen Zeitraum von mehreren Jahren keine Steuern abführen und daher nicht davon ausgegangen werden kann, dass sie auf Anreize des Steuersystems reagieren. Auf der anderen Seite ist zu erwarten, dass die Unternehmen, die steuerpflichtige bleiben, ihre Investitionstätigkeit deutlich stärker an die steuerliche Belastung anpassen, als der Durchschnittseffekt vermuten lässt. Dies muss bei der Beurteilung der Auswirkungen einer Steuerreform auf die Investitionen und die Kapitalmärkte in Betracht gezogen werden. Kapitel 3 unterstreicht außerdem, dass die Heterogenität auf der Mikroebene eine bedeutsame Rolle spielt. Die Mikrosimulation nutzt die Merkmale einzelner Wertpapiere und Kreditinstitute aus, um die möglichen Auswirkungen einer Transaktionskostenänderung auf den Wert der Sicherheiten zu berechnen. Die Änderung des Preises eines Wertpapiers als Folge einer Veränderung der Transaktionskosten für dieses Wertpapier hängt entscheidend von den Eigenschaften des betreffenden Instruments ab. Darüber hinaus sind die Sicherheitenbecken, die Finanzinstitute beim Eurosystem vorhalten um sich den Zugang zu Zentralbankliquidität zu sichern, heterogen zusammengesetzt und auch die Höhe der Überdeckung der Banken variiert. Es kann nicht ausgeschlossen werden, dass einzelne Geschäftspartner mit geringer Überdeckung und wenigen notenbankfähigen Sicherheiten aufgrund einer steuerinduzierten Veränderung der Wertpapierpreise eine Einschränkung ihres Zugang zu Zentralbankliquidität hinnehmen müssen. Im Fall von Kapitel 4 ist die Heterogenität auf der Mikroebene eine weniger vorherrschende Herausforderung, da die Beobachtungseinheiten größer sind. Es handelt sich um Kommunen und nicht um Einzelpersonen, Wertpapiere oder Unternehmen. Vielmehr zeigt diese Arbeit, dass die Ergebnisse für kleine Gemeinden mit weniger als 10.000 Einwohnern sich nicht signifikant von den Auswirkungen für die gesamte Population unterscheiden. Auch die finanzielle Situation der Gemeinde scheint irrelevant zu sein, weil Variablen wie Kredit-oder Investitionsausgaben in den entsprechenden Schätzungen nicht signifikant sind oder nur kleine Effekte vorweisen. Dennoch darf erwartet werden, dass die Auswirkungen von Unternehmensteuern auf die lokalen Arbeitsmärkte von den Eigenschaften der jeweiligen Arbeitnehmerschaft abhängen.

Schließlich zeigen alle drei Kapitel, dass kleine Details in der Ausgestaltung einer spezifischen Steuer starken Einfluss auf die Inzidenz oder die verzerrenden Auswirkungen dieser Steuer haben können. In Kapitel 2 wurde deutlich, wie eine relativ großzügige Regelung unbegrenzter Verlustvorträge großen Einfluss auf den steuerlichen Status der Unternehmenssteuerzahler hat. Als Reaktion auf diese Situation führte die Politik die sogenannte Mindestbesteuerung ein, die die Nutzung steuerlicher Verlustvorträge dem Volumen nach begrenzt. Diese scheinbar geringfügige Änderung des Steuerrechts führt zu einer Änderung des Steuerstatus für viele Unternehmen und hat damit wiederum Auswirkungen auf das Investitionsverhalten von Unternehmen und die Kapitalmärkte im Allgemeinen. Eine generelle Aussage über die Faktorinzidenz einer Körperschaftsteuer kann daher nicht getroffen werden. Kapitel 4 zeigt, wie die Bildung einer Formel, die der Verteilung einer steuerlichen Bemessungsgrundlage auf öffentliche Körperschaften dient, die Auswirkungen auf die lokalen Arbeitsmärkte beeinflussen kann. Im deutschen Fallbeispiel des Kapitels liegt der Verteilungsformel ausschließlich die in der Gemeinde gelegene Lohnsumme zugrunde. Daher sind die Auswirkungen auf den lokalen Arbeitsmarkt erheblich.

LIST OF PUBLICATIONS BASED ON THIS DISSERTATION

Lennkh, R., & Walch, F. (2015). Collateral damage? Micro-simulation of transaction cost shocks on the value of central bank collateral. *ECB Working Paper No. 1793*. Frankfurt am Main: European Central Bank.

Erklärung

Gemäß §10(3) der Promotionsordnung zum Dr. rer. pol. des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin vom 13. Februar 2013 erkläre ich hiermit, dass ich meine Dissertation soweit im Folgenden nicht anders vermerkt selbstständig verfasst habe.

Kapitel zwei basiert auf einem Artikel der zu gleichen Teilen zusammen mit Nadja Dwenger verfasst wurde (Dwenger & Walch, mimeo). Kapitel drei basiert auf einem Artikel der zu gleichen Teilen zusammen mit Rudolf Alvise Lennkh verfasst wurde (Lennkh & Walch, 2015). Kapitel vier wurde eigenständig verfasst.

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