Progressive Income Taxation and Inflation: The Macroeconomic Effects of Bracket Creep*

Lukas Hack

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Abstract

Under nominal progressive taxation, inflation drives up tax rates if the schedule is not adjusted, leading to bracket creep. To isolate bracket creep from other sources of tax rate changes, I propose a non-parametric decomposition approach. Applying the decomposition to German administrative tax records, I find sizeable bracket creep episodes. While the overall importance of bracket creep has decreased over time due to institutional changes, the post-Covid inflation surge led to a resurgence. Theoretically, I show how bracket creep affects labor supply decisions in a partial equilibrium framework and estimate a theory-consistent measure of bracket creep, the indexation gap, which is used to discipline a New Keynesian model with incomplete markets. The model predicts that bracket creep leads to a transitory steepening of the Phillips curve arising endogenously in response to a monetary shock. Such a steepening may alleviate the output costs of monetary disinflation.

Keywords: Progressive taxation, inflation, bracket creep.

JEL Codes: E31, E62, H24.

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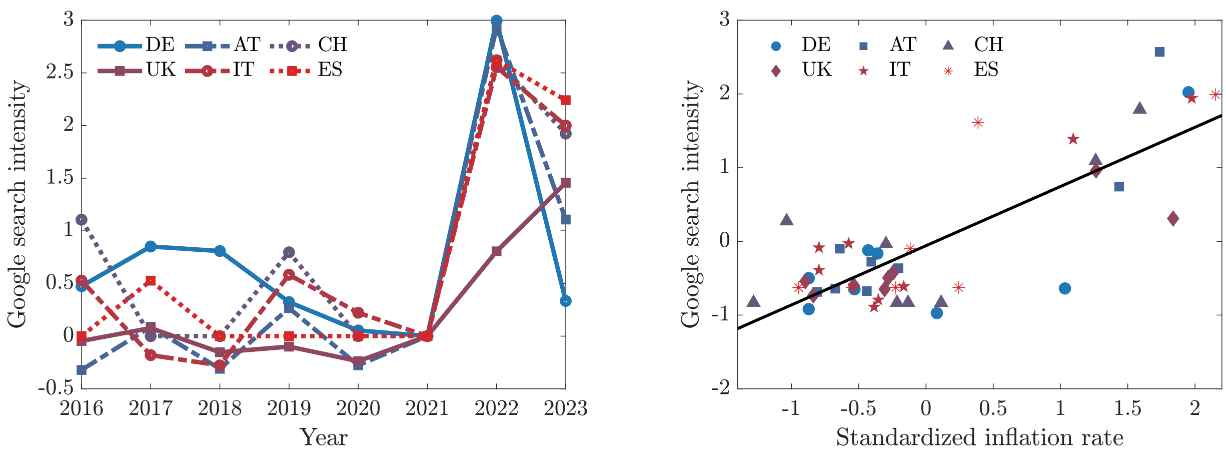
1 Introduction

Most research on progressive income taxation assumes that average and marginal tax rates are a function of real taxable income (e.g., Heathcote et al., 2017). In practice, however, tax rates are a function of nominal taxable income. In this paper, I refer to any wedge between tax rates under real taxation vs nominal taxation as bracket creep.[1] Such wedges arise when tax parameters are not adjusted to changes in the price level, i.e., the tax code is not indexed to inflation. Many developed economies lack such indexation schemes, suggesting that agents should care about bracket creep when inflation is elevated and increases these wedges.[2] This can be seen from Google searches for bracket creep, which strongly correlate with the increase of inflation during the post-Covid inflation surge, as I show in Figure 1.

Figure 1: Google searches for bracket creep

(a) Time series of searches (b) Searches vs CPI inflation



Notes: This figure shows annual Google search intensities using Google Trends. The search keyword is "kalte progression" for Germany, Austria, and Switzerland, "fiscal drag" for the United Kingdom and Italy, and "inflacion irpf" for Spain. I have chosen these keywords to account for the country-specific terminology. Panel (a) displays the data re-normalized to a zero search intensity in 2021 since prices increased the most in 2022. Panel (b) uses annual CPI inflation rates from the OECD.

[1]Bracket creep in the literal sense refers to taxpayers who get pushed into the next tax bracket with a higher tax rate, even when only nominal income but not real income grows. The notion of bracket creep entertained in this paper encompasses this effect.

[2]When inflation becomes persistently elevated, as e.g., in Turkey or Argentina, one expects the government to adjust its tax schedule frequently to preserve its progressivity. Otherwise, everyone would eventually pay the top tax rate. However, a lack of indexation is often prevalent in countries with more moderate inflation rates. For example, ten out of twenty Euro Area member states that account for 63% of Euro Area GDP had no automatic annual indexation implemented by the end of 2022 (see, e.g., https://taxfoundation.org/data/all/global/income-tax-inflation-adjustments-europe/).

The fact that agents "google" bracket creep suggests that this dimension of the tax code is relevant for individual taxpayers. Furthermore, bracket creep matters from a macroeconomic point of view since it implies that tax rates are differently affected by macroeconomic shocks. Demand shocks move real income and prices in the same direction, implying that nominal income responds more strongly than real income. The stronger response in the nominal tax base may translate into a greater tax rate change under nominal taxation. Conversely, under nominal taxation, tax rates may become less responsive to supply shocks as real income and prices move in opposite directions, implying a weaker nominal tax base response. Such changes in tax rates generally matter for the macroeconomy since tax changes have large aggregate effects (e.g., Mertens and Ravn, 2013). Moreover, from a policy perspective, bracket creep implies a new source of monetary non-neutrality and constitutes a novel dimension of fiscal-monetary interactions. The latter suggests the effects of monetary policy shocks are partly shaped by fiscal indexation choices via a bracket creep channel.

This paper investigates the quantitative consequences of bracket creep on the macroeconomy. Empirically, I isolate bracket creep from other sources of tax rate changes based on a non-parametric decomposition approach. Applying the decomposition to German administrative tax records uncovers two sizable bracket creep episodes between 2002 and 2020. While the overall importance of bracket creep has decreased over time due to institutional changes, the post-Covid inflation surge led to a resurgence. Motivated by these facts, I characterize how bracket creep affects labor supply decisions in a partial equilibrium framework. Based on this framework and administrative tax records, I estimate a theory-consistent measure of bracket creep, the indexation gap, which is used to discipline a New Keynesian model with incomplete markets. The model predicts that bracket creep leads to a transitory steepening of the Phillips curve arising endogenously in response to a monetary shock. Such a steepening may alleviate the output costs of monetary disinflation in an economy with bracket creep. Put differently, the output cost of monetary disinflation is aggravated when the tax code is indexed to inflation, revealing a potential caveat of such indexation schemes.

To obtain a tax rate decomposition that separates bracket creep from other sources of tax rate changes, I propose to measure the tax function adjustments that compensate for inflation based on a ratio statistic at the individual taxpayer level. This ratio is based on year-over-year changes in tax rates and assumes a taxpayer with the same real income in both years. The ratio statistic is given by the actual change in tax rates divided by the hypothetical change in tax rates under the assumption that the nominal tax code was not adjusted to inflation – the latter being a benchmark of "full" bracket creep. When the numerator and, hence, the ratio is zero, the taxpayer is fully compensated since tax rates remain unchanged. This is the case of full indexation, i.e., there is no bracket creep. Conversely, when this ratio is unity, then there is full bracket creep, as the actual change in tax rates coincides with the full bracket creep benchmark. This is the case of zero indexation because the taxpayer is not compensated at all. I use this ratio statistic to decompose year-over-year changes in average and marginal tax rates into three distinct components: (i) bracket creep, (ii) real income growth, and (iii) discretionary tax changes. The decomposition builds on the assumption that any observed tax cut is attributed to indexation until full compensation is reached. Beyond this, the decomposition only requires progressivity and non-negative inflation rates, both satisfied in the data, but no further restrictions are required.

Empirically, I implement the decomposition based on German administrative tax records from 2002 to 2018. The administrative tax data is desirable because I need to know the entire distribution of gross incomes and claimed deductions to compute tax rates accurately. Further, the German setting is suitable because, unlike in the U.S., there is no automatic annual indexation scheme. Moreover, I can evaluate a 2012 tax reform that aimed at reducing bracket creep. The reform requires the government to publish a mandatory bracket creep report, along with suggestions to undo bracket creep. While not mandated by law, since then, the government has frequently adjusted the tax code based on inflation forecasts, which may address bracket creep due to anticipated inflation. To evaluate this policy regime in the presence of a large inflation surprise, I take the 2018 distribution of taxpayers and impute the data until 2023 using aggregate data on income growth.

Applying my decomposition approach to the tax data, I find pronounced bracket creep effects arise in years when the government does not adjust the tax schedule for multiple consecutive periods. There are two such bracket creep episodes before 2012. During these episodes, bracket creep accounts for a total increase in average and marginal tax rates between 0.64 and 0.86 percentage points, cumulated over each three-year bracket creep episode. The cumulated percentage points correspond to the increase in tax rates due to bracket creep in the final year of a bracket creep episode.[3] In contrast, from 2013 until 2018, I find relatively little bracket creep, suggesting that the 2012 tax reform successfully eliminated bracket creep during a period of low and stable inflation. However, the post-Covid inflation surge, a large inflation surprise, led to a resurgence of bracket creep with sizable effects on average and marginal tax rates, which increased by 0.51 and 0.83 percentage points, respectively. Overall, bracket creep may account for non-negligible changes in tax rates, affecting taxpayers' disposable income and economic incentives.

To understand how household choices respond to bracket creep, I propose an analytical partial equilibrium framework with a tax schedule that allows for bracket creep and nests the schedule from Heathcote et al. (2017). I study the labor-leisure choice of a household facing this tax schedule. A fraction of the tax revenues is used by the government for public good provision. The remaining tax revenues are returned to the household via a transfer. In this environment, I show that the labor supply response to bracket creep is theoretically ambiguous and crucially depends on how the government uses tax revenues. Intuitively, when all tax revenues (from bracket creep) are returned to the households, the income effects of bracket creep are eliminated, and only a substitution effect prevails, reducing labor supply. Conversely, labor supply may increase when the government does not return enough tax revenues to the household via transfers. This highlights the importance of the government's

[3] The total impact of a bracket creep episode is larger because tax rate increases due to bracket creep from the initial two years must be included too. Summing up all tax rate increases for each year within a bracket creep episode roughly doubles these numbers.

use of funds for the consequences of bracket creep.[4]

An appealing feature of my proposed tax schedule is that a scalar statistic, the indexation gap, can conveniently summarize bracket creep. The indexation gap is determined by the degree of inflation adjustments to the tax code and the inflation rate. The time series of indexation gaps can be estimated based on the decomposition results and restrictions derived from my tax schedule, delivering a theory-consistent measurement of bracket creep. Finally, I provide reduced-form evidence that supports my tax schedule formulation and use the indexation gap series to discipline the subsequent quantitative analysis.

The quantitative analysis of bracket creep is based on a standard one-asset New Keynesian model with incomplete markets (e.g., Auclert et al., 2021), which also nests my analytical framework. Households consume, supply labor, and may save in a liquid asset. The production side features nominal price rigidities. A fiscal authority uses the tax revenues to finance spending and transfers, and a monetary policy authority controls the nominal interest rate. I calibrate the model to the German economy before the 2012 tax reform, using the estimated indexation gaps to discipline how the fiscal authority adjusts the tax schedule to inflation.

In this setup, I study the responses to a monetary policy shock and compare them with the counterfactual responses under full indexation. The results suggest that bracket creep dampens the effects of monetary policy on output, whereas the impact on inflation dynamics is negligible. Quantitatively, the impact output response under full indexation is roughly thirty percent larger than with bracket creep, but the difference vanishes roughly within a year. This result can be interpreted as an endogenous steepening of the Phillips curve through the presence of bracket creep that materializes in response to the monetary policy shock. Intuitively, this effect operates via firms' marginal costs that are affected by the tax system. Finally, one interpretation of this finding is that the output costs of reducing inflation via monetary policy are aggravated when the tax code is indexed to inflation (via

[4] The importance of transfers is often overlooked. This also applies to the previous bracket creep literature that assumes all tax revenues are returned lump-sum in standard New Keynesian models (Edge and Rudd, 2007; Keinsley, 2016), or in a money growth model with incomplete markets (Heer and Süssmuth, 2013).

a flattening of the Phillips curve), revealing a potential caveat of such indexation schemes.

Related literature. This research contributes to the surprisingly scant literature on bracket creep. Empirically, most papers study bracket creep based on micro-simulations focusing on particular historical episodes in the European (e.g., Immervoll, 2005, 2006; Paulus et al., 2020), or specifically in the German context (e.g., Zhu, 2014; Blömer et al., 2023).[5] My contribution lies in a comprehensive and transparent documentation of bracket creep effects over twenty years for Germany and a comparison with other sources of tax rate changes through my analytical decomposition approach.

Theoretically, bracket creep has been studied in New Keynesian models with complete markets (Edge and Rudd, 2007; Keinsley, 2016) and in a money growth model with incomplete markets (Heer and Süssmuth, 2013). Relative to these papers, I analytically show that the use of tax revenues crucially shapes the labor supply response to bracket creep, and I offer a quantitative analysis of bracket creep using a workhorse New Keynesian model that accounts for household heterogeneity.

More broadly, I relate to studies that focus on inflation and its interaction with taxation in general (e.g., Süssmuth and Wieschemeyer, 2022; Cloyne et al., 2023; Altig et al., 2024), and with capital taxation specifically (e.g., Feldstein, 1983; Gavin et al., 2007, 2015). Further related is research on how fiscal policy affects the transmission of monetary policy (e.g., Bouscasse and Hong, 2023; Breitenlechner et al., 2024), on monetary non-neutrality (e.g., Afrouzi et al., 2024), and on inflation and its impact on households (e.g., Erosa and Ventura, 2002; Doepke and Schneider, 2006; Adam and Zhu, 2016; Pallotti, 2022; Pallotti et al., 2024). Finally, I relate to the broad literature on progressive taxation (e.g., Benabou, 2002; Conesa and Krueger, 2006; Mattesini and Rossi, 2012; Heathcote et al., 2017, 2020; McKay and Reis, 2021), as well as to the literature on New Keynesian models with incomplete markets (e.g., Kaplan et al., 2018; Auclert et al., 2021, 2024).

[5]For a current discussion of bracket creep during the recent inflation surge, see Bundesbank (2022).

2 Empirical analysis

In this section, I propose a new approach to measure bracket creep based on tax data. My approach rests on measuring the degree of indexation of the tax schedule to compute a decomposition of the changes in tax rates into three distinct components: (i) real income growth, (ii) discretionary tax changes, and (iii) bracket creep. I apply this approach to German administrative tax records and identify two sizable bracket creep episodes before 2012 and a decline in the quantitative importance of bracket creep thereafter. However, the post-Covid inflation surge led to a sizable resurgence of bracket creep because of imperfect inflation adjustments of the tax code.

2.1 Measuring bracket creep

I derive a decomposition of the year-over-year changes in average and marginal tax rates of a single taxpayer, while suppressing individual subscripts for notational convenience. Thus, let $Y_t > 0$ denote nominal pre-tax income in year t. Taxable income is $Z_t = Y_t - D_t$ with $D_t \geq 0$ being the amount of deductions. The tax code can be represented as a mapping $\tau_t : \mathbb{R}^+ \to \mathbb{R}^+$ from nominal taxable income to a tax rate. I deliberately leave it open whether this refers to the average or the marginal tax rate because my approach can and will be applied to both tax rates separately.[6] This mapping to tax rates incorporates tax exemptions.[7] I assume that the tax schedule is progressive, which implies that the average tax rate is strictly increasing in nominal taxable income while the marginal tax rate is weakly increasing in taxable income. I further assume that taxable income Z_t is sufficiently large to ensure $\tau_t(Z_t) > 0$ for all t, focusing on individuals who actually pay taxes. Put differently, this rules out incomes below the tax exemption threshold.

[6]Marginal tax rates matter for taxpayers' intensive margin labor supply choices, whereas average tax rates matter for the corresponding extensive margin decisions. Average tax rates are further relevant because they impact disposable income and, hence, consumption.

[7]The tax exemption implies that $\tau_t(Z_t) = 0$ for all $Z_t \leq \underline{Z}$, where $\underline{Z}$ is the exemption amount. This exemption amount is a parameter of the tax function that the government may adjust. Indeed, anticipating the empirical application, the exemption amount is adjusted on an annual basis in Germany.

Given Z_{t-1}, I consider a counterfactual taxable income, Z_t^{Π}, where the taxpayer has the same real income as in $t-1$. Absent deductions, this is simply given by the last period's nominal income adjusted for inflation, i.e., $Z_{t-1}\Pi_t$, where $\Pi_t = P_t/P_{t-1} > 1$ is the gross inflation rate. Deductions complicate the calculation because some deduction amounts reflect actual expenses that should grow with inflation (itemized deductions), whereas other deduction amounts are specified in the tax law and may or may not be adjusted to inflation. Thus, the appropriate deduction amount for this constant real income scenario may be anything in between, i.e., $D_t^{\Pi} \in [D_{t-1}, D_{t-1}\Pi_t]$, and, thus, $Z_t^{\Pi} = Z_{t-1}\Pi_t - D_t^{\Pi}$. In the empirical application, I will consider both $D_t = D_{t-1}$ and $D_t = D_{t-1}\Pi_t$ to obtain an upper and lower bound result. Given this, I can define a counterfactual tax function as follows.

Definition 1.

$$\tau_t^{\mathcal{I}}\left(Z_t^{\Pi},\ Z_{t-1}\right) = \alpha_t\, \tau_{t-1}\left(Z_{t-1}\right) + \left(1-\alpha_t\right) \tau_{t-1}\left(Z_t^{\Pi}\right). \tag{2.1}$$

The tax function is a (point-wise) convex combination of two cases where $\alpha_t \in [0,1]$ measures the degree of indexation of the tax function. With $\alpha_t = 1$, the tax function is perfectly indexed to inflation since the tax rate in period t coincides with the tax rate in the previous period. In other words, tax rates are unaffected by nominal income growth that compensates for inflation. Conversely, when $\alpha_t = 0$, the tax function is not indexed at all because nominal income in t is evaluated at the schedule from the previous year. Thus, there is no inflation adjustment to the tax schedule, and the tax rate may change relative to $t-1$ whenever $Z_t^{\Pi} \neq Z_{t-1}$.[8]

Decomposition. Given the tax function from Definition 1, I decompose the year-over-year changes in tax rates as

[8]Marginal tax rates may also stay constant when both Z_t^{Π} and Z_{t-1} fall in a tax bracket with the same constant marginal tax rate. The average tax rate necessarily adjusts under a progressive schedule when $Z_t^{\Pi} \neq Z_{t-1}$ because the average tax rate is strictly increasing in nominal income.

$$\tau_t(Z_t) - \tau_{t-1}(Z_{t-1}) = \Psi_t^{bc} + \Psi_t^{rg} + \Psi_t^{tc}, \tag{2.2}$$

and

$$\Psi_t^{bc} = \underbrace{\tau_t^{\mathcal{I}}\left(Z_t^{\Pi},\ Z_{t-1}\right) - \tau_{t-1}(Z_{t-1})}_{\textbf{b}\text{racket }\textbf{c}\text{reep}},$$

$$\Psi_t^{rg} = \underbrace{\tau_t(Z_t) - \tau_t\left(Z_t^{\Pi}\right)}_{\textbf{r}\text{eal income }\textbf{g}\text{rowth}},$$

$$\Psi_t^{tc} = \underbrace{\tau_t\left(Z_t^{\Pi}\right) - \tau_t^{\mathcal{I}}\left(Z_t^{\Pi},\ Z_{t-1}\right)}_{\text{discretionary }\textbf{t}\text{ax }\textbf{c}\text{hange}}.$$

The first term measures bracket creep, that is, changes in tax rates due to a lack of indexation of the tax schedule. The second term captures the changes in tax rates due to real income growth. Taken together, both terms show increases in tax rates due to nominal income growth. The third term captures discretionary changes to the tax schedule that are not captured by indexation through $\tau_t^{\mathcal{I}}(\cdot)$. Next, I can characterize the bracket creep term.

Proposition 1. *Given Definition 1, the bracket creep term from* (2.2) *is given by*

$$\Psi_t^{bc} = (1-\alpha_t)\left[\tau_{t-1}\left(Z_t^{\Pi}\right) - \tau_{t-1}(Z_{t-1})\right].$$

If $\Pi_t > 1$, $\alpha_t < 1$, *and* $\frac{\partial \tau_{t-1}(Z)}{\partial Z} > 0$ *for all* $Z \in [Z_{t-1},\ Z_t^{\Pi}]$, *then it holds that* $\Psi_t^{bc} > 0$.

The proof is in Appendix A. Note that under a progressive tax system, the third condition, $\frac{\partial \tau_{t-1}(Z)}{\partial Z} > 0$, is always satisfied for the average tax rate but not necessarily for the marginal tax rate.[9] Suppose $\tau_t(\cdot)$ is indeed the average tax rate to illustrate the proposition. Then, the proposition states that the bracket creep term in the decomposition is strictly positive when three conditions apply: (i) there is positive inflation, (ii) the tax code is not perfectly indexed to the actual rate of inflation, and (iii) the tax code is progressive. In contrast, the

[9] When marginal tax rates are constant within a tax bracket and inflation does not push a taxpayer with constant real income into the next bracket, then there is no bracket creep in terms of the marginal tax rate.

bracket creep term is zero under full indexation or absent inflation or under a linear tax schedule. This suggests that Ψ_t^{bc} captures only bracket creep when expected.

Degree of indexation. To operationalize the decomposition, I need to measure α_t. I propose a measurement of α_t that leverages observed changes in the tax schedule, irrespective of whether these adjustments are discretionary or implemented via an automatic indexation scheme. This corresponds to a notion of *effective* indexation measured as

$$\alpha_t = \begin{cases} 1 - \max\left\{\min\left\{\frac{\tau_t\left(Z_t^{\Pi}\right)-\tau_{t-1}(Z_{t-1})}{\tau_{t-1}\left(Z_t^{\Pi}\right)-\tau_{t-1}(Z_{t-1})}, 1\right\}, 0\right\} & \text{if} \quad \tau_{t-1}\left(Z_t^{\Pi}\right) > \tau_{t-1}\left(Z_{t-1}\right), \\ 1 & \text{otherwise.} \end{cases} \tag{2.3}$$

Focusing on the first case in (2.3), the denominator captures the amount of bracket creep under constant real income that prevails when the tax code is not adjusted at all, i.e., $\tau_t(Z) = \tau_{t-1}(Z)$. This is the benchmark of "full" bracket creep, or equivalently, no indexation. The numerator measures the change in the tax rate, accounting for actual adjustments in the tax function. The ratio can be interpreted as a measure of the "distance" between the actual change in the tax rate and the full bracket creep benchmark. Therefore, I refer to this ratio as the degree of bracket creep and, conversely, to α_t as the degree of indexation. The underlying assumption of this measurement approach is that any adjustment of the tax function is interpreted as indexation up until full compensation of bracket creep is reached. This can be seen since the degree of indexation increases as the numerator falls. When the numerator turns negative, the taxpayer enjoys a discretionary tax cut on top of full indexation. This is implemented via the max operator that ensures that α_t remains bounded from above by unity such that bracket creep can, at most, be fully compensated. Conversely, when the numerator is larger than the denominator, then the degree of indexation is zero. Any increase in the tax rate larger than the full bracket creep benchmark must be a discretionary tax hike. This is implemented via the min operator that ensures that α_t remains bounded from below by zero, such that bracket creep can, at most, be as large as the full bracket creep benchmark. Finally, considering the second case in (2.3), the degree of indexation is also unity when the denominator is zero. It may only happen when considering marginal tax rates that are constant within a tax bracket, and both Z_t^{Π} and Z_t lie in the same tax bracket with a constant marginal tax rate.

This approach to quantifying the degree of indexation is appealing because it imposes no parametric restriction on the tax schedule. It can be implemented with relatively mild information requirements. One only needs to measure taxable income, deductions, inflation, and the exact tax schedule as specified in the tax law, including tax exemptions.

Aggregation. The presented decomposition applies to a single taxpayer. It may be a single person who files taxes on her behalf or married spouses who file their taxes jointly. The decomposition does not require to distinguish between these two cases. Aggregation to sample averages is straightforward since the decomposition is additive. Thus, I can readily compute arithmetic averages $\bar{\Psi}_A^k = \sum_{(i,t)\in A} \Psi_{i,t}^k$ for any decomposition term k, where A denotes the set of taxpayers i and time periods t over which the average is computed.

Alternative mechanical decomposition. An alternative decomposition may measure bracket creep as changes in tax rates under constant real income, keeping the tax schedule unchanged, i.e., $\tau_t(\cdot) = \tau_{t-1}(\cdot)$. From Proposition 1, it becomes clear that this naive mechanical decomposition is nested when imposing $\alpha_t = 0$. Based on this, one could still compute the bracket creep term and subtract the discretionary tax change term after aggregation to check whether there is bracket creep that is not compensated with tax function changes. However, even when both terms net out, one cannot conclude that all taxpayers got compensated for bracket creep every year because it does not take into account how the compensation via discretionary tax changes is distributed across taxpayers and time. For example, it could be that some taxpayers are benefiting from large tax cuts (that over-compensate bracket creep), whereas others receive no compensation and, therefore, see tax rates changing due to bracket creep. Whether or not these composition effects matter is an empirical question. Thus, I also report the results of the mechanical decomposition.

Deductions. It may be important to account for deductions because many fixed-amount deductions are specified in the tax law and only infrequently adjusted. For example, this applies to work-related deductions that are lump-sum or calculated based on commuting distance in Germany.[10] Accounting for deductions is important for the constant real income scenario, where I aim to measure how taxable income would have evolved when the taxpayer's behavior is kept constant. In this case, deduction amounts may only increase when the deductions reflect actual nominal payments that increase with inflation (itemized deductions) or when the government raises the deduction amounts specified in the tax law. Unfortunately, discriminating these two cases is infeasible in the data.[11] Thus, I will present two versions of the decomposition. As a conservative baseline, I assume that all deductions grow with inflation, i.e., $D_t^{\Pi} = D_{t-1}\Pi_t$. Alternatively, I present results where the deductions are kept constant, i.e., $D_t^{\Pi} = D_{t-1}$. The former may be a lower bound on the quantitative importance of bracket creep, while the latter delivers an upper bound. In practice, the appropriate value of $\mathcal{D}_t^{\Pi}$ should be in between these two extreme cases. Reporting both reveals to what extent my results depend on deductions. Finally, note that tax exemptions are part of the tax rate function $\tau_t(\cdot)$. Thus, I account for the empirically observed changes in exemption amounts, irrespective of the treatment of deductions.

[10] In practice, the available deduction possibilities may affect economic choices, e.g., the work location and commuting distance. While the decomposition does not take a stand on these incentive effects, I abstract from this in the theoretical models presented in Sections 3-4. This is a common assumption when one studies the (macroeconomic) consequences of taxation (see, e.g., Heathcote et al., 2017).

[11] This is because the actual computation of deductions in the tax data is extremely complex since the tax declarations involve more than 2000 variables, of which most matter for this computation. While it is ex-ante unclear, it turns out that deductions are not crucial for the empirical results.

2.2 Administrative tax records

Institutional setting. I analyze administrative tax records from Germany, where income from most sources is subject to the progressive income tax schedule.[12] A fixed amount of around 10,000 euros (varying over time) is exempt. Any taxable income beyond the exemption is taxed. Figure B.1 in Appendix B illustrates the schedule for different years in my sample. An important feature of the schedule is that marginal tax rates increase linearly within each tax bracket, except for taxable income above around 60,000 euros. It implies that bracket creep can increase marginal tax rates for any taxpayer below the top brackets, even if she stays within her tax bracket. Moreover, all taxpayers may experience bracket creep effects in terms of the average tax rate, as this rate is always strictly increasing in income, regardless of the marginal tax rate.

Germany also offers a preferential tax scheme for married spouses. Under this joint taxation scheme, the tax function is evaluated only at the average taxable income of both spouses.[13] Turning to indexation, Germany has no automatic inflation adjustments to the tax code. However, a tax reform in 2012 mandated the government to prepare a bracket creep report every other year (e.g., Bundesbank, 2022). Along with this obligation, the Federal Ministry of Finance developed a voluntary fiscal routine to regularly adjust the tax schedule based on inflation forecasts every other year for the subsequent two years. The adjustment procedure applies only to the statutory tax code, but not to deductions. Below, I study the extent to which this reform eliminated bracket creep.

[12] A noteworthy exception is that capital income has been taxed at a flat rate of 25% since 2009. A further special case is that taxpayers may opt to pay regular income taxes on their capital income (as opposed to the flat rate) when the progressive tax schedule implies a lower tax rate. In practice, these cases are likely negligible. It only applies to taxpayers with sufficiently low taxable income (including capital income) so that the regular income tax rate (based on the progressive tax schedule) does not exceed 25%, but capital income still exceeds the exemption amount on capital income, the so-called "Sparerfreibetrag".

[13] The final nominal tax payment is given by two times the tax payment that a single taxpayer with this average income would have to pay. This lowers the per-person tax burden of both taxpayers when their taxable income differs because the average tax rate is a concave increasing function of taxable income.

Taxpayer panel. The data is an annual panel of income taxpayers in Germany from 2002 to 2018. It contains administrative tax records that are provided by the German Federal Statistical Office.[14] An individual taxpayer may be an individual or married spouses who file their taxes jointly. Specifically, I define a taxpayer conditional on filing status. For example, a taxpayer filing taxes individually is considered a different cross-sectional unit than the same taxpayer when filing jointly in another year. The data is a five percent random sample taken from the universe of taxpayers. For my analysis, I focus on taxpayers who file their tax declarations, have positive tax liabilities, and do not apply specific widow tax schemes.[15] The resulting sample contains around 14 million tax records. Restricting the attention to taxpayers with observations available for at least two consecutive years leaves me with around 10 million tax records as the baseline sample for the tax rate decomposition.

Variables. The Taxpayer panel contains all variables that can be filed in German income tax declarations. I primarily use gross income, taxable income, and the final tax liability for my analysis. Gross income refers to all reported income before deductions are subtracted, whereas taxable income is gross income minus deductions. I use these two variables to compute the total amount of deductions. Finally, I use the tax liability to verify that my implementation of the tax schedule is accurate for all years.[16] The descriptive statistics are presented in Table B.1 in Appendix B.

[14]To be precise, the data source is the Research Data Center of the Federal Statistical Office and Statistical Offices of the Laender, Taxpayer Panel, 2002-2018. All presented results are based on my own calculations. The Figures that present averages across time show results for slightly different treatment of deductions. I did not update these charts because (i) data protection laws limit the number of legally feasible exports, so I need to save exports for later revisions. Further, (ii), I assessed the not-yet-exported results and found that the findings hardly changed with the updated deduction treatment.

[15]Not all taxpayers in Germany need to file their taxes. Not filing is possible when taxpayers have only one source of labor income, such that the monthly withholding tax can be expected to be close to the tax liability when filing (these are the so-called “Lohnsteuerfälle”). I exclude these taxpayers to maintain a consistent sample because they are not in the tax data before 2012.

[16]The difference between the actual tax liability and my own calculations is less than 1 euro per average monthly income of each taxpayer for more than 99% of the tax declarations.

Additional data. I use the inflation rate of the German CPI to obtain nominal income that maintains constant real value. To study the post-Covid inflation surge, I use average household income growth from the German Federal Statistical Office to impute the income distribution for years beyond 2018. Specifically, I take the 2018 cross-sectional distribution of taxpayers as given and assume that all Euro-value variables grow at the rate at which average household income was growing; see Table B.2 for the data used for imputation.

2.3 Results

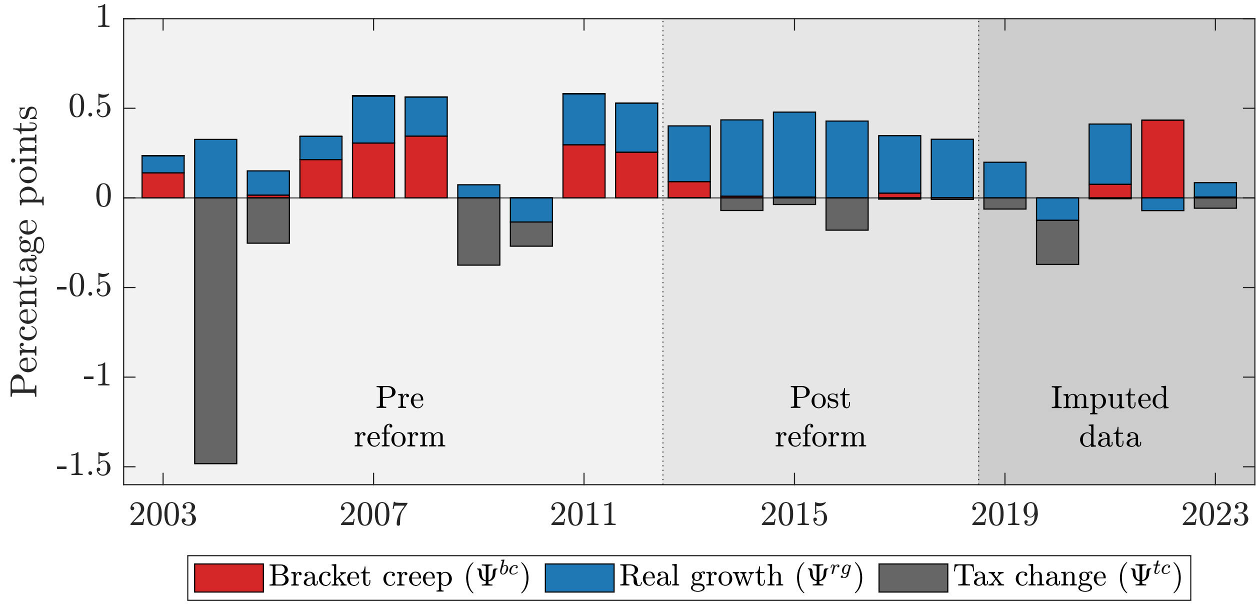
I report empirical results based on the decomposition developed in Section 2.1. First, I show how the effects vary across years to understand the cyclical properties. I find two sizable bracket creep episodes before 2012 and a resurgence of bracket creep during the post-Covid inflation period. Finally, I also present longer-term trends by summing the year-over-year estimates over the full sample, the pre-reform, and the post-reform period.

Time variation. In Figure 2, I present the baseline tax rate decomposition for average and marginal tax rates in Panels (a) and (b), respectively. Each vertical bar refers to changes in tax rates averaged across all taxpayers in the stated year, relative to the previous year. The red, blue, and gray bars show the year-over-year changes in tax rates that are attributed to bracket creep, real income growth, and discretionary tax reforms, respectively. The shaded areas indicate the time sample before and after the reform that mandated the government to publish a bracket creep report, and the time sample that is imputed with aggregate income growth data, as explained in Section 2.2.

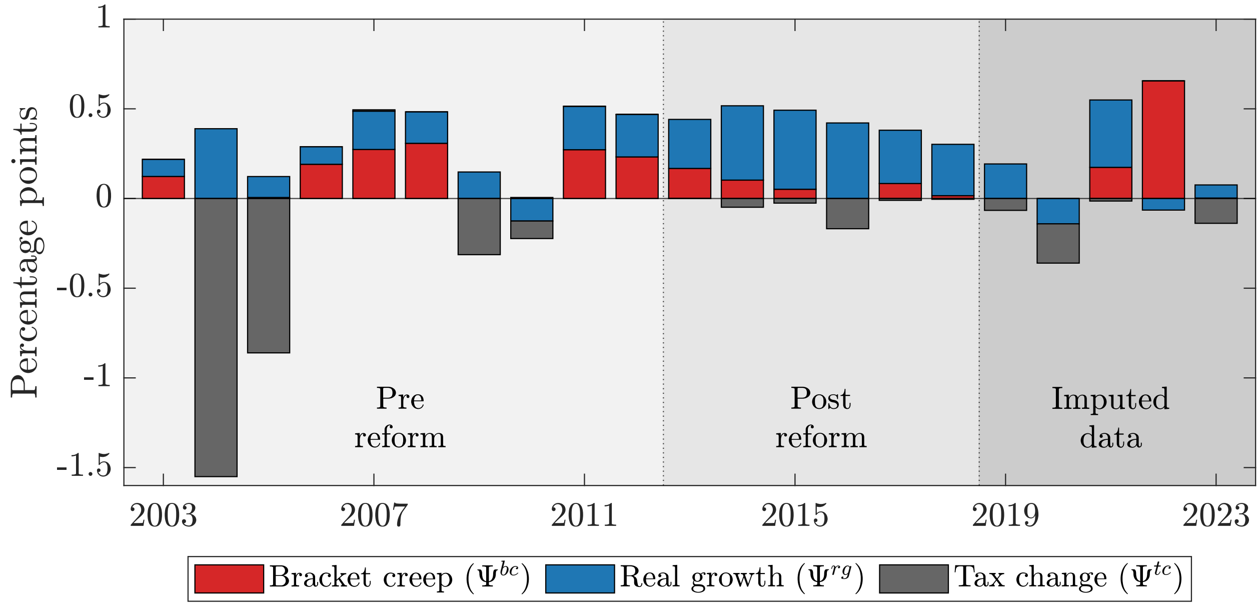
In 2004 and 2005, there were large tax cuts implemented, leading to a sizable decline in tax rates that fully compensated bracket creep and also strongly over-compensated tax rate increases due to real income growth. In contrast, between 2006 and 2008, there were virtually no changes to the tax function, so nominal income growth led to higher tax rates. Decomposing these increases into real income growth and bracket creep suggests that bracket creep

Figure 2: Time variation in the tax rate decomposition

(a) Average tax rate



(b) Marginal tax rate



Notes: The figure shows the decomposition of year-over-year changes in average and marginal tax rates as stated in equation (2.2). *Bracket creep* refers to the change in the tax rate that a taxpayer with constant real income experiences, absent discretionary tax reforms, whereas *Tax change* refers to changes due to discretionary tax reforms. *Real growth* refers to changes in tax rates due to real income growth under the contemporaneous tax schedule. The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018; all non-zero estimates are significant at the 5% level, for standard errors, see Table B.3. The imputed data is based on average household income growth as explained in Section 2.3.. Panel (a) and (b) show the results for the average and marginal tax rate, respectively.

accounts for the larger fraction of tax rate increases during these years. Since there were no tax adjustments, the increases in bracket creep accumulate over multiple years: on average, in 2008, a taxpayer with the same real income as in 2005 faces an average tax rate that is 0.86 percentage points higher and a marginal tax rate that is 0.77 percentage points higher.[17] To see the cross-sectional impact of this episode, I display how the 2005 distribution of tax rates would have shifted until 2008 when all taxpayers had the same real income as in 2005 in Panels (a) and (b) of Figure B.2 in Appendix B. This figure suggests that the entire distribution of average and marginal tax rates has shifted upward to higher tax rates.

While bracket creep played no role in 2009 and 2010, there is a second bracket creep episode from 2011 until 2013. During these years, bracket creep accumulated to 0.64 and 0.67 percentage points in terms of the average and marginal tax rates, respectively. The distribution of tax rates, assuming constant real income, shifted similarly as for the first bracket creep episode; see Panels (c) and (d) of Figure B.2. Comparing tax rate changes due to real income growth and bracket creep, I find that real income growth turns out to be more important. Yet, bracket creep still implies a sizable amplification relative to tax rate changes under real income growth only.

From 2013 until 2018, I find sizable increases in tax rates due to real income growth corresponding to comparatively high GDP growth during that time. In contrast, bracket creep seems negligible in terms of the average tax rate, while there is modest bracket creep in terms of the marginal tax rate. This suggests that the 2012 tax reform successfully reduced bracket creep. The differences between average and marginal tax rates might be explained by policymakers thinking about disposable income and less about marginal incentives when designing the tax code adjustments to undo bracket creep.

The tax code adjustments that regularly occur since 2012 are based on inflation forecasts, as discussed in Section 2.2. It is not surprising that adjustments based on inflation forecasts successfully compensate for bracket creep during a period of low and stable inflation. Thus, I

[17] These numbers can be computed by summing up the red bars for 2006 until 2008 from Figure 2.

use the imputed data to evaluate to what extent there is bracket creep during the post-Covid inflation surprise episode. I find a sizable resurgence of bracket creep because inflation was underestimated for 2021 and especially for 2022. Cumulated over both years, this amounts to an increase of 0.51 and 0.83 percentage points in average and marginal tax rates, respectively.

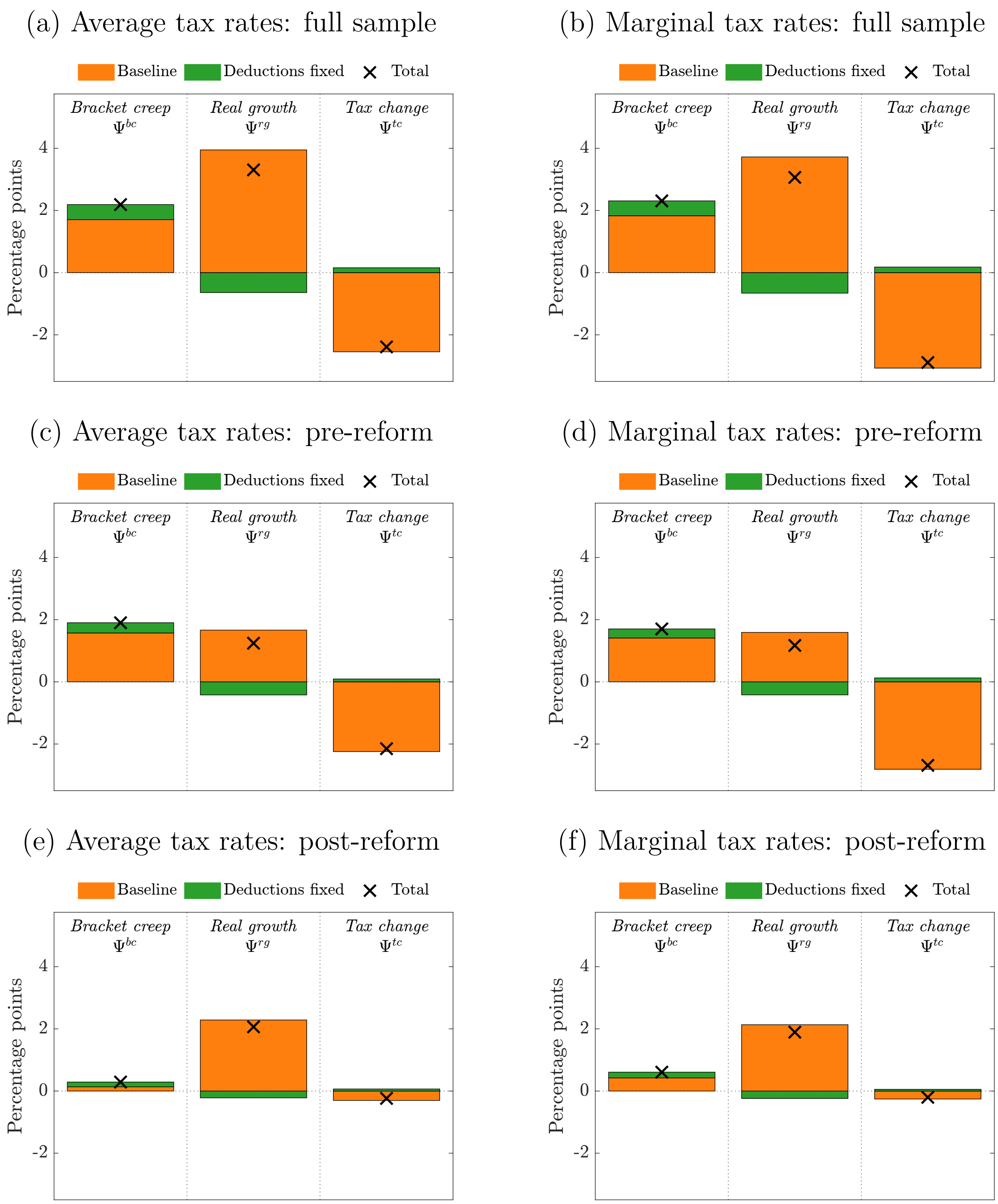
Total effects. To assess the total effects over the full sample and over the pre- and post-reform periods, I sum up the year-over-year results from above and present the totals in Figure 3. Panels (a) and (b) show the decomposition over the full sample from 2002 to 2018 for average and marginal tax rates, respectively. The baseline decomposition results are depicted as orange bars. The (smaller) green bars indicate how the decomposition would change when deductions are assumed to be constant in nominal terms.[18] Finally, the cross markers give the total effect under constant deductions.[19] According to the baseline decomposition, I find that bracket creep accounts for 1.71 percentage points when measured in average tax rates and 1.83 percentage points when measured in marginal tax rates. Keeping deductions constant raises these numbers by 0.48 percentage points (for both tax rates). Thus, the overall tax rate increase due to bracket creep with fixed deduction is 2.19 and 2.32 percentage points for the average and marginal tax rate, respectively. This shows that the treatment of deductions is less important and confirms that my baseline deduction treatment constitutes a conservative way of measuring bracket creep.

In comparison, real income growth accounts for changes in average and marginal tax rates of 3.95 and 3.72 percentage points, respectively. These numbers get attenuated to 3.31 and 3.06 percentage points when keeping deductions fixed. Lastly, discretionary tax changes reduce average and marginal tax rates by 2.56 and 3.07 percentage points, respectively. These numbers are only mildly attenuated when keeping deductions fixed. However, importantly, the discretionary tax rate changes do not fully compensate bracket creep because they occur

[18] Recall the baseline decomposition assumes that deductions grow at the rate of inflation, which is a conservative way of measuring bracket creep. The tax-exempt income level is directly included in $\tau_t(\cdot)$ and not kept constant, even when nominal deductions are fixed.

[19] For completeness, I present the corresponding year-over-year results (not aggregated across years) under the constant-deductions assumption in Figure B.3 in Appendix B.

Figure 3: Cumulative decomposition of tax rates



Notes: The figure shows the decomposition of year-over-year changes in average and marginal tax rates as stated in equation (2.2). *Bracket creep* refers to the change in the tax rate that a taxpayer with constant real income experiences, absent discretionary tax reforms, whereas *Tax change* refers to changes due to discretionary tax reforms. *Real growth* refers to changes in tax rates due to real income growth under the contemporaneous tax schedule. The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018; all estimates are computed by summing up the year-over-year results for the years corresponding to the stated period. The periods are as follows. Full sample: 2002-2018. Pre-reform: 2002-2012. Post-reform: 2012-2018. For reference, the average annual CPI inflation rate over the three periods was 1.43, 1.61, and 1.13 percentage points, respectively. The orange bars show the baseline decomposition that assumes deductions grow with inflation. The green bars show the change in results when assuming that the deduction amounts are kept fixed, and the cross markers indicate the total effect under the same constant-deductions assumption.

in different years, as shown in Figure 2.

Tax reform effects. Figure 3 also shows a breakdown of the total effect separately for the pre-reform period from 2002 to 2012 in Panels (c) and (d), and the post-reform period from 2013 until 2018 in Panels (e) and (f).

The pre-reform estimates for the average tax rate indicate that bracket creep was of similar importance as tax rate changes due to real income growth, amounting to 1.57 and 1.66 percentage points, respectively. These baseline numbers change to 1.90 for bracket creep and 1.24 for real income growth when keeping deductions fixed. Further, discretionary tax reforms led to a decline in the average tax rate by 2.15 percentage points. The estimates for the marginal tax rate in Panel (d) lead to similar conclusions.

The post-reform estimates for the average tax rate show a very different picture, especially in terms of the average tax rate. As Panel (e) reveals, bracket creep accounts only for 0.29 percentage point increases, even when one keeps all deductions fixed. This suggests that the tax reform successfully eliminated bracket creep, as measured by the average tax rate. In comparison, robust real income growth led to increases in the average tax rate between 2.06 and 2.29 percentage points, depending on the treatment of deductions. Lastly, discretionary tax reforms tend to be as unimportant as bracket creep, with an average tax rate decrease of 30 basis points according to the baseline. Finally, in terms of the marginal tax rate in Panel (f), I find that bracket creep is somewhat more important and accounts for a marginal tax rate increase between 0.42 and 0.61 percentage points. However, marginal tax rate changes due to real income growth strongly dominate these numbers, reflecting robust real income growth during the post-reform period.

Overall, my findings show that bracket creep accounts for a non-negligible fraction of the changes in tax rates, irrespective of whether it is measured via average or marginal tax rates. It suggests that analysis based on a tax function that only depends on real income misses important aspects of taxation.

Mechanical decomposition. The presented decomposition estimates α_t based on equation (2.3). Thus, the bracket creep term already accounts for inflation adjustments of the tax function if they occur. An alternative is the naive mechanical decomposition, where I set $\alpha_t = 0$ for all taxpayers and years instead. This decomposition variant computes the hypothetical bracket creep that may occur when the nominal tax code is kept constant, ignoring actual inflation adjustments if they occur. The resulting decomposition is presented in Figure B.4 in Appendix B. Two observations are noteworthy. First, during the above-highlighted bracket creep episodes, there is virtually no change in the tax function, which implies that the mechanical decomposition coincides with my baseline. Second, I can use the results from this mechanical decomposition and subtract the tax change term, Ψ^{tc}, from the mechanical bracket creep term, Ψ^{bc}, and set the difference to zero if negative because bracket creep is fully compensated in this case (circular markers in Figure B.4). Then, this difference mostly coincides with my baseline bracket creep term (plus markers in Figure B.4), suggesting that the mechanical decomposition leads to similar conclusions as the baseline version. This is ex-ante unclear because the mechanical decomposition ignores the covariance between bracket creep and tax function changes in the cross-section of taxpayers.

3 A tractable model with bracket creep

I develop an analytical partial equilibrium model that encompasses (i) a progressive income tax schedule allowing for bracket creep, (ii) a household choosing consumption and labor, and (iii) a government that uses tax revenues for government spending or transfers to the household. I characterize the labor supply response to bracket creep, which is useful to understand what we miss when abstracting from bracket creep by modeling the tax system only in real terms. Finally, I use the decomposition results to estimate a theory-consistent measure of bracket creep, the indexation gap.

3.1 Model

Progressive tax schedule. I consider the following generalized version of the progressive income tax schedule in Heathcote et al. (2017) where

$$T(Y) = Y - \lambda \, \frac{Y^{1-\tilde{\tau}}}{1-\tilde{\tau}} \, (\mathcal{P}^g)^{\tilde{\tau}} \tag{3.1}$$

maps nominal income $Y \geq \underline{Y}$ into a nominal tax liability $T(Y)$. The parameter $\tilde{\tau} \in [0, 1)$ measures the degree of tax progressivity, and $\lambda \geq 0$ captures the average level of taxation. In the special case of no progressivity, i.e., $\tilde{\tau} = 0$, the system reduces to a linear tax on Y at rate $1 - \lambda$. The degree of indexation to inflation is captured by $\mathcal{P}^g > 0$, which denotes the price level to which the tax code is anchored.[20] Full indexation requires that $\mathcal{P}^g$ coincides with the (market) price level $P > 0$, whereas there will be bracket creep effects when $\mathcal{P}^g \neq P$.[21] Throughout, I assume that $\underline{Y} > \left(\frac{\lambda}{1-\tilde{\tau}}\right)^{1/\tilde{\tau}} \mathcal{P}^g$ to ensure that income is sufficiently high to have only positive tax payments because I focus on progressive income taxation and bracket creep, and not on the entire tax and transfer system. Furthermore, this assumption is in line with my decomposition results, which focus on taxpayers with positive tax liabilities as explained in Section 2.2. The tax schedule implies that real net-of-tax income is

$$y^{net} = \lambda \, \frac{y^{1-\tilde{\tau}}}{1-\tilde{\tau}} \, x^{-\tilde{\tau}}, \tag{3.2}$$

where $y = Y/P$ is real pre-tax income, and $x \equiv P \,/\, \mathcal{P}^g$ is the *indexation gap* that measures the "distance" between the market price level and the level to which the tax code is anchored. The tax schedule in real terms coincides with the version from Heathcote et al. (2017) when

[20] The parameter $\mathcal{P}^g$ could be subsumed in λ. However, I aim to distinguish between taxation under full indexation, as captured by λ, $\tilde{\tau}$, and additional bracket creep effects that crucially depend on $\mathcal{P}^g$. In Section 2.3, I also show that German administrative tax data support my formulation of the tax schedule.

[21] Bracket creep in the sense of higher tax rates because of higher nominal income despite no real income gains is captured by $\mathcal{P}^g < P$, i.e., the tax code is not (fully) adjusted to increases in the price level.

the indexation gap is closed, i.e., $x = 1$. The tax schedule further implies

$$ATR = 1 - \lambda \frac{(yx)^{-\tilde{\tau}}}{1-\tilde{\tau}} \qquad \text{and} \qquad MTR = 1 - \lambda \, (yx)^{-\tilde{\tau}} \,, \tag{3.3}$$

where $ATR \equiv T(Y) \,/\, Y$ and $MTR \equiv T'(Y) \,/\, P$ denote the average and (real) marginal tax rate, respectively. Both tax rates increase in the indexation gap, i.e., $\partial_x ATR > 0$ and $\partial_x MTR > 0$, where ∂_x denotes the partial derivative regarding the indexation gap x. The magnitude of the increase declines in income as $\partial_{x,y} ATR < 0$ and $\partial_{x,y} MTR < 0$, where $\partial_{x,y}$ denotes the second partial derivative regarding the indexation gap x and income y.[22] It implies that bracket creep effects are stronger at the bottom of the income distribution because tax rates are more sensitive to changes in nominal income. Finally, it is worthwhile reiterating that I refer to bracket creep as the difference between real and nominal taxation. Such a difference exists whenever the indexation gap is not unity. For example, it encompasses the circumstances where the price level increases, but nominal income stays constant, leading to a decline in $y = Y/P$. If the tax schedule is perfectly indexed ($x = 1$), then average and marginal tax rates would fall, partly compensating for the decline in real income. However, when the tax code is not adjusted, then the indexation gap exceeds unity, providing a counteracting force. In the knife-edge case of constant nominal incomes, both forces cancel, leaving tax rates unchanged despite real income losses.

Household decision problem. I consider a single household that decides on consumption and labor supply, subject to the progressive income tax schedule from (3.1). Formally,

$$\max_{c,\ell} \frac{c^{1-\sigma}}{1-\sigma} - \varphi \frac{\ell^{1+\gamma}}{1+\gamma} + \log(G) \qquad \text{s.t.} \qquad c = \lambda \, \frac{(w\ell)^{1-\tilde{\tau}}}{1-\tilde{\tau}} \, (x)^{-\tilde{\tau}} + \mathcal{T}, \tag{3.4}$$

[22] Both properties are consistent with the German tax schedule where the ATR and the MTR increase with decreasing magnitude in nominal taxable income within and across tax brackets. The MTR only jumps from 42 to 45 percent at an income level of around 250,000 euros since 2009, affecting only very few taxpayers. Further, Heathcote et al. (2017) argues that their schedule provides a good approximation for the U.S. despite marginal tax rates being constant within tax brackets.

where c and ℓ are consumption and labor supply. The real wage is given by $w = W/P$, with W being the nominal wage. Parameters $\sigma \geq 0$ and $1/\gamma \geq 0$ denote relative risk aversion and the Frisch elasticity of labor supply, respectively. The parameter φ shifts disutility from labor and may be used to normalize equilibrium labor supply to unity. Finally, the government provides a transfer $\mathcal{T}$ and public goods G, both taken as given by the household.

Government. The government returns a fraction $\theta \in [0, 1]$ of the tax revenues to the household, which yields the real transfer

$$\mathcal{T} = \theta \left(w\ell - \lambda \, \frac{(w\ell)^{1-\tilde{\tau}}}{1-\tilde{\tau}} \, (x)^{-\tilde{\tau}} \right). \tag{3.5}$$

The remaining tax revenues are used for government spending to finance the public good. The parameter θ matters for the effects of bracket creep because it governs the strength of the income effects of taxation on labor supply.[23] For the comparative statics below, I assume the indexation gap x is exogenous in this static framework. In Section 4, I embed the tax schedule into a dynamic general equilibrium framework with endogenous indexation gaps where the government chooses a time path for $\mathcal{P}^g$, and changes in the price level P are determined in general equilibrium.

3.2 Theoretical results

I study how the household's labor supply responds to bracket creep. Let (c^*, ℓ^*) denote the optimal consumption and labor supply choices. I further set φ such that labor supply equals unity in the stationary equilibrium. The following proposition provides comparative statics that characterize how labor supply responds to bracket creep.

[23] All previous theoretical papers that study bracket creep assume full lump-sum redistribution of tax revenues due to bracket creep, i.e., $\theta = 1$ (Edge and Rudd, 2007; Keinsley, 2016; Heer and Süssmuth, 2013).

Proposition 2. *Let $\sigma \geq 1$. Then, there exists a threshold value $\bar{\theta} \in [0,1]$ such that*

$$\frac{d\ell^*}{dx} \geq 0 \Longleftrightarrow \theta < \bar{\theta} \equiv \frac{\chi}{1+\chi}, \tag{3.6}$$

with $\chi = (\sigma - 1)\frac{\lambda}{1-\tilde{\tau}}\,(x\,w)^{-\tilde{\tau}} \geq 0$.

The proof is in Appendix A. The proposition states that the labor supply response to bracket creep is ambiguous and depends crucially on θ, the share of tax revenues returned to the household. Intuitively, an increase in the indexation gap x raises average and marginal tax rates, giving rise to income and substitution effects on labor supply. It also generates additional tax revenues for the government. Returning these tax revenues to the household diminishes the income effect of bracket creep. Hence, when θ is large enough, the substitution effect dominates, and the household works less due to higher marginal tax rates. Moreover, the threshold $\bar{\theta}$ increases in the relative risk aversion σ since the income effect increases in this parameter. This means that more tax revenues must be given back to obtain a reduction in labor supply in response to bracket creep when risk aversion is high.

Next, I focus on bracket creep and real wage fluctuations jointly. It is useful to consider the first-order response of labor supply around a (stationary) equilibrium without bracket creep, i.e., $x = 1$. The approximate labor supply response is

$$\hat{\ell} = \Gamma_w\,\hat{w} + \Gamma_x\,\hat{x}, \tag{3.7}$$

where $\hat{\ell} = \ell^*/\ell_0^* - 1$, and ℓ_0^* denotes optimal labor supply at the point of approximation, the stationary equilibrium, and similarly for $\hat{w}$ and $\hat{x}$. The following proposition characterizes how the coefficients Γ_w and Γ_x depend on relative risk aversion σ and the usage of tax revenues θ.

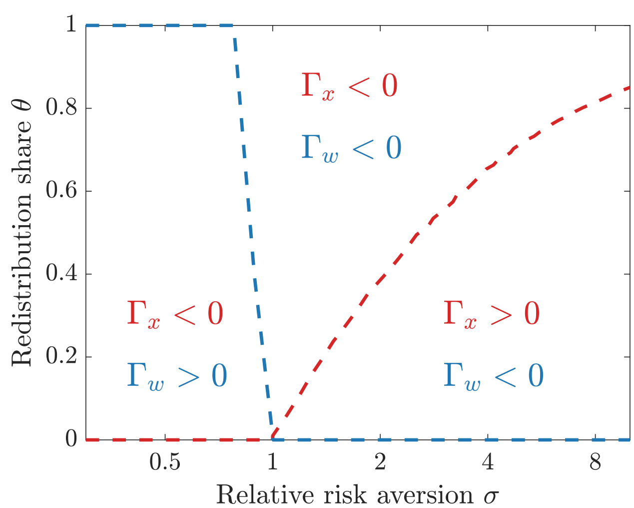
Proposition 3. *Conditional on σ, there exist threshold values $\bar{\theta}_x(\sigma)$ and $\bar{\theta}_w(\sigma)$ such that*

$$\theta \geq \bar{\theta}_x(\sigma) \Longrightarrow \Gamma_x \leq 0 \quad \text{and} \quad \theta \geq \bar{\theta}_w(\sigma) \Longrightarrow \Gamma_w \leq 0.$$

Moreover, if $\sigma > 1$, then $\bar{\theta}_x(\sigma) \in (0,1)$ and $\bar{\theta}_w(\sigma) = 0$.

The proof is in Appendix A. The proposition states that there are threshold values for the share of tax revenues returned to the household, the redistribution share θ, that determine the labor supply response to changes in the real wage and to changes in the indexation gap. In the empirically plausible case that relative risk aversion exceeds unity, we have that the threshold value for the indexation gap strictly exceeds the threshold for real wages.

Figure 4: Labor supply response regions



Notes: The figure shows parameter regions for which an increase in the real wage leads to higher labor supply ($\Gamma_w > 0$), and for which an increase in the indexation gap leads to higher labor supply ($\Gamma_x > 0$), based on the first-order dynamics from (3.7). The remaining parameters are $\tilde{\tau} = 0.2$, $\lambda = 0.6$, $\gamma = 2$ and $w = 1$.

Examples. To illustrate the implications of the proposition, I display a numerical example in Figure 4. There are distinct parameter regions that govern whether or not increases in the real wage and in the indexation gap have opposing effects on labor supply.

For concreteness, suppose that the price level P and the nominal wage W increase with inflation at a rate $\Pi > 1$, but the government keeps $\mathcal{P}^g$ constant. Thus, the real wage stays constant, but the indexation gap increases, i.e., $\hat{x} = \Pi - 1 > 0$. This exemplifies what is commonly understood as bracket creep, i.e., an increase in the nominal wage that only compensates for inflation leads to higher average and marginal tax rates, which affect labor supply. The effect on labor supply is only negative when relative risk aversion is sufficiently small or the redistribution share is high enough, as illustrated in Figure 4.

Alternatively, consider that nominal wages remain unchanged, but the price level still grows at the rate Π, implying that the indexation gap increases and the real wage falls.[24] The overall effect on labor supply now depends on the response to both variables. When risk aversion is sufficiently low, the decline in the real wage leads to less labor supply. This is amplified by bracket creep, which further reduces labor supply (left region in Figure 4).[25] When risk aversion and the redistribution share are sufficiently high, then the real wage loss leads to a higher labor supply, but bracket creep effects lead to a lower labor supply, dampening the overall effect (center region in Figure 4). Finally, when risk aversion is sufficiently high and redistribution is not too high, then both the real wage loss and bracket creep lead to a higher labor supply. Thus, bracket creep amplifies the effects of the price level increase in the latter case (right region in Figure 4).

Overall, this shows that bracket creep can either amplify or dampen the effects of progressive taxation that would prevail when the tax system is perfectly indexed to inflation.

3.3 Empirical indexation gaps

Next, I develop an approach to estimate the time series of the indexation gap, which is useful to discipline the quantitative model in Section 4. Additionally, I present regression results that support the tax schedule formulation presented in Section 3.1.

[24] This gives rise to bracket creep effects because tax rates do not fall as they would under full indexation to partly compensate for the real income loss; see the discussion along with (3.3).

[25] Note that the effects of $\hat{w}$ and $\hat{x}$ on labor supply have the same sign when Γ_w and Γ_x have opposite signs as x increases but w decreases in this example.

Estimation strategy. I use the empirical measure of the degree of indexation as defined in equation (2.3) to obtain an empirical measurement of the indexation gap. This only requires assuming the tax schedule specified in equation (3.1), but not the remainder of the analytical model. Under my tax schedule formulation, consider the change in the average tax rate

$$ATR_t(y, x_t) - ATR_{t-1}(y, x_{t-1}) = \frac{\lambda}{1-\tilde{\tau}} \left(y x_{t-1}\right)^{-\tilde{\tau}} \left(1 - \left(\frac{\Pi_t}{\Pi_t^g}\right)^{-\tilde{\tau}}\right), \tag{3.8}$$

for a taxpayer with constant real income $y = y_t = y_{t-1}$, and $\Pi_t^g \equiv \mathcal{P}_t^g / \mathcal{P}_{t-1}^g$ and the inflation rate jointly determine the strength of bracket creep. When $\Pi_t > \Pi_t^g = 1$, then this corresponds to the change in average tax rates in the model under a full bracket creep benchmark, analogously to the measurement of indexation in Section 2.1. Next, I define a model counterpart to the degree of indexation measured in the data. The model counterpart is one minus equation (3.8) divided by the same equation but under the assumption of full bracket creep, $\Pi_t^g = 1$, and given by.

$$\tilde{\alpha}_t = 1 - \frac{1 - \left(\Pi_t / \Pi_t^g\right)^{-\tilde{\tau}}}{1 - \left(\Pi_t\right)^{-\tilde{\tau}}}. \tag{3.9}$$

Imposing the empirical degree of indexation equals the model counterpart, i.e., $\alpha_t = \tilde{\alpha}_t$, yields $\Pi_t^g = \left(\alpha_t \Pi_t^{\tilde{\tau}} + (1 - \alpha_t)\right)^{1/\tilde{\tau}}$. Hence, given the empirical degree of indexation α_t and an estimate of the progressivity parameter $\tilde{\tau}$, I can measure the growth rate of the indexation parameter $\mathcal{P}_t^g$. Under the assumption of no bracket creep at date zero, i.e., $\mathcal{P}_0^g = P_0$, I compute the indexation parameter as

$$\mathcal{P}_t^g = \begin{cases} \mathcal{P}_{t-1}^g \Pi_t^g & \text{if} \quad \alpha_t > 0 \\ P_t & \text{otherwise.} \end{cases} \tag{3.10}$$

When there is bracket creep from one year to the other, as captured by $\alpha_t > 0$, then $\mathcal{P}_t^g$ grows with the estimated rate Π_t^g. Conversely, when $\alpha_t = 0$, I assume the government fully compensates for the increase in the price level relative to the last period: I do this because the empirical decomposition takes no stance on what happens with accumulated bracket creep from the past periods. Thus, for these cases, I assume full make-up for accumulated past bracket creep when $\alpha_t = 0$. The idea is that the government at least compensates for contemporaneous bracket creep and, at most, all accumulated bracket creep from the past. By assuming the latter, I follow a conservative approach and obtain a time series of $\mathcal{P}^g$ that likely yields a lower bound estimate of the indexation gap $x_t = P_t/\mathcal{P}^g_t$. This interpretation requires that the government only compensates past bracket creep but does not compensate for future bracket creep through over-compensating contemporaneous bracket creep. I view this as the empirically most plausible case.[26] In addition, this allows me to remain agnostic about whether the politically desired tax system shifts over time. For example, it could be that politicians deliberately do not compensate for all accumulated past bracket creep because bracket creep moved the tax code closer to their desired tax code.[27]

Implementation. To obtain the tax progressivity $\tilde{\tau}$, I follow Heathcote et al. (2017) and run an OLS regression of log real net-of-tax income on log real pre-tax income, using the full sample of taxpayers from 2002 until 2018. The coefficient on log pre-tax income is an estimate of $1 - \tilde{\tau}$. The results are given in column (1) of Table 1, with standard errors clustered at the taxpayer level in parentheses. The estimate is significant at any conventional level and implies $\tilde{\tau} = 0.14$. It is further reassuring that my estimate is close to the estimate of 0.16 presented in Heathcote et al. (2020) for Germany in the year 2005. Given this estimate, I can readily compute indexation gaps at the taxpayer level.[28]

I compute indexation gaps at the taxpayer level (since α_t is measured at this level) and

[26] Maintaining this assumption is needed to disentangle bracket creep and indexation from discretionary tax changes. Without such an assumption, it is not possible to discriminate between compensation for bracket creep and discretionary tax code changes that are unrelated to inflation. This is because any tax cut can be interpreted as only compensating for future inflation.

[27] Through the lens of the structural tax schedule from equation (3.1), this would correspond to politicians preferring a larger value of λ over time. The accumulated indexation gap could then be subsumed in a higher value of λ.

[28] I use the baseline results for α_t where deductions are assumed to grow at the inflation rate.

Table 1: Estimated tax parameters

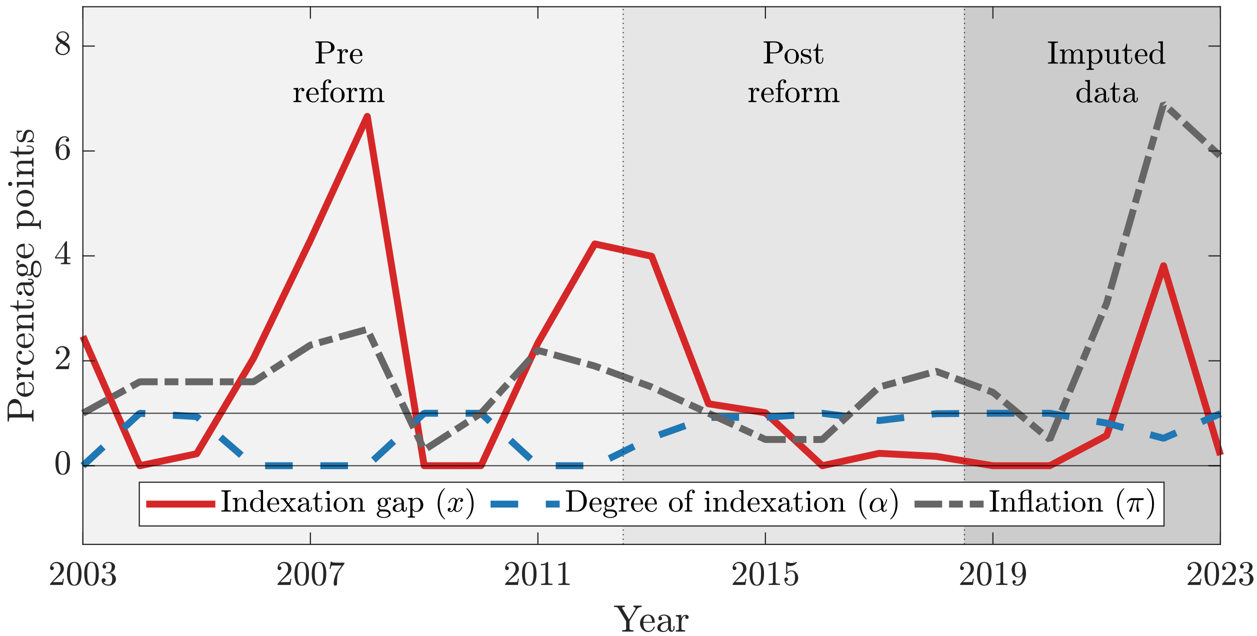
	(1)	(2)
Real pre-tax income: $\log(y)$	0.86	0.86
	(0.0001)	(0.0001)
Indexation gap: $\log(x)$		-0.12
		(0.0004)
Constant	0.70	0.70
	(0.0005)	(0.0007)
R^2	0.999	0.999
Taxpayer FE	✓	✓
Observations (Mio.)	14.371	9.203

Notes: The table shows OLS regression results based on equation (3.11) using the administrative tax records from 2002 until 2018, as presented in Section 2.2. Standard errors are clustered at the taxpayer level and provided in parentheses.

then average across the cross-section of taxpayers for each year. The resulting time series is presented in Figure 5. I further display the degree of indexation and the inflation rate to illustrate how both relate to indexation gaps. There is sizable time variation in the indexation gap, which peaks at 6.7 percentage points in 2008. This means that the market price level is 6.7 percentage points above the indexation parameter $\mathcal{P}^g$. Despite the tax reform in 2012, it took until 2016 to close the aggregate indexation gap. During the post-Covid inflation surge, a sizable indexation gap emerged again, albeit less pronounced than the peak gap in 2008. This reflects the fact that the lack of indexation was very transitory during the post-Covid inflation surge. In this period, the increase in the indexation gap is primarily driven by the inflation surge and less by the degree of indexation, which remains relatively high. Finally, I note that, by construction, the indexation gap is strongly correlated with the bracket creep term from the decomposition in Section 2.3.

Testing the tax schedule. My approach to estimating indexation gaps imposes the tax function from equation (3.1). To check whether this tax function is supported by the data,

Figure 5: Time variation in the indexation gap



Notes: The figure shows the time series of the indexation gap, based on equations (3.8)-(3.10); the empirical degree of indexation based on equation (2.3); and the annual CPI inflation rate. Note that the degree of indexation is defined to be between 0 and 1, whereas the remaining series have a percentage point interpretation. The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018. The imputed data is based on average household income growth as explained in Section 2.3.

I consider the following regression

$$\log y_{i,t}^{net} = a_i + b\log(y_{i,t}) + c\log(x_{i,t}) + u_{i,t}, \tag{3.11}$$

where i and t index individual taxpayers and years, a_i are taxpayer fixed effects, and $u_{i,t}$ is an error term. A testable prediction of my tax schedule is $b - c = 1$. It follows from taking the log of real net-of-tax income in equation (3.2). The OLS estimates of this specification are presented in column (2) of Table 1. The results are remarkably close to the theoretical prediction and imply $b - c = 0.98$.[29] I interpret this result as lending support to my proposed tax schedule.

[29] Ex-ante, a concern could be that the regression to obtain $\tilde{\tau}$ in the first place (without indexation gaps) was misspecified. Ex-post, however, it turns out that including indexation gaps in the specification does not change the implied $\tilde{\tau}$ estimate as measured by the estimate of b.

4 A New Keynesian model with bracket creep

I study how nominal progressive taxation affects the propagation of macroeconomic shocks through the bracket creep channel. The analysis is based on a one-asset New Keynesian model with incomplete markets. Calibrating the model to the German economy before the indexation reform in 2012, I show that bracket creep dampens the short-run output effects of monetary policy via an endogenous steepening of the Phillips curve.

4.1 Model

The model is a closed economy populated by a continuum of households with unit mass, and time is discrete.

Households. I consider a generalized version of the household setup in the analytical model from Section 3. Households consume a final good, supply labor, and may save in a liquid bond, $b_{i,t}$. All households are ex-ante identical and solve the following dynamic problem

$$
\begin{aligned}
V_t(e_{i,t}, b_{i,t-1}) = \max_{c_{i,t},\ell_{i,t},b_{i,t}} & \left(\frac{c_{i,t}^{1-\sigma}}{1-\sigma} - \varphi \frac{\ell_{i,t}^{1-\gamma}}{1-\gamma} + \log(G) + \beta \mathbb{E}_t \Big[V_{t+1}(e_{i,t+1}, b_{i,t}) \Big] \right) \qquad (4.1) \\
\text{s.t. } c_{i,t} + b_{i,t} = \lambda \ & \frac{(w_t e_{i,t} \ell_{i,t})^{1-\tilde{\tau}}}{1-\tilde{\tau}} \ (x_t)^{-\tilde{\tau}} + b_{i,t-1}(1+r_t) + \mathcal{T}_{i,t} + d_{i,t}, \\
- \underline{b} \leq b_{i,t}, \quad & \text{and} \quad \ln(e_{i,t+1}) = \rho_e \ln(e_{i,t}) + v_{i,t+1},
\end{aligned}
$$

where $e_{i,t}$ is the idiosyncratic endowment of labor efficiency units and $v_{i,t} \overset{iid}{\sim} N(0, \sigma_e)$, and $|\rho_e| < 1$. Borrowing must not exceed $-\underline{b}$. The government transfer $\mathcal{T}_{i,t}$ and dividends from the firms $d_{i,t}$ are distributed proportionally to labor efficiency units as in (Auclert et al., 2021). Both are taken as given by households. The level of public good provision is given by G. Aggregate variables w_t, r_t, and x_t denote the real wage, the real interest rate, and the indexation gap, respectively. Flow utility is additively separable and depends on constant relative risk aversion σ, inverse Frisch elasticity of labor supply γ, and a labor disutility shifter φ. The beginning-of-period bond holdings $b_{i,t-1}$ are given, and households choose labor supply $\ell_{i,t}$ and allocate the disposable income to consumption $c_{i,t}$ and liquid bond holdings $b_{i,t}$.

Production. The final consumption good is produced from a continuum of varieties by a representative final good firm based on a technology with constant elasticity of substitution given by $\mu/(\mu-1)$. The varieties are produced by intermediate good firms $j \in [0,1]$ that use a constant returns-to-scale technology, and labor is the only production input. The intermediate good producers are monopolistically competitive and take the demand schedule of the final good firm as given when setting retail prices $p_{j,t}$, subject to quadratic adjustment costs $\mathcal{C}_t = \mathcal{K}\ \log(p_{j,t}/p_{j,t-1})^2\, Y_t$, with Y_t being aggregate output and the firm discount rate is given by the real interest rate.[30] The adjustment cost parameter $\mathcal{K} = \frac{\mu}{2(\mu-1)\kappa}$ is defined such that κ will represent the slope of the Phillips curve. Solving the firm problem and imposing a symmetric equilibrium across intermediate good producers gives rise to a standard New Keynesian Phillips curve

$$\log(\Pi_t) = \kappa\left(\frac{w_t}{Z} - \frac{1}{\mu}\right) + \frac{1}{1+r_{t+1}}\frac{Y_{t+1}}{Y_t}\log(\Pi_{t+1}), \tag{4.2}$$

where $\Pi_t = P_t/P_{t-1}$ is the gross inflation rate, and Z is total factor productivity. The slope of the Phillips curve is given by κ, which measures the price adjustment costs. Finally, profits or losses of the firm are distributed to households through dividends $d_t = Y_t - w_t N_t - \mathcal{C}_t$, where N_t is total labor demand.

Government. The government consists of a fiscal and a monetary authority. The fiscal authority issues the liquid bond, collects real tax revenues from progressive income taxation

[30] I assume a price and not a wage rigidity because endogenous labor supply is key for my mechanism. In contrast, rigid wages are typically implemented via a labor union that sets wages and hours uniformly for all households, implying that agents are not on their individual labor supply curves (e.g., Auclert et al., 2021).

R_t, and decides on the amount of aggregate transfers $\mathcal{T}_t$ and government spending for the public good G_t. It faces the following period-by-period real budget constraint

$$R_t = r_t B^g + G_t + \mathcal{T}_t. \tag{4.3}$$

Let variables without time subscript denote the steady-state values, then the government behavior (for deviations from the steady-state) is described by

$$G_t - G = \phi_g(R_t - r_t B^g - G - \mathcal{T}) \quad \text{and} \quad \mathcal{T}_t - \mathcal{T} = (1 - \phi_g)(R_t - r_t B^g - G - \mathcal{T}).$$

The equations state that a fraction ϕ_g from the tax revenues after paying interest, as well as steady-state transfers and government spending, is used for additional government spending, and the remainder constitutes an additional transfer to households. I follow this approach because it allows me to calibrate ϕ_g such that the composition of government expenses for public good provision and transfers is kept constant in response to shocks. This is important because it ensures that the results are not driven by the government using bracket creep tax revenues to alter the composition of government expenses.[31] Finally, the fiscal authority decides the indexation parameter $\mathcal{P}_t^g$ that determines the indexation gap $x_t = P_t/\mathcal{P}_t^g$ such that

$$(x_t - x) = \phi_x(x_{t-1} - x) + (1 - \alpha)(\Pi_t - 1), \tag{4.4}$$

where α determines how much of inflation is instantaneously compensated and ϕ_x governs how fast $\mathcal{P}_t^g$ is adjusted given the already accumulated indexation gap x_{t-1}. Importantly, the tax system is fully indexed when $\alpha = 1$ such that the indexation gap is always at its steady-state value, i.e., $x_t = x$, $\forall t$. Finally, the model is closed with a standard Taylor rule

[31] It would be desirable to measure how tax revenues due to bracket creep are used in the data. Unfortunately, this is infeasible because it would require exogenous variation in bracket creep that does not affect the government budget constraint through other channels.

that governs the behavior of the monetary authority

$$i_t = \phi_\Pi(\Pi_t - \Pi) + m_t, \tag{4.5}$$

where i_t is the nominal interest rate that maps into the real rate via the Fisher equation $r_t = (1+i_t)/\Pi_t - 1$, and m_t is an autocorrelated monetary policy shock that follows a stable auto-regressive process with $m_t = \rho_m m_{t-1} + \varepsilon_t^{mp}$ and standard normal innovations ε_t^{mp}.

Model solution. An equilibrium consists of sequences for all household, firm, and governmental variables such that all private agents behave optimally (given prices and the transfer) and such that the goods-, labor- and asset markets clear at any date t. The model is solved based on a first-order perturbation in sequence space (Auclert et al., 2021) around a steady state with zero inflation and zero indexation gaps, i.e., $\Pi_t - 1 = x_t - 1 = 0$. By studying an economy with zero trend inflation, I follow most of the New Keynesian literature (e.g., Galí, 2015; Auclert et al., 2024).

Calibration. The model is calibrated to the German economy before the 2012 tax reform that reduced bracket creep and a period is a quarter. All parameters are summarized in Table 2. Relative risk aversion and the inverse Frisch elasticity of labor supply are set to conventional values. The discount factor and the labor disutility shifter are set to match an annualized real interest rate of two percent and an effective steady-state labor supply of unity under the normalization that TFP $Z = 1$. The parameters that govern the endowment with idiosyncratic labor efficiency units are set to match the annual moments according to the GRID database, which is constructed from German administrative data. The remaining supply-side parameters are set to standard values. The borrowing limit corresponds to the average monthly income in the steady-state. The supply of government bonds from the government matches an annual debt-to-GDP ratio of 60%. The tax progressivity parameter is set to $\tilde{\tau} = 0.14$, in line with my estimation results from above, and the tax level is set to match the ratio of aggregate tax payments to income in the same data. The government spending to GDP ratio is set to 12.5%, which implies that 40% of the tax revenues net of interest payments are used for government spending to provide the public good G_t, and the remainder is redistributed to households. The parameter ϕ_g is set to keep the ratio of government spending to transfers constant in response to shocks. Finally, I set $\alpha = 0$ as there were multiple periods with no compensation for bracket creep before 2012 and estimate the degree of mean reversion ϕ_x based on the computed indexation gaps.[32] The Taylor rule coefficients and the autocorrelation of the monetary shock are set to conventional values.

4.2 Results

The baseline calibration corresponds to the German economy before the 2012 tax reform that reduced bracket creep. In this setup, I study how the propagation of macroeconomic shocks is altered through the presence of bracket creep. The underlying idea is that any shock that affects inflation impacts tax rates through the bracket creep channel. Thus, from a monetary policy perspective, it implies that the responses to monetary shocks are partly shaped by bracket creep, revealing a new dimension of fiscal-monetary interactions and also a new source of monetary non-neutrality.

In Figure 6, I display the responses to an expansionary monetary policy shock that equals a 25 basis point rate cut on impact. The blue solid line shows the baseline "bracket creep economy" without indexation, and the dashed red line shows the same economy but with a perfectly indexed tax code, i.e., $\alpha = 1.0$. Panel (a) displays the response of the indexation gap. In the bracket creep economy, the indexation gap equals the rate of inflation on impact but then further builds up because the fiscal authority adjusts the tax code only slowly to the new price level. In contrast, under full indexation, the indexation gap is always closed and remains at the steady-state level. In Panel (b), I show the implied effects on average tax rates. Already under full indexation, the average tax rate increases because of larger

[32]Since the indexation gap series is annual, I interpolate to quarterly frequency by assuming that the indexation gap remains constant within a given year and estimate ϕ_x using OLS.

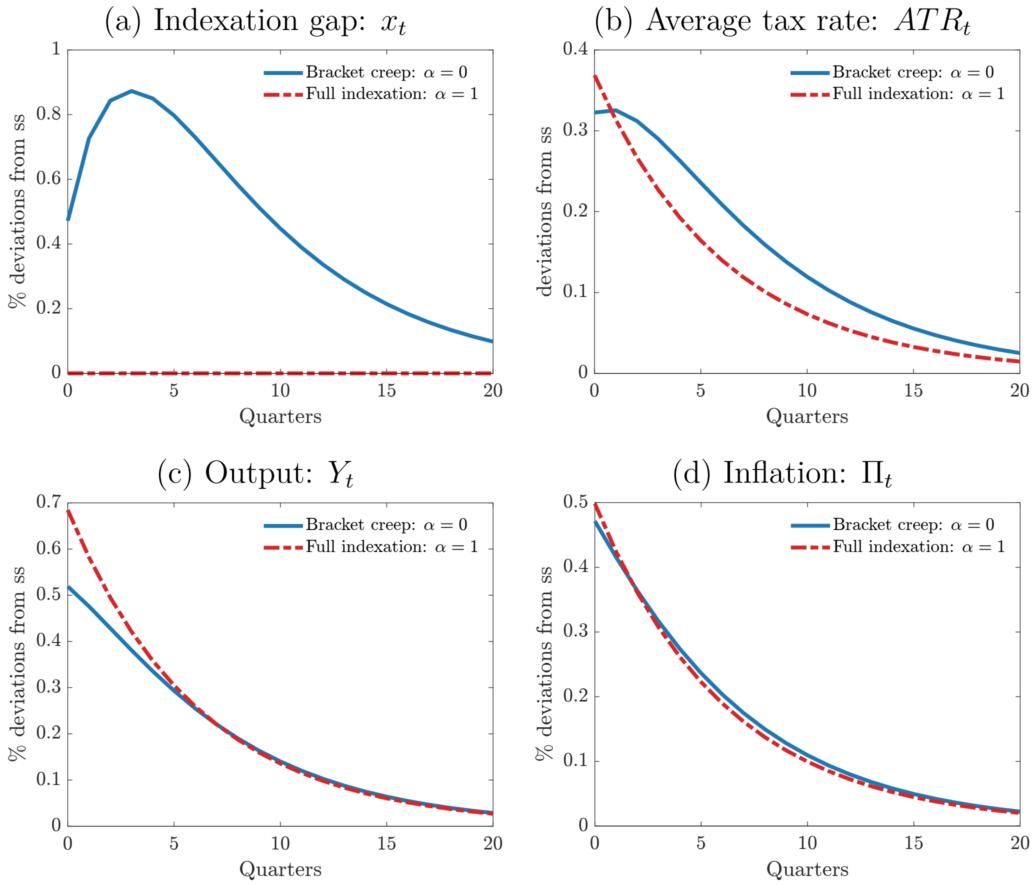
Table 2: Calibration

Variable		Value	Target/Source
Relative risk aversion	σ	2.00	standard value
Inverse Frisch elasticity	γ	4.00	standard value
Discount factor	β	0.99	Annual real rate of 2%
Labor disutility shifter	φ	0.66	Steady-state labor $\int e_i \ell_i di = 1$
Borrowing limit	$\underline{b}$	0.33	Steady-state monthly average income
SD of idiosy. endowment	σ_e	0.25	Annual SD of income
Autocorr. of idiosy. endowment	ρ_e	0.90	Annual autocorr. of income
Steady-state markup	μ	1.10	10% markup
Slope of the Phillips curve	κ	0.025	standard value
Steady-state TFP	Z	1.00	Normalization
Tax progressivity	$\tilde{\tau}$	0.14	Estimated based on tax data
Tax level	λ	0.65	Tax-income ratio in tax data
Gov't bond supply	B^g	2.40	Debt-to-GDP of 60%
Steady-state share of G	G/Y	0.125	Spending-transfer ratio of 40%
G spending response	ϕ_g	0.40	Steady-state spending-transfer ratio
Degree of indexation	α	0.00	Full bracket creep
Autocorr. of indexation gap	ϕ_x	0.66	Estimated based on tax data
Taylor rule coefficient	ϕ_Π	1.50	standard value
Autocorr. of MP shock	ρ_m	0.85	standard value

Notes: Calibration for the baseline economy, corresponding to Germany for the period 2003 until 2012 before the bracket creep tax reform. The annual income data moments are taken from the GRID database.

real income. In the bracket creep economy, this is further amplified through bracket creep effects. Quantitatively, the increase in the average tax rate is 36% larger after one year. Note that the (first-order) response of the marginal tax rate coincides with the average tax rate response under the tax schedule that I assume. Moving to the output response in Panel (c), one can see that bracket creep dampens the expansionary effects of monetary policy

Figure 6: Responses to an expansionary monetary policy shock



Notes: The figure shows impulse responses based on the one-asset New Keynesian model with incomplete markets as specified in Section 4.1. The expansionary monetary policy shock is a nominal interest rate cut of 25 basis points.

on real activity. Interestingly, this difference across both economies is relatively short-lived and dissipates after around one year. Finally, the inflation responses are given in Panel (d). While, ex-ante, it is unclear whether the presence of bracket creep meaningfully alters inflation dynamics, it turns out that it is quantitatively irrelevant for a monetary shock.

The results for output and inflation can be interpreted as an endogenous steepening of the Phillips curve through bracket creep. This endogenous steepening is transitory and therefore temporarily alters the monetary policy tradeoff between output and inflation stabilization. Intuitively, this endogenous steepening is driven by the response of firms' marginal costs, as given by the real wage rate. The wage response is directly linked to the labor supply incentives that are altered through the presence of bracket creep.

Finally, such a steepening of the Phillips curve implies that expansionary monetary policy leads to lower GDP growth for a given increase in inflation. However, when monetary policy is contractionary to reduce inflation, it follows that the GDP costs of a given reduction of inflation are reduced through bracket creep via the steepening of the Phillips curve. Put differently, the output costs of monetary disinflation are aggravated when the tax code is indexed to inflation, revealing a potential caveat of such indexation schemes.

Overall, the model results suggest that bracket creep (or indexation) may alter the transmission of monetary policy shocks in a meaningful way.

5 Conclusion

Bracket creep effects occur when inflation changes tax rates because the progressive income tax schedule is not adjusted. I document the quantitative importance of bracket creep over time using German administrative tax records. I find that bracket creep played an important role in changes in tax rates until around 2012. In 2012, a tax reform led to a substantial decline in bracket creep because tax code adjustments based on inflation forecasts performed well when inflation was relatively low and stable. However, the post-Covid inflation surge led to a resurgence with sizable bracket creep effects. My theoretical analysis departs from the empirical result that bracket creep may account for considerable changes in tax rates. To connect these findings to household choices, I characterize how bracket creep affects labor supply decisions in a partial equilibrium framework. Further, I estimate a theory-consistent measure of bracket creep, the indexation gap, which is used to discipline a New Keynesian model with incomplete markets. The model predicts a transitory and endogenous steepening of the Phillips curve in response to a monetary shock. This steepening lowers the output cost of monetary disinflation in an economy with bracket creep.

Going forward, there are several avenues for expanding this research. First, not only the income tax schedule but also many other government policies are specified in nominal terms, including unemployment insurance, childcare subsidies, and more. Inflation adjustments are often infrequent and incomplete. Thus, quantifying the effects of imperfect inflation adjustments would be valuable to investigate whether they impact shock transmission and to understand where large gains from indexation are available. Second, potentially inefficient fluctuations in taxes due to bracket creep and delayed compensation may amplify the welfare costs of inflation. This provides a motive for a lower inflation target by the central bank when imperfectly indexed taxes are taken as given. Future work may quantify the importance of this channel. Finally, extending the empirical analysis to more countries within and beyond the Euro Area would be important to quantify bracket creep effects more broadly.

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A Derivations

Proof of Proposition 1. Inserting Definition 1 in Ψ_t^{bc} yields

$$\begin{aligned}\Psi_t^{bc} &= t_t^{\mathcal{I}}\left(Z_t^{\Pi},\ Z_{t-1}\right) - t_{t-1}\left(Z_{t-1}\right)\\ &= \left[\left(1-\alpha_t\right) t_{t-1}\left(Z_t^{\Pi}\right) + \alpha_t\, t_{t-1}\left(Z_{t-1}\right)\right] - t_{t-1}\left(Z_{t-1}\right)\\ &= \left(1-\alpha_t\right)\left[t_{t-1}\left(Z_t^{\Pi}\right) - t_{t-1}\left(Z_{t-1}\right)\right].\end{aligned}$$

When $\Pi_t > 1$ and $Z_t > 0$ (the latter being assumed throughout in the main text), then $Z_t^{\Pi} > Z_t$. As $\frac{\partial t_{t-1}(Z)}{\partial Z} > 0,\ \forall Z \in [Z_{t-1}, Z_t^{\Pi}]$, it follows that $t_{t-1}(Z_t^{\Pi}) > t_{t-1}(Z_{t-1})$, which completes the proof. □

Proof of Proposition 2. Substituting the budget constraint for c in the household problem yields the first-order condition

$$\begin{aligned}0 &= \left(c^*\right)^{-\sigma} \lambda w^{1-\tau} x^{-\tau} - \varphi\left(\ell^*\right)^{\gamma+\tau}\\ &= \left(\theta \ell^* w + (1-\theta)\frac{\lambda}{1-\tau}\left(w\ell^*\right)^{1-\tau} x^{-\tau}\right)^{-\sigma} \lambda w^{1-\tau} x^{-\tau} - \varphi\left(\ell^*\right)^{\gamma+\tau},\end{aligned} \tag{A.1}$$

where the second equality uses the budget constraint and the definition of $\mathcal{T}$. Totally differentiating with respect to x and ℓ^* gives

$$\begin{aligned}0 =& \left(-\tau\left(c^*\right)^{-\sigma} \lambda w^{1-\tau} x^{-\tau-1}\left[1-\sigma\left(c^*\right)^{-1}(1-\theta)\frac{\lambda}{1-\tau}\left(w\ell^*\right)^{1-\tau} x^{-\tau}\right]\right) dx\\ &+ \left(-\sigma\left(c^*\right)^{-\sigma-1}\left[\theta\lambda w^{2-\tau} x^{-\tau} + (1-\theta)\left(\lambda w^{1-\tau} x^{-\tau}\right)^2\left(\ell^*\right)^{-\tau}\right] - (\gamma+\tau)\varphi\left(\ell^*\right)^{\gamma+\tau-1}\right) d\ell^*\\ \iff \frac{d\ell^*}{dx} =& \frac{-\tau\left(c^*\right)^{-\sigma} \lambda w^{1-\tau} x^{-\tau-1}\left[1-\sigma\left(c^*\right)^{-1}(1-\theta)\frac{\lambda}{1-\tau}\left(w\ell^*\right)^{1-\tau} x^{-\tau}\right]}{\sigma\left(c^*\right)^{-\sigma-1}\left[\theta\lambda w^{2-\tau} x^{-\tau} + (1-\theta)\left(\lambda w^{1-\tau} x^{-\tau}\right)^2\left(\ell^*\right)^{-\tau}\right] + (\gamma+\tau)\varphi\left(\ell^*\right)^{\gamma+\tau-1}}.\end{aligned}$$

The denominator is strictly positive as all parameters, as well as the real wage, the indexation gap and equilibrium choices c^*, ℓ^* are strictly positive. For the same reason, it follows that the sign of $d\ell^*/dx$ is pinned down by the term in square brackets as the multiplicative term in front of it is strictly negative. Hence, the cutoff $\bar{\theta}$ is determined via

$$\begin{aligned}
0 &= 1 - \sigma\,(c^*)^{-1}\,(1-\bar{\theta})\frac{\lambda}{1-\tau}\,(w\ell^*)^{1-\tau}\,x^{-\tau} \\
&= \bar{\theta}\ell^* w + (1-\bar{\theta})\frac{\lambda}{1-\tau}\,(w\ell^*)^{1-\tau}\,x^{-\tau} - \sigma(1-\bar{\theta})\frac{\lambda}{1-\tau}\,(w\ell^*)^{1-\tau}\,x^{-\tau} \\
&= \bar{\theta} - (\sigma-1)(1-\bar{\theta})\frac{\lambda}{1-\tau}\,(xw\ell^*)^{-\tau} \\
&= \bar{\theta} - (1-\bar{\theta})\chi
\end{aligned}$$

where the second equality follows from multiplying with c^*. Since $\chi \geq 0 \iff \sigma \geq 1$, it follows that $0 < \theta - (1-\theta)\chi \iff \theta > \bar{\theta}$ which implies $d\ell^*/dx < 0$, and analogously for $\theta < \hat{\theta}$. Note that the last equality also uses that $\ell^* = 1$ as stated in the main text.

□

Proof of Proposition 3. I first establish a Lemma that will be useful for this proof.

Lemma 1. *The coefficients from equation* (3.7) *in the main text are*

$$\Gamma_x = \frac{\tau\,\vartheta_0}{\gamma+\tau+\sigma\,\vartheta_1} \qquad \text{and} \qquad \Gamma_w = \frac{1-\tau-\sigma\,\vartheta_1}{\gamma+\tau+\sigma\,\vartheta_1},$$

with

$$\vartheta_0 = \frac{(\sigma-1)(1-\theta)\lambda\,(1-\tau)^{-1}\,(w\ell^*)^{-\tau} - \theta}{\theta + (1-\theta)\lambda\,(1-\tau)^{-1}\,(w\ell^*)^{-\tau}} \quad \text{and} \quad \vartheta_1 = \frac{\theta + (1-\theta)\lambda\,(w\ell^*)^{-\tau}}{\theta + (1-\theta)\lambda\,(1-\tau)^{-1}\,(w\ell^*)^{-\tau}}.$$

Proof. A first order approximation of (A.1) around (ℓ^*, w, x) with $x = 1$ yields

$$\begin{aligned}
0 = &\left[-\sigma\,(c^*)^{-\sigma-1}\left(\theta w\ell^* + (1-\theta)\lambda\,(w\ell^*)^{1-\tau}\right) - (\gamma+\tau)\,\varphi\,(\ell^*)^{\gamma+\tau}\right]\hat{\ell} \\
&+ \left[-\sigma\,(c^*)^{-\sigma-1}\left(\theta w\ell^* + (1-\theta)\lambda\,(w\ell^*)^{1-\tau}\right)\lambda w^{1-\tau} + (c^*)^{-\sigma}\,\lambda(1-\tau)w^{1-\tau}\right]\hat{w} \\
&+ \left[\sigma\,(c^*)^{-\sigma-1}\,(1-\theta)\,\lambda^2\,(w\ell^*)^{1-\tau}\,(1-\tau)^{-1}\,\tau w^{1-\tau} - (c^*)^{-\sigma}\,\lambda w^{1-\tau}\tau\right]\hat{x}
\end{aligned}$$

Inserting the household budget constraint and equilibrium transfers $\mathcal{T}$ for c^*, and inserting (A.1) for $\varphi\,(\ell^*)^{\gamma+\tau}$, and rearranging gives the result. □

Now I turn to the proof of Proposition 3 from the main text.

Existence of $\bar{\theta}_x(\sigma)$. Lemma 1 implies $\vartheta_1 \geq 0$ and that the denominator of Γ_x is strictly positive under the parameter restrictions stated in the main text. It also implies that the denominator of ϑ_0 is strictly positive. It follows that, conditional on σ, the sign of Γ_x is pinned down by

$$f(\theta;\sigma) \equiv \tau\left[(\sigma-1)(1-\theta)\lambda\left(1-\tau\right)^{-1}\left(w\ell^{*}(\theta;\sigma)\right)^{-\tau}-\theta\right],$$

where I make explicit that $\ell^{*}>0$ depends on σ and θ. First, consider $\sigma\in[0,1]$. In this case, I have $f(\theta;\sigma)\leq 0$, and hence, $\Gamma_x\leq 0$, regardless of θ. This implies that $\bar{\theta}_x(\sigma)=0$ for $\sigma\in[0,1]$. Second, consider $\sigma>1$. Now, I have $f(1;\sigma)<0$ and $f(0,\sigma)>0$. The existence of $\bar{\theta}_x(\sigma)\in(0,1)$ such that $f(\bar{\theta}_x(\sigma);\sigma)=0$ follows from the intermediate value theorem. Taken together, a threshold $\bar{\theta}_x(\sigma)$ exists for all $\sigma\geq 0$ such that $\Gamma_x\leq 0$ if $\theta\geq\bar{\theta}_x(\sigma)$.

Existence of $\bar{\theta}_w(\sigma)$. From Lemma 1 (using the same arguments as for $\bar{\theta}_x(\sigma)$), we can see that the sign of Γ_w is determined by

$$g(\theta;\sigma)\equiv 1-\tau-\sigma\vartheta_1(\theta;\sigma).$$

Note that $\vartheta_1\equiv\vartheta_1(\theta;\sigma)\in[1-\tau,1]$ and $\partial\vartheta_1/\partial\theta>0,\ \forall\theta$. Consider $\sigma\in[0,1-\tau]$. Then $g(1;\sigma)=1-\tau-\sigma\geq 0$. As $\partial\vartheta_1/\partial\theta>0$, we have $g(\theta;\sigma)\geq 0,\ \forall\theta$ which implies $\bar{\theta}_w(\sigma)=1$ in this parameter region. Consider $\sigma\in(1-\tau,1]$ where $g(1;\sigma)<0$ but $g(0;\sigma)=(1-\tau)(1-\sigma)\geq 0$. The intermediate value theorem implies existence of $\bar{\theta}_w(\sigma)$ such that $g(\bar{\theta}_w(\sigma);\sigma)=0$ and it is easy to see that $\bar{\theta}_w(1)=0$. Finally, for $\sigma>1$, we have $g(0;\sigma)<0$ and hence, $g(\theta;\sigma)<0\ \forall\ \theta$ which implies that $\bar{\theta}_w(\sigma)=0$. Taken together, this establishes the existence of $\bar{\theta}_w(\sigma)$.

□

B Empirical analysis

Table B.1: Summary statistics

	Mean	SD	N
(a) All years (2002-2018)			
Market income: Y	49168.67	90315.72	14394702
Deductions: D	7683.13	12972.97	14394702
Taxable income: Z	41485.54	84983.04	14394702
Tax payment: $T(Z)$	8753.28	36689.79	14394702
(b) Pre reform (2002-2012)			
Market income: Y	45854.74	88134.82	8828636
Deductions: D	6616.06	12698.82	8828636
Taxable income: Z	39238.68	83306.25	8828636
Tax payment: $T(Z)$	8110.09	36043.61	8828636
(c) Post reform (2013-2018)			
Market income: Y	54555.22	93502.15	5566066
Deductions: D	9417.57	13224.18	5566066
Taxable income: Z	45137.65	87517.12	5566066
Tax payment: $T(Z)$	9798.75	37693.08	5566066

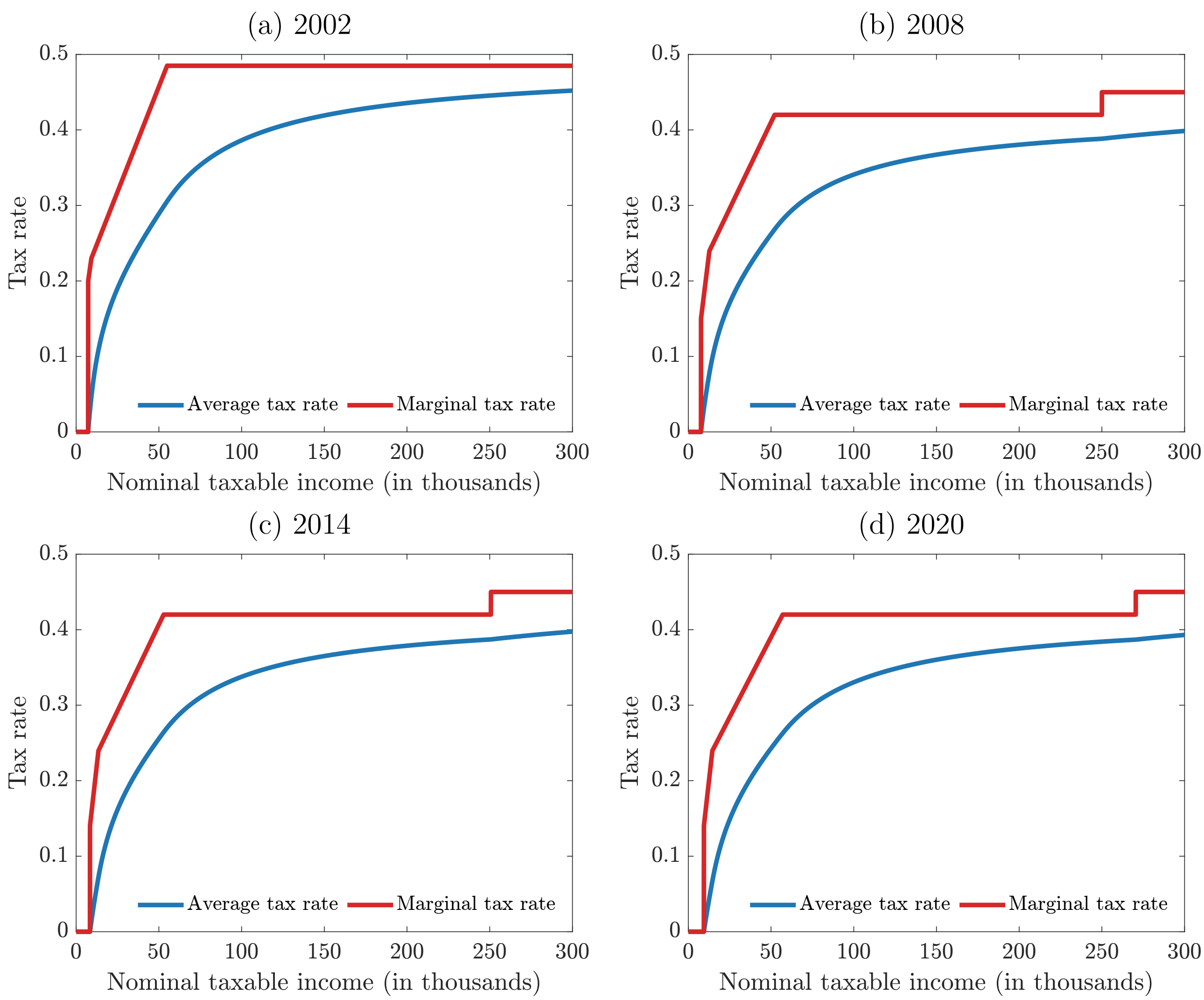
Notes: The table shows summary statistics of selected variables computed from German administrative tax records.

Table B.2: CPI inflation and average household income growth

Year	Household income growth	CPI inflation
2019	2.9	1.4
2020	0.0	0.5
2021	5.6	3.1
2022	6.4	6.9
2023	6.5	5.9

Notes: The table shows the annual average household income growth rate and the CPI inflation rate between 2019 and 2023. The former is used to impute the administrative tax records until 2023, and the latter is used to compute nominal incomes that maintain constant real value.

Figure B.1: German tax schedules



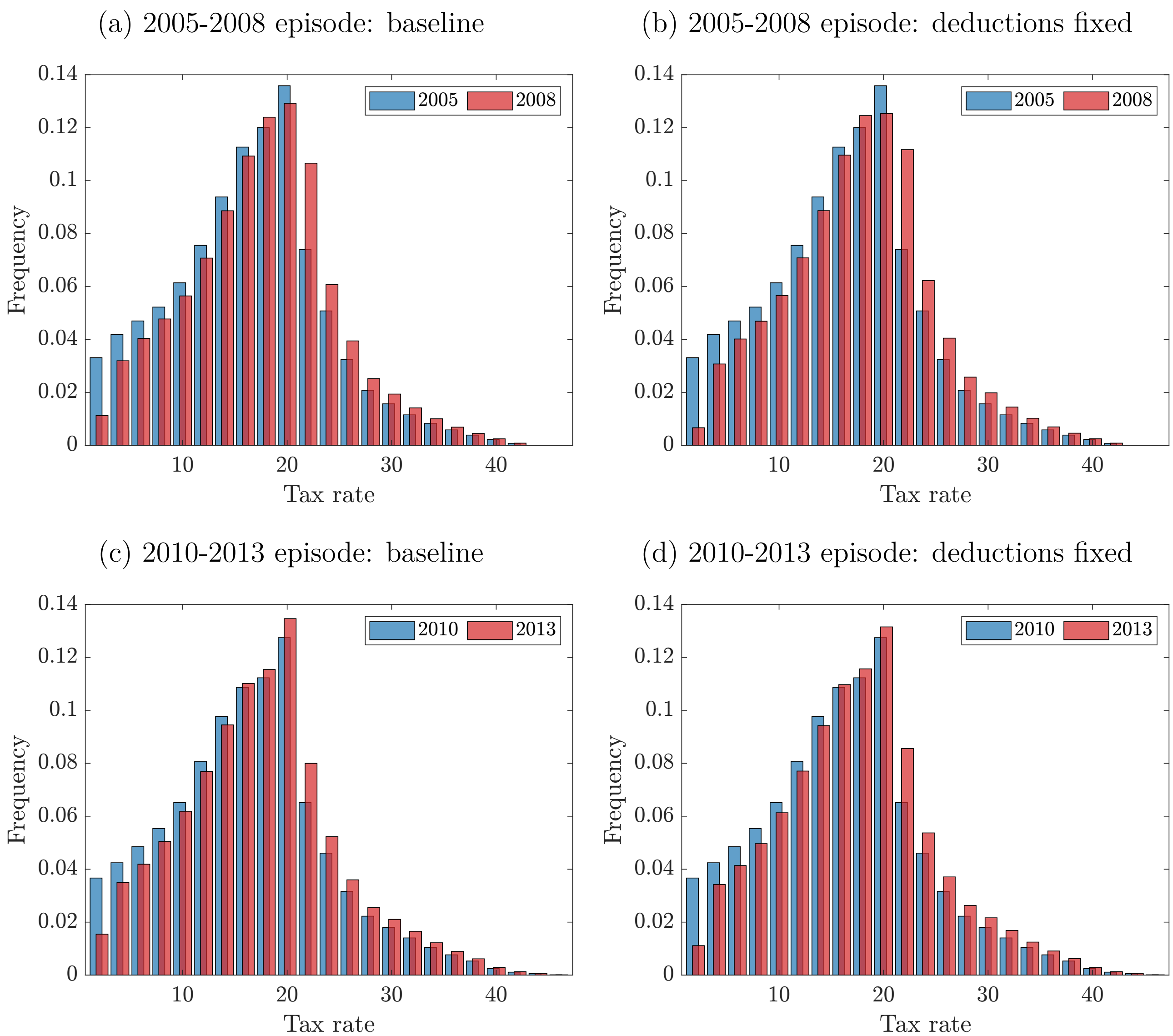
Notes: The figure illustrates the personal income tax schedule in Germany for selected years. The flat parts where both lines correspond to a zero tax rate indicate the tax-exempt income.

Table B.3: Decomposition of average and marginal tax rates by year

	ATR			MTR			
	Bracket creep	Tax change	Real growth	Bracket creep	Tax change	Real growth	N
Year	Ψ^{bc}	Ψ^{tc}	Ψ^{rg}	Ψ^{bc}	Ψ^{tc}	Ψ^{rg}	
2003	0.17	0.00	0.07	0.14	0.00	0.07	745290
	(0.0000)	(0.0000)	(0.0038)	(0.0001)	(0.0000)	(0.0033)	
2004	0.00	-1.44	0.28	0.00	-1.49	0.33	757885
	(0.0000)	(0.0003)	(0.0038)	(0.0000)	(0.0018)	(0.0038)	
2005	0.04	-0.24	0.10	0.01	-0.83	0.08	797060
	(0.0001)	(0.0004)	(0.0035)	(0.0001)	(0.0009)	(0.0031)	
2006	0.25	0.00	0.09	0.23	0.00	0.06	827996
	(0.0001)	(0.0000)	(0.0034)	(0.0001)	(0.0000)	(0.0030)	
2007	0.36	0.00	0.21	0.32	0.01	0.16	815173
	(0.0001)	(0.0001)	(0.0035)	(0.0002)	(0.0002)	(0.0031)	
2008	0.41	0.00	0.15	0.37	0.00	0.12	807104
	(0.0001)	(0.0000)	(0.0036)	(0.0002)	(0.0000)	(0.0031)	
2009	0.00	-0.37	0.07	0.00	-0.30	0.14	782609
	(0.0000)	(0.0001)	(0.0039)	(0.0000)	(0.0010)	(0.0037)	
2010	0.00	-0.11	-0.16	0.01	-0.07	-0.16	800770
	(0.0000)	(0.0000)	(0.0036)	(0.0000)	(0.0005)	(0.0034)	
2011	0.36	0.00	0.22	0.33	0.00	0.18	839959
	(0.0001)	(0.0000)	(0.0034)	(0.0002)	(0.0000)	(0.0031)	
2012	0.31	0.00	0.22	0.29	0.00	0.18	708472
	(0.0001)	(0.0000)	(0.0036)	(0.0002)	(0.0000)	(0.0033)	
2013	0.14	-0.00	0.26	0.21	0.00	0.23	911690
	(0.0000)	(0.0000)	(0.0032)	(0.0001)	(0.0000)	(0.0029)	
2014	0.02	-0.05	0.39	0.13	-0.03	0.37	932753
	(0.0000)	(0.0001)	(0.0032)	(0.0001)	(0.0007)	(0.0030)	
2015	0.01	-0.03	0.46	0.06	-0.02	0.42	950161
	(0.0000)	(0.0000)	(0.0032)	(0.0000)	(0.0005)	(0.0030)	
2016	0.00	-0.16	0.41	0.00	-0.15	0.40	974531
	(0.0000)	(0.0000)	(0.0031)	(0.0000)	(0.0007)	(0.0030)	
2017	0.07	-0.00	0.27	0.13	-0.00	0.24	981555
	(0.0000)	(0.0000)	(0.0031)	(0.0001)	(0.0001)	(0.0028)	
2018	0.05	-0.00	0.26	0.07	-0.00	0.23	976609
	(0.0000)	(0.0000)	(0.0031)	(0.0001)	(0.0000)	(0.0028)	
2019	0.00	-0.02	0.15	0.00	-0.02	0.14	1051350
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	
2020	0.00	-0.23	-0.14	0.00	-0.20	-0.16	1051350
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0006)	(0.0006)	
2021	0.18	-0.00	0.23	0.29	-0.00	0.25	1051350
	(0.0001)	(0.0000)	(0.0001)	(0.0005)	(0.0000)	(0.0007)	
2022	0.66	0.00	-0.30	0.87	0.00	-0.28	1051350
	(0.0002)	(0.0000)	(0.0001)	(0.0005)	(0.0000)	(0.0002)	
2023	0.15	-0.00	-0.11	0.06	-0.01	-0.11	1051350
	(0.0001)	(0.0000)	(0.0001)	(0.0002)	(0.0000)	(0.0001)	

Notes: The table shows the decomposition of year-over-year changes in average and marginal tax rates, see equation (**2.2**). *Bracket creep* refers to the change in the tax rate that a taxpayer with constant real income experiences, absent discretionary tax reforms, whereas *Tax change* refers to changes due to discretionary tax reforms. *Real growth* refers to changes in tax rates due to real income growth under the contemporaneous tax schedule.The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018. Standard errors are in parentheses.

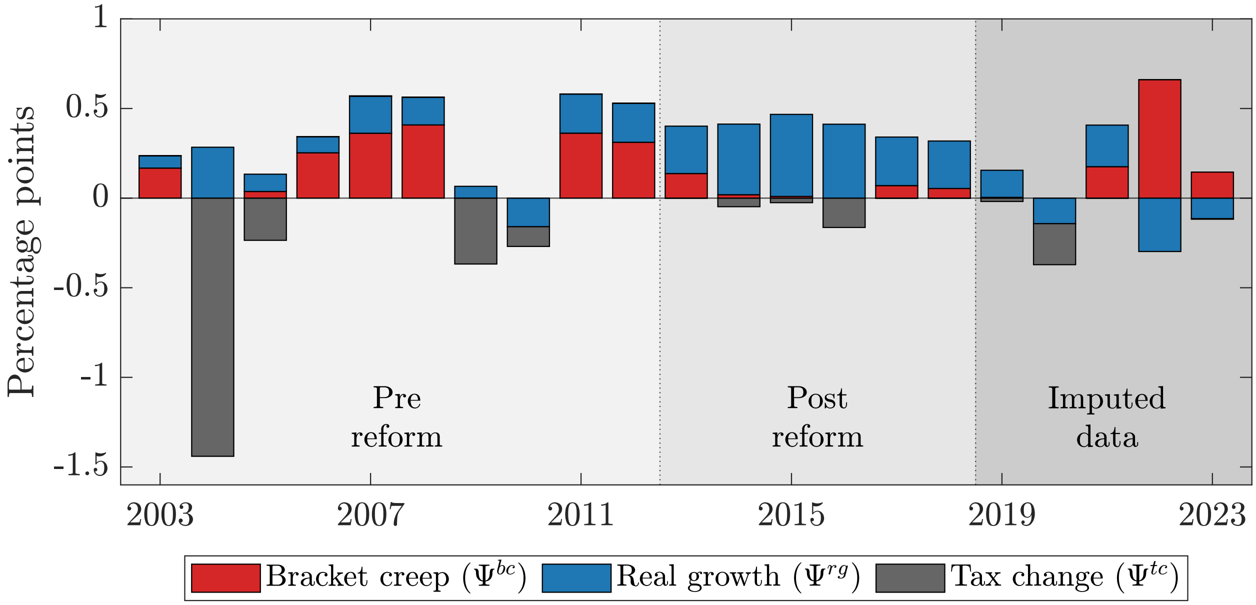
Figure B.2: Distributional changes of average tax rates during bracket creep episodes



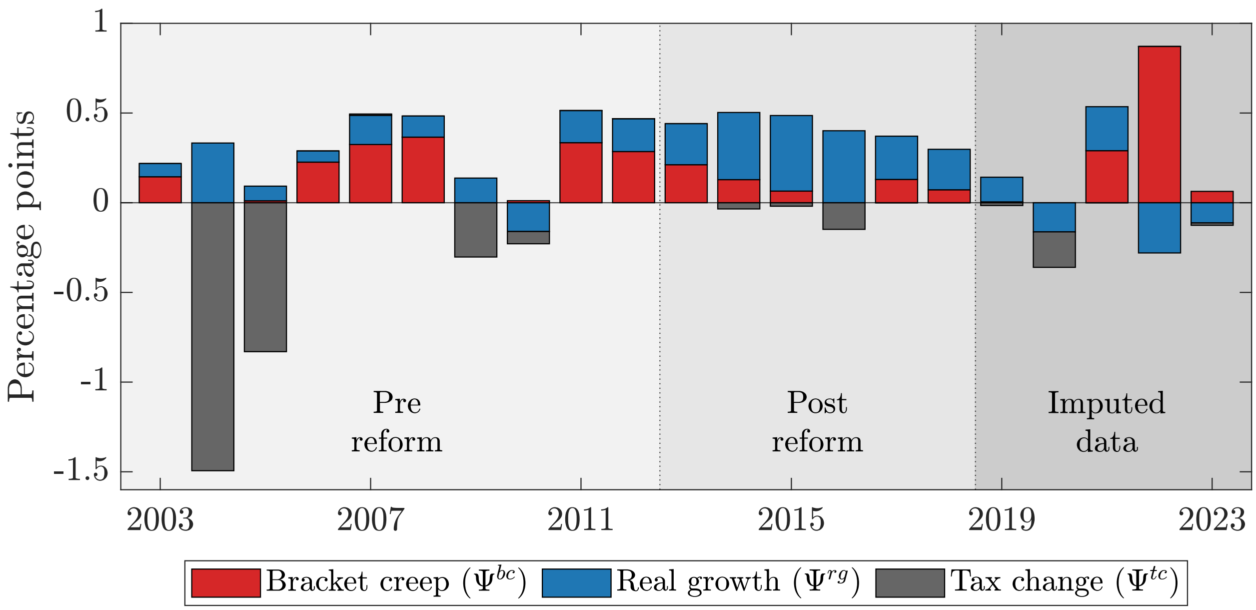
Notes: The figure shows the how the distribution of average tax rates shifts over time under constant real income during the bracket creep episodes from 2005-2008 and 2010-2013, respectively.

Figure B.3: Time variation in the tax rate decomposition: Fixed deductions

(a) Average tax rate



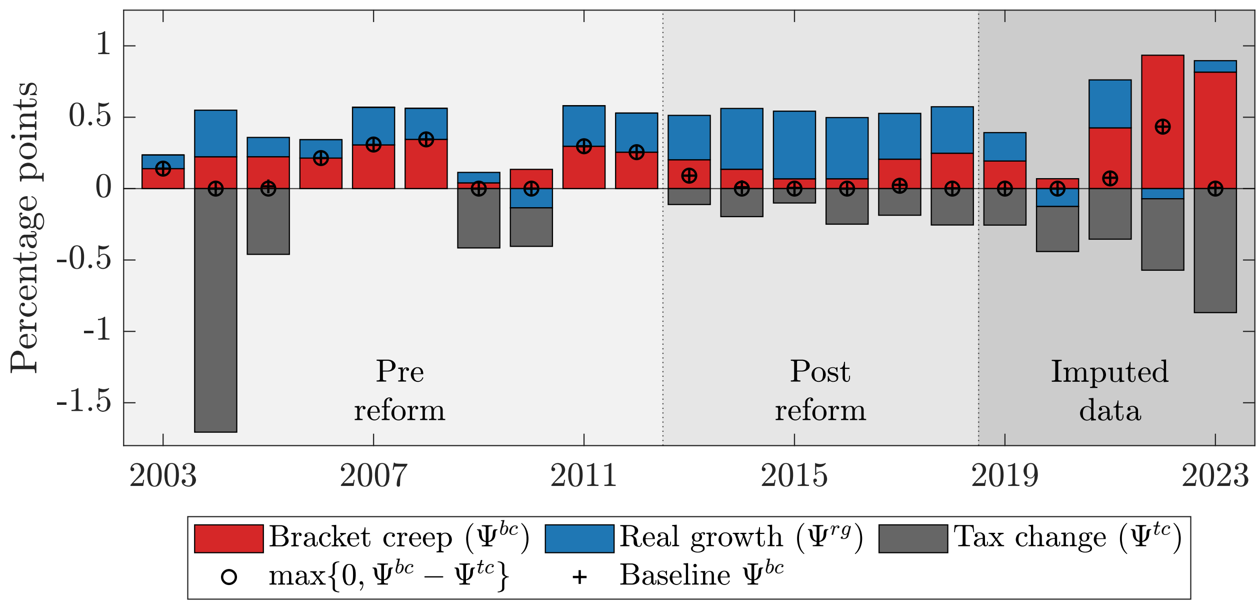
(b) Marginal tax rate



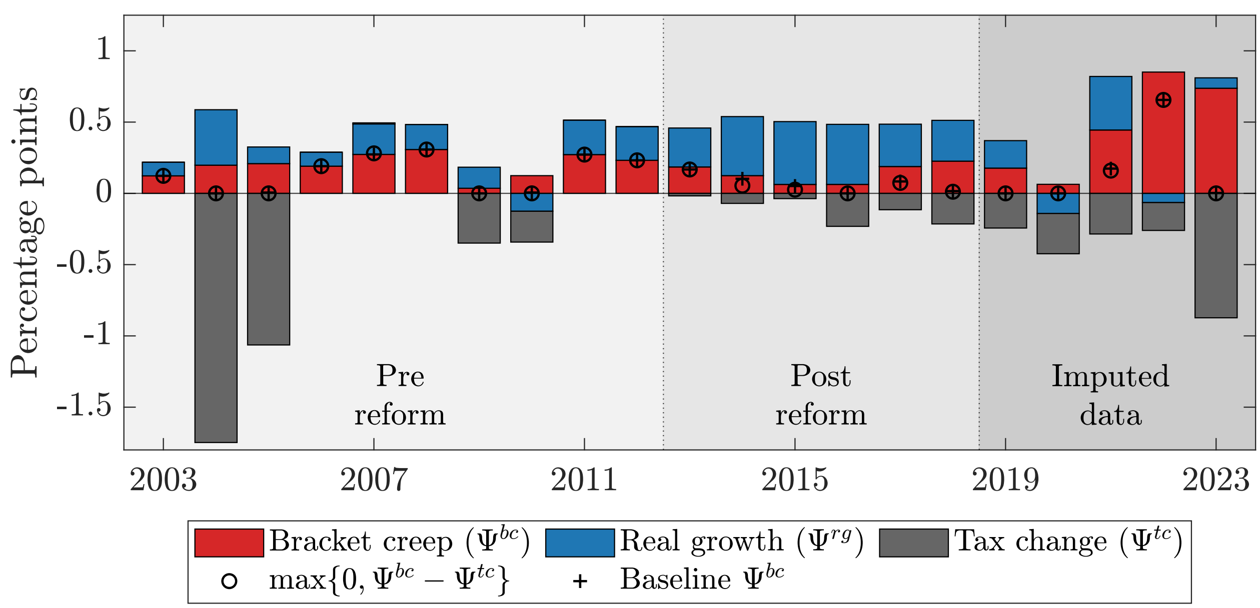
Notes: The figure shows the decomposition of year-over-year changes in average and marginal tax rates as stated in equation (2.2). *Bracket creep* refers to the change in the tax rate that a taxpayer with constant real income experiences, absent discretionary tax reforms, whereas *Tax change* refers to changes due to discretionary tax reforms. *Real growth* refers to changes in tax rates due to real income growth under the contemporaneous tax schedule. The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018; all non-zero estimates are significant at the 5% level, for standard errors, see Table B.3. The imputed data is based on average household income growth as explained in Section 2.3.. Panel (a) and (b) show the results for the average and marginal tax rate, respectively. The year-over-year change in deductions is assumed to be zero; for details, see Section 2.1.

Figure B.4: Mechanical decomposition with $\alpha_t = 0$

(a) Average tax rate



(b) Marginal tax rate



Notes: The figure shows the decomposition of year-over-year changes in average and marginal tax rates as stated in equation (2.2). *Bracket creep* refers to the change in the tax rate that a taxpayer with constant real income experiences, absent discretionary tax reforms, whereas *Tax change* refers to changes due to discretionary tax reforms. *Real growth* refers to changes in tax rates due to real income growth under the contemporaneous tax schedule. The results refer to the mechanical decomposition where $\alpha_t = 0$ is imposed. The circle markers indicate the differences between the bracket creep term and the tax change term, which is set to zero when the difference is negative. The plus markers indicate the value of the bracket creep term from the baseline decomposition. The results are arithmetic averages based on 10 Mio. German administrative tax records between 2002 and 2018. The imputed data is based on average household income growth as explained in Section 2.3.. Panel (a) and (b) show the results for the average and marginal tax rate, respectively.