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Abstract

Several recent studies show that the elasticity of taxable income (ETI) is not a sufficient statistic for the welfare costs of taxation due to factors such as taxbase shifting. This paper provides an additional argument demonstrating the non-sufficiency of the ETI, namely tax deductions. Building on a theoretical framework which incorporates deductions in a standard optimal-tax model, we show that the ETI is not sufficient for welfare analysis if (i) deductions generate externalities and if (ii) deductions are responsive to tax-rate changes. While the first condition should arguably hold true for the majority of tax deductions, we provide an empirical examination of the second condition. Relying on rich German panel data from administrative tax records, we exploit several tax reforms that were implemented in Germany between 2001 and 2008. Our main estimates indicate an overall ETI between 0.35 and 0.68 and an elasticity of deductions with respect to the net-of-tax rate between -0.3 and -0.9. These results suggest that the ETI is not sufficient to calculate the welfare cost of taxation.

JEL-Code: H240, H310.

Keywords: elasticity of taxable income, deductions, tax expenditures, sufficient statistic, administrative data, Germany.

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1 Introduction

The large literature on the elasticity of taxable income (ETI) estimates the responsiveness of taxpayers to income-tax changes (see Saez et al. 2012 for an overview). Recent studies find elasticities with respect to the net-of-tax rate in the range of about 0.1 to 0.8 (e.g., Weber 2014; Kleven and Schultz 2014), suggesting that income taxpayers are sensitive to taxes and alter their taxable income in response to tax rate changes. Following the seminal contributions by Feldstein (1995, 1999), the literature often used, and sometimes still does, such ETI estimates as a "sufficient statistic" to estimate the deadweight loss of income taxes.[1] This assumes that all types of behavioral responses that affect taxable income, such as labor supply adjustments, charitable donations, or illegal evasion, have the same impact on welfare, and thus can be boiled down to one single number, the ETI. Chetty (2009), however, shows that the channel along which taxable income responses occur, may make a difference for the efficiency losses induced by income taxes. If behavioral adjustments to reduce taxable income generate externalities, such as transfers to other agents in the economy, losses to overall welfare are lower compared to cases in which behavioral adjustments are associated with real resource costs.

In this paper, we explore the welfare effects of tax reforms in the presence of tax deductions. We hence focus on a specific adjustment channel that is common and important in almost all personal income tax systems across the world. For instance, in the US, itemized deductions represent approximately 12% of all taxable income, worth a total of $80 billion (Saez 2004).[2] We set up a theoretical model building on Saez (2004) which incorporates deductions in a standard optimal-tax framework. The model shows that the ETI is not a sufficient statistic for the efficiency costs of income taxation if *(i)* claimed deductions generate externalities and if *(ii)* deductions are responsive to tax rate changes. The rationale for this result is closely related to the argument in Chetty (2009): if behavioral responses in the form of deductions contribute to a public good, they generate less efficiency costs than other behavioral adjustments such as reduced labor supply.

An economic rationale for the allowance of deduction possibilities in the tax law is to encourage certain behavior or expenses that produce welfare benefits – in the future or present. In other words, the motivation behind deductions is usually to

[1] For example, Saez et al. (2012, page 4) state that the ETI "holds the promise of more accurately summarizing the marginal efficiency cost of taxation than a narrower measure of taxpayer response such as the labor supply elasticity, and therefore is a worthy topic of investigation."

[2] The ratio of deductions to taxable income is 1.25 in Germany (see below). Deductions generally play an important role in all developed countries' personal income tax codes (Ernst & Young 2013), suggesting that our results are not only relevant for Germany or the US.

incentivize behavior that generates interpersonal or intertemporal externalities. For example, deductions in the form of charitable donations are transferred to another agent in the economy, implying that the amount deducted is not lost, but serves society. Deductible investments in education or professional training will increase human capital, leading to higher incomes and hence higher future tax revenues. Given the purpose and character of most deductions, we argue that the first condition for the ETI *not* to be a sufficient statistic is likely to be fulfilled: almost all deductions generate non-negligible externalities and therefore have different welfare costs than other adjustment margins.[3]

The second condition for a non-sufficient ETI is fulfilled if the elasticity of deductions with respect to changes in the net-of-tax rate is different from zero. From a theoretical perspective, tax deductions should respond to tax rate changes through an income and a substitution effect. A higher tax reduces the relative price of deductions and should therefore have a positive effect on claimed deductions via the substitution effect, while the income effect goes in the opposite direction. That is, the overall effect is ambiguous and the sign of the deduction elasticity with respect to the net-of-tax rate boils down to an empirical question.

In order to answer this question, we use comprehensive German panel data from administrative tax records that provide detailed information on all income-tax relevant parameters including all available tax deductions. We exploit variation in tax rates induced by various income tax reforms implemented in Germany in the early 2000s. These reforms affected different types of taxpayers differently. For instance, over this period, the top marginal tax rate decreased from 53% to 42% in several steps and the lowest marginal tax rate fell from 24% to 15%, while tax rates in the middle of the distribution partly increased. These differential reform intensities allow identification of the tax-rate effect on deduction behavior. Given our research question, studying the case of Germany is of particular interest as the German tax system allows for a very large set of deductions: on average, taxable income is more than 20% lower than reported gross income. In total, there are more than 500 different deduction possibilities, with variation in the use of deductions over the income distribution and by income source (Kirchhof 2011).[4]

[3]Although most deductions arguably generate positive externalities, we acknowledge that some deductions may additionally incur welfare losses. For example, if deduction possibilities trigger overconsumption, sheltering behavior will be associated with resource costs that reduce the economic pie. Welfare costs may also arise because of the opportunity costs of filing deductions. However, the sum of all claimed deductions should have positive effects on welfare.

[4]Bach et al. (2013) analyze the ratio of taxable income in reported broad income over time. Their findings are broadly in line with our numbers although they employ a different concept of broad income and use a different data source.

We start our empirical analysis with estimating tax elasticities for gross and taxable income and continue with the analysis for different types of deductions. Identifying the impact of tax changes on deductions is generally subject to the same econometric challenges as estimating the ETI. First, there exists a mechanical relationship between tax deductions and tax rates in progressive tax systems, and second, mean reversion as well as heterogeneous income trends have to be accounted for. This motivates us to employ an empirical strategy for estimating the ETI and deduction elasticities that follows the recent contribution by Weber (2014).[5]

Our findings suggest a statistically significant elasticity of taxable income with respect to the net-of-tax rate in the range of 0.34 to 0.68. In compliance with most other studies, we find a lower elasticity of gross income (EGI), with estimates between 0.14 and 0.28. The results further show that the difference between ETI and EGI is driven by deductions that are indeed responsive to changes in the net-of-tax rate: the elasticity of the sum of deductions is estimated to be between -0.91 and -0.30. Hence, on average, the substitution effect dominates the income effect. We additionally show that the behavioral response is mainly due to (itemized) deductions which are relatively less likely to be third-party reported and where taxpayers have more control over the deduction decision. We also explore the tax responsiveness of different categories of deductions. The results show that those categories, which arguably generate some type of externality, are sensitive to changes in the tax rate, suggesting that the elasticity of the sum of deductions is mostly driven by responses of externality-generating deductions.

Our paper makes three contributions to the literature. First, we add to the discussion on the potential role of the ETI as a sufficient statistic for welfare analysis. Besides the contributions by Chetty (2009) and Gorodnichenko et al. (2009), a series of earlier papers has identified revenue offset, i.e., shifting income to other tax bases, as a threat to the interpretation of the ETI as a sufficient statistic (Slemrod 1998; Gordon and Slemrod 2002; Slemrod and Yitzhaki 2002; Saez 2004). We present an additional argument as to why the ETI is hardly able to be interpreted as a sufficient statistic for the efficiency costs of income taxation, namely that tax deductions generate externalities and are responsive to tax-rate changes. As a theoretical contribution, we show that the non-sufficiency result of Chetty (2009) translates to an optimal-tax model with heterogeneous agents following Saez (2004).[6]

[5]The Weber (2014) approach is an advancement of the seminal empirical strategy proposed by Gruber and Saez (2002). Other recent studies such as Chetty et al. (2011) or Kleven and Schultz (2014) also exploit local kinks in tax schedules to identify the ETI. Such an approach is, however, not applicable to the German case since there are no tax brackets in the German tax schedule.

[6]Our theoretical findings are related to An (2015) who extends the representative-agent model of Chetty (2009) to allow for charitable giving and warm-glow, but does not account for redistribution.

Second, we provide further insights on the "anatomy of tax systems".[7] As pointed out by Slemrod (1996), Saez (2003) or Saez et al. (2012), detailed knowledge about the different adjustment channels underlying the ETI is desirable as the government has full control over the definition of taxable income. Knowing the responsiveness of its components can hence help to design (more) efficient tax systems.[8] So far, direct evidence on the effect of taxes on tax deduction behavior is relatively scarce. Exceptions are Matikka (2014), who presents suggestive evidence from Finland that certain deductions are responsive to income taxes, and Bastani and Selin (2014), whose analysis indicates that taxable income responses of Swedish self-employed mainly occur through legal tax avoidance rather than through real adjustments. Moreover, Slemrod and Kopczuk (2002) and Kopczuk (2005) show that the ETI is considerably larger in tax systems with more deduction possibilities providing evidence that the ETI is not an immutable parameter but rather a policy choice (see, e.g., Slemrod 1994, 1995, 1998). There is also evidence that gross income is less responsive to tax changes than taxable income (Saez et al. 2012; Kleven and Schultz 2014). These studies indicate that the adjustment of tax deductions might be relevant. They do not, however, provide direct evidence that deduction behavior is responsive to tax rate changes since an EGI smaller than the ETI does not necessarily imply that deductions are responsive, as shown in Section 2.1.

Providing new ETI estimates for Germany is our third contribution. There are only a few studies that examine the ETI for Germany (Gottfried and Witczak 2009; Schmidt and Müller 2012; Werdt 2015) which we extend by using a larger panel-data set along with additional estimation methods. Besides the vast amount of deduction possibilities, the case of Germany is interesting because of the unique German tax schedule that does not have tax brackets but a tax formula that generates linearly increasing *marginal* tax rates over a large segment of the taxable income distribution.

Our paper proceeds as follows. Section 2 presents our optimal-tax model building on Saez (2004) and our empirical strategy. In Section 3, we describe the institutional background and the tax reforms that we exploit for identification. Section 4 provides information about the data we use and reports summary statistics. Our results are presented and discussed in Section 5. Section 6 concludes the paper.

[7] Our study is also related to the literature showing that charitable donations (which are usually deductible) are responsive to tax changes (see, e.g., Joulfaian 2000, Andreoni 2006 and Yörük 2013 for surveys).

[8] Among all possible adjustment channels that are summarized in the ETI, the responsiveness of labor supply has so far received the most attention in the literature finding modest behavioral elasticities (see Blundell and MaCurdy 1999 and Bargain et al. 2014 for surveys). Other channels that have been found to contribute to the ETI are, e.g., inter- and intra-temporal income shifting (Auerbach and Slemrod 1997, Kreiner et al. 2013, Harju and Matikka 2013, le Maire and Schjerning 2013, Kreiner et al. 2014), or tax non-compliance (Gorodnichenko et al. 2009; Kleven et al. 2011).

2 Conceptual Framework

2.1 Theoretical Model

Tax deductions are intended to either compensate (disadvantaged) individuals for distributional reasons (e.g., deductions for disabled people) or to encourage certain behaviors or expenses that generate benefits for society (Poterba 2011). Examples of the latter include deductions of charitable donations, insurance fees to encourage the healthy to buy insurance or child-care costs to stimulate labor supply. Other deductions often exist to expense investments in human capital. Since the returns to these investments are taxed in later periods, there are no efficiency costs over the life-cycle if deducting investment costs leads to efficient investment decisions.

Thus, deductions usually serve the purpose to incentivize taxpayers – by offering reductions in the tax burden – to behave in a way that produces externalities to society. Overall, while we acknowledge that not all deductions come with a benefit for society,[9] it seems to be the case that the majority of deductions are associated with either an interpersonal or intertemporal transfers.[10] As a consequence, taxable-income adjustments in the form of deductions should affect the available economic pie differently than other adjustment margins (e.g., labor supply). Deductions might even increase efficiency relative to an allocation in which the externalities of the deductible expense are not generated. If the value of each deduction (deductible amount times marginal tax rate) corresponded to the optimal Pigouvian subsidy, individuals would spend the socially optimal amount on deductible expenses.[11]

To study the role of deductions for the welfare effects of income taxation more formally, we adjust the theoretical model developed by Saez (2004), which incorporates deductible expenditures into an optimal tax framework. Individuals are indexed by $h \in H$. The total population is normalized to one. Individuals may differ in their ability and therefore have different gross incomes. Individual h's utility u^h depends positively on consumption c and negatively on gross income z. In addition, there are *individual* expenses d, which may have positive or negative effects on utility.[12] As discussed above, deductions are generally intended to encourage

[9]For example, governments may implement certain deductions to serve lobby groups, although these deductions do not generate externalities. Also see footnote 3.

[10]Our static framework does not explicitly account for intertemporal transfers such as education investments from the present to the future. However, the intuition is similar since transfers over time do not decrease (the present value of) the economic pie. Hence, interpersonal transfers can be interpreted as intertemporal ones in this setting.

[11]An interesting question beyond the scope of this paper is whether direct subsidies or deduction possibilities are preferable to internalize the externality (see, e.g., Bastani et al. 2015).

[12]On the one hand, some deductions, such as charitable donations, may have a positive warm-

welfare-enhancing behavior or expenditures. Hence, the sum of deductions may be seen as a public good. For this reason, the sum of deductions per capita, which is denoted by D, also enters individual utility and is assumed to have a positive marginal effect. Eventually, utility of individual h is defined as $u^h = u^h(c, z, d, D)$.

The government sets a tax τ on earnings with a lump-sum demogrant R and decides which share α of expenses are deductible from the personal income-tax base. Hence, the individual budget constraint reads $c+d \leq z(1-\tau)+\alpha\tau d+R$. Solving the individual problem yields the indirect utility of individual h which depends on the tax rate τ, the price of the deduction $\alpha\tau$, the lump sum payment R and deductions per capita D: $v^h = v^h(1-\tau, 1-\alpha\tau, R, D)$. The government maximizes social welfare, $W = \int \mu^h v^h(1-\tau, 1-\alpha\tau, R, \bar{D})dv(h)$, which is defined as the sum of the indirect utilities, with $dv(h)$ as the density of individuals over H and μ^h as the social welfare weight attached to individual h.[13] Defining $\bar{Z} = \bar{Z}(1-\tau, 1-\alpha\tau, R)$ and $\bar{D} = \bar{D}(1-\tau, 1-\alpha\tau, R)$ as the average earnings and deductions for given prices, the government problem reads:

$$\max_{\tau,\alpha,R} \mathcal{L} = \int \mu^h v^h(1-\tau, 1-\alpha\tau, R, \bar{D})dv(h) + \lambda[\tau\bar{Z} - \alpha\tau\bar{D} - R - E] \tag{1}$$

where $\tau\bar{Z} - \alpha\tau\bar{D} - R - E = 0$ is the government's budget constraint with E being the exogenously given government consumption per capita, and λ the Lagrangian multiplier measuring the marginal value of public funds. First order conditions with respect to τ, α and R are:[14]

$$\int \frac{\mu^h}{\lambda}\left[v^h_{1-\tau} + v^h_D\bar{D}_{1-\tau} + \alpha v^h_{1-\alpha\tau} + \alpha v^h_D\bar{D}_{1-\alpha\tau}\right]dv(h) = \left[\bar{Z} - \alpha\bar{D} - \tau\bar{Z}_{1-\tau} + \alpha\tau\bar{D}_{1-\tau} - \alpha\tau\bar{Z}_{1-\alpha\tau} + \alpha^2\tau\bar{D}_{1-\alpha\tau}\right] \tag{2}$$

$$\int \frac{\mu^h}{\lambda}\left[v^h_{1-\alpha\tau} + v^h_D\bar{D}_{1-\alpha\tau}\right]dv(h) = -\tau\bar{Z}_{1-\alpha\tau} - \bar{D} + \alpha\tau\bar{D}_{1-\alpha\tau} \tag{3}$$

$$\int \frac{\mu^h}{\lambda}\left[v^h_R + v^h_D\bar{D}_R\right]dv(h) = 1 - \tau\bar{Z}_R + \alpha\tau\bar{D}_R \tag{4}$$

glow effect on utility (Andreoni 1990). On the other hand, however, claiming deductions might come along with resource costs, e.g. distorted consumption or administrative costs, which have a negative impact on utility. So d can be interpreted as the net utility of consumption of deductible expenditures; the effect of d on utility may either be positive or negative. Given that we rely on the envelope conditions, the marginal utility of d is of secondary interest for our model.

[13] It is possible to extend the model and assume that the government can also contribute directly to the public good D, which, however, would not yield additional insights in our case as we are not interested in crowding out effects.

[14] Subscripts denote the partial derivatives; that is, $v^h_{1-\tau}$ is the partial derivative of individual h's indirect utility v^h with respect to the net of tax rate $(1-\tau)$.

In the following, we simplify the three general first-order conditions.[15]

Redistributive taste and welfare externality. We define the social marginal value of consumption of individual h as $\beta^h = \frac{\mu^h v_R^h}{\lambda}$. β^h measures the value, in terms of public funds, of increasing consumption of individual h by one. If the government favors redistribution, β^h is negatively correlated with earnings z^h. If the government does not value redistribution all β^h's would be equal. We now define four measures of average marginal social values. First, the average social value of giving all individuals one extra dollar lump sum is defined as $\beta(R) = \int \beta^h dv(h)$. Second, the average social value of a one dollar lump-sum transfer weighted by gross income is $\beta(Z) = \int z^h \beta^h dv(h)/\bar{Z}$. If the government values redistribution, i.e. β^h is decreasing in z^h, it follows that $\beta(R) > \beta(Z)$. Third, average social value of increasing R by one dollar for everybody, weighted by deductions, is defined as $\beta(D) = \int d^h \beta^h dv(h)/\bar{D}$. If government favors redistribution and if deductions are more concentrated among rich individuals than earnings (this is the case in many countries, including in the U.S. and Germany; see Table 5), it follows that $\beta(R) > \beta(Z) > \beta(D)$. In the case where the government does not value redistribution, $\beta(Z) = \beta(R) = \beta(D)$. We further define the marginal value of deductions D in terms of public funds as $e = \int \frac{\mu^h v_D^h dv(h)}{\lambda}$. Put differently, e measures the welfare externality of a marginal increase in deductions.

Assumptions. We follow Saez (2004) in making two simplifying assumptions:

- **A1:** There are no income effects $\bar{Z}_R = 0$. This assumption is standard in the literature and is backed up by many empirical studies, which find relatively small income effects (Saez et al. 2012; Bargain et al. 2014).
- **A2:** Changes in the price of deductions do not affect gross income $\bar{Z}_{1-\alpha\tau} = 0$. This assumptions complies with the literature on charitable giving, which usually assumes that gross income is not affected by the price of the contribution – in our case: the price of the deduction (Clotfelter 1985; List 2011).

Note that Saez (2004) makes a third assumption, namely that the compensated supply of expenditures does not depend on the labor tax rate. Intuitively, this assumption would imply that a decrease in the tax affects deductions only through an increase in disposable income; the substitution effect between consumption c and deductible expenditures d would be zero. While the optimal tax formulas are

[15] We assume that our problem is well behaved in the sense that all derivatives of the partial indirect utility function exist and are smooth for all types. This makes sense given that we have linear tax rates and linear prices and hence a linear budget constraint.

similar, we argue that this assumption is too strong in the context of our study since we intend to estimate the direct uncompensated effect of tax changes on deductions. In fact, previous evidence suggests that deductions respond negatively to increases in the net-of-tax rate. This result can only occur if the substitution effect (from consumption to deducting) dominates the income effect (see List 2011 for the case of tax deductible charitable donations). If the compensated elasticity of deductions with respect to the tax rate was zero, we would see a positive effect of the net-of-tax rate on deductions. Whether the substitution or income effect dominates is an empirical question, which we explore below.

Using the above definitions and assumptions and applying Roy's identity ($v^h_{1-\tau} = z^h v^h_R$ and $v^h_{1-\alpha\tau} = -d^h v^h_R$), first-order conditions (2), (3) and (4) simplify to:

$$\frac{\tau}{1-\tau}\epsilon_Z \bar{Z} + (e-\alpha\tau)\bar{D}_{1-\tau} + \alpha(e-\alpha\tau)\bar{D}_{1-\alpha\tau} = (1-\beta(Z))\bar{Z} - (1-\beta(D))\alpha\bar{D} \quad (5)$$

$$(1-\beta(D))\bar{D} = -(e-\alpha\tau)\bar{D}_{1-\alpha\tau} \quad (6)$$

$$1-\beta(R) = (e-\alpha\tau)\bar{D}_R \quad (7)$$

where $\epsilon_Z = \bar{Z}_{1-\tau}\frac{(1-\tau)}{\bar{Z}}$ and $\epsilon_D = \bar{D}_{1-\tau}\frac{(1-\tau)}{\bar{D}}$ measure the elasticities of gross income and deductions with respect to the net of tax rate.

In the following, we interpret the conditions for the optimal share of expenses that is deductible and the optimal tax rate in turn. Condition (6) shows that in a world in which the government does not have a taste for redistribution, ($\beta(D) = 1$), α should correspond to the optimal Pigouvian subsidy such that the marginal benefit of increasing the deductibility share, i.e. the marginal welfare externality e, is equal to the marginal costs in terms of tax revenue $\alpha\tau$. If deductions are somewhat concentrated and the government values redistribution ($\beta(D) < 1$), the formula implies that the marginal benefits of increasing the deductibility share have to be larger than the marginal costs for a given behavioral response $\bar{D}_{1-\alpha\tau}$. The more concentrated deductions are among high income earners (i.e. the lower $\beta(D)$), the larger the gap between marginal benefits and the costs of deductions. A high concentration of deductions at the top implies that, for a given externality and tax rate, the government should reduce the deductibility share α.[16]

We now turn to condition (5) for the optimal tax rate τ. In the absence of deduction possibilities ($D = 0$) and if the government favors redistribution ($\beta(Z) < 1$), the standard result holds that the optimal tax rate τ is such that efficiency gains

[16]Note that the same rationale also applies to the case of heterogeneous deductible expenditures: the higher the externality, the higher the respective optimal α, ceteris paribus.

induced by an increase in the net of tax rate $\frac{\tau}{1-\tau}\epsilon_Z\bar{Z}$ have to equal the welfare loss induced by making the tax system less progressive $(1-\beta(Z))\bar{Z}$. Evaluating the formula conditional on the optimal choice of α, that is substituting in condition (6), equation (5) simplifies to:

$$\frac{\tau}{1-\tau}\bar{Z}\epsilon_Z + \frac{(e-\alpha\tau)}{1-\tau}\bar{D}\epsilon_D = (1-\beta(Z))\bar{Z}. \tag{8}$$

Increasing the net-of-tax rate induces efficiency gains through higher gross income $\frac{\tau}{1-\tau}\bar{Z}\epsilon_Z$. If the substitution effect of deductions dominates the income effect ($\epsilon_D < 0$), these efficiency gains are, however, diminished by the term $\frac{(e-\alpha\tau)}{1-\tau}\bar{D}\epsilon_D$ since deductions decrease. In the optimum, net efficiency gains have to equal the equity costs which are depicted by $(1-\beta(Z))\bar{Z}$.

As argued above, the elasticity of taxable income (ETI) is a frequently used parameter to assess the welfare costs of taxation. Defining the ETI as $\epsilon_Y = \bar{Y}_{1-\tau}\frac{(1-\tau)}{\bar{Y}}$, we can use the identity $\epsilon_Z = \frac{\bar{Y}}{\bar{Z}}\epsilon_Y + \alpha\frac{\bar{D}}{\bar{Z}}\epsilon_D$ to introduce the ETI in formula (8):

$$\frac{1}{1-\tau}\left[\tau\bar{Y}\epsilon_Y + e\bar{D}\epsilon_D\right] = (1-\beta(Z))\bar{Z}. \tag{9}$$

Several implications can be drawn from equation (9).[17] First, even in the absence of deductions ($\bar{D}=0$), the ETI alone is not a sufficient statistic to calculate the marginal *welfare* costs of taxation if the social planner values redistribution, i.e. $\beta(Z) < 1$, as not only efficiency costs but also equity concerns have to be taken into account. Second, the elasticity of taxable income is not a sufficient statistic for the *efficiency* costs of taxation if (i) the tax code allows for deduction possibilities ($\bar{D} > 0$), (ii) there is a welfare externality ($e > 0$) and (iii) deductions respond to the tax rate ($\epsilon_D \neq 0$). The intuitive explanation for our main result that the ETI is not sufficient to evaluate the efficiency costs of taxation, is that deductions contribute to a public good and hence generate externalities. As a consequence, taxable income adjustments in the form of altered deduction behavior have different efficiency implications than real adjustments. This intuition corresponds with the main mechanisms put forward by Chetty (2009). Hence, we show that Chetty's results translate to a world with heterogeneous agents and redistribution.

While our first and second conditions for the non-sufficiency of the ETI should be fulfilled in essentially all Western tax systems, the third condition, namely that

[17] Note that for the case without redistributive taste of the government, condition (9) is exactly equal to the main formula (1) in an earlier version of this paper (Doerrenberg et al. 2014), which used Chetty (2009)'s representative-agent framework.

deductions respond to taxes, is to be tested empirically. Many studies imply that deductions are responsive to tax rates by finding a difference between the ETI and the elasticity of gross income.[18] However, this allegation does not prove deduction responsiveness. Given that $Y = Z - \alpha D$, the ETI can be decomposed as $\epsilon_Y = \frac{\bar{Z}}{\bar{Y}}\epsilon_Z - \alpha\frac{\bar{D}}{\bar{Y}}\epsilon_D$, which illustrates that the elasticity of taxable income ϵ_Y depends on the responsiveness of gross income, ϵ_Z, and deductions, ϵ_D, as well as the shares of gross income and deductions in taxable income, $\frac{\bar{Z}}{\bar{Y}}$ and $\alpha\frac{\bar{D}}{\bar{Y}}$. Note that $\frac{\bar{Z}}{\bar{Y}}$ is larger than one because some type of deductions or exemptions are usually subtracted from gross income in any tax system.[19] Hence, ϵ_Y would be larger than ϵ_Z, even if deductions were not responsive to tax rate changes, i.e., even if $\epsilon_D = 0$.

2.2 Empirical Model and Identification

This section describes the empirical model and outlines our identification strategy. To estimate the effect of the net-of-tax rate on different income or deduction measures, we employ a panel-regression model following Weber (2014), which constitutes an advancement of the standard approach by Gruber and Saez (2002). For taxpayer i in year t, we regress the change in our left-hand side variable of interest (either taxable income, gross income or deductions), $\Delta Y_{i,t}$, on the change in the marginal net-of-tax rate, $\Delta(1 - \tau_{i,t})$. The operator Δ indicates the difference between year t and base-year $t - k$. Following the literature, we estimate the model given below in 1-year, 2-year and 3-year differences:

$$\Delta \ln Y_{i,t} = \epsilon_Y \Delta \ln(1 - \tau_{i,t}) + f(GI_{i,t-k}) + \phi \mathbf{X}_{i,t} + \gamma_t + \eta_{i,t}, \tag{10}$$

where $f(GI_{i,t-k})$ is a function of individual base-year gross income, $\mathbf{X}_{i,t}$ a vector containing standard demographic variables (dummies for joint filing / marital status, number of children, age, and West- vs. East-Germany), γ_t a set of year fixed effects and $\eta_{i,t}$ an individual error term.[20]

The coefficient of interest, ϵ_Y, can be interpreted as an elasticity since the outcome measure, $Y_{i,t}$, and the net-of-tax rate, $(1 - \tau_{i,t})$, enter the regression in logs. We follow standard practice in the literature to address potential threats to

[18] For example, Saez et al. (2012, page 39) state that "Gruber and Saez's elasticity estimate for broad income, 0.12, is notably smaller than their corresponding estimate for taxable income, suggesting that much of the taxable income response comes through deductions, exemptions, and exclusions".

[19] In Germany, $\frac{\bar{D}}{\bar{Y}}$ is 1.25 on average, see Section 4 for more detailed summary statistics.

[20] Note that in our empirical specification we abstract from estimating income effects as this is common in the literature (Saez, Slemrod, and Giertz 2012). See, e.g., Blomquist and Selin (2010) for a study allowing for income effects.

identification (Saez et al. 2012). First, we use panel data and estimate the model in differences to wipe out time-invariant individual confounders. Second, we account for mean reversion and secular trends in income inequality by controlling for gross income (Auten and Carroll 1999). Since the literature shows that ETI estimates are fairly sensitive to the way of controlling for income, we report results for a variety of different income controls. In our main estimations, we follow the idea of Kopczuk (2005) – recently applied in Kleven and Schultz (2014) – and include 10-piece splines in logged $t-k-1$ income as well as 10-piece splines in the difference between logged income in $t-k$ and logged income in $t-k-1$. These two income controls serve the purpose of controlling for transitory income – through the difference between base-year income and its lag – as well as permanent income – through lagged base-year income. We also report robustness checks where we include 10-piece splines in logged $t-k$ income and 10-piece splines in logged $t-k-1$ income.

Third, we have to account for the mechanical relationship between our left-hand-side variables and the net-of-tax rate. An increase in income automatically changes the net-of-tax rate because, in progressive systems, higher incomes are taxed at higher marginal tax rates. The same reasoning applies when tax deductions are used on the left-hand side of the equation: higher deduction claims reduce taxable income and therefore also affect the tax rate. This mechanical relationship between the left-hand side variables and $(1-\tau_{i,t})$ requires to find an instrument for the net-of-tax rate that is unrelated to the error term in the above regression model. Following Gruber and Saez (2002), most studies in the literature use an instrument which is based on predicted changes in tax rates that are solely due to legislative tax reforms (e.g., Chetty et al. 2011; Kleven and Schultz 2014). The net-of-tax rate in year t is instrumented with the "synthetic" net-of-tax rate that is constructed by applying the tax schedule in year t to income in base-year $t-k$. As a result, the synthetic instrument intents to capture statutory tax rate changes caused by reforms while it abstracts from mechanical tax-rate changes in progressive tax systems that are due to changing income (or deductions).

However, there is a growing concern in the literature that this synthetic net-of-tax rate is not sufficiently exogenous. In fact, it depends on base-year income and shocks to base-year income are part of the error term in the regression equation – despite flexible ways of controlling for base-year income (Blomquist and Selin 2010; Weber 2014). To overcome this potential threat of endogeneity, we employ an instrument that was proposed by Weber (2014), and which we denote $(1-\tau_{i,t}^{synth})$. Instead of making the instrument a function of base-year income, the synthetic instrument is a function of some lag of base-year income. That is, the instrument we use is constructed by applying the tax schedule of year t to income in the year before the base-year, $t - k - 1$. Weber (2014) shows that such an instrument is more exogenous to the error term than an instrument that is simply based on base-year income, and therefore reduces the correlation between the error term and the instrument.

Fourth, mechanical effects induced by simultaneous tax-rate and tax-base reforms may have important implications for the definition and construction of variables for our analysis. Note that this is a general problem faced by most studies estimating the ETI. To circumvent this complication, the literature uses the broadest definition of the tax base (see Saez et al. 2012). We follow this approach in our paper. At the same time, by using the broadest tax base, we might underestimate the responsiveness of deductions. The reason for this is that the broadest base might mask some behavioral responses in case of changes in deduction cap limits or minimum amounts.[21]

3 Institutional Background

3.1 The personal income tax in Germany

All individuals in Germany are subject to personal income taxation. Residents are taxed on their global income; non-residents are taxed on income earned in Germany only.[22] The basic steps for the calculation of the personal income tax under German tax law are illustrated in Table 1.

Gross income, GI. The first step is to determine a tax unit's gross income from different sources and to allocate it to the seven forms of income the German tax law distinguishes between: income from agriculture and forestry, business income, self-employment income, salaries and wages from employment, investment income, rental income, and other income (including, for example, annuities and certain capital gains).[23] GI is used in our regression analyses to identify the sensitivity of gross income.

[21]We believe that this potential bias is small in our context since (i) very few caps exist on deductions in the German tax law and (ii) there were almost no changes to the existing caps over time, especially not for the most relevant deductions (such as investment in education). Hence, in order to be consistent with the standard ETI literature, we apply the standard tax base definition for our analysis.

[22]The legal norm setting up the German tax system is called *Einkommensteuergesetz (EStG)*.

[23]The following types of income are tax exempt: payments from health insurance, accident insurance and insurance for disability and old age, welfare benefits and scholarships.

Table 1: Calculation of the personal income tax

	Sum of gross income (GI) from 7 sources (3 types of self-employment income; labor income; 3 types of capital income)
-	Income-related deductions (D^{income})
=	Adjusted gross income (AGI)
-	Deductions and allowances for "Special expenses" and "Extraordinary burden" (D^{other})
-	Child allowance
=	Taxable Income (TI)
·	Tax formula
=	Tax liability
+	Tax credits
=	Tax due (T)

Adjusted gross income Second, for each type of income, the tax law allows for certain income-related expenses (*Werbungskosten*). In principle, all expenses that are necessary to obtain, maintain or preserve the income from a source are deductible. These include, for instance, commuting costs, expenses for work materials or costs of training. For non-itemizing taxpayers, there is an allowance for labor earnings (€920 in 2008) and capital income (€750 in 2008). The sum of gross income minus income-related deductions per income source yields the adjusted gross income.

Taxable income, TI. As a third step, further deductions are taken into account and subtracted from adjusted gross income yielding taxable income. These other deductions comprise special expenses (*Sonderausgaben*) and expenses for extraordinary burdens (*außergewöhnliche Belastungen*). A detailed list of examples for other deductions is shown in Table 2.[24] Moreover, negative income from the preceding assessment period (loss deduction carried back) can be subtracted from adjusted gross income. Last, each tax unit with children receives either a child allowance or a child benefit, depending on which is more beneficial. We use TI as a dependent variable in the regressions to derive the ETI.

Deductions, D. The German personal income tax law allows for a vast number of potential deductions: According to Kirchhof (2011), there are "at least 534 different" deduction possibilities. First, as mentioned above, all income-related deductions,

[24]In contrast to many other countries, mortgage interest payments are not tax deductible.

Table 2: Overview of other (itemized) deductions

Category	
Special Expenses	Alimony payments Church tax Tax consultant fees Expenses for professional training School fees of children Charitable donations Donations to political parties Insurance fees Social insurance contributions
Extraordinary Burden Expenses	Expenses for the education of dependents, for the cure of illness, for home help with elderly or disabled people, commuting expenses caused by disability Child care costs Tax allowances for self used proprietary, premises and historical buildings Allowances for disabled persons, surviving dependents and persons in need of care

D^{inc}, that are necessary to generate or earn income can be deducted. This includes, e.g., commuting costs or expenses to buy work clothes. In addition, expenses for mandatory public or voluntary private pension insurance, as well as health and unemployment insurance, can be deducted. Compared to other deductions, income-related deductions are more likely to be third-party reported and automatically deducted from gross income. This implies that taxpayers often have no choice as to whether they incur an expense in the first place, or as to whether they claim it on the tax return

Second, other deductions, D^{other}, which are split into special expenses and extraordinary-burden expenses, can be deducted. These itemized deductions are typically self-reported and involve (to a greater extent) choices of the individual taxpayers. The former category includes expenses for investment in human capital (own education or professional training as well as expenses for education of children), child care costs, donations to charity or political parties and church tax payments.[25] These examples show that allowing "sheltering" in the form of tax deductions usually does not serve the purpose of maximizing after-tax income, but

[25]Extraordinary burden expenses, which are relatively unimportant in magnitude on average, grant taxpayers allowances in extraordinary circumstances: disabled persons, surviving dependents and persons in need of care.

is instead intended to internalize externalities such as transfers to other agents in the economy or investments that yield higher taxable income in the future and are hence taxed later in the life-cycle.

In our regressions, we use income-related deductions, D^{inc}, other deductions, D^{other}, as well as their sum (called total deductions D^{total}) as dependent variables to estimate the deductions elasticity. To explore single categories of deductions in more detail, we further decompose D^{other} into deductible expenses for donations (D^{other}_{don}), investment in one's own future (i.e. education and retirement savings; D^{other}_{inv}), and deductions with a redistributive motive (such as alimony payments or allowances for disabled individuals; D^{other}_{redis}). Arguably, the first two sub-categories, D^{other}_{don} and D^{other}_{inv}, clearly generate externalities,[26] whereas the latter, D^{other}_{redis}, might not come with an external effect and has a pure redistributive motive.

Tax due, T. The income tax is calculated by applying the tax schedule to taxable income. In contrast to most other countries, which use a bracket system with constant marginal tax rates within a bracket, Germany uses a formula (which is quadratic in income) to compute the tax liability. As a consequence, marginal tax rates increase linearly in income (up to an top marginal tax rate of 42%). The formula for the year 2008 is defined as follows[27]:

$$T = \begin{cases} 0 & \text{if}\, TI \leq 7,664 \\ (883.74\frac{TI-7,664}{10,000} + 1,500)\frac{TI-7,664}{10,000} & \text{if}\, 7,664 < TI \leq 12,739 \\ (228.74\frac{TI-12,739}{10,000} + 2,397)\frac{TI-12,739}{10,000} + 989 & \text{if}\, 12,739 < TI \leq 52,151 \\ 0.42TI - 7,914 & \text{if}\, 52,151 < TI \leq 250,000 \\ 0.45TI - 15,414 & \text{if}\, TI > 250,000. \end{cases} \tag{11}$$

In addition to the personal income tax, households additionally pay the "Solidaritätszuschlag", a tax supplement originally introduced to finance the German reunification. During the period of interest, 2000 - 2008, the supplement amounts to 5.5% of the income tax liability.[28]

[26] The level of positive externalities associated with charitable giving might be questioned. Some clearly produce external benefits. However, others do not target low income groups and may be viewed as a tax subsidy for "club goods" benefiting upper income groups. Other deductions, such as fees for tax consultants, other taxes paid or mortgage interest deductions (which do not exist in Germany) might also not generate positive externalities either.

[27] For married taxpayers filing jointly, the tax is twice the amount of applying the formula to half of the married couple's joint taxable income: $T(TI_1 + TI_2) = 2 * T\left(\frac{TI_1+TI_2}{2}\right)$.

[28] The exact rule is slightly more complicated with a minimum tax amount resulting in the kink visible in Figure 2 at roughly 15,000€ .

3.2 Reforms 2001–2008

Appendix Figure 2 shows the marginal tax rate schedule for the years 2001-03, 2004 and 2005-08.[29] Between 2000 and 2005, a major reform of the German personal income tax took place. The basic tax allowance was increased in several steps from €6902 in 2000 to €7664 (2004–2008) with €7206 in 2001 and €7235 in 2002/03. The lowest marginal tax rate decreased from 22.9% in 2000 to 15% (2005–2008) with 19.9% (2001–03) and 16% (2004) in between. The top marginal tax rate was reduced from 51% in 2000 to 42% in 2005 with 48.5% (2001-03) and 45% (2004) in between. The threshold for application of the top marginal tax rate was reduced from €58,643 in 2000 to €52,151 in 2004 with intermediary values of €55,007 (2001-03). In 2007, an additional tax bracket at the top (for taxable income above €250,000) was introduced with a top marginal tax rate of 45%.

Figure 1: Percent change in the net-of-tax rate

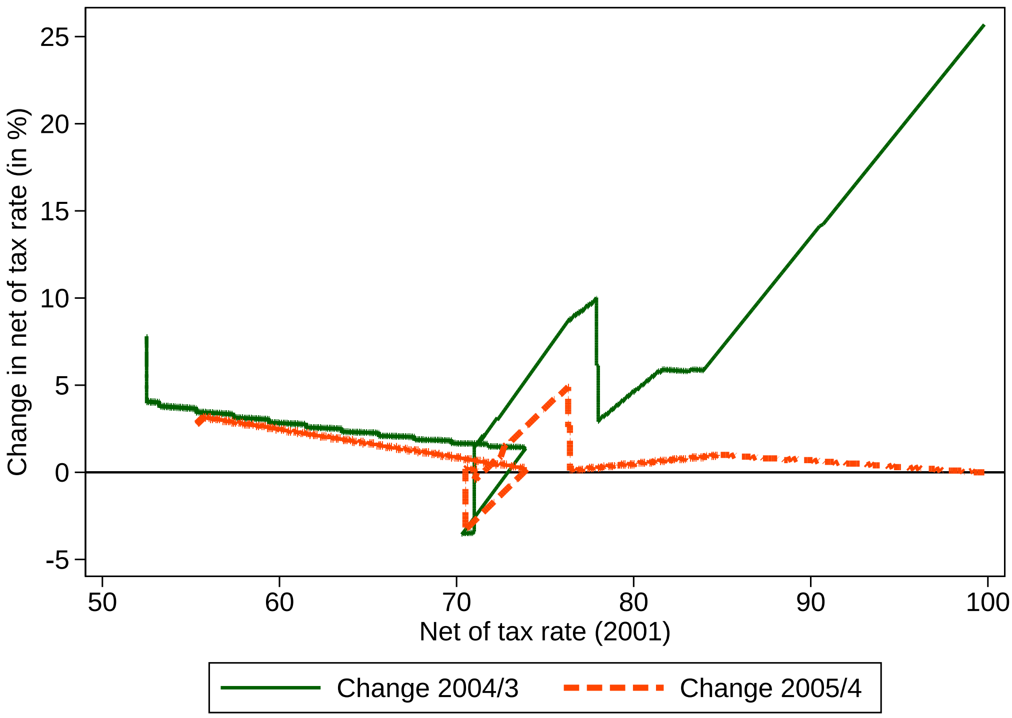

Figure 1 shows the percentage change in the net-of-tax rate as a function of the initial value of the net-of-tax rate at the key dates of the tax reforms. Taxpayers with a high net-of-tax rate and those close to the top marginal tax rate (i.e., with a net-of-tax rate close to 50%) experienced the largest marginal tax-rate cuts whereas for some taxpayers in the middle of the tax-rate distribution marginal tax rates (net-of-tax rate) increased (decreased). Note also that taxpayers with similar baseline

[29]Figure 3 in the Appendix plots the income distribution along the marginal tax rate schedule.

net-of-tax rates were affected differently by the reforms. Hence, we can conclude that different groups of taxpayers were affected differently by the reforms, providing us with identification beyond simple time-series variation.

4 Data and Summary Statistics

Data set. We use the German Taxpayer Panel, which is an administrative data set collected by German tax authorities, provided and administered by the German Federal Statistical Office (Kriete-Dodds and Vorgrimler 2007), based on the universe of personal income tax returns. The unit of observation is the taxpayer, i.e., either a single individual or a couple filing jointly. The dataset is a balanced panel covering all German tax units filing tax returns in the period 2001 to 2008. We have access to a 5% stratified random sample of the Taxpayer Panel and employ the respective weights provided by the Statistical Office. The dataset contains all information necessary to calculate a taxpayer's annual income tax, this includes basic socio-demographic characteristics such as birth date, gender, family status, number of children as well as detailed information on income sources and tax base parameters such as work-related expenses and deductions.

Sample selection. We follow standard practice in the literature (e.g., Saez et al. 2012) and especially Weber (2014) to select our estimation sample. The sample is restricted to taxpayers who have a positive income above €10,000 (in real 2001 terms) in each period. We further exclude taxpayers who change their marital status during the sample period as this implies a change from individual to joint filing or vice versa, and we restrict the sample to individuals in the range of ages 18 to 65 (the pension age in Germany). We also have to exclude a few taxpayers with implausible demographic characteristics (e.g., change of gender or date of birth) that are due to data errors. These restrictions leave us with a sample of approximately 3.6 million observations. Note that we estimate the regression equation in differences, implying that we lose at least two years of observations (with 1-year differences and the Weber (2014)-type instrument) and hence have between 1.8 (with 3-year differences) and 2.7 (with 1-year differences) million observations in our regressions. In compliance with the relevant literature, our regressions are weighted with taxable income and the provided sample weights.

Summary Statistics. For our analysis, we first look at five different dependent variables (see Sections 2.2 and 3.1): (1) taxable income TI, (2) gross income GI, (3) total deductions D^{total}, which consist of (4) income-related deductions D^{inc} and

(5) other deductions D^{other} (with $D^{total} = D^{inc} + D^{other}$). We further explore the responsiveness of different categories of D^{other}: deductible expenses for charitable giving D^{other}_{don}, investments in one's own future D^{other}_{inv}, and expenses for redistribution to people in need D^{other}_{redis}. Table 5 in the Appendix shows descriptive statistics for all these variables. On average, the ratio between TI and GI is 0.80, which implies that total deductions account for about 20% (25%) of gross (taxable) income. Comparing D^{inc} and D^{other}, the table shows that income-related expenses only make up for 13% of total deductions on average. Hence, "other" (itemized) deductions are relatively more important for the reduction of taxable income in Germany. Further decomposing D^{other} shows that the largest share constitutes investments in human capital and savings (88.6% of D^{other}), whereas donations and redistributive deductions play a smaller role. Looking at the extensive margin, it becomes obvious that every taxpayer has some income-related deductions and investment deductions whereas only 47% claim deductions for donations and less than 15% claim redistributive deductions.

Table 6 in the Appendix shows the distribution of the different dependent variables across deciles of gross income in terms of the respective decile's shares. Taxable income is a bit more concentrated at the top of the distribution than gross income (the shares of the top 10% are 42% for TI and 39% for GI, respectively). The shares of the deduction categories are also increasing in income – which suggests that, on average, deductions favor the highest income households, resulting in negative distributional effects of deductions. The highest concentration of deductions among rich taxpayers is found for donations, which might support the view that some donation deductions are indeed tax subsidies for "club goods" (Cordes 2011).

5 Results

This section presents regression-based evidence using all tax reforms between 2001 and 2008 for identifying variation. We estimate regression model (10) using two-stage least squares and cluster standard errors on the individual level (see section 2.2 for details on the estimation techniques). First-stage regressions (not shown) of $\Delta \ln(1 - \tau_{i,t})$ on $\Delta \ln(1 - \tau^{synth}_{i,t})$ are very strong with large $F-$statistics exceeding at least 400 in all our estimations. Figure 4 in the Appendix provides graphical evidence of the first stage (Panel A) and the reduced-form regression (Panel B) for regression model (10) for 2-year differences (i.e. specification (I) of Panel B in Table 3 below) following the exposition of Weber (2014). More precisely, in panel A (B), the figure plots a fourth-order local polynomial regression of the change in the log marginal net-of-tax rate (log taxable income) on the changes in the predicted log marginal net-of-tax rate. Looking at panel A, the instrument is performing well even for large changes in the marginal net-of-tax rates as indicated by the narrow 95% confidence bands over the whole distribution of tax changes. Panel B indicates that the average taxable income change is increasing with predicted marginal net-of-tax rate changes.

5.1 Taxable income, gross income and aggregate deductions

Table 3 displays the regression estimates for different dependent variables. The dependent variables (in columns $I - V$) are k-year growth rates of taxable income (TI), gross income (GI), total deductions (D^{total}), income-related deductions (D^{inc}), and other deductions (D^{other}). Each panel of the table shows the results for different lengths in differences k, with $k \in 1, 2, 3$, to provide short-run and medium-run effects.

Table 3 depicts in column (I) that we estimate an elasticity of taxable income (ETI) in the range of 0.34 to 0.68, depending on the choice of the length of differences (see below for a discussion of timing effects). In line with the previous literature, the elasticity of gross income (EGI) is always smaller than the ETI – as shown in column (II). The EGI ranges between 0.14 for 3-year differences and 0.28 for 1-year differences. These estimates are broadly in line with the results in Weber (2014) for the US.

Column (III) shows that the observed difference between the ETI and the EGI is due to deduction responses, which we estimate to be negative with respect to the net-of-tax rate. For the sum of all deductions D^{total}, we estimate highly significant elasticities in the range of -0.91 to -0.30, again depending on the lengths of differences. This deduction response to the net-of-tax rate is driven by (itemized) other deductions D^{other} (V) rather than income-related deductions D^{inc} (IV). While we estimate (mostly) non-significant elasticities around zero for the income-related items, the coefficients for the "other" type of deductions are statistically significant and lie between -1.06 and -0.23. This is reassuring given that taxpayers have much more discretion when it comes to claiming (itemized) D^{other}-type deductions.

Comparing the regression results for different lengths of year differences, we shed some light on the issue of transitory versus permanent responses to tax-rate changes. One reason for differences could be households changing the timing of income realizations (Kreiner et al. 2013) or bringing forward or postponing deductions from one year to the next due to changing tax rates, regardless of any "real" and permanent behavioral change. Indeed, looking at all of the columns of Table 3, we observe that the (absolute values of the) estimated elasticities are declining in the lengths of the differences (from 1-year in Panel A to 3-year differences in Panel

Table 3: ETI and deduction elasticities.

Dependent Variable	(I) TI	(II) GI	(III) D^{total}	(IV) D^{inc}	(V) D^{other}
***Panel A**: 1-year differences*					
$\Delta log(1-\tau)$	0.675***	0.281***	-0.906***	0.0956**	-1.059***
	(14.88)	(10.62)	(-22.18)	(2.03)	(-23.08)
N	2713842	2713842	2689990	2560921	2713713
***Panel B**: 2-year differences*					
$\Delta log(1-\tau)$	0.548***	0.162***	-0.872***	0.0150	-0.935***
	(15.63)	(6.93)	(-26.01)	(0.40)	(-25.08)
N	2261535	2261535	2241284	2125828	2261417
***Panel C**: 3-year differences*					
$\Delta log(1-\tau)$	0.338***	0.136***	-0.298***	0.0340	-0.231***
	(9.28)	(4.93)	(-8.25)	(0.88)	(-5.83)
N	1809228	1809228	1792942	1697994	1809127

Notes: 2SLS regressions based on equation (10) with t-statistics in parentheses. Standard errors clustered on the tax-unit level. Significance levels are * < 0.10, **< 0.05, *** < 0.01. German tax return data for 2001-2008. Results are based on a 5% stratified random sample of the universe of German taxpayers. Dependent variables in all panels are (I) taxable income TI, (II) gross income GI, (III) total deductions D^{total}, (IV) income-related deductions D^{inc} and (V) other (itemized) deductions D^{other}. All dependent variables are logged. Independent variable of interest is the k-year growth rate in the logged marginal net-of-tax rate (i.e., $\Delta log(1-\tau)$), instrumented with the k-year growth rate in the synthetic net-of-tax rate based on lagged base-year $t-k-1$ behavior (Weber (2014)-type instrument). Reported coefficients can be interpreted as elasticities identified from tax reforms. All specifications include year fixed effects, region fixed effects (East vs. West Germany), controls for demographic variables (Dummies for number of children, marital status, age) as well as the following income controls: 10-piece splines of logged gross income in $t-k-1$, and 10-piece splines of the difference between logged gross income in $t-k$ and logged gross income in $t-k-1$. The sample is restricted to tax units with taxable income above €$10,000$ (in real 2001 terms), who are 18-65 years old and do not change their filing status throughout the sample period. All specifications are weighted with taxable income and provided sample weights. N is the number of observations. Panel A is estimated in 1-year differences, i.e. $k=1$. Panel B is estimated in 2-year differences, i.e. $k=2$. Panel C is estimated in 3-year differences, i.e. $k=3$.

C). These findings suggest that taxpayers might anticipate tax reforms (note that most tax reforms are known long before the new fiscal year begins) and respond by re-timing income to periods of lower marginal tax rates and by realizing deductions in periods of higher marginal tax rates. However, our overall conclusion that the ETI is larger than the EGI because of tax-responsive deductions, holds true for all year differences, including the most permanent responses in Panel C.

We conduct several robustness checks to explore the sensitivity of our main results. Table 7 in the Appendix is set-up as Table 3, but reports the coefficients using the commonly used estimator by Gruber and Saez (2002). The basic patterns are entirely in line with the previous results: the ETI is always larger than the EGI, with this difference being driven by negative responses of "other" deductions. However, in line with the findings of Weber (2014), the estimated coefficients are closer to zero with the Gruber/Saez-type instrument than with the Weber-type instrument. The ETI ranges between 0.25 and 0.34, and the EGI is between 0.11 and 0.14. The response for the sum of all deductions is between -0.16 and -0.45.

Appendix Table 8 explores the sensitivity of the results with respect to the choice of income controls. In our baseline, we use a rather restrictive set of income controls that aims to capture changes in permanent and transitory income. Table 8 replicates the Weber results in Table 3 using two other commonly used controls: 10-piece splines in logged base-year income ($t-k$) or 10-piece splines in the lag of logged base-year income ($t-k-1$). The results again confirm the previous pattern of the ETI being larger than the EGI and negative deduction elasticities. However, and not surprisingly considering previous studies, the coefficients deviate from our baseline estimates. For example, controlling for base-year income generally generates higher ETIs and EGIs. In specifications where we control for lagged income, the estimates become comparable to our baseline.

5.2 Different categories of deductions

In a next step, we split the responsive "other" deductions, D^{other}, into different categories to explore how different deduction types respond to changes in the net-of-tax rate. In an effort to have a sufficient number of non-zero observations in each category, we set-up the following major categories: (i) D^{other}_{don} summarizes all donations to charitable organizations. (ii) D^{other}_{inv} represents investments in one's own future. These include, amongst other things, education expenses and deductible savings. (iii) D^{other}_{redis}, includes deductible expenses that present a transfer to dependents and non-dependents in need such as expenses for the care of disabled. Table 4 displays how each of these categories responds to tax-rate changes. The table is set-up in the same way as our main Table 3; that is, we present results using the Weber-type instrument for different lengths in differences.

The results presented in the table indicate that donations D^{other}_{don} (column I) respond positively to increases in the net-of-tax rate. The sign of the coefficient is therefore opposite to the negative sign that we saw for aggregate deductions. This suggests that for donations, the income effect dominates the substitution effect: if the tax rate goes down (net-of-tax rate up) the individual has more money in his pocket which will be partially spent on charitable giving. Investments in the own future D^{other}_{inv} (column II) respond negatively to increases in the net-of-tax

Table 4: Elasticities of different deduction categories

	(I)	(II)	(III)
Dependent Variable	D^{other}_{don}	D^{other}_{inv}	D^{other}_{redis}
***Panel A**: 1-year differences*			
$\Delta log(1-\tau)$	0.927***	-1.079***	-0.769**
	(6.35)	(-24.59)	(-1.99)
N	1373590	2711951	385427
***Panel B**: 2-year differences*			
$\Delta log(1-\tau)$	0.806***	-0.981***	0.104
	(7.86)	(-27.95)	(0.46)
N	1118974	2259816	296747
***Panel C**: 3-year differences*			
$\Delta log(1-\tau)$	0.593***	-0.278***	0.104
	(6.07)	(-7.15)	(0.50)
N	881404	1807755	222083

Notes: 2SLS regressions based on equation (10) with t-statistics in parentheses. Standard errors clustered on the tax-unit level. Significance levels are $^{*} < 0.10$, $^{**} < 0.05$, $^{***} < 0.01$. German tax return data for 2001-2008. Results are based on a 5% stratified random sample of the universe of German taxpayers. Dependent variables in all panels are the following categories of deductions: deductible expenses for charitable giving D^{other}_{don}, investments in one's own feature D^{other}_{inv}, and expenses for redistribution to people in need D^{other}_{redis}. All dependent variables are logged. Independent variable of interest is the k-year growth rate in the logged marginal net-of-tax rate (i.e., $\Delta log(1-\tau)$), instrumented with the k-year growth rate in the synthetic net-of-tax rate based on lagged base-year $t-k-1$ behavior (Weber (2014)-type instrument). Reported coefficients can be interpreted as elasticities identified from tax reforms. All specifications include year fixed effects, region fixed effects (East vs. West Germany), controls for demographic variables (Dummies for number of children, marital status, age) as well as the following income controls: 10-piece splines of logged gross income in $t-k-1$, and 10-piece splines of the difference between logged gross income in $t-k$ and logged gross income in $t-k-1$. The sample is restricted to tax units with taxable income above €$10,000$ (in real 2001 terms), who are 18-65 years old and do not change their filing status throughout the sample period. All specifications are weighted with taxable income and provided sample weights. N is the number of observations. Panel A is estimated in 1-year differences, i.e. $k=1$. Panel B is estimated in 2-year differences, i.e. $k=2$. Panel C is estimated in 3-year differences, i.e. $k=3$.

rate. As with the aggregate deduction response, this shows that the substitution effect dominates for that category. The results for the third category, expenses for redistribution D^{other}_{redis} in column (III), suggest that expenses for redistributive purposes hardly respond to tax-rate changes: the coefficients are not statistically significant when estimating the equation in 2-year or 3-year differences, and only slightly significant for the 1-year differences.[30] That is to say that redistributive deductions, if at all affected by increases in the net-of-tax rate, respond by way of

[30]Note that the estimates become noisy for this category because of small sample sizes – less than 15% of taxpayers claim these deductions.

negative short-run responses.

5.3 Discussion of the results

Our estimations show that aggregate deductions strongly respond to tax rate changes. In the context of our theoretical model, this implies that the ETI is not sufficient if deductions contribute to a public good and hence generate externalities. We argued before that the majority of deductions should have inter-temporal or intra-temporal external effects. In support of this claim, our empirical results show that single categories of deductions such as donations or investment into eduction or retirement, which arguably generate externalities, are also responsive to tax-rate changes. This indicates that the overall response in the aggregate measure of deduction is at least partly driven by externality-generating deductions. As a result, we argue that our empirical results, along with the insights provided by our theoretical framework, suggest that the ETI is not the relevant parameter for evaluating the welfare costs of income-taxation – at least in Germany.

We acknowledge that a fraction of overall deduction responses to tax rate changes might be driven by evasion through overreporting rather than "real" changes in deduction behavior. Unfortunately, our data do not allow us to make a quantitative statement on such evasion responses because they do not contain results from audits. We are neither aware of any aggregate evidence which could help us to get a sense of the extent of overreported expenditures in Germany (this is partly due the fact that the German tax authorities neither employ randomized audits nor publish the results from their endogenous audits). The only recent evidence we are aware of, that provides credible evidence of overreported deductions in a country with a "modern" tax system, is Kleven et al. (2011). They report the results from large-scale randomized audits in Denmark and quantify the extent to which deductions are overreported. They find that overall 5.7% of all taxpayers overreported their deductible expenditures. Not surprisingly, this share can be almost fully attributed to self-reported deductible items, rather than to third-party reported deductions. Looking at the absolute amounts of evaded deductible expenditures, the paper shows that hardly any third-party reported deductions and slightly more than 5% of all self-reported deductions were wrongly reported.

While these numbers are not excessively large, they yet suggest that some of the deduction responses that we find might be due to evasion, especially because we find that most responses stem from self-reported expenditures. What does this mean for our theoretical finding that the ETI is not sufficient in the presence of deductions that generate external effects to other agents? As emphasized by Chetty (2009), if taxpayers are risk-neutral and have no evasion costs (a reasonable assumption for the case of overstated tax expenditures), evasion responses could be (at least partly) offset by future increases in tax revenues through eventual audit fines. Following this argument, even evasion responses should trigger external effects to other agents, implying that the non-sufficiency of the ETI holds true even for the extreme, though unlikely, case that all deduction responses are driven by evasion.

6 Conclusion

In this paper, we show both theoretically and empirically that the ETI is not a sufficient statistic for analyzing the efficiency costs of tax reforms in the presence of tax deductions. Our theoretical framework reveals that the ETI is not the appropriate welfare parameter if (*i*) deductions generate externalities and if (*ii*) deductions are responsive to tax-rate changes. While the first condition arguably holds for most deductible expenses – at least in the German context – , we use German tax return data to demonstrate empirically that deductions respond negatively to net-of-tax rates, implying that the second condition also holds true.

Given that most tax systems around the world allow for deduction possibilities, the findings in our paper cast doubt on the merits of using the ETI to design optimal tax systems in practice. If the value of the deduction, i.e. $\tau \cdot \alpha D$, corresponded to the optimal Pigouvian subsidy and if distributional issues did not arise, then the EGI would sufficiently measure the efficiency (and welfare) consequences of a tax-rate change. If the degree of deductibility is optimal, but justified solely by distributional considerations, then the ETI appropriately measures the efficiency consequences of a change in tax rate (while the welfare consequences still depend on the redistributive taste). When both efficiency and distributional considerations affect the choice of deductibility, then a combination of the ETI, the deduction elasticity, the marginal externality of deductible expenses and the redistributive taste of the government determines the efficiency and welfare effects of a tax increase.

In existing tax systems, it is hard to imagine that tax policy makers manage to set the optimal deduction level for every single deduction possibility – particularly in view of the fact that in most tax systems deductible expenditures are deducted from taxable income and hence valued with the marginal tax rate of the taxpayer. If this is the case, the marginal externality of deductible expenses plays a crucial role. Equation (9) implies that $\frac{dW}{d\tau} = \frac{1}{1-\tau}\left[\tau \bar{Y}\epsilon_Y + e\bar{D}\epsilon_D\right] - (1-\beta(Z))\bar{Z}$. Using this expression, we can try to assess how relevant the presence of deduction possibilities is for the interpretation of the ETI as a sufficient statistic. Assuming that the government does not care about redistribution ($\beta(Z) = 1$), the relative magnitudes of the first and the second part of the term in brackets is crucial for the sufficiency of the ETI: $\tau\bar{Y}\epsilon_Y$ versus $e\bar{D}\epsilon_D$. The resulting welfare effects in the presence of tax responsive deductions ($\bar{D}\epsilon_D < 0$) hence depend on the externalities generated by the deductible expenses. If these are close to zero, the ETI is still a sufficient measure for welfare analysis.[31] The more (positive) externalities are generated, the lower the marginal costs of a tax increase, and the less sufficient is the ETI. With redistributive preferences, things become a bit more complicated since the distributive corrections have to be taken into account when assessing welfare. The challenge for researchers, therefore, is to develop research designs that allow to estimate not only the ETI and deduction elasticity, but also to identify the marginal externality and/or the redistributive taste of the government. While this paper provides a set of results on the former measures, the question of how to empirically pin down the marginal externality is yet to be answered.[32]

Since the responses along the various margins are all functions of policy decisions (Slemrod and Kopczuk 2002; Kopczuk 2005), an interesting question is whether our results derived for Germany also hold for other countries. Given that many studies find that the ETI is larger than the EGI (Saez et al. 2012), one can speculate that deductions are also responsive in other countries. Hence, it would be interesting to estimate the deduction elasticities for other countries. Another question is whether all deductions, that are featured in different tax systems around the world, actually generate (positive) externalities. For instance, it is not clear whether the deductibility of mortgage interests (without taxation of an imputed rent on owner-occupied housing), tax consultant fees, local or church taxes really generate positive externalities. Furthermore, deductions for charitable giving could be viewed as a tax subsidy for club goods. Analyzing the externalities of various deductible expenditures could hence be a fruitful avenue for future research.

[31] If deductions mainly generated negative externalities, the welfare costs would be even larger than estimated by the ETI.

[32] Note that Chetty (2009) derives the welfare loss as a weighted average of the ETI and the EGI. However, estimating the weight, i.e., the marginal resource cost of sheltering in his model, is not trivial either (see, e.g., the concluding discussion in Chetty 2009).

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A Appendix

Table 5: Descriptive statistics for dependent variables

Variable	mean	sd	p10	p25	p50	p75	p90
GI	63,447	122,790	30,583	38,144	51,776	71,807	99,558
TI	50,649	120,898	19,048	26,502	39,120	58,718	85,128
D^{total}	12,797	9,766	3,776	6,590	12,402	17,3111	22,748
D^{inc}	1,639	5,403	943	996	1,562	2,024	2,648
D^{other}	11,158	7,905	2,686	4,757	10,889	15,507	20,603
D^{other}_{don}	164	6,539	0	0	0	99	307
D^{other}_{inv}	9,890	6,310	2,433	4,305	9,686	13,826	18,213
D^{other}_{redis}	377	2,343	0	0	0	0	740

Notes: Summary statistics for variables that are used as dependent variables in the regressions. Gross income GI, taxable income TI, total deductions D^{total}, income-related deductions D^{inc}, other (itemized) deductions D^{other} (where $D^{total} = D^{inc} + D^{other}$), deductible expenses for charitable giving D^{other}_{don}, investments in one's own feature D^{other}_{inv}, and expenses for redistribution to people in need D^{other}_{redis}. German tax return data for 2001-2008. Statistics are based on a representative stratified 5% sample of the universe of German taxpayers. All money variables in 2001 euro. $N = 3,618,456$. Means and standard deviations (sd). pX indicates the X-th percentile.

Table 6: Shares for dependent variables by income decile

	1	2	3	4	5	6	7	8	9	10
TI	0.0153	0.0225	0.0307	0.0386	0.0487	0.0648	0.0873	0.1156	0.1560	0.4206
GI	0.0198	0.0286	0.0362	0.0434	0.0530	0.0682	0.0897	0.1162	0.1531	0.3918
D^{total}	0.0552	0.0765	0.0791	0.0813	0.0870	0.0952	0.1082	0.1205	0.1305	0.1664
D^{inc}	0.0488	0.0656	0.0772	0.0830	0.0878	0.0950	0.1029	0.1093	0.1119	0.2185
D^{other}	0.0562	0.0782	0.0793	0.0811	0.0869	0.0952	0.1090	0.1221	0.1334	0.1586
D^{other}_{don}	0.0095	0.0167	0.0219	0.0265	0.0355	0.0513	0.0731	0.1086	0.1504	0.5065
D^{other}_{inv}	0.0597	0.0820	0.0831	0.0851	0.0913	0.0993	0.1103	0.1219	0.1302	0.1371
D^{other}_{redis}	0.0280	0.0459	0.0492	0.0473	0.0542	0.0662	0.0921	0.1286	0.1719	0.3166

Notes: Shares for variables that are used as dependent variables in the regressions by income decile. Displayed is the share in a variable that a decile holds relative to the total sum of that variable over all deciles. Gross income GI, taxable income TI, total deductions D^{total}, income-related deductions D^{inc}, other (itemized) deductions D^{other} (where $D^{total} = D^{inc} + D^{other}$), deductible expenses for charitable giving D^{other}_{don}, investments in one's own feature D^{other}_{inv}, and expenses for redistribution to people in need D^{other}_{redis}. German tax return data for 2001-2008. Statistics are based on a representative stratified 5% sample of the universe of German taxpayers. All money variables in 2001 euro. $N = 3,618,456$. Means and standard deviations (sd).

Table 7: ETI and deduction elasticities. Gruber/Saez-type IV

Dependent Variable	(I) TI	(II) GI	(III) D^{total}	(IV) D^{inc}	(V) D^{other}
***Panel A**: 1-year differences*					
$\Delta log(1-\tau)$	0.337***	0.144***	-0.452***	0.0158	-0.528***
	(14.91)	(10.44)	(-22.25)	(0.59)	(-23.53)
N	2713842	2713842	2689990	2560921	2713713
***Panel B**: 2-year differences*					
$\Delta log(1-\tau)$	0.406***	0.139***	-0.512***	0.105***	-0.573***
	(19.70)	(10.17)	(-25.09)	(4.44)	(-25.21)
N	2261535	2261535	2241284	2125828	2261417
***Panel C**: 3-year differences*					
$\Delta log(1-\tau)$	0.250***	0.109***	-0.161***	0.143***	-0.150***
	(10.45)	(5.88)	(-6.75)	(5.65)	(-5.76)
N	1809228	1809228	1792942	1697994	1809127

Notes: 2SLS regressions based on equation (10) with t-statistics in parentheses. Standard errors clustered on the tax-unit level. Significance levels are $^{*} < 0.10$, $^{**} < 0.05$, $^{***} < 0.01$. German tax return data for 2001-2008. Results are based on a 5% stratified random sample of the universe of German taxpayers. Dependent variables in all panels are (I) taxable income TI, (II) gross income GI, (III) total deductions D^{total}, (IV) income-related deductions D^{inc} and (V) other (itemized) deductions D^{other}. All dependent variables are logged. Independent variable of interest is the k-year growth rate in the logged marginal net-of-tax rate (i.e., $\Delta log(1-\tau)$), instrumented with the k-year growth rate in the synthetic net-of-tax rate based on base-year $t-k$ behavior (Gruber/Saez-type instrument). Reported coefficients can be interpreted as elasticities identified from tax reforms. All specifications include year fixed effects, region fixed effects (East vs. West Germany), controls for demographic variables (Dummies for number of children, marital status) as well as the following income controls: 10-piece splines of logged gross income in $t-k-1$, and 10-piece splines of the difference between logged gross income in $t-k$ and logged gross income in $t-k-1$. The sample is restricted to tax units with taxable income above €$10,000$ (in real 2001 terms), who are 18-65 years old and do not change their filing status throughout the sample period. All specifications are weighted with taxable income and provided sample weights. N is the number of observations. Panel A is estimated in 1-year differences, i.e. $k=1$. Panel B is estimated in 2-year differences, i.e. $k=2$. Panel C is estimated in 3-year differences, i.e. $k=3$.

Table 8: ETI and deduction elasticities. Different income controls

Dependent Variable	(I) TI	(II) GI	(III) D^{total}	(IV) D^{inc}	(V) D^{other}
***Panel A1**: 1-year differences, 10-piece spline in logged $t-k$ income*					
$\Delta log(1-\tau)$	1.391***	0.824***	-0.974***	0.0553	-1.150***
	(22.50)	(22.04)	(-21.14)	(1.06)	(-22.09)
N	2713842	2713842	2689990	2560921	2713713
***Panel A2**: 1-year differences, 10-piece spline in logged $t-k-1$ income*					
$\Delta log(1-\tau)$	0.614***	0.236***	-0.888***	0.0750	-1.034***
	(13.70)	(9.06)	(-22.07)	(1.61)	(-22.86)
N	2713842	2713842	2689990	2560921	2713713
***Panel B1**: 2-year differences, 10-piece spline in logged $t-k$ income*					
$\Delta log(1-\tau)$	1.419***	0.827***	-0.902***	0.0557	-0.979***
	(29.77)	(26.35)	(-23.48)	(1.31)	(-22.94)
N	2261535	2261535	2241284	2125828	2261417
***Panel B2**: 2-year differences, 10-piece spline in logged $t-k-1$ income*					
$\Delta log(1-\tau)$	0.611***	0.211***	-0.873***	0.00120	-0.935***
	(17.41)	(9.23)	(-25.58)	(0.03)	(-24.65)
N	2261535	2261535	2241284	2125828	2261417
***Panel C1**: 3-year differences, 10-piece spline in logged $t-k$ income*					
$\Delta log(1-\tau)$	1.568***	1.093***	-0.207***	0.144 ***	-0.134***
	(29.25)	(27.81)	(-4.69)	(3.05)	(-2.78)
N	1809228	1809228	1792942	1697994	1809127
***Panel C2**: 3-year differences, 10-piece spline in logged $t-k-1$ income*					
$\Delta log(1-\tau)$	0.461***	0.230***	-0.298***	0.0313	-0.231***
	(12.66)	(8.49)	(-7.96)	(0.80)	(-5.62)
N	1809228	1809228	1792942	1697994	1809127
$F-Stat$	11032.8	11032.8	10787.5	10152.2	11030.8

Notes: 2SLS regressions based on equation (10) with t-statistics in parentheses. Standard errors clustered on the tax-unit level. Significance levels are $^{*} < 0.10$, $^{**} < 0.05$, $^{***} < 0.01$. German tax return data for 2001-2008. Results are based on a 5% stratified random sample of the universe of German taxpayers. Dependent variables in all panels are (I) taxable income TI, (II) gross income GI, (III) total deductions D^{total}, (IV) income-related deductions D^{inc} and (V) other (itemized) deductions D^{other}. All dependent variables are logged. Independent variable of interest is the k-year growth rate in the logged marginal net-of-tax rate (i.e., $\Delta log(1-\tau)$), instrumented with the k-year growth rate in the synthetic net-of-tax rate based on lagged base-year $t-k-1$ behavior (Weber (2014)-type instrument). Reported coefficients can be interpreted as elasticities identified from tax reforms. All specifications include year fixed effects, region fixed effects (East vs. West Germany), controls for demographic variables (Dummies for number of children, marital status, age) as well as one the following income controls: 10-piece splines of logged gross income in $t-k$, or 10-piece splines of the logged gross income in $t-k-1$. The sample is restricted to tax units with taxable income above €$10,000$ (in real 2001 terms), who are 18-65 years old and do not change their filing status throughout the sample period. All specifications are weighted with taxable income and provided sample weights. N is the number of observations. Panel A is estimated in 1-year differences, i.e. $k=1$. Panel B is estimated in 2-year differences, i.e. $k=2$. Panel C is estimated in 3-year differences, i.e. $k=3$.

Figure 2: Marginal tax rates

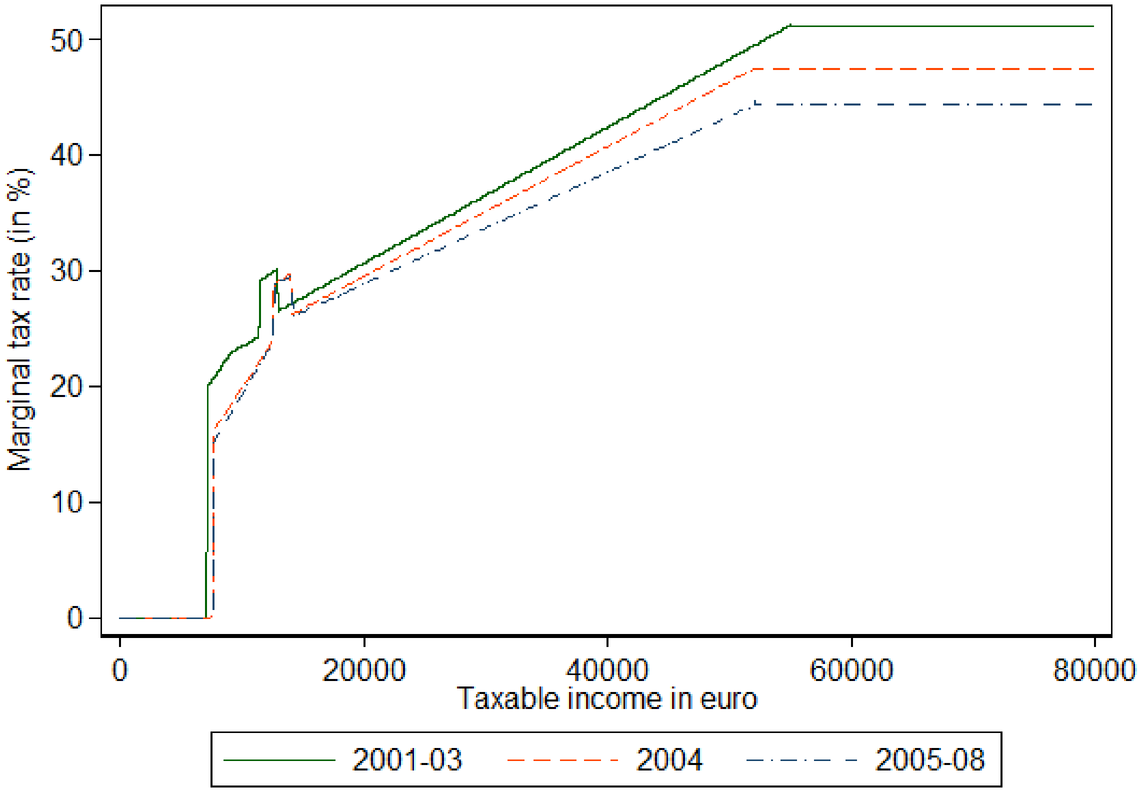
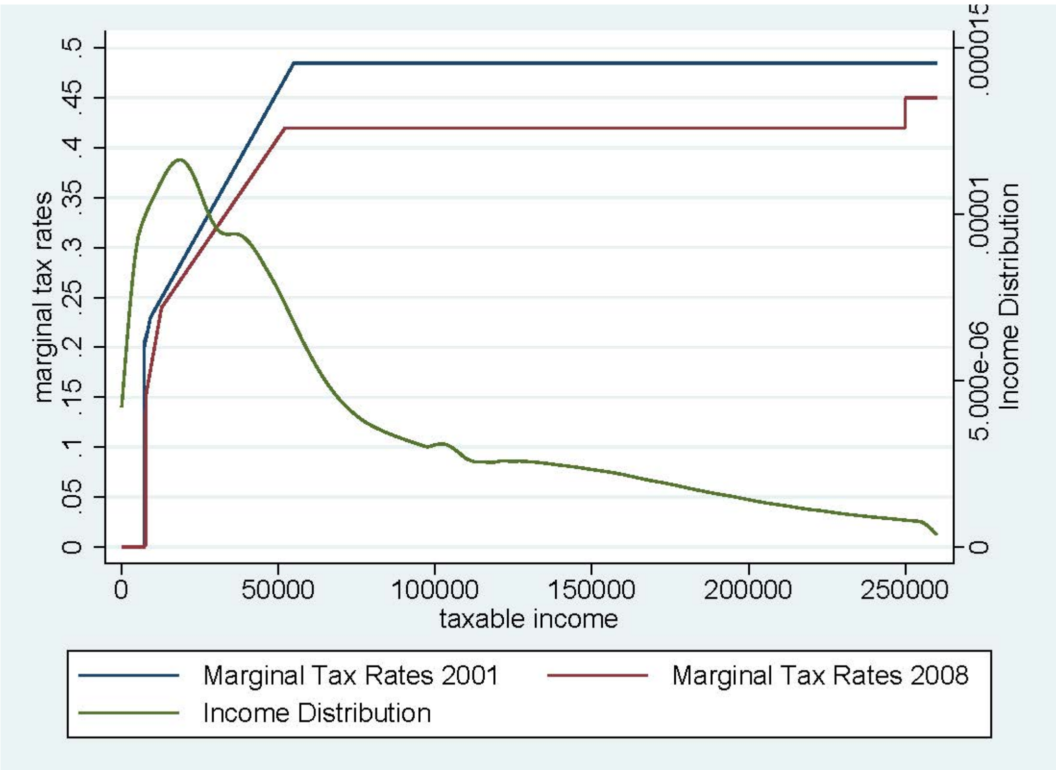
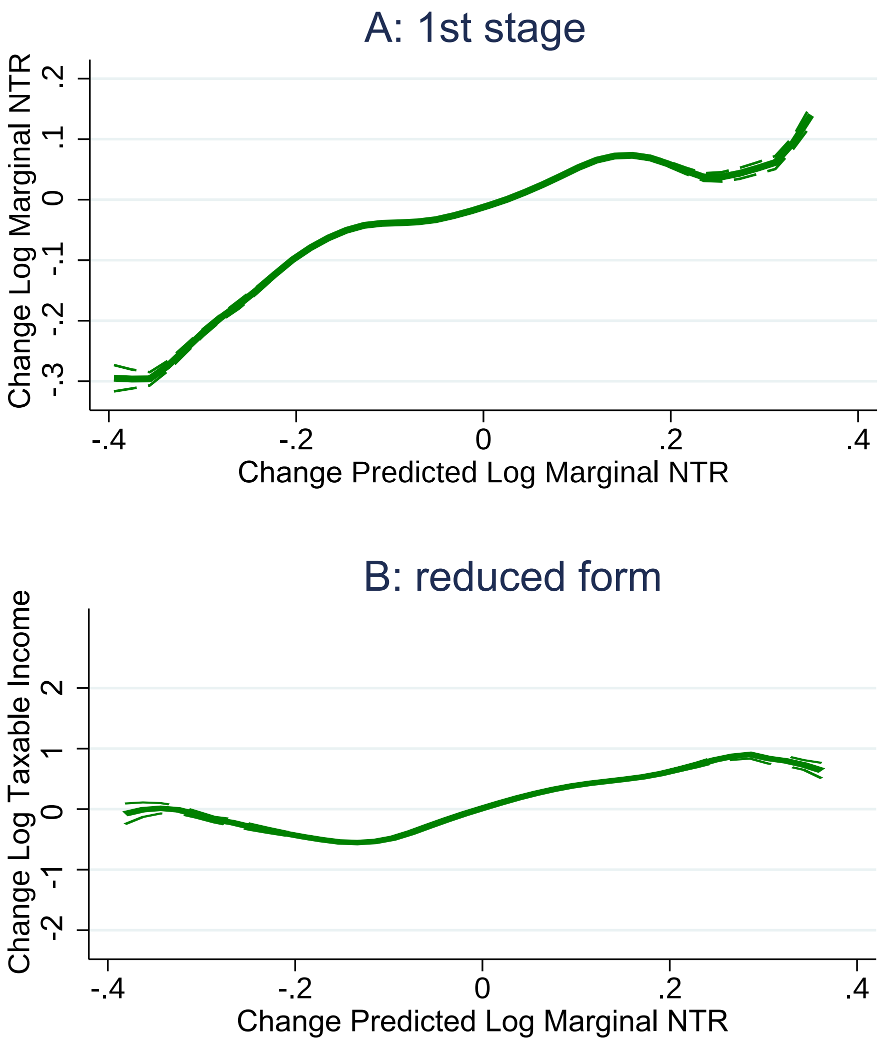


Figure 3: **Marginal tax rates and income distribution**



Notes: Marginal tax rates in 2001 and 2008 and income distribution in 2001.

Figure 4: **First-stage and reduced form**



Notes: Graphical evidence of the first-stage and reduced-form regressions for specification (I) of Panel B in Table ETI-reg. German tax return data for 2001-2008. Graphs are based on a 5% sample of the universe of German taxpayers. Panel A plots a fourth-order local polynomial regression of the change in the log marginal net-of-tax rate (log taxable income) on the changes in the predicted log marginal net-of-tax rate. Panel B is based on a fourth-order local polynomial regression of the change in log taxable income on the changes in the predicted log marginal net-of-tax rate. The dashed lines are 95% confidence intervals. The graphical illustration is based on Weber (2014).