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Felix J. Bierbrauer (University of Cologne)
Pierre C. Boyer (École Polytechnique)
Andreas Peichl (LMU Munich & ifo Institute)

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Ludwig-Maximilians-Universität München | Humboldt-Universität zu Berlin
Spokesperson: Prof. Dr. Klaus M. Schmidt, University of Munich, 80539 Munich, Germany
+49 (89) 2180 3405 | info@rationality-and-competition.de

Politically feasible reforms of non-linear tax systems*

Felix J. Bierbrauer Pierre C. Boyer Andreas Peichl

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Abstract

We study reforms of non-linear income tax systems from a political economy perspective. We present a median voter theorem for monotonic tax reforms, reforms so that the change in the tax burden is a monotonic function of income. We also provide an empirical analysis of tax reforms, with a focus on the US. We show that past reforms have, by and large, been monotonic. We also show that support by the median voter was aligned with majority support in the population. Finally, we develop sufficient statistics that enable to test whether a given tax system admits a politically feasible reform.

Keywords: Non-linear income taxation; Tax reforms; Political economy; Optimal taxation.
JEL classification: C72; D72; D82; H21.

*[*] **Bierbrauer** (corresponding author): CMR - Center for Macroeconomic Research, University of Cologne, Germany (bierbrauer@wiso.uni-koeln.de); **Boyer**: CREST, École Polytechnique, France (pierre.boyer@polytechnique.edu); **Peichl**: ifo Munich, LMU Munich, CESifo, IHS and IZA (peichl@econ.lmu.de). We are grateful to Henrik Kleven (editor) and three anonymous referees for many insightful comments and suggestions. We are extremely grateful to Dan Feenberg for granting us access to the NBER TAXSIM model and providing feedback on our simulations. We thank Marcus Berliant, Laurent Bouton, Micael Castanheira, Vidar Christiansen, Sébastien Courtin, Allan Drazen, Antoine Ferey, Clemens Fuest, Sidartha Gordon, Olivier Gossner, Hans Peter Grüner, Bard Harstad, Emanuel Hansen, Andreas Haufler, Bas Jacobs, Laurence Jacquet, Kai Konrad, Yukio Koriyama, Étienne Lehmann, Jean-Baptiste Michau, Benny Moldovanu, Massimo Morelli, Abdoulaye Ndiaye, Carlo Prato, Anasuya Raj, Alessandro Riboni, Navid Sabet, Dominik Sachs, Michaël Sicsic, Laurent Simula, Johannes Spinnewijn, Stefanie Stantcheva, Alain Trannoy, Aleh Tsyvinski, Paul-Armand Veillon, Marius Vogel, John Weymark, Nicolas Werquin, Jan Zapal, and Floris Zoutman. We also appreciate the comments of seminar and conference audiences at Yale, Paris-Dauphine, Oslo, Cologne, CREST-École Polytechnique, Leuven, Caen, Mannheim, ENS-Lyon, Toulouse, Paris Fiscal Study Group, 3rd Belgian-Japanese Public Finance Workshop in Louvain, Transatlantic Theory Workshop in Paris, CESifo Area Conference on Public Sector Economics, PET 2017, Tax-Day at MPI Munich, 67th Annual Meeting of the French Economic Association, Taxation Theory Conference in St. Louis, LMU Munich, ifo Institute, CRC Competition and Rationality meeting 2019, Canazei Winter School 2020. Elie Gerschel, Paul Grass, Jelena Todorovic, Jakob Wegmann, and Niels Westerkamp provided excellent research assistance. The authors gratefully acknowledge the Max Planck Institute in Bonn for hospitality and financial support, and the Investissements d'Avenir (ANR-11-IDEX-0003/Labex Ecodec/ANR-11-LABX-0047) and Institut des Politiques Publiques (Paris) for financial support. Support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2126/1– 390838866 is gratefully acknowledged.

1 Introduction

This paper presents a new approach for a political economy analysis of non-linear tax systems. It develops a theory of tax reforms that are politically feasible in the sense that a majority of individuals prefers the reform over the status quo. The theory gets traction from focusing on monotonic tax reforms, i.e. reforms so that changes in the tax burden are a monotonic function of income. We investigate empirically to what extent this premise is satisfied in actual tax policy. We also investigate to what extent past reforms were, through the lens of our framework, politically feasible.

The previous literature has focused on models of voting over tax schedules. The set of non-linear tax policies is a multi-dimensional policy space. Thus, the median voter's preferred policy is not a Condorcet winner. This complicates any analysis of voting over non-linear tax schedules. One way of dealing with this complication is to restrict attention to a subset of tax systems for which a median voter theorem applies.[1] These restrictions, however, limit the scope for a comprehensive political economy analysis of top tax rates, earning subsidies for the "working poor", or taxes for the middle class.

One advantage of our approach is that restrictions on marginal tax rates are not needed. Another advantage is that it allows for an easy connection between a normative perspective and a political economy perspective on tax reforms. Normative analyses frequently analyze the welfare implications of raising or lowering the marginal tax rates in a narrow bracket of incomes. These tax perturbations satisfy the monotonicity assumption on which our political economy analysis is based. Thus, we can also analyze whether a given tax system can be reformed in a way that is both politically feasible and welfare-improving, or whether the tax system is efficient in the sense that the scope for politically feasible welfare improvements has been exhausted.

Theorem I: A median voter theorem for monotonic tax reforms. Monotonic tax reforms play an important role both in our theoretical and in our empirical analysis. To fix ideas, we give two stylized examples of monotonic tax reforms: A reform that involves tax cuts for all incomes, with larger cuts for larger incomes is a monotonic tax reform. Another type of monotonic reform is one that involves higher taxes, with increases that are a larger for "the rich." Theorem 1 is a median voter result for such tax reforms: a monotonic tax reform is supported by a majority of the population if and only if the person with median income is among the beneficiaries.

We prove this result in the context of a basic model of income taxation: individuals derive utility from consumption and the generation of income requires costly effort. A non-linear tax system is in place and we analyze whether it can be reformed so that a

[1] For instance, the well-known prediction due to Meltzer and Richard (1981) that tax rates are an increasing function of the difference between median and average income is obtained by focusing on linear income taxes.

majority of individuals is in favor of the reform. We consider budget-balanced reforms and assume that changes in tax revenue are rebated lump-sum.[2]

At the heart of the median voter result is an application of the envelope theorem. Accordingly, whether a person is beneficiary of a reform depends on how the change in tax revenue relates to the change in the person's tax bill. A person benefits if there is a revenue gain that outweighs higher taxes, or if there is a tax cut that outweighs a loss of revenue. With a monotonic tax reform, there is a single cutoff level of income dividing the proponents and the opponents of the reform. For instance, with a reform that involves tax cuts that are larger for richer people and which causes a loss of revenue, individuals with an income below the cutoff are harmed and individuals with an income above the cutoff are made better off. In any case, the group that includes the person with median income forms a majority.

Empirical analysis I. Theorem 1 guides our empirical analysis of tax reforms: we investigate to what extent past tax reforms were monotonic. We also look into whether the median voter actually was a beneficiary, and whether there was support for the reform in the population at large. Ultimately, we check whether majority support and support by the median voter are not just aligned in theory, but also in the data. To answer these questions we provide a detailed analysis of the post war federal income tax reforms in the US, using NBER's TAXSIM microsimulation model and tax return micro data from the Internal Revenue Service (IRS).[3]

In studying the extent to which reforms of the federal income tax in the US were monotonic reforms we take account of the fact that tax reforms often times involved not only a change of tax rates, but also a change in the definition of the tax base. We moreover do justice to the fact that several reforms were gradually phased in over several years. Finally, we document the heterogeneity in the way in which people were affected by these tax reforms (e.g., depending on the number of kids, marital status, or the mix between capital and labor income). We find that the tax reforms were, by and large, monotonic, with monotonic tax cuts – i.e. larger tax cuts for richer taxpayers – being the most prevalent reform type. There were fewer reforms leading to higher taxes on high incomes, but those were also broadly monotonic.

We also document that there was substantial individual heterogeneity in the effects of a tax reform: the correlation between taxpayers' ranks in the income distribution and the change of their tax burden is large, but not perfect. These deviations then lead to the question whether the tax reforms in the US were monotonic enough in the sense of our theory. The answer is "yes" provided that, for these reforms, support by the median voter was aligned with majority support in the population at large.

[2]We discuss extensions of this basic setup in the Online-Appendix.

[3]We complement this analysis by looking at a large set of tax reforms in OECD countries, and by looking at various reform proposals that were part of political campaigns in the US, but which were not enacted.

In answering this question, we deal with various challenges: for any taxpayer in our data, we need an assessment of whether or not she was a beneficiary of a reform. Thus, we develop a measure of the effects of a reform on individual welfare. Using this measure, we prove a median voter theorem that applies to large reforms, transcending the analysis of local effects based on the envelope theorem. We address the heterogeneity in the effects of a reform on people with close to median incomes, which complicates the analysis of whether "the median voter" gained or lost from a particular reform. Finally, we don't observe the taxpayers' post-reform incomes, complicating the analysis of the behavioral responses to a reform and of its revenue implications. One of this paper's contributions is to outline an approach that deals with all these issues. Its overall logic is to relate an estimate of the change in total tax revenue to an estimate of how a taxpayer's specific tax burden changed.

The estimates of the revenue implications and of the changes of individual tax burdens that go into this analysis depend on assumptions about the elasticity of taxable income (ETI). We find that, with an ETI of zero, the reforms involving higher taxes on "the rich" were both in the interest of the median voter and of a majority of taxpayers. The reforms involving tax cuts were neither in the median voters' interest, nor in the interest of a majority. For the latter type of reform, the overall revenue loss looms substantial so that only individuals with incomes far above the median benefited. When imputing larger ETI values, this finding is eventually reversed. The tax cuts then appear to have been close to self-financing and therefore also in the interest of most taxpayers, including those with close to median incomes. The reforms involving higher taxes on "the rich" are diagnosed as aggravating an inefficiency and as being neither in the median voter's interest, nor in the interest of a majority of taxpayers.

In any case, we find that majority support goes together with support by the median voter. This finding does not depend on any specific value of the ETI. If the median voter liked a reform, so did a majority of taxpayers. If the median voter disliked a reform, then a majority of taxpayers disliked it. The value of the ETI matters only for which of these two possibilities actually applies.

For values of the ETI that are considered plausible in the contemporaneous empirical literature – reviewed in Saez et al. (2012) – the reforms involving monotonic tax cuts seem to have made both the median voter and a majority of the population worse off. It is interesting to note, however, that much higher values of the ETI were considered plausible at times when some of the prominent tax cuts were prepared or had already been enacted; see, in particular, the seminal articles by Feldstein (1995, 1999).

Theorem II: Political feasibility and welfare. In some of our analysis, we focus on *simple* reforms. Such a reform involves a small change of the marginal tax rates for incomes in a narrow bracket. Simple reforms are monotonic so that Theorem 1 applies.

Moreover, they have welfare implications that are well understood.[4] Hence, by focusing on simple reforms we can provide a more detailed analysis of how the set of politically feasible reforms relates to the set of welfare-maximizing reforms.[5]

Theorem 2 provides a characterization: if the status quo is a Pareto-efficient tax system, tax cuts for below median incomes and tax increases for above median incomes are politically feasible. If tax rates on high incomes are revenue-maximizing in the status quo, only tax cuts below the median are politically feasible. An implication of the Theorem is that a sequence of politically feasible reforms should lead to lower and lower marginal tax rates below the median and, possibly, to higher and higher marginal tax rates above the median. Moreover, such a sequence should give rise to an income range with a pronounced progression of marginal tax rates that connects the low rates below the median with the high rates above the median.[6]

As a corollary, Theorem 2 also provides an answer to the question whether a given tax system can be reformed in way that is both welfare-improving and politically feasible. If tax rates below the median are too high from a welfare perspective, then tax cuts are both politically feasible and welfare-improving. If tax rates are too low above the median, then they can be increased in way that is both politically feasible and welfare-improving. Otherwise, there is no simple reform that is both welfare-improving and politically feasible.

Empirical analysis II. We present an empirical analysis that is motivated by Theorem 2. Specifically, we check whether US tax reforms since World War II (WWII) led to lower marginal tax rates below the median, possibly, in connection with higher marginal tax rates above the median, and, in any case, more pronounced progression over a range of middle incomes. We argue that the introduction and the expansion of the Earned Income Tax Credit (EITC) indeed led to lower marginal tax rates for low incomes and more pronounced progression for incomes not quite as low. There is no move towards higher tax rates for above median incomes.

To provide a more detailed explanation for these observations, we employ sufficient statistics that enable us to identify politically feasible reforms empirically. We derive upper and lower Pareto bounds which determine the range over which reforms towards lower marginal tax rates below the median, or towards higher marginal tax rates above

[4]See Piketty (1997), Saez (2001), Golosov et al. (2014), or Jacquet and Lehmann (2016).

[5]A caveat that applies to any approach based on small reforms is that it can only identify directions for reform. While this is informative, it does not extend without further assumptions to large reforms, see Kleven (2018). This qualification also applies to Theorem 2 and the subsequent analysis. It identifies politically feasible reform directions.

[6]In our empirical analysis we present suggestive evidence of this pattern for the US. In the German income tax, progression is indeed particularly pronounced for middle incomes, a phenomenon referred to as the "Mittelstandsbauch" (middle class belly). This is similar in the Netherlands, see Jacobs et al. (2017).

the median are politically feasible. How tight these Pareto bounds are depends, again, on the behavioral responses to taxation, i.e. the ETI.

We then look at past reforms and find that the upper Pareto bound got close to the status quo schedule for values of this elasticity that are discussed in the empirical literature. Thus, the discussion about the appropriate value of the ETI has implications for whether taxes on "the rich" could be increased in a politically feasible way. Low estimates suggest that the answer is "yes", high estimates suggest that the answer is "no." The lower bound does not give rise to such controversies. It was far away from the status quo for plausible values of the ETI. Thus, marginal taxes on "the poor" could be lowered in a politically feasible way. These findings are consistent with the US reforms, as sketched in the previous paragraph, that is, with the pattern that taxes on the "working poor" were lowered, whereas taxes on "the rich" were not increased.

Outline. The next section discusses the related literature. The formal framework is introduced in Section 3. Section 4 presents the median voter theorem for monotonic reforms. The characterization of simple reforms that are politically feasible can be found in Section 5. Section 6 contains the results of our empirical analysis. The last section contains concluding remarks. Formal proofs are relegated to the Online-Appendix. There we also discuss extensions of the median voter theorem for monotonic reforms to models that are richer than our basic setup.[7]

2 Related literature

Most of the previous literature on the political economy of taxation has focussed on models of *voting over tax schedules.* Contributions differ in the specification of the policy domain – e.g. whether taxes are linear or non-linear – and in the specification of the political economy model, e.g. whether there is party competition as in Downs (1957) or competition between candidates as in the citizen-candidate framework due to Osborne and Slivinski (1996) and Besley and Coate (1997). Below we explain in more detail how our work relates to this literature. An advantage of our focus on monotonic tax reforms is that it allows for a political economy analysis on a domain that is relevant for optimal non-linear taxation. This allows to analyze the tension between what is welfare-improving and what is politically feasible. In particular, it connects with the literature on optimal taxes and/or welfare-improving tax reforms that invokes the perturbation method. Simple reforms play an important role in this literature. Simple reforms are monotonic. Hence, our political economy analysis applies to them.

[7]Specifically, we consider the possibility to mix direct and indirect taxes as in Atkinson and Stiglitz (1976) the possibility to add sources of heterogeneity among individuals such as fixed costs of labor market participation or public goods preferences, and the possibility that taxpayers seek to mitigate income differences that are due to luck as opposed to effort as in Alesina and Angeletos (2005).

Our approach is, moreover, inspired by an older literature in public finance that seeks to complement the theory of optimal taxation – which characterizes welfare-maximizing tax systems and has no role for current tax policy – by a theory of incremental changes that apply to a given status quo, see Feldstein (1976).[8] Our analysis goes beyond this earlier literature by combining results from social choice theory on the validity of median voter theorems, see in particular Rothstein (1990, 1991), with the perturbation approach to the analysis of non-linear tax systems; see Piketty (1997), Saez (2001) Golosov et al. (2014) and Jacquet and Lehmann (2016) for important references.

The seminal contribution on linear income taxation and Downsian competition is Roberts (1977). This paper is known for a median voter result. Gans and Smart (1996) note the connection between this result and the more general analysis by Rothstein. Our work is related in that we also draw on Rothstein's insight to prove a median voter theorem, albeit one that applies to tax reforms.[9] Median voter results are also established by Röell (2012), Bohn and Stuart (2013) and Brett and Weymark (2016; 2017) who study non-linear taxes in the citizen-candidate framework.[10]

Median voter theorems for linear income taxation are known for the prediction that more inequality, measured by the gap between average and median income, leads to more redistributive taxation, see Meltzer and Richard (1981). The explanatory power of this framework was found to be limited – see, for instance, the review in Acemoglu et al. (2015) – and has led to analyses in which the preferences for redistributive tax policies are also shaped by prospects for upward mobility or a desire for a fair distribution of incomes.[11] In the Online-Appendix, we extend our basic analysis and prove a median voter theorem for reforms of non-linear tax systems that takes account of such demands for fairness.

Pareto bounds for non-linear taxes play an important role in our characterization of politically feasible tax reforms. This links our analysis to work on Pareto-efficient

[8] Weymark (1981), for instance, studies the scope for Pareto-improving reforms of a commodity tax system. Guesnerie (1995) provides a survey of this literature and contains an analysis of tax reforms that emphasizes political economy forces, formalized as a requirement of coalition-proofness.

[9] Gans and Smart (1996) also show that the median voter result due to Roberts (1977) extends to a set of non-linear tax systems, namely those that can be ordered according to their degree of progressivity; among them tax schedules with a constant rate of progressivity, see Heathcote et al. (2017). Bénabou (2000) uses this framework for a dynamic political economy analysis of redistributive taxation.

[10] There are also political economy approaches to non-linear taxation that do not give rise to median voter results. Non-linear taxation has, for instance, been squared with probabilistic voting, political agency models, or pork-barrel spending; see Farhi et al. (2012), Scheuer and Wolitzky (2016), Acemoglu et al. (2008; 2010), or Bierbrauer and Boyer (2016). Saez and Stantcheva (2016) study generalized welfare functions with weights that may reflect such political equilibrium outcomes. Our approach differs in that we do not solve for an equilibrium policy in a game of political competition. Instead, we provide a characterization of a set of politically feasible reforms. The more specific models of political competition can be used to select an equilibrium policy from this set.

[11] See, for instance, Piketty (1995), Bénabou and Ok (2001), Alesina and Angeletos (2005), Bénabou and Tirole (2006), or Alesina et al. (2018).

taxation, see Stiglitz (1982), Werning (2007) or Lorenz and Sachs (2016). We complement this literature by characterizing a lower Pareto bound for marginal tax rates on top of the classical upper Pareto bound, and we provide an application of these Pareto bounds to the data.

The empirical analysis in this paper makes use of tax return micro data and of NBER's TAXSIM microsimulation model. In terms of research methodology, we build on and extend work by Eissa et al. (2008) and Bargain et al. (2015). Similar approaches have also been used for the purpose of *ex ante* policy evaluation, see Immervoll et al. (2007) for a prominent example. Our analysis makes use of these tools for a political economy analysis, and, at the same time, for an analysis of how various aspects of US tax policy have evolved since WWII.[12] Our empirical analysis focusses on questions that have not been addressed in the previous literature: To what extent are tax reforms monotonic? To what extent is support by people with close to median income aligned with majority support in the population? To what extent are lower taxes on "the poor" and higher taxes on "the rich" politically feasible. Our answers also take account of the behavioral responses to taxation.

In answering these questions we also extend existing literature on tax reforms in the US.[13] Eissa et al. (2008) analyze four tax reforms of 1986, 1990, 1993 and 2001 using survey data from Current Population Survey (*CPS*) and focus on single mothers. Bargain et al. (2015) also include the reforms of 1981 and 2003. We complement their analysis by also investigating the five additional reforms of 1964, 1969, 1978, 2012 and 2017.

3 The model

We study the political economy of tax reforms through the lens of a generic Mirrleesian model of income taxation: individuals value consumption and the generation of income requires costly effort. They maximize utility subject to a budget constraint that is shaped by a non-linear income tax system. We begin with a specification of preferences and then describe how individual choices as well as measures of tax revenue, welfare and political support are affected by reforms of the tax system.

[12]Broadly related, but with a difference in focus, are Piketty and Saez (2007) and Roemer (2011). Piketty and Saez (2007) analyze changes in the progressivity of the US federal income tax over time. Roemer (2011) looks at five US tax income reforms (1981, 1986, 1993, 1997, 2001) with data assembled by Piketty and Saez (2007) and the Tax Policy Center. He focusses on the hypothesis that the tax policy proposed by leftist and rightist parties has similar implications for the middle class. See, also, Egger et al. (2019) who analyze the development of labor income in many countries around the world from 1980 to 2007.

[13]Several policy studies by the Joint Committee on Taxation, the Congressional Budget Office, or the Tax Policy Center analyze single reforms – see Appendix H.

Preferences. There is a continuum of individuals of measure 1. Individuals have a utility function u that is increasing in private goods consumption, or after-tax income, c, and decreasing in earnings or pre-tax income y. Individuals differ in their willingness to work harder in exchange for increased consumption. To formalize this we distinguish different types of individuals. The set of possible types is denoted by Ω with generic entry ω. The utility that an individual with type ω derives from c and y is denoted by $u(c, y, \omega)$.[14] For ease of exposition, we assume that preferences are quasi-linear in private goods consumption and that the effort costs are iso-elastic,[15]

$$u(c, y, \omega) = c - \frac{1}{1+\frac{1}{\varepsilon}} \left(\frac{y}{\omega}\right)^{1+\frac{1}{\varepsilon}} .$$

With this utility function, preferences satisfy the Spence-Mirrlees single crossing property. This implies that higher types choose higher incomes than lower types, and, in particular, that this ordering does not depend on the tax system. The set Ω is taken to be a compact subset of the non-negative real numbers, $\Omega = [\underline{\omega}, \overline{\omega}] \subset \mathbb{R}_+$. The cross-section distribution of types in the population is represented by a cumulative distribution function F with density f. We denote the median of this distribution by ω^M.

Tax reforms. Individuals are confronted with a predetermined income tax schedule T_0 that assigns a (possibly negative) tax payment $T_0(y)$ to every level of pre-tax income $y \in \mathbb{R}_+$. Individuals with no income receive a transfer equal to $c_0 \geq 0$. A reform induces a new tax schedule T_1 that is derived from T_0 so that, for any level of pre-tax income y, $T_1(y) = T_0(y) + \tau\, h(y)$, where τ is a scalar and h is a function. We represent a reform by the pair (τ, h) where τ measures the size the reform.

A tax reform is said to be monotonic over a range of incomes $\mathcal{Y}$ if $T_1(y) - T_0(y) = \tau\, h(y)$ is a monotonic function for $y \in \mathcal{Y}$. Given a cross-section distribution of income, we say that a reform is monotonic above (below) the median if $T_1 - T_0$ is a monotonic function for incomes above (below) the median income. As will become clear, monotonicity at least above or below the median is key for our median voter results.

A reform induces a change in tax revenue denoted by $R(\tau, h)$. For now we assume that this additional tax revenue is used to increase the basic consumption level c_0. Alternative uses of tax revenue are considered in the Online-Appendix.

Simple reforms. Some of our results follow from looking at a special class of reforms that we refer to as *simple* in what follows. Simple reforms play a prominent role in the literature, see e.g. Saez (2001) and Piketty and Saez (2013). Such a reform involves a change of marginal tax rates for incomes in a given bracket. More formally, there exists a threshold level of income y_a, so that the new and the old tax schedule coincide for

[14] The literature often interprets ω as an hourly wage and $l = \frac{y}{\omega}$ as the time that an individual needs to generate a pre-tax-income of y, see e.g. Mirrlees (1971) or Diamond (1998).

[15] A generalization that allows for income effects can be found in Bierbrauer and Boyer (2019).

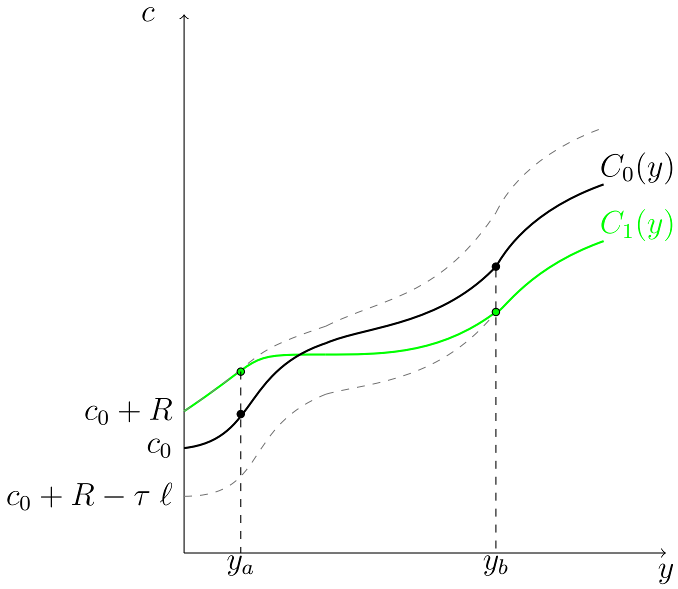

Figure 1: A simple reform

Figure 1 shows how a simple reform that generates positive tax revenue, $R > 0$, affects the combinations of consumption c and earnings y that are available to individuals. Specifically, the figure shows the curves $C_0(y) = c_0 + y - T_0(y)$ and $C_1(y) = c_0 + R + y - T_0(y) - \tau h(y)$. For incomes below y_a and above y_b the curves have the same slopes. The basic transfer increases by R so that more consumption is available at income levels smaller than y_a. Less consumption is available at income levels larger than y_b: in Figure 1 we assume that, at these income levels, the loss from the additional tax payment $\tau\ \ell$ exceeds the gain from the increase of the basic transfer. Otherwise the reform would be Pareto-improving, leading to additional consumption at all levels of income. Between y_a and y_b the increased marginal tax rate implies that the consumption schedule becomes flatter.

all income levels below the threshold, $T_0(y) = T_1(y)$ for all $y \leq y_a$. For incomes in the bracket, marginal tax rates change by τ. Let ℓ be the length of the bracket, and $y_b = y_a + \ell$ be the end of the bracket. Then, $T_0'(y) + \tau = T_1'(y)$ for all $y \in (y_a, y_b)$. For all incomes above y_b, marginal tax rates do not change, so that $T_0'(y) = T_1'(y)$ for all $y \geq y_b$. Hence, the function h is such that

$$h(y) = \begin{cases} 0, & \text{if} \quad y \leq y_a\ , \\ y - y_a, & \text{if} \quad y_a < y < y_b\ , \\ \ell, & \text{if} \quad y \geq y_b\ . \end{cases} \tag{1}$$

For reforms of this type we will write (τ, ℓ, y_a) rather than (τ, h), see Figure 1 for an illustration.

Notation and terminology. To describe the implications of reforms for measures of revenue, welfare and political support it proves useful to introduce the following optimization problem: choose y so as to maximize

$$c_0 + R + y - T_1(y) - \frac{1}{1 + \frac{1}{\varepsilon}} \left(\frac{y}{\omega}\right)^{1+\frac{1}{\varepsilon}}\ , \quad \text{where} \quad T_1(y) = T_0(y) + \tau h(y)\ .$$

We assume that this optimization problem has, for each type ω, a unique solution that we denote by $y^*(\tau, h, \omega)$. The corresponding level of indirect utility is given by

$$c_0 + R + v(\tau, h, \omega) \ ,$$

where the function v gives indirect utility net of government transfers. We can now express the reform-induced change in tax revenue as

$$R(\tau, h) := \int_{\underline{\omega}}^{\overline{\omega}} \{T_1(y^*(\tau, h, \omega)) - T_0(y^*(0, h, \omega))\} f(\omega) \, d\omega \ .$$

We assume that $R(\cdot, h)$ is a differentiable function of τ and denote the derivative by R_τ. The reform-induced change in indirect utility for a type ω individual is given by

$$V(\tau, h, \omega) := R(\tau, h) + v(\tau, h, \omega) - v(0, h, \omega) \ .$$

Pareto-improving reforms. A reform (τ, h) is said to be Pareto-improving if, for all $\omega \in \Omega$, $V(\tau, h, \omega) \geq 0$, and if this inequality is strict for some $\omega \in \Omega$.

Welfare-improving reforms. Consider a social welfare functions with welfare weights $g : \omega \mapsto g(\omega)$ that are non-increasing. The welfare change that is induced by a reform is given by

$$W(\tau, h) := \int_{\underline{\omega}}^{\overline{\omega}} g(\omega) \ V(\tau, h, \omega) f(\omega) \, d\omega \ .$$

A reform (τ, h) is said to be welfare-improving if $W(\tau, h) > 0$.

Political support for reforms. Political support for the reform is measured by the mass of individuals who are made better off if the initial tax schedule T_0 is replaced by T_1,

$$S(\tau, h) := \int_{\underline{\omega}}^{\overline{\omega}} \mathbf{1}\{V(\tau, h, \omega) > 0\} f(\omega) \, d\omega \ ,$$

where $\mathbf{1}\{\cdot\}$ is the indicator function. A reform (τ, h) is supported by a majority of the population if $S(\tau, h) \geq \frac{1}{2}$. We call such reforms politically feasible.

4 Median voter theorems for monotonic reforms

The focus on monotonic reforms enables a characterization of reforms that are politically feasible. As we show in this section, checking whether or not a reform is supported by a majority of individuals is, with some qualifications, the same as checking whether or not the taxpayer with median income is a beneficiary of the reform. We begin with an analysis of small reforms and turn to large reforms subsequently.

We say that an individual of type ω benefits from small reform if, starting from some reform intensity τ', the reform intensity is increased at the margin, i.e. if

$$V_\tau(\tau', h, \omega) := \frac{d}{d\tau} V(\tau, h, \omega) \mid_{\tau = \tau'} \quad > \quad 0 \ .$$

If this derivative is negative, the individual benefits from a reduction of the reform intensity. For a simple reform, an increase of τ simple means that marginal tax rates in the given bracket are increased.

Theorem 1 *Let h be a monotonic function. The following statements are equivalent:*

1. *The median voter benefits from a small reform.*
2. *There is a majority of voters who benefit from a small reform.*

The proof in Online-Appendix A makes use of the envelope theorem:[16]

$$V_\tau(\tau, h, \omega) = R_\tau(\tau, h) - h(y^*(\tau, h, \omega)) \; . \tag{2}$$

For concreteness, consider a reform that involves tax cuts for everybody and that the cuts for richer people are larger than the ones for poorer people. Also suppose that the median voter supports the reform; that is, from the median voter's perspective, the gain from the tax cut outweighs the loss of tax revenue. For taxpayers with above median incomes, the gains are even larger. Hence, everyone who is richer than the median will also support the reform. The same logic applies if the median voters opposes the reform. Then everyone who is poorer than the median will oppose it too. Thus, support of the median voter is both necessary and sufficient for political feasibility.

The median voter result in Theorem 1 exploits the Spence-Mirrlees single crossing condition.[17] In the Online-Appendix we also consider extensions where the Spence-Mirrlees single crossing condition does not hold.[18] In such a setting, the taxpayer with median income under the initial tax system T_0 may be different from the taxpayer with median income under the new tax system, T_1. The median voter theorem then only holds for small reforms in a neighborhood of the status quo; that is, such a small reform is politically feasible if and only if it is in the interest of the taxpayer with median income in the status quo. Technically, we need to add a qualifications to Theorem 1: it only holds locally, at $\tau = 0$.

Non-monotonic reforms. Not all conceivable reforms are such that h is monotonic for all levels of income. The following Proposition gives conditions under which support of the median voter is a sufficient condition for political feasibility.

[16]The validity of the Envelope Theorem follows from the analysis of Milgrom and Segal (2002). This theorem does not require differentiability of the status quo schedule T_0, the direction of the reform h, or continuity of the behavioral responses y^*. It only requires that utility functions satisfy continuity and differentiability assumptions that are fulfilled in our case.

[17]A discussion of how the Spence-Mirrlees single crossing condition relates to single crossing conditions that are used in social choice theory to prove median voter theorems, see Bierbrauer and Boyer (2019).

[18]For instance, we consider a setup where individuals differ in their variable effort costs as in the Mirrlees-model and in their fixed costs of labor market participation, as in Saez (2002) or Jacquet et al. (2013).

Proposition 1

1. *Let h be non-decreasing for $y \geq y^*(\tau, h, \omega^M)$. If the median voter benefits from a small reform with $\tau < 0$, then it is politically feasible.*

2. *Let h be non-decreasing for $y \leq y^*(\tau, h, \omega^M)$. If the poorest voter benefits from a small reform with $\tau < 0$, then it is politically feasible.*

The first part of Proposition 1 covers reforms that are monotonic and involve tax cuts that are larger for richer individuals. We present empirical examples of tax reforms with this property below. A way of making sure that such a reform is appealing to a majority of voters is to have the median voter among the beneficiaries. If, from the median voter's perspective, the reduced tax burden outweighs the loss of tax revenue, then everybody with above median income benefits from the reform.

The second part applies the same logic to tax cuts for low incomes. If the poorest individuals benefit from a tax cut and h is non-decreasing for below median incomes, then individuals with incomes closer to the median benefit even more. Individuals with below median incomes then constitute a majority in favor of the reform. This case applies, in particular, to reforms so that $T_1 - T_0$ is negative and decreasing for incomes below a threshold $\hat{y}$, see below for empirical examples. In this case, political feasibility is ensured by putting the threshold (weakly) above the median, so that everybody with below median income is a beneficiary of the reform.

Large reforms. The results in Theorem 1 can be easily extended to large reforms. Say that an individual of type ω benefits from a reform (τ, h) if $V(\tau, h, \omega) > 0$ and note that the gains or losses from the reform can be written as

$$\begin{aligned} V(\tau, h, \omega) &= \int_0^\tau V_\tau(s, h, \omega)\, ds \\ &= R(\tau, h) - \int_0^\tau h(y^*(s, h, \omega))\, ds \\ &=: R(\tau, h) - H(\tau, h, \omega)\ . \end{aligned}$$

Also note that $H(\tau, h, \cdot)$ is a monotonic function of ω if h is a monotonic function. Thus, upon replacing h by H in the proof of Theorem 1 we obtain the following Corollary.

Corollary 1 *Let h be a monotonic function. The following statements are equivalent:*

1. *The median voter benefits from a reform (τ, h).*

2. *The reform (τ, h) is politically feasible.*

Proposition 1 also extends to large reforms with the appropriate qualifications.

In our empirical analysis that is based on Theorem 1 (see Section 6) we investigate to what extent past reforms were monotonic and also whether the taxpayer with median income was a beneficiary of the reform. When bringing the theory to data, we will make use of the following insight: suppose that the function h is non-decreasing and that median income $y^*(s, h, \omega^M)$ is a monotonic function of the reform intensity s.[19] Also, for concreteness, suppose that the reform involves an increase of the marginal tax rate for the median income. Then, using the shorthand $y_1^M := y^*(\tau, h, \omega^M)$ for median income after the reform,

$$\tau\, h(y_1^M) \quad \leq \quad H(\tau, h, \omega) \quad \leq \quad \tau\, h(y_0^M)$$

or, equivalently,

$$T_1(y_1^M) - T_0(y_1^M) \quad \leq \quad H(\tau, h, \omega) \quad \leq \quad T_1(y_0^M) - T_0(y_0^M)\,. \tag{3}$$

As a consequence,

$$\begin{aligned} & R(\tau, h) - \Big(T_1(y_0^M) - T_0(y_0^M)\Big) \\ & \quad \leq V(\tau, h, \omega^M) \\ & \qquad \leq \quad R(\tau, h) - \Big(T_1(y_1^M) - T_0(y_1^M)\Big)\,. \end{aligned} \tag{4}$$

Thus, when the median voter experiences an increase of the marginal tax rate, we underestimate her utility gain when we compare the overall revenue effect to the change of the tax burden and thereby take account only of the mechanical effect. By contrast, we overestimate her utility gain, when we base the change of her tax burden on the post-reform income.[20] This pattern is reversed when there is a decrease of the marginal tax rate at the median level of income. In this case,

$$\begin{aligned} & R(\tau, h) - \Big(T_1(y_1^M) - T_0(y_1^M)\Big) \\ & \quad \leq V(\tau, h, \omega^M) \\ & \qquad \leq \quad R(\tau, h) - \Big(T_1(y_0^M) - T_0(y_0^M)\Big)\,. \end{aligned} \tag{5}$$

In the light of (4) and (5), a sufficient condition under which the median voter is a beneficiary of a tax reform is

$$R(\tau, h) - \max\left\{T_1(y_1^M) - T_0(y_1^M), T_1(y_0^M) - T_0(y_0^M)\right\} \quad \geq \quad 0\,. \tag{6}$$

Analogously, the median voter is worse off if

$$R(\tau, h) - \min\left\{T_1(y_1^M) - T_0(y_1^M), T_1(y_0^M) - T_0(y_0^M)\right\} \quad < \quad 0\,. \tag{7}$$

We will make use of these conditions in our empirical analysis in Section 6 when we check whether past reforms were in the median voter's interest.

[19]Substantively, this requires that there is an unambiguous effect on the marginal tax rate faced by the median voter, i.e. this tax rate increases or decreases in the reform intensity. The assumption is satisfied with simple reforms.

[20]The lower and the upper bound coincide when there are no behavioral responses, so that $y_1^M = y_0^M$.

5 Detecting politically feasible reforms

By the median voter theorem, in order to understand whether a given tax system can be reformed in a politically feasible way, we need to understand whether or not it can be reformed in a way that makes the voter with median income better off. But how do we tell whether that's the case? In this section, we focus on simple reforms.[21] Theorem 2 below provides a characterization of the conditions under which such a reform is politically feasible. Based on this characterization we develop sufficient statistics that make it possible to identify politically feasible reforms empirically. By squaring this approach with sufficient statistics for the welfare implications of reforms, we finally obtain conditions under which welfare improvements are politically feasible.

5.1 Pareto-efficient tax systems and politically feasible reforms

A tax schedule T_0 is Pareto-efficient if there is no Pareto-improving reform. If it is Pareto-efficient, then for all y_a and l,

$$\ell \quad \geq \quad R_\tau(0, \ell, y_a) \quad \geq \quad 0\,,$$

where $R_\tau(0, \ell, y_a)$ is the marginal change in tax revenue that results as we slightly rise τ above 0, while keeping y_a and ℓ fix. This follows from equations (1) and (2): if we had $R_\tau(0, \ell, y_a) < 0$, a small reform (τ, ℓ, y_a) with $\tau < 0$ would be Pareto-improving: all individuals would benefit from increased transfers and individuals with an income above y_a would, in addition, benefit from a tax cut. With $\ell < R_\tau(0, \ell, y_a)$, a small reform (τ, ℓ, y_a) with $\tau > 0$ would be Pareto-improving. All individuals would benefit from increased transfers. Individuals with an income above y_a would not benefit as much because of increased marginal tax rates. They would still be net beneficiaries because the increase of the tax burden was dominated by the increase of transfers. Under a Pareto-efficient tax system there is no scope for such reforms. We say that T_0 is an *interior Pareto-optimum* if, for all y_a and ℓ,

$$\ell \quad > \quad R_\tau(0, \ell, y_a) \quad > \quad 0\,.$$

Theorem 2 *Suppose that T_0 is an interior Pareto-optimum.*

1. *For any $y_a < y_0^M$, there is a simple reform with $\tau < 0$ that is politically feasible.*

2. *For any $y_a > y_0^M$, there is a simple reform with $\tau > 0$ that is politically feasible.*

[21] Simple reforms induce discontinuities in marginal tax rates. For ease of exposition, the formal proofs for this section use smooth approximations of simple reforms that avoid these discontinuities. Thereby we follow Golosov et al. (2014). Working directly with simple reforms is possible and yields the same conclusions, but at the cost of longer and more detailed derivations, see Bierbrauer and Boyer (2019).

According to the theorem, one can find a politically feasible reform for any level of income $y_a \neq y_0^M$ if the status quo is an interior Pareto optimum. Specifically, reforms that involve a shift towards lower marginal tax rates for below median incomes and reforms that involve a shift towards higher marginal tax rates for above median incomes are politically feasible. A lowering of marginal taxes comes with a loss of tax revenue. For individuals with incomes above $y_b = y_a + \ell$, the reduction of their tax burden outweighs the loss of transfer income so that they benefit from such a reform. If y_b is smaller than the median income, this applies to all individuals with an income (weakly) above the median. Hence, the reform is politically feasible. By the same logic, an increase of marginal taxes for incomes between y_a and y_b generates additional tax revenue. If y_a is chosen so that $y_a \geq y_0^M$, only individuals with above median income have to pay higher taxes with the consequence that all individuals with below median income, and hence a majority, benefit from the reform.

Proposition 2 below presents sufficient statistics that characterize upper and lower Pareto bounds for marginal tax rates. Given data on the distribution of incomes, the current tax system and the behavioral responses to taxation, these sufficient statistics provide an answer to the question, whether the status quo is an interior Pareto-optimum. We can then apply Theorem 2 to see what types of reforms are politically feasible. Upon combining these insights with a characterization of welfare-improving reforms we finally obtain sufficient statistics formulas for politically feasible welfare improvements (see Corollary 3 below). Table 1 provides both a preview and a summary of this analysis.

The table refers to three functions that can be used to $\mathcal{D}$iagnose whether marginal taxes rates in the status quo are inefficiently low or inefficiently high, or whether a change of marginal tax rates would be politically feasible and/or welfare-improving. Formally, they are defined by

$$\mathcal{D}^{low}(y) := \quad -\frac{F(\omega_0(y))}{f(\omega_0(y))\,\omega_0(y)} \left(1+\frac{1}{\varepsilon}\right) ,$$

$$\mathcal{D}^{up}(y) := \quad \frac{1-F(\omega_0(y))}{f(\omega_0(y))\,\omega_0(y)} \left(1+\frac{1}{\varepsilon}\right) ,$$

and

$$\mathcal{D}^{W}(y) := \frac{1-F(\omega_0(y))}{f(\omega_0(y))\,\omega} \left(1+\frac{1}{\varepsilon}\right)(1-\mathcal{G}(\omega_0(y))) ,$$

where $\omega_0(y)$ is the type with an income of y in the status quo and $\mathcal{G}(\omega_0(y)) := \mathbb{E}[g(s) \mid s \geq \omega_0(y)]$ is the average welfare weight associated to individuals with types above ω_0. These expressions are related to $\frac{T_0'(y)}{1-T_0'(y)}$, i.e. to an increasing function of the marginal tax rate $T_0'(y)$. An inequality such as $\mathcal{D}^W(y) > \frac{T_0'(y)}{1-T_0'(y)}$ indicates that the marginal tax rate at income level y is below a threshold, and hence that an increase would be welfare-improving. More generally, an arrow pointing upwards (resp. downwards) indicates that raising (resp. lowering) marginal tax rates for incomes in a neighborhood of y is

Pareto-improving, politically feasible, or welfare-improving. The symbol "-" indicates that changes of marginal tax rates are neither Pareto-improving nor Pareto-damaging.

According to the first line of Table 1, if a tax system is such that the marginal tax rate at income y exceeds the upper Pareto bound, then lowering marginal tax rates for incomes in a neighborhood of y is Pareto-improving, welfare-improving, and politically feasible. Analogously, according to the last line, if tax rates are inefficiently low in the status quo, then increased rates are Pareto-improving, welfare-improving and politically feasible. The second and third line consider tax reforms that are not Pareto-improving. For below median incomes, only tax cuts are politically feasible. If marginal tax rates are too high according to a given welfare function, then there is scope for a politically feasible welfare-improvement. Otherwise, there is a conflict between what is politically feasible and what is desirable from a welfare perspective. For above median incomes, only higher tax rates are politically feasible. Thus, there is scope for a politically feasible welfare improvement if and only if moving towards higher rates is also welfare-improving.

	Income (y) below median			Income (y) above median		
	Pareto	Political	Welfare	Pareto	Political	Welfare
$\frac{T_0'(y)}{1-T_0'(y)} > \mathcal{D}^{up}(y)$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$
$\mathcal{D}^{up}(y) > \frac{T_0'(y)}{1-T_0'(y)} > \mathcal{D}^{W}(y)$	-	$\downarrow$	$\downarrow$	-	$\uparrow$	$\downarrow$
$\mathcal{D}^{W}(y) > \frac{T_0'(y)}{1-T_0'(y)} > \mathcal{D}^{low}(y)$	-	$\downarrow$	$\uparrow$	-	$\uparrow$	$\uparrow$
$\frac{T_0'(y)}{1-T_0'(y)} < \mathcal{D}^{low}(y)$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$

Table 1: Detecting politically feasible and welfare-improving reforms

5.2 Pareto bounds for marginal tax rates

According to the following Proposition 2, if the status quo tax schedule is Pareto-efficient, then marginal tax rates are bounded from above by an upper Pareto bound and from below by a lower Pareto bound. Formally, for any income level y',

$$\mathcal{D}^{up}(y') \quad \geq \quad \frac{T_0'(y')}{1-T_0'(y')} \quad \geq \mathcal{D}^{low}(y') \, .$$

Proposition 2 *Suppose that income in the status quo $\omega_0 : y \mapsto \omega_0(y)$is a strictly monotonic and continuous function.*[22] *Also suppose that income in the status quo satisfies the first-order conditions of utility-maximization.*

[22]The assumption that income in the status quo is a strictly monotonic function avoids complications due to bunching. Bunching would arise at points at which marginal tax rates jump upwards. Downward jumps, by contrast, would give rise to discontinuities in the function y_0. Modifying the analysis so as to allow for these phenomena is not difficult, see Bierbrauer and Boyer (2019). It merely requires additional case distinctions that we omit here for ease of exposition.

1. *Suppose that the status quo schedule T_0 is such that, at income level y',*

$$\frac{T_0'(y')}{1-T_0'(y')} \quad > \quad \mathcal{D}^{up}(y') := \quad \frac{1-F(\omega_0(y'))}{f(\omega_0(y'))\,\omega_0(y')}\left(1+\frac{1}{\varepsilon}\right)\;, \tag{8}$$

then there is a simple Pareto-improving reform (τ, ℓ, y') that involves a decrease of the marginal tax rate at y'.

2. *Suppose that the status quo schedule T_0 is such that, at income level y',*

$$\frac{T_0'(y')}{1-T_0'(y')} \quad < \quad \mathcal{D}^{low}(y') := -\frac{F(\omega_0(y'))}{f(\omega_0(y'))\,\omega_0(y')}\left(1+\frac{1}{\varepsilon}\right)\;, \tag{9}$$

then there is a simple Pareto-improving reform (τ, ℓ, y') that involves an increase of the marginal tax rate at y'.

The upper Pareto bound. The right hand side of equation (8), $\mathcal{D}^{up}(y')$, is a product of two terms, an inverse hazard rate and an inverse elasticities term. To see the role that they play, consider a reform that involves an increase of marginal tax rates for incomes in a small neighborhood of y': the inverse hazard rates relates the number of people who pay higher taxes and show no behavioral response, $1 - F(\cdot)$, to the number of people who show a behavioral response and choose to earn less, $f(\cdot)$. The smaller this ratio, the smaller is the revenue effect of the tax reform. The elasticity ε measures the size of this behavioral response. Thus, a larger a behavioral response and a larger hazard rate make it more difficult to raise revenue with such a simple reform at y'. If these terms exceed critical values, then there is a loss rather than a gain of revenue. Tax cuts are then Pareto-improving.

We can relate Proposition 2 also to the tax policy that maximizes tax revenue, or, equivalently, a Rawlsian social welfare function. As we show in Online-Appendix B, under such a tax policy,

$$\frac{T'(y^R(\omega))}{1-T'(y^R(\omega))} = \frac{1-F(\omega^R(y))}{f(\omega^R(y))\,\omega^R(y)}\left(1+\frac{1}{\varepsilon}\right)\;. \tag{10}$$

where $y^R(\omega)$ is the income realized by type ω under the Rawlsian tax policy. Thus, under the Rawlsian tax policy marginal tax rates are equal to the upper Pareto bound $\mathcal{D}^{up}$.

The lower Pareto bound. Equation (9) provides a lower bound for marginal tax rates. Consider a reform that involves an increase of marginal taxes at y'. As we argued above, the revenue that is thereby raised is larger the larger is the inverse hazard rate and the smaller is the elasticity ε. To be Pareto-improving the revenue effect must be so strong that even those who are hit hardest by the tax increase are compensated by the additional transfers that are financed with this revenue. The right hand side of (9), $\mathcal{D}^{low}(y')$, has a negative sign. This shows that such a situation can only occur if the status quo involves earning subsides, or, equivalently, negative marginal tax rates. A situation in which the lower Pareto bound is violated indicates that these subsidies are excessive: a move towards lower subsidies would then be Pareto-improving.

The smaller the elasticity ε the more negative is the right hand side of (9) and the more difficult it is to have a Pareto-improving tax increase. Thus, a small behavioral response implies a more permissive Pareto bound: the set of efficient tax policies is larger in this case.

We have argued above that there is close connection between the upper Pareto bound and the tax schedule that maximizes a Rawlsian social welfare function. There is an analogous connection between the lower Pareto bound and the tax schedule that maximizes the well-being of the richest taxpayer, the maxi-max tax schedule. As we show in part B of the Online-Appendix, the maxi-max schedule is such that

$$\frac{T'(y^X(\omega))}{1-T'(y^X(\omega))} = -\frac{F(\omega^X(y))}{f(\omega^X(y))\,\omega^X(y)}\left(1+\frac{1}{\varepsilon}\right)\,, \tag{11}$$

where $y^X(\omega)$ is the income earned by type ω under the maxi-max schedule.

5.3 Politically feasible reforms

According to Theorem 2, tax cuts are political feasible for below median incomes and tax increases are politically feasible for above median incomes – provided that the status quo is an interior Pareto optimum. Proposition 2 provides a characterization of Pareto bounds that make it possible to check whether this condition is fulfilled. The following Corollary combines these insights and thereby provides a characterization of politically feasible tax reforms.

Corollary 2 *Suppose that income in the status quo is a strictly monotonic and continuous function of ω. Also suppose that income in the status quo satisfies the first order conditions of utility-maximization.*

1. *Let $y' < y_0^M$. There is a politically feasible reform, involving a decrease of marginal tax rate at y', if $\frac{T_0'(y')}{1-T_0'(y')} > \mathcal{D}^{low}(y')$.*

2. *Let $y' > y_0^M$. There is a politically feasible reform, involving an increase of marginal tax rate at y', if $\frac{T_0'(y')}{1-T_0'(y')} < \mathcal{D}^{up}(y')$.*

Corollary 2 involves a discontinuity at the median level of income. Below, tax cuts are politically feasible. Above, higher taxes are politically feasible. Thus, if the status quo indeed is an interior Pareto-optimum, a sequence of politically feasible reforms should give rise to lower and lower tax rates below the median and to higher and higher tax rates above the median. If the status quo schedule hits the upper bound above the median, then only a lowering of marginal tax rates below the median is to be expected. There must also be a transition from the low rates below the median to the high rates above. If the tax schedule is continuous, this necessitates pronounced progression at some middle income range. We get back to these predictions in our empirical analysis.

Brett and Weymark (2016; 2017) provide a characterization of the tax schedule that the median voter would choose if she could dictate tax policy. Specifically, they show that the median voter's preferred schedule coincides with the Rawlsian one for above median incomes, and with the maxi-max schedule for below median incomes. In between is a region of transition that gives rise to bunching. As we discussed before, the maxi-max schedule coincides with the lower Pareto bound and the Rawlsian schedule with the upper Pareto bound. Thus, outside the bunching region, a politically feasible reform can also be viewed as one that brings the status quo closer to the median voter's preferred tax policy.

5.4 Politically feasible welfare improvements

Diamond (1998)'s formula provides a characterization of a welfare-maximizing tax system:

$$\frac{T'(y^W(\omega))}{1-T'(y^W(\omega))} = \frac{1-F(\omega^W(y))}{f(\omega^W(y))\,\omega^W(y)}\left(1+\frac{1}{\varepsilon}\right)\left(1-\mathcal{G}(\omega^W(y))\right)\ . \tag{12}$$

where $\mathcal{G}(\omega) := \mathbb{E}[g(s) \mid s \geq \omega]$ is the average welfare weight among those with a type above ω and $y^W(\omega)$ is the income earned by type ω under the welfare-maximizing tax system. As we show formally in Online-Appendix A, a simple reform is welfare-improving if it brings marginal tax rates closer to the ones stipulated by Diamond's formula. Together with Corollary 2 this insight yields a characterization of politically feasible welfare improvements.

Corollary 3 *Suppose that income in the status quo is a strictly monotonic and continuous function of ω. Also suppose that income in the status quo satisfies the first order conditions of utility-maximization.*

1. *Consider an income level $y' < y^{0M}$. Suppose that*

$$\frac{T_0'(y')}{1-T_0'(y')} > \mathcal{D}^W(y') := \frac{1-F(\omega_0(y'))}{f(\omega_0(y'))\,\omega}\left(1+\frac{1}{\varepsilon}\right)\left(1-\mathcal{G}(\omega_0(y'))\right),$$

then a simple reform that leads to lower marginal tax rates at y' is both politically feasible and welfare-improving.

2. *Consider an income level $y' > y^{0M}$. Suppose that $\frac{T_0'(y')}{1-T_0'(y')} < \mathcal{D}^W(y')$ then a simple reform that leads to higher marginal tax rates at y' is both politically feasible and welfare-improving.*

Tax cuts are welfare-improving if taxes in the status quo exceed the level stipulated by Diamond's formula. The marginal tax rates according to Diamond's formula lie above the lower Pareto bound. Thus, for below median incomes, if a tax cut is welfare-improving, then it is also politically feasible. This is the first statement in the Corollary. The second statement applies the same logic to above median incomes. Higher tax rates are welfare-improving if they fall short of the level prescribed by Diamond's formula - in which case they are also below the upper Pareto bound. Consequently, for above median incomes, welfare-improving tax raises are also politically feasible.

Corollary 3 states sufficient conditions for the existence of welfare-improving and politically feasible reforms. This raises the question of necessary conditions. The Corollary has been derived from focusing on "small" reforms, i.e., on small increases of marginal tax rates applied to a small range of incomes. The arguments in the Appendix – more specifically in proof of Proposition 2 and in the derivation of $\mathcal{D}^W$ – imply that these conditions are also necessary in the following sense: if either

$$y' < y^{0M} \quad \text{and} \quad \frac{T_0'(y')}{1 - T_0'(y')} \leq \mathcal{D}^W(y') \ ,$$

or

$$y' > y^{0M} \quad \text{and} \quad \frac{T_0'(y')}{1 - T_0'(y')} \geq \mathcal{D}^W(y') \ ,$$

then there is no "small" reform for incomes close to y' that is both welfare-improving and politically feasible.[23]

The analysis suggests that existing tax schedules might be viewed as resulting from a compromise between concerns for welfare-maximization on the one hand, and concerns for political support on the other. If the maximization of political support was the only force in the determination of tax policy, we would expect to see tax rates close to the revenue-maximizing rate $\mathcal{D}^{up}$ for incomes above the median and negative rates close to $\mathcal{D}^{low}$ for incomes below the median. Concerns for welfare dampen these effects. A welfare-maximizing approach will generally yield higher marginal tax rates for incomes below the median and lower marginal tax rates for incomes above the median.

Our analysis also raises a question. Diamond (1998) and Saez (2001) have argued that, for plausible specifications of welfare weights, existing tax schedules have marginal tax rates for high incomes that are too low. Corollary 3 shows that an increase of these tax rates is not only welfare-improving but also politically feasible. Why don't we see more reforms that involve higher tax rates for the rich? Proposition 1 provides a possible answer to this question: reforms that involve tax cuts that are larger for richer taxpayers may as well prove to be politically feasible.

6 Empirical analysis

In our empirical analysis, we proceed in four steps. First, guided by Theorem 1, we check to what extent past tax reforms were monotonic. Second, we investigate whether the

[23] We omit a more formal version of this statement that would require ϵ-δ-arguments.

median voter was a beneficiary of these reforms. Moreover, we check whether support of a reform by the median voter goes together with majority support in the population at large, i.e. we check whether the "median voter theorem holds in our data." Third, guided by Theorem 2, we check whether we can observe a trend towards steeper progressivity at or below the median. Fourth, we compute upper and lower Pareto bounds which determine the range over which reforms are politically feasible. Extensive sensitivity checks are provided in Online-Appendix F.

6.1 Are tax reforms monotonic?

We look at this question from three different angles. First, we take a broad overview look at the annual changes of statutory tax rates in 33 OECD countries for the years 2000-2016. This leads to the conclusion that a large fraction of these "reforms" were monotonic, but there were exceptions. Second, we take an in-depth look at 11 major reforms of the federal personal income tax in the US since WWII using tax return micro data and microsimulation tools. This provides insights on the heterogeneity in the reform induced change of individual tax burdens accounting not only for statutory tax rate changes but also changes in the tax base. We find that the rank correlation between individual incomes and the changes of individual tax burdens is large, but not perfect. Finally, we look at tax reform proposals that were part of political campaigns, but which were not enacted. This reinforces the previous conclusion that tax reforms, whether implemented or just debated, are usually monotonic. The conclusion that tax reforms are, by and large, monotonic leads to the question whether they are monotonic enough for our theory to apply, i.e. whether majority support and support by the median voter are aligned. We get to this question in Section 6.2 below.

6.1.1 Tax reforms in OECD countries

The OECD provides annual data on the statutory tax systems of its member countries. In particular, for singles without dependents, it documents tax brackets and tax rates for labor income, see Online-Appendix D for a more detailed description. We use this information to construct a tax function.[24] A reform takes place when this tax function changes from one year to the next. It is classified as monotonic when the change of the tax burden is a monotonic function of income.

Table 2 shows that 78% of the reforms in the sample were monotonic.[25] The com-

[24]The OECD also reports personal allowances and tax credits. We incorporate this information.

[25]Not all countries have a fraction of monotonic reforms close to the average of 78%. For instance, the fraction of monotonic reforms is much smaller in Israel and Italy, and much larger in Belgium and Sweden. Summary statistics for all OECD countries can be found in the supplementary material. The Supplement also reports on findings obtained from additional sources for the US, the UK and France. The share of monotonic reforms is 80% for the US (1981-2016), 84% for France (1916-2016) and 77% for the UK (1981-2016).

Total number of possible reforms (#years*#countries):	528	
Total number of reforms:	394	
Number of monotonic reforms:	309	(78%)
Number of non-monotonic reforms:	85	(22%)

Table 2: Monotonic tax reforms in a panel of 33 OECD countries (2000-2016).

Table 2 is based on the OECD database (Table I.1. Central government personal income tax rates and thresholds: accessible on `http://stats.oecd.org/Index.aspx?DataSetCode=TABLE_I1`). See Online-Appendix D for a list of the countries that we cover.

plementary set includes reforms that are monotonic either above or below the median. It also includes reforms with non-monotonicities that seem economically negligible. We provide more specific examples of such reforms in the supplementary material.

6.1.2 Tax reforms in the US

There were 11 major reforms of the US federal personal income tax between 1964 and 2017 – see Online-Appendix H for details. As documented in Table H.1, some of these reforms were phased in over several years and we account for this in our analysis.

Methodology. Our analysis is based on NBER's microsimulation model TAXSIM and (tax return) micro data. Specifically, we use the public use files (IRS-SOI PUF) of tax return micro data from the Statistics of Income (*SOI*) division of the Internal Revenue Service (*IRS*). These data include all information reported on tax returns of individuals (the number of observations varies between 90,000 - 200,000 across years) and are available bi-annually for the years 1960–1966 and annually for the years 1966–2012.[26] We use TAXSIM to calculate income and payroll taxes as well as tax credits.[27]

For now, the question is whether tax reforms are monotonic. To answer it in line with our theory, we construct a (counterfactual) measure of the change in a taxpayer's tax burden that is only due to the reform, holding all individual characteristics, including the person's income, fixed.[28] Take the example of TRA86 which was phased in between 1985 and 1988. Let T_0 be the tax system in 1985 and T_1 be the tax system in 1988.

[26]For the years after 2012, we use the uprated data for each year available on the NBER's server. This only affects the analysis of TCJA17 which should therefore treated with a bit more caution compared to the other reforms as our analysis for this reform is not based on the actual tax return micro data as of 2017.

[27]For more information on TAXSIM see Feenberg and Coutts (1993) or visit `http://www.nber.org/taxsim/`. To be precise, we use the TAXPUF version of TAXSIM which is designed to run on the IRS-SOI PUF data.

[28]For a more extensive discussion of this counterfactual simulation approach, see, e.g., Eissa et al. (2008) or Bargain et al. (2015).

We observe an individual i's pre-tax income y_0^i, and all further characteristics relevant to compute the individual's tax burden in the year 1985. We then use TAXSIM to calculate the person's tax payment $T_0(y_0^i)$.[29] To account for the fact that T_1 becomes effective three years later, we compute an inflation-adjusted version of y_0^i that we denote by $\hat{y}_0^i$.[30] Our measure of the reform induced change of the person's tax burden is then $T_1(\hat{y}_0^i) - T_0(y_0^i)$. In the literature, this also known as the *direct policy effect*. To see whether TRA86 was a monotonic tax reform we then rank individuals according to pre-tax income[31] and investigate to what extent tax units with higher incomes experience larger changes of their tax burden than individuals with lower incomes.

We have to take some modeling choices on the way and follow the literature - especially Piketty and Saez (2007) and Eissa et al. (2008) in doing so. In our baseline, we determine a tax unit's rank in the income distribution based on pre-tax incomes excluding capital gains as they are not a regular stream of income. For the calculation of tax payments capital gains are included. For couples filing jointly, we allocate to each spouse 50% of the couple's incomes and taxes ("equal-split couples"). We check the sensitivity of our results with respect to these (and other) choices in Online-Appendix F.

We explore whether tax reforms are monotonic over the whole income distribution, or possibly only above or below the median. For robustness, we invoke alternative ways of determining the median in the income distribution. First, there is the median position in the tax return data we are using. Second, we make a correction for non-filers, i.e. low income households who do not submit a tax declaration. The median is then poorer than the one in the data.[32] Third, for a political economy analysis, the median income among voters is relevant. Since richer individuals are more likely to turn out, the median voter is richer than the median taxpayer in our data.[33] Taking account both of non-filers and of differential turnout brings us coincidentally back to the median position in our data, i.e. these effects are neutralizing each other.

[29] We also observe the actual tax payment of the person. It coincides with the calculated tax payment in more than 99% of the cases, and there is no systematic pattern in the few cases with no coincidence.

[30] We use the Consumer Price Index research series using current methods (CPI-U-RS) as an uprating factor to inflate/deflate incomes.

[31] Our income measure includes all sources of market income which are reported on tax returns, i.e. wages and salaries; bonuses and exercised stock-options; employer and private pensions; self-employment income; business income; dividends, interest, and rents; and realized capital gains.

[32] To give an example, this shifts the median to the 44th percentile in 2016 in the IRS-SOI PUF data. To be precise, we use data from Piketty and Saez (2007) to assess the share of non-filing tax units: it varies between 4-8% in the period of our analysis.

[33] For turnout rates by income we rely on data from the US Census: `https://www.census.gov/topics/public-sector/voting/data/tables.html`. This shifts the median to the 57th percentile in the 2016 IRS-SOI PUF data.

Results. For each reform, Figure 2 shows, separately for each decile of the income distribution, the average value of $T_1(\hat{y}_0^i) - T_0(y_0^i)$.[34] Of these reforms, seven can be broadly classified as tax cuts that are larger for richer taxpayers (RA64, RA78, ETRA81, TRA86, EGTRRA01, JGTRRA03, TCJA17). Three reforms involve higher taxes on the top decile (OBRA90, OBRA93, ATRA12). TRA69 is a hybrid with tax cuts for the middle class, and higher taxes at the top and bottom deciles. Broadly speaking, the figure shows a monotonic pattern, but there are also deviations from monotonicity. ERTA81 has a non-monotonicity for low incomes, but is monotonic above the median. TRA69 is monotonic below the median. TRA86 and OBRA90 have non-monotonicities both below and above the median.

Figure 3 provides additional information on the underlying heterogeneity by means of box plots. Several insights can be taken away form this. First, looking at the monotonicity of decile medians gives a similar picture as looking at the monotonicity of decile averages: by and large, the changes are monotonic. Second, there is significant heterogeneity, despite this general pattern and non-monotonicities can be found all over the place. To see this, pick a reform and consider a pair of neighboring deciles: The minimum in the lower decile is usually lower than the minimum in the next higher decile, but not lower than the maximum. Still, the overall (rank) correlation is high for all reforms (see Table F.1 in the Online-Appendix) but the ultimate question is whether there is enough monotonicity for our theory to apply, i.e. so that support by the median voter is aligned with support in the population at large. We get to this question below. Third, for the reforms that involve higher taxes on the rich, the box plots make apparent that only a very small group of taxpayers was actually hit by higher taxes. For OBRA90, OBRA93 and ATRA12, the top ten percent pay higher taxes on average as shown by Figure 2, but the box plots reveal that most taxpayers in this decile still experienced a tax cut.

6.1.3 Reform proposals

Does the finding that tax reforms are, by and large, monotonic, extend to tax reforms proposals which are publicly debated, but not enacted? Providing an answer faces the challenge that such reform proposals often remain vague, so that researchers have to make assumptions on the missing details.[35] To avoid own judgment calls, we invoke the systematic analysis of reform proposals in the US that is provided by the Tax Policy Center. Their analysis covers 69 reform proposals for the Federal personal income tax that were made in the period 2003-2019: some proposals were made during presidential

[34] To check the sensitivity of our results with respect to the choices made, we replicate Figure 2 in Online-Appendix F using (i) tax units (instead of equal split couple, see Figure F.1); (ii) statutory tax rates (instead of effective tax rates, see Figure F.2); (iii) different bin sizes (50 instead of 10, see Figure F.3); (iv) different income definitions: gross income including capital gains (see Figure F.4) and adjusted gross income (see Figure F.5); and (v) including state-level and payroll taxes (see Figure F.6). Results are robust across different specifications and the most noticeable changes affect the three oldest reforms.

[35] The Netherlands are a notable exception, see Jacobs et al. (2017)

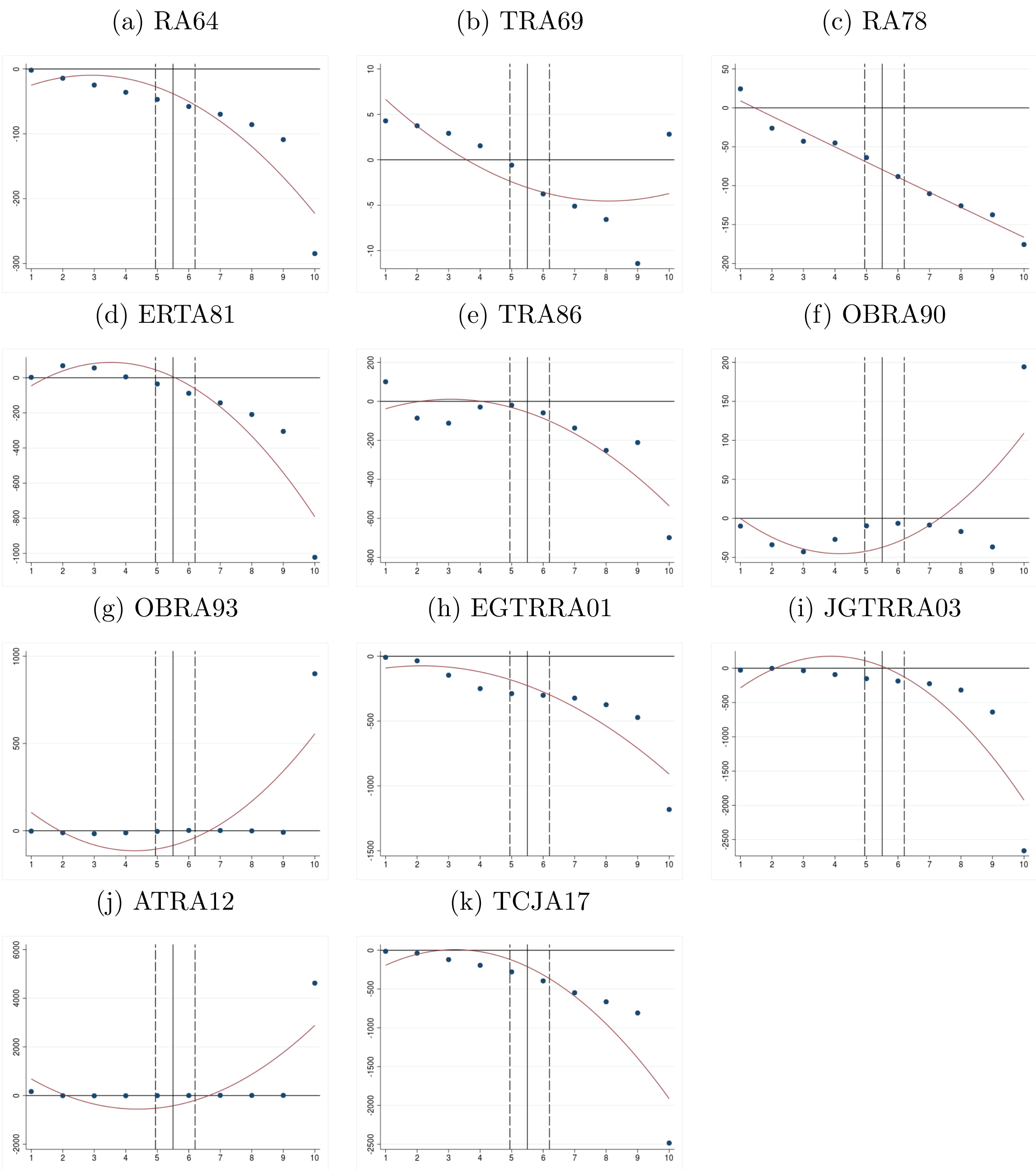

Figure 2: Changes in tax liability: Average values per decile

Notes: Figure 2 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income decile. The red line represents a quadratic fit based on the underlying micro data. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

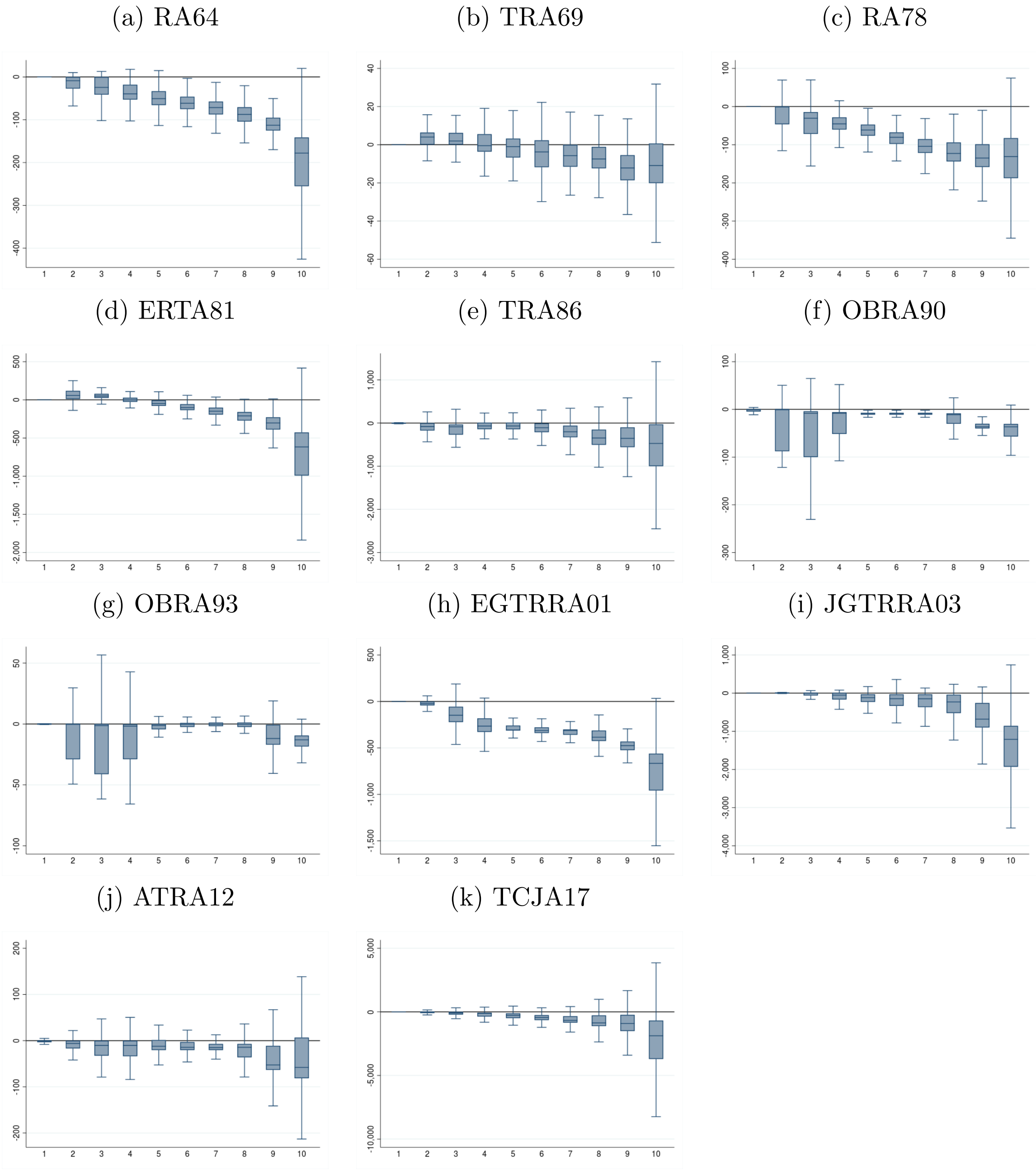

Figure 3: Changes in tax liability: Heterogeneity within deciles

Notes: Figure 3 illustrates, for each decile, the cross-sectional distribution of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by means of a box plot. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

campaigns and primaries, others were proposed by the Administration during the legislative process. The methodology and data used are described in the Tax Policy Center's documentation, see also Online-Appendix G for details. Figure 4 illustrates the results for four proposals made during the 2016 Presidential campaign. Note that the Tax Policy Center's analysis provides only information for quintile and not deciles. The proposals by the two Democratic candidates were of the "tax increase on the rich"-type while the Republican proposals were of the "tax cuts for everybody"-type. Figures G.1 – G.8 and Tables G.1 – G.8 in Online-Appendix G summarize our findings for all 69 proposals: the large majority of tax reform proposals are monotonic. The two reform types observed during the 2016 Presidential campaign are prevalent with the qualification that the "tax increase on the rich"-type is often combined with tax cuts for low incomes.[36]

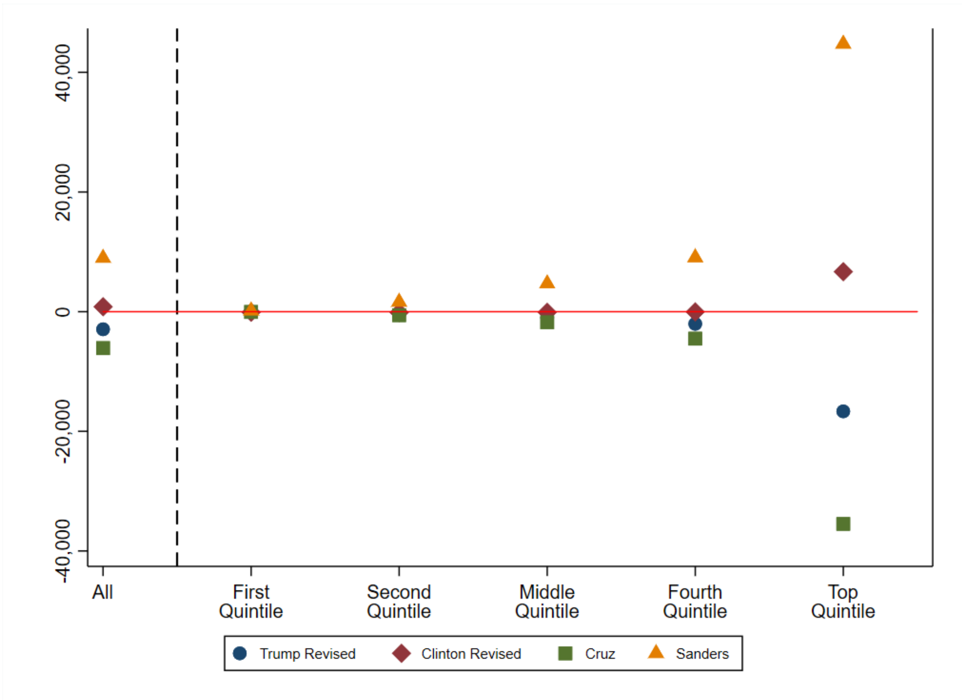

Figure 4: Changes in tax liability by quintile, 2016 US Presidential campaign

Notes: Figure 4 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals made during the 2016 Presidential campaign for the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The data is taking from the Tax Policy Center's ex ante analysis of each reform proposal (see Figure G.1 and Table G.1 for details).

Source: Authors' calculations based on Tax Policy Center.

[36]The exceptions are proposals made by Cain (Presidential campaign 2012, see Figure G.2), Bowles-Simpson Plans (bipartisan Presidential Commission created in 2010, see Figure G.4) and the Working Families Tax Relief Act (a 2019 proposal initiated by Democratic Senators, see Figure G.4).

Summary. Our analysis of reforms of the federal income tax in the US and the analysis of tax reforms in OECD countries in the Supplementary Material show that two types of tax reforms are particularly frequent: First, reforms that involve monotonic tax cuts, i.e. tax cuts which are larger for higher incomes. Second, reforms that lead to higher taxes on high incomes, possibly in combination with tax cuts for low incomes. In the latter case, monotonicity holds only above or below the median. In the US, the monotonic tax cuts are more prevalent for the reforms of the federal income tax after WWII. Fewer reforms led to higher taxes on top incomes.

6.2 Did the median voter gain? Was there majority support?

We return to the reforms of the US federal income tax after WWII. We first analyze whether the median voter was a beneficiary of these reforms.

Inequality (6) provides a sufficient condition under which the median voter gains from a reform. Remember that the condition relates the change in overall tax revenue to the change in the median voter's tax burden, both according to the pre-reform income and according to the post-reform income. The median voter is better off if there is a loss of overall revenue and her tax cut is even larger, or if there is a revenue gain exceeding the increase of her tax bill.[37] We extend this analysis to see whether there was majority support for tax reforms. Any taxpayer i in our data is a reform beneficiary if

$$R(\tau, h) - \max\left\{T_1(y_1^i) - T_0(y_1^i), T_1(y_0^i) - T_0(y_0^i)\right\} \quad \geq \quad 0 \,. \tag{13}$$

Thus, there is majority support for a reform if this inequality holds for at least half of the population.

A detailed explanation of how we bring inequalities (6) and (13) to the data can be found in Online-Appendix C. Assumptions about the ETI play a role for our estimate of the revenue effect, $R(\tau, h)$. For large elasticities, the revenue gains from higher taxes and the revenue losses from reduced taxes appear small. The pattern is reversed for low elasticities. We also simulate counterfactual post-reform incomes for individuals in our data set, again using assumptions about the ETI.

Benchmark: ETI of zero. If there are no behavioral responses to taxation, inequality (13) simplifies. In this case, an individual i gains from a tax reform if the revenue effect $R(\tau, h)$ exceeds $T_1(y_0^i) - T_0(y_0^i)$, where y_0^i is the individual's pre-reform income, and loses otherwise.

Figure 5 is an adaptation of Figure 2 above. Recall that the latter shows, for each decile, the average value of $T_1(\hat{y}_0^i) - T_0(y_0^i)$. Figure 5 now shows, again for each decile,

[37] As discussed in Section 4, with these conditions we can remain agnostic on whether the median voter's marginal tax rate increased or decreased. In Section 6.1.2 we documented that there is substantial heterogeneity in the effects of a reform. Thus, an advantage of our approach is that it does not require a specific assumption on the change of marginal tax rates for close to median incomes.

$T_1(\hat{y}_0^i) - T_0(y_0^i) - R(\tau, h)$, where $R(\tau, h)$ is calculated assuming an ETI of zero (blue dots). Thus, positive values in Figure 5 indicate an overall loss, an increase of the tax burden that is not compensated by the revenue implications of the reform. Negative values, by contrast, correspond to an overall gain, i.e. a reduction in tax payments.

Some of these reforms appear to be perfectly in line with our theory. For instance, RA78 is a monotonic reform with tax cuts above the median, and the median being among the beneficiaries. OBRA90, OBRA93 and ATRA12 have higher taxes on the rich so that the bottom 90 percent and hence also the median are made better off. Other reforms with, by and large, monotonic tax cuts (RA64, ERTA81,TRA86, EGTRRA01, JGTRRA03, TCJA17) are qualitatively similar to RA78, but, for an ETI of zero, do not include the median voter in the set of reform winners. For TRA69, depending on the exact definition of the median voter, the median voter either gains from the reform, or is close to being indifferent.

Alternative assumptions on the ETI. Figure 5 also shows that alternative assumptions about the ETI affect who was a reform winner, or a reform loser, and hence also whether the median voter was a beneficiary. The reforms involving tax cuts were in the median voter's interest for high values of the ETI, but not for low ones. By contrast, the reforms involving higher taxes on "the rich" were in the median voter's interest for low values of the ETI, but not for high ones.

We have seen before that there is substantial heterogeneity in the way in which individuals were affected by a tax reform. Figure E.2 in the Online-Appendix therefore supplements Figure 5 by showing, for each decile, the fractions of winners and losers, respectively. The Figure shows that support for tax cuts gets larger with income, and that, for an ETI of zero, there are only few supporters with close to median income. The reforms involving higher taxes on high incomes, by contrast, receive more support than opposition.

Majority support and support by the median voter. According to Theorem 1, for monotonic tax reforms, there is an equivalence of support by the person with median income and majority support. We have seen in Section 6.1 that tax reforms are broadly monotonic. We also saw, however, that numerous deviations from this broad pattern can be found. This raises the question whether there is enough monotonicity for our theory to apply. To provide an answer, we check whether majority support and support by the median voter are aligned. If this is indeed the case, majority support fails whenever the median voter is made worse off by a reform, and majority support holds, whenever the median voter is made better off.

As explained above, whether the median voter, or any other person, gained depends on the ETI. Figure 6 therefore shows majority support and support by voters with close to median income for different values of the ETI. Specifically, the vertical axis measures

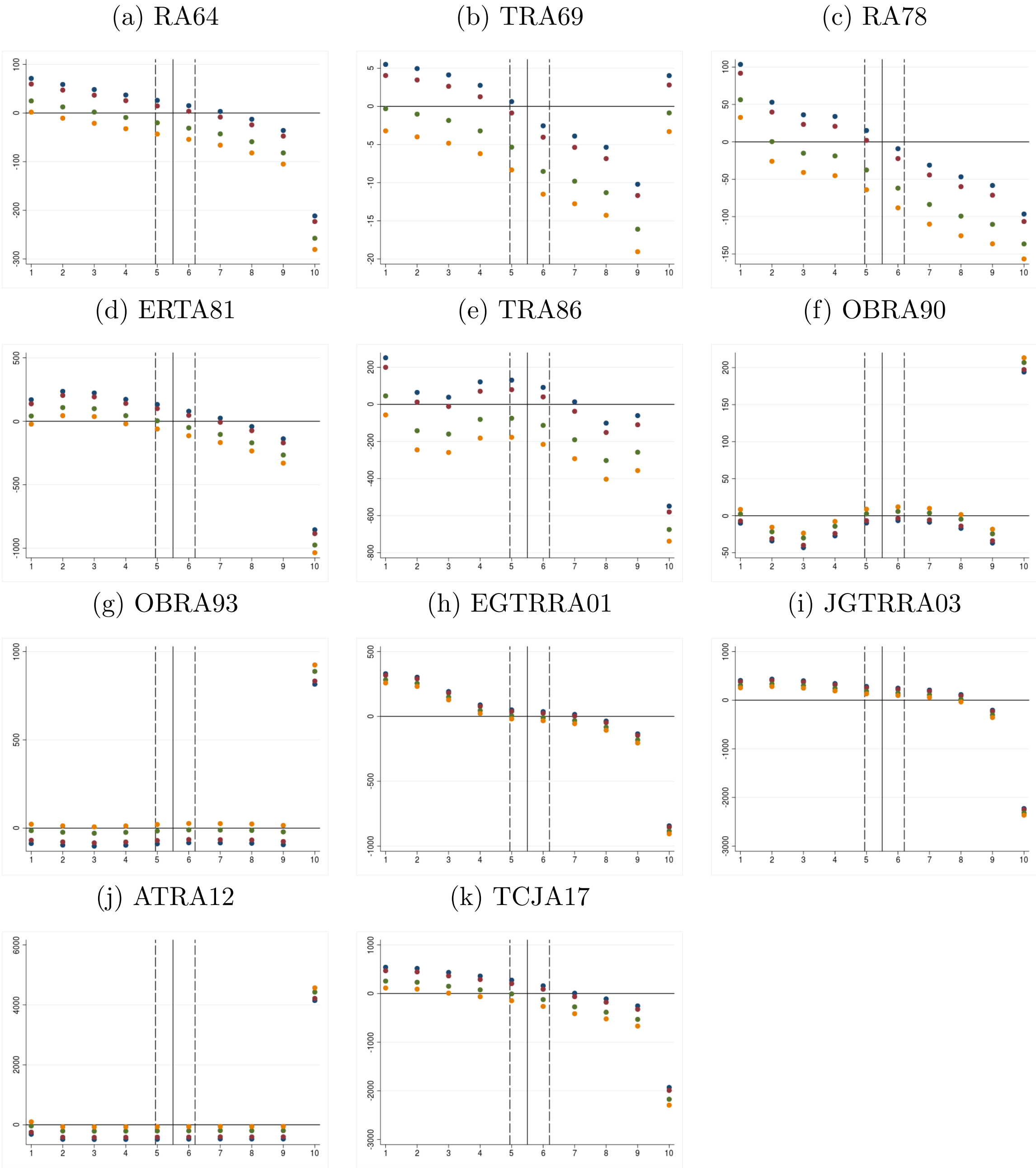

Figure 5: Winners and losers of major US tax reforms

Notes: Figure 5 shows the average of the counterfactual change in tax liability $\max\left\{T_1(y_1^i) - T_0(y_1^i), T_1(y_0^i) - T_0(y_0^i)\right\} - R(\tau, h)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income decile for four different ETI values: 0 (blue), 0.25 (red), 1 (green) and 1.5 (yellow). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously. See Figure E.1 in the Online-Appendix for the cross-sectional heterogeneity within each decile.
Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

support in the population at large and the horizontal axis measures support by people with close to median incomes (more precisely the average of percentiles P45-P55, i.e. the range in which the different median definitions fall). Points in the upper right quadrant indicate that there was both majority support and support by most people with close to median income. Points in the lower left quadrant indicate that there was no majority support and that most people with close to median income opposed the reform. Thus, points in the upper right quadrant and in the lower left quadrant are in line with the median voter theorem. By contrast, points in the lower right quadrant and in the upper left quadrant indicate a discrepancy between support by the median voter and majority support. The figure reveals that, whatever our assumption on the ETI, majority support and support by people with close to median incomes are aligned. We hence conclude that reforms in the US were "sufficiently monotonic" and that the "median voter theorem holds in the data."

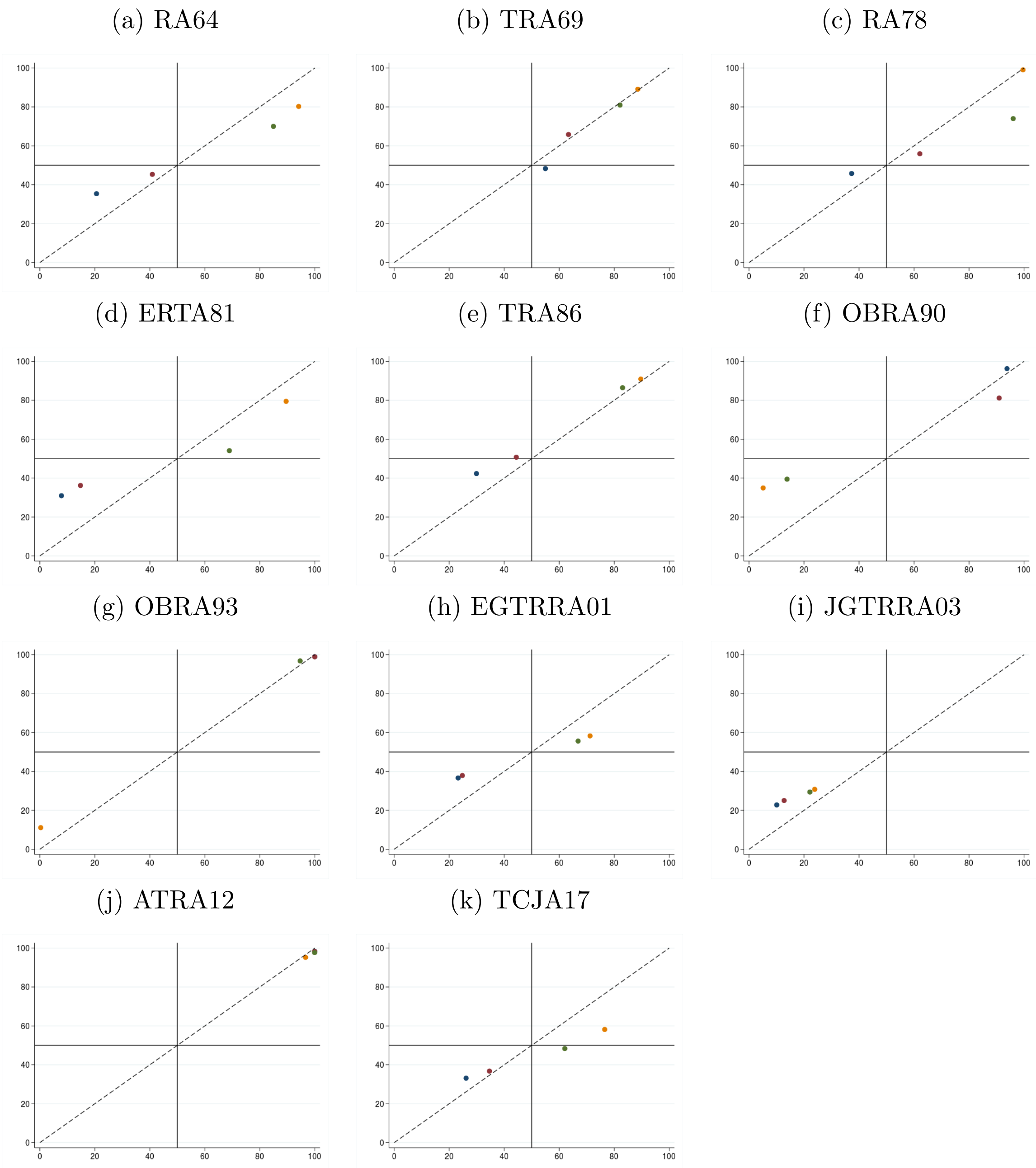

Figure 6: Majority support versus support by the median voter

Notes: Figure 6 shows the shares of reform winners, i.e. of tax units i with $\max\left\{T_1(y_1^i) - T_0(y_1^i), T_1(y_0^i) - T_0(y_0^i)\right\} - R(\tau, h) \leq 0$ for the full population (vertical axis) and the middle of the distribution (average of P45-P55, horizontal axis) for major reforms of the US federal personal income tax (see Table H.1 for details) and for four different ETI values (see Figure 5): 0 (blue), 0.25 (red), 1 (green) and 1.5 (yellow). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. See Figure E.2 and Figure E.3 in the Online-Appendix for the shares of winners in all income deciles.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

6.3 Increased progressivity in the middle?

Theorem 2 implies that a sequence of politically feasible tax reforms should push tax rates in the direction of the lower Pareto bound for below median incomes and, possibly, in the direction of the upper Pareto bound for above median incomes. Mechanically, this should lead to more pronounced progression over an intermediate range of incomes.

To check whether we can find this pattern in our data for the US, we document the evolution of effective marginal tax rates T' in Figure 7 by plotting the pre- and the post-reform values of the ratio $\frac{T'}{1-T'}$.[38] The transition from RA64 to ATRA12 reveals that there was indeed a lowering of marginal tax rates for low incomes and increased progression for incomes that were somewhat higher. These changes are associated with the introduction and then the expansion of the earned income tax credit ($EITC$). The EITC led to lower, in fact negative, marginal tax rates for the working poor. Low-income households with children were the main recipients of these earnings subsidies. The negative marginal tax rates were phased out over a range of higher incomes, beginning with the income level qualifying for the maximal credit. This led to a strong increase of marginal tax rates in the next higher segment of the income distribution.

In contrast, Figure 7 does not reveal a strong tendency towards higher marginal tax rates above the median. The sufficient statistics that we present in the subsequent Section 6.4 provide a possible explanation: the conclusion that there was room to lower marginal tax rates for "the poor", is robust to alternative assumptions about the ETI. This is not true for higher taxes on "the rich." With an ETI around 1, which has been considered plausible by scholars in the 1990s (see, in particular, Feldstein, 1995, 1999), such tax increases appear Pareto-damaging.

[38]We focus on the ratio $\frac{T'}{1-T'}$ for consistency with the other figures that we present. Figure E.4 in the Online-Appendix shows T' directly.

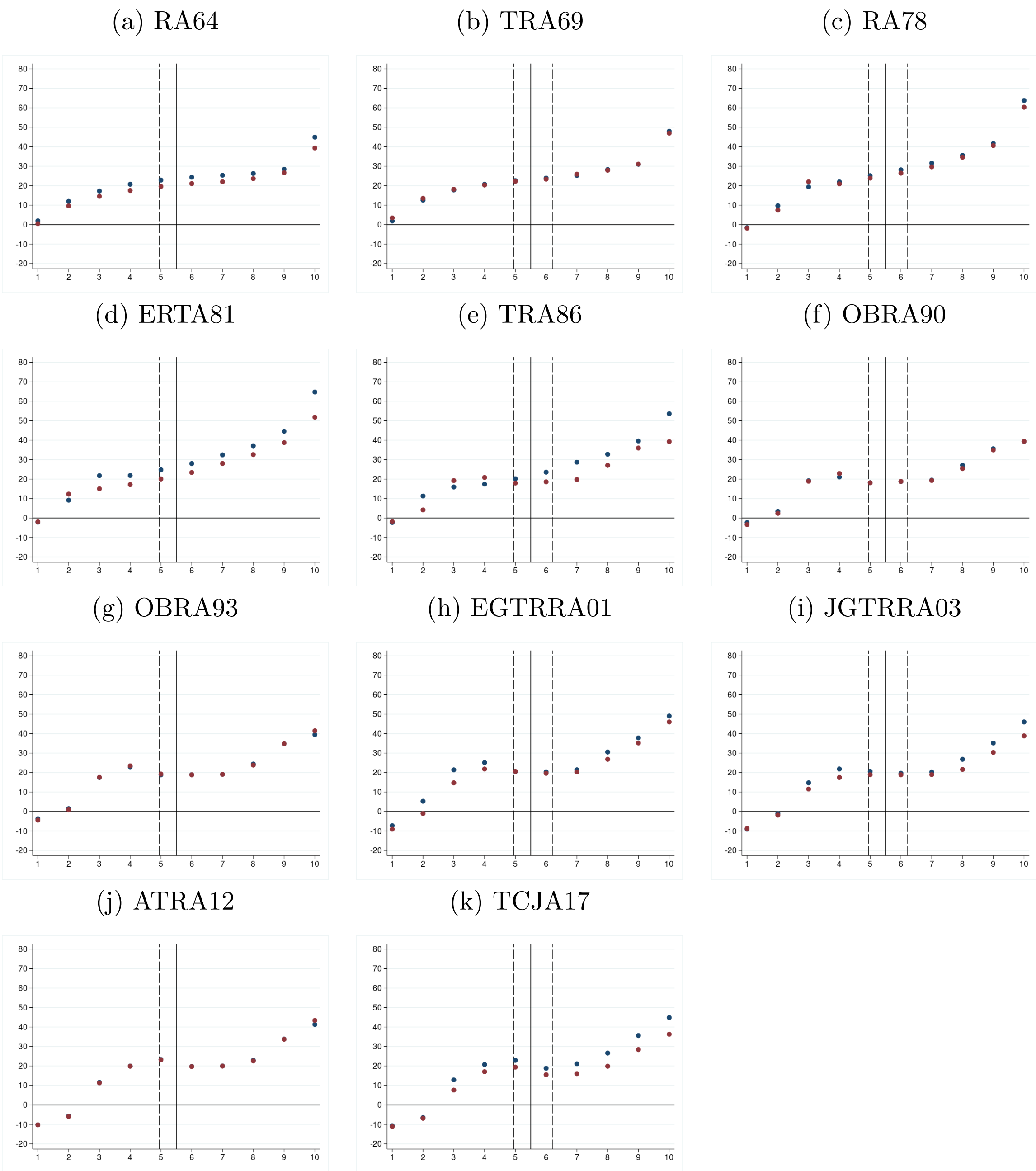

Figure 7: $\frac{T'}{1-T'}$ by decile before and after each reform

Notes: Figure 7 shows, separately for each decile, the ratio $\frac{T'}{1-T'}$ based on effective marginal tax rates (EMTRs) before (blue) and after (red) major reforms of the US federal personal income tax (see Table H.1 for details). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously. See Figure E.4 for EMTRs T'.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

6.4 Sufficient statistics for politically feasible and/or welfare improving reforms

In the following, we present an analysis of tax reforms using the upper Pareto bound $\mathcal{D}^{up}$ and the lower Pareto bound $\mathcal{D}^{low}$. We will focus on whether the tax reforms in the US were Pareto-improving or politically feasible. In our data we observe the endogenous (to the tax system) distribution of incomes (instead of the exogenous distribution of types).[39] We therefore use a representation of $\mathcal{D}^{up}$ and $\mathcal{D}^{low}$ that invokes the income distribution, as represented by the *cdf* F_y and the density f_y:[40]

$$\mathcal{D}^{low}(y) := \quad -\frac{F_y(y_0(\omega))}{f_y(y_0(\omega))\; y_0(\omega)}\;\frac{1}{\varepsilon}\;, \quad \text{and} \quad \mathcal{D}^{up}(y) := \quad \frac{1-F_y(y_0(\omega))}{f_y(y_0(\omega))\; y_0(\omega)}\;\frac{1}{\varepsilon}\;. \tag{16}$$

Upper Pareto bound. Figure 8 shows, for each reform of the US federal income tax, and each level of income y, the upper Pareto bound $\mathcal{D}^{up}(y)$, the pre-reform value of $\frac{T'(y)}{1-T'(y)}$ (in blue) and the post-reform value (in red). The first four reforms (RA64, TRA69, RA78, ERTA81) involved tax cuts that were larger for richer taxpayers. For plausible values of the ETI, these reforms can be viewed as responses to inefficiently high tax rates on "the rich": For values of the ETI above 0.4, the pre-reform schedule crossed the upper Pareto bound. The fifth reform (TRA86) again involved tax cuts. Those can be rationalized as being Pareto-improving for an ETI above 0.5, but not for lower values of the ETI. The tax cuts in the early 2000s (EGTRRA01, JGTRRA03) and the Trump tax plan (TCJA17) are Pareto-improving for an ETI above 0.75, but not otherwise. The reforms involving higher taxes on the rich (OBRA90, OBRA93, ATRA12) appear politically feasible for ETI values below 0.75. For higher values of the ETI, the reforms led to inefficiently high tax rates.

Thus, whether higher taxes on the rich were politically feasible depends on the ETI. With an ETI of 1 or higher, as suggested e.g. by Feldstein (1995, 1999) or more recently by Mertens and Olea (2018), higher taxes on "the rich" were Pareto-damaging and therefore not politically feasible. With an ETI around 0.25 as suggested by some of the subsequent

[39] The idea of identifying types by their position in the income distribution is due to Saez (2001).

[40] The characterization of $\mathcal{D}^{up}$ and $\mathcal{D}^{low}$ in Proposition 2 refers to the distribution of types F, with density f. These distributions are related to each other via

$$F_y(y) = F(\omega_0(y)) \quad \text{and} \quad f_y(y) = f(\omega_0(y))\;\frac{\partial \omega_0(y)}{\partial y}\;. \tag{14}$$

Moreover, for a piecewise linear tax system, i.e. one with $T''(y) = 0$, the first order conditions characterizing the function $y_0 : \omega \to y_0(\omega)$ that gives incomes in the status quo, and its inverse $\omega_0 : y \mapsto \omega_0(y)$, imply that

$$\left(1+\frac{1}{\varepsilon}\right)\frac{\partial \omega_0(y)}{\partial y}\,\frac{1}{\omega_0(y)} = \frac{1}{y_0(\omega)}\;\frac{1}{\varepsilon}\;. \tag{15}$$

Using Proposition 2, (14) and (15) yields 16.

literature, see Saez et al. (2012) for a survey and Neisser (2017) for a meta-study, higher taxes on the rich have been politically feasible from the mid 80s onward.

Lower Pareto bound. Figure 9 shows, for each reform of the US federal income tax, and each level of income y, the lower Pareto bound $\mathcal{D}^{low}(y)$, and, again, the pre-reform value (in blue) and the post-reform value (in red) of $\frac{T'(y)}{1-T'(y)}$. All reforms give rise to the same conclusion: the lower bound came nowhere close to the pre- or the post-reform schedule. Hence, lower tax rates for "the poor" were politically feasible. The introduction and subsequent expansion of the EITC from the mid 1970s onward went in this direction. It lowered marginal tax rates, predominantly, for low income households with children.

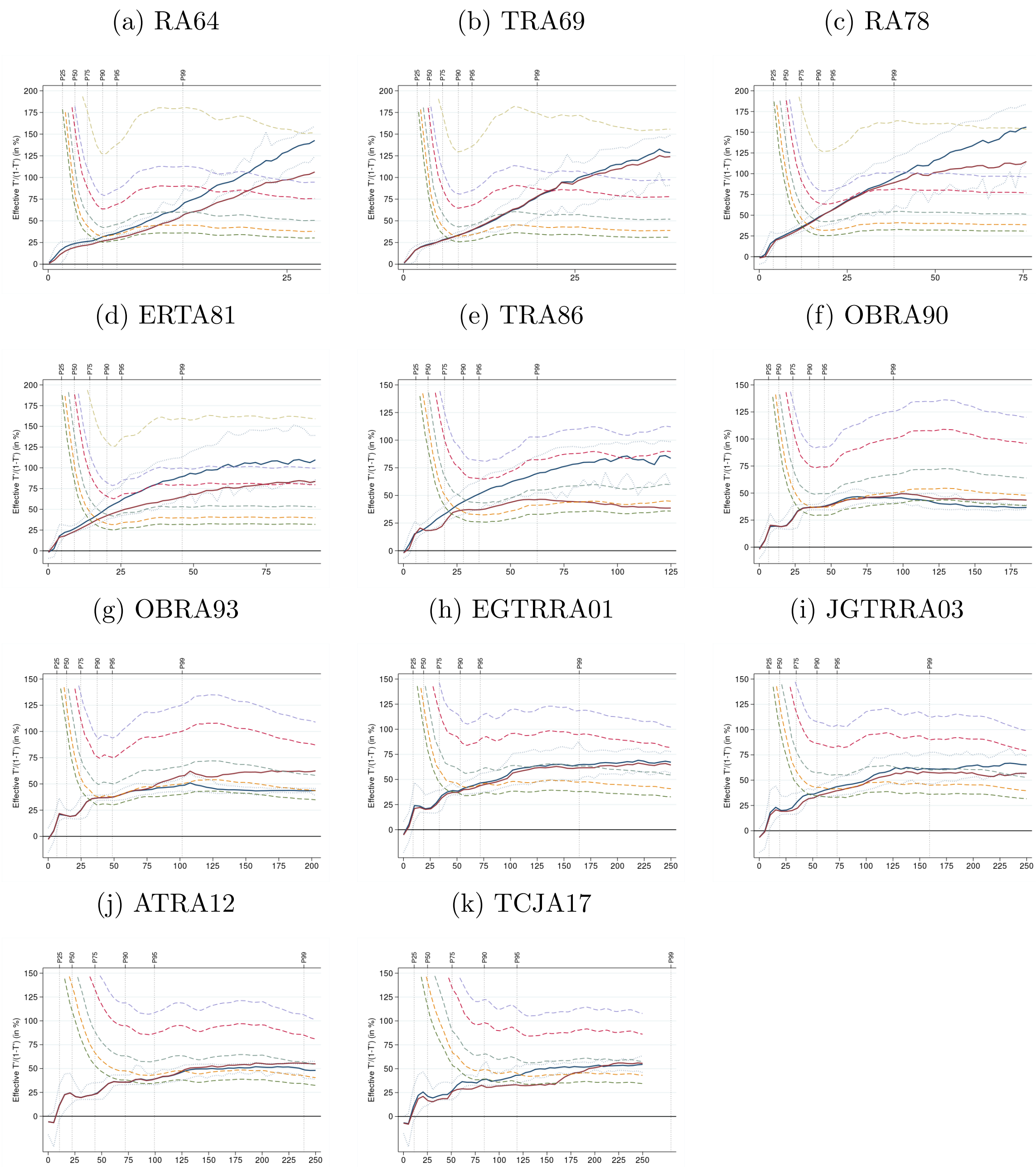

Figure 8: Upper Pareto bounds $\mathcal{D}^{up}$

Notes: Figure 8 shows the ratio $\frac{T'}{1-T'}$ of the effective marginal tax rates (EMTRs) before (solid blue line; blue lines in short dashes represent, for each income level, the 10^th and the 90^th percentiles of the EMTR function) and after (solid red line) major reforms of the US federal personal income tax (see Table H.1 for details) as well as upper Pareto bounds $\mathcal{D}^{up}$ (dashed lines) for five different ETI values: 0.25 (khaki), 0.4 (lavender), 0.5 (cranberry), 0.75 (teal), 1 (orange) and 1.25 (green). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. Vertical dashed lines show different percentiles of the income distribution.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

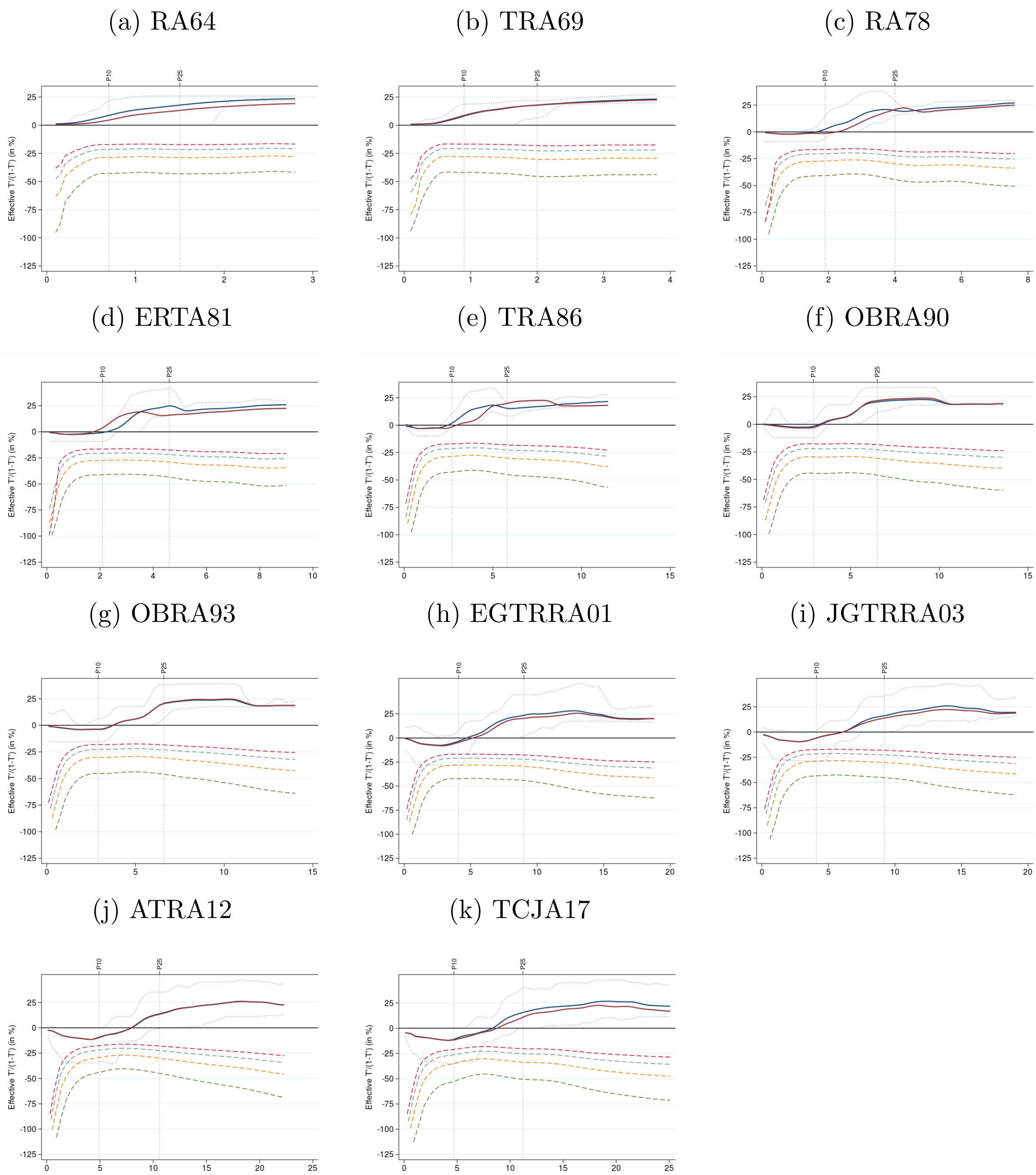

Figure 9: Lower Pareto bounds $\mathcal{D}^{low}$

Notes: Figure 9 shows the ratio $\frac{T'}{1-T'}$ of the effective marginal tax rates (EMTRs) before (solid blue line; blue lines in short dashes represent, for each income level, the 10^th and the 90^th percentiles of the EMTR function) major reforms of the US federal personal income tax (see Table H.1 for details) as well as lower Pareto bounds $\mathcal{D}^{low}$ (dashed lines) for four different ETI values: 5 (cranberry), 4 (teal), 3 (orange) and 2 (green). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. Vertical dashed lines show different percentiles of the income distribution.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

7 Concluding remarks

This paper develops a theory of politically feasible tax reforms, i.e. of reforms that are preferred by a majority of citizens over some predetermined status quo in tax policy. We also present an empirical analysis of tax reforms that is guided by this theory.

The theoretical analysis rests on the assumption that the reform-induced change in the tax burden is a monotonic function of income. With this assumption we can establish a median voter theorem for reforms of non-linear tax systems. Accordingly, a reform is politically feasible if and only if it is preferred by the person with median income. We also clarify the conditions under which a change of the marginal tax rates for incomes in a certain range – such as higher taxes on "the rich" or larger earnings subsidies for "the poor" – are politically feasible.

Our empirical analysis focuses on reforms of the US federal income tax after WWII, makes use of tax return micro data and NBER's TAXSIM microsimulation model. Even though there is heterogeneity in the effects of a tax reform on taxpayers, we find that actual tax reforms, by and large, satisfy the monotonicity property on which our theoretical analysis is based. We also find that tax reforms often look as if their had been a deliberate effort to include people with close to median income into the set of beneficiaries.

Finally, we derive sufficient statistics that make it possible to identify politically feasible reforms, given data on the distribution of incomes and the behavioral responses to taxation. Future research might use this framework to complement existing studies on the history of income taxation.[41]

The analysis in the main text is based on the workhorse of analyses of non-linear taxation, the Mirrleesian model. In the Online-Appendix, we present extensions to richer models of taxation, such as models with variable and fixed costs of labor market participation, models that include heterogeneity in preferences over public goods, or models that include an investment in human capital. In the main text, we also assume that the revenue that is generated by a tax reform is rebated lump-sum. In the Online-Appendix, we also consider that additional revenue from income taxation is used to finance public goods, or to lower other taxes, e.g. indirect taxes or taxes on capital income. We show that versions of our median voter theorem for tax reforms also hold in these settings.[42]

Real-world tax reforms often have revenue implications that are not felt in the same period in which tax rates change. For instance, tax cuts may yield budget deficits that

[41] For instance, Scheve and Stasavage (2016) study whether tax systems have become more progressive in response to increases in inequality or in response to extensions of the franchise. Their analysis compares tax policies that have been adopted at different points in time, or by countries with different institutions. It does not include an analysis of the reforms that appear to have been politically feasible or welfare-improving in a given year, for a given country, and a given status quo tax schedule. The framework that is developed in this paper lends itself to such an analysis.

[42] A restriction that is needed in these richer models is that reforms are small, so that the people with close to median income in the status quo are also people with close to median income after the reform.

necessitate an adjustment of public spending in later periods. Our analysis is based on a static model, and a formal treatment of the dynamic effets of tax reforms is an important topic for future research. Still, we provide some tentative remarks on how our framework might be extended: The important assumption in our baseline analysis is that the revenue implications of a reform affect all taxpayers similarly, whereas the change of the tax schedule affects people depending on their incomes. Thus, a scenario in which spending cuts in later periods hit all taxpayers in a similar fashion, should give rise to similar conclusions as our baseline analysis. A scenario where future tax cuts hit some people more than others should correspond to our extension in the Online-Appendix in which additional tax revenues are spent on public goods and preferences for public goods are heterogeneous. Thus, we conjecture that our main conclusions extend to environments with explicit dynamics or uncertainty.

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Appendix for Online Publication: Politically feasible reforms of non-linear tax systems

Felix J. Bierbrauer Pierre C. Boyer Andreas Peichl

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Bierbrauer (corresponding author): CMR - Center for Macroeconomic Research, University of Cologne, Germany (bierbrauer@wiso.uni-koeln.de); **Boyer**: CREST, École Polytechnique, France (pierre.boyer@polytechnique.edu); **Peichl**: ifo Munich, LMU Munich, CESifo, IHS and IZA (peichl@econ.lmu.de).

A Proofs

A.1 Proof of Theorem 1

Step 1. By the envelope theorem

$$V_\tau(\tau, h, \omega) = R_\tau(\tau, h) - h(y^*(\tau, h, \omega)) \, , \tag{A.1}$$

where $R_\tau(\tau, h, \omega)$ is the derivative of tax revenue with respect to $\tau > 0$. The validity of the envelope theorem follows from Corollary 4 in Milgrom and Segal (2002).

Step 2. Suppose that h is a non-decreasing function. An analogous argument applies if h is non-increasing. We show that $V_\tau(\tau, h, \omega^M) > 0$ implies $V_\tau(\tau, h, \omega) > 0$ for a majority of individuals. By Step 1, $V_\tau(\tau, h, \omega^M) > 0$ holds iff $R_\tau(0, h) - h(y^*(\tau, h, \omega^M)) > 0$. As h and $y^*(\tau, h, \cdot)$ are non-decreasing functions, this implies $R_\tau(\tau, h) - h(y^*(\tau, h, \omega)) > 0$, for all $\omega \leq \omega^M$, and hence $V_\tau(\tau, h, \omega) > 0$ for all $\omega \leq \omega^M$.

Step 3. Suppose that h is a non-decreasing function. An analogous argument applies if h is non-increasing. We show that $V_\tau(\tau, h, \omega^M) \leq 0$ implies $V_\tau(\tau, h, \omega) \leq 0$ for a majority of individuals. By Step 1, $V_\tau(\tau, h, \omega^M) \leq 0$ holds iff $R_\tau(\tau, h) - h(y^*(\tau, h, \omega^M)) \leq 0$. As h and $y^*(\tau, h, \cdot)$ are non-decreasing functions, this implies $R_\tau(\tau, h) - h(y^*(\tau, h, \omega)) \leq 0$, for all $\omega \geq \omega^M$, and hence $V_\tau(\tau, h, \omega) \leq 0$ for all $\omega \geq \omega^M$.

A.2 Proof of Proposition 1

To prove the first statement in the Proposition, let

$$V_\tau(\tau, h, \omega^M) = R_\tau(\tau, h) - h(y^*(\tau, h, \omega^M)) < 0 \, ,$$

so that the median voter benefits from a small decrease of tax rate $\tau < 0$. With h non-decreasing for $y \geq y^*(\tau, h, \omega^M)$, this implies that

$$V_\tau(\tau, h, \omega) = R_\tau(\tau, h) - h(y^*(\tau, h, \omega) < 0 \, ,$$

for all $\omega \geq \omega^M$. Hence a majority of the population benefits from the tax cut.

The second statement in the Proposition follows from the same argument: If the poorest individual benefits from a tax cut and individuals with incomes closer to the median also benefit as h is non-decreasing for below median incomes, then there is majority support for the reform.

A.3 Proof of Theorem 2

For a simple reform (τ, ℓ, y_a) the envelope theorem implies that

$$V_\tau(0, \ell, y_a, \omega) = R_\tau(0, \ell, y_a) - h(y^*(0, \ell, y_a, \omega)) \, . \tag{A.2}$$

To prove the first statement in Theorem 2, suppose that $y_a < y^{0M} = y^*(0, \ell, y_a, \omega^M)$. Choose ℓ so that $y_a + \ell < y^{0M}$. Then $h(y^*(0, \ell, y_a, \omega)) = \ell$, for all $\omega \geq \omega^M$. Since

$R_\tau(0,\ell,y_a) < \ell$, it follows that $V_\tau(0,\ell,y_a,\omega) < 0$, for all $\omega \geq \omega^M$, which implies that a small tax cut, $\tau < 0$, makes a majority of individuals better off. To prove the second statement, suppose that $y_a > y^{0M}$. Then $h(y^*(0,\ell,y_a,\omega)) = 0$, for all $\omega \leq \omega^M$. Hence, if $R_\tau(0,\ell,y_a) > 0$, then $V_\tau(0,\ell,y_a,\omega) > 0$, for all $\omega \leq \omega^M$, which implies that a small raise of marginal tax rate, $\tau > 0$, makes a majority of individuals better off.

A.4 Proof of Proposition 2

Preliminaries. Let $T_1 = T_0 + \tau\ h$. We consider a perturbation that affects marginal tax rates in a bracket that starts at income level y_a and has length ℓ. The function $h : (y,\ell) \mapsto h(y,\ell)$ is assumed to have the following properties, for any given ℓ:

(i) It is a continuously differentiable and non-decreasing function of y.

(ii) $h(y,\ell) = 0$, all $y \leq y_a$.

(iii) $h(y,\ell) = \ell$, for all $y \geq y_a + \ell$.

(iv) $h_y(y,\ell) = 1$ for $y \in [y_a + \epsilon\,\ell, y_a + (1-\epsilon)\ell]$, where $\epsilon > 0$ is a fixed parameter.

(v) $h_y(y,\ell) > 0$ for $y \in (y_a, y_a + \ell)$.

Note that $T_1'(y) = T_0'(y) + \tau\ h_y(y,l)$. Thus, marginal tax rates change by $\tau\ h_y(y,l)$, and this change is different from zero only for incomes in the bracket. There, they change by τ, except for incomes in the neighborhood of the bracket's endpoints. In these neighborhoods the changes of marginal tax rates are, respectively, phased in and phased out in a smooth way. We continue to summarize such a reform by the triple (τ,ℓ,y_a)

We first analyze how tax revenue is affected by a simple reform and then turn to the proof of statements (1.) and (2.) in Proposition 2.

Tax revenue. The additional tax revenue that is generated by a reform (τ,ℓ,y_a) is given by

$$R(\tau,\ell,y_a) := \int_{\underline{\omega}}^{\overline{\omega}} \Big(T_1(y^*(\tau,\ell,y_a,\omega)) - T_0(y_0(\omega))\Big) f(\omega)\, d\omega\ ,$$

where $y_0(\omega) := y^*(0,\ell,y_a,\omega)$ is a shorthand for the income of type ω in the status quo. We are interested in clarifying the conditions under which a small tax cut raises revenue, i.e. the conditions under which $R_\tau(0,\ell,y_a) < 0$ holds, for some level of income y_a and some $\ell > 0$.

Let $\omega_a(\tau,\ell,y_a)$ be the smallest type with an income larger or equal to y_a given a reform (τ,ℓ,y_a). Likewise let $\omega_b(\tau,\ell,y_a)$ be the largest type with an income below $y_b = y_a + \ell$. In the absence of income effects, the reform does not affect the behavior of individuals with earnings below y_a or above y_b. For these individuals, marginal tax rates do not change. Since $h(y) = 0$, for $y \leq y_a$, there is also no effect on the tax liability of individuals with earnings below y_a. By contrast, the tax liability of individuals with earnings above y_b increase by $\tau\,\ell$. Thus, we can write

$$\begin{aligned} R(\tau,\ell,y_a) &= \int_{\omega_a(\tau,\ell,y_a)}^{\omega_b(\tau,\ell,y_a)} \Big(T_0(y^*(\tau,\ell,y_a,\omega)) + \tau\ h(y^*(\tau,\ell,y_a,\omega)) - T_0(y_0(\omega)) \Big) f(\omega) d\omega \\ &+ \ \tau\,\ell \left(1 - F(\omega_b(\tau,\ell,y_a)) \right) . \end{aligned} \tag{A.3}$$

Computing the derivative with respect to τ, using Leibnitz' rule, and evaluating at $\tau = 0$ yields

$$\begin{aligned} R_\tau(0,\ell,y_a) &= \int_{\omega_0(y_a)}^{\omega_0(y_a+\ell)} \Big(T_0'(y_0(\omega))\ y_{0\tau}(\omega) + h(y_0(\omega)) \Big) f(\omega) d\omega \\ &+ \ \ell \left(1 - F(\omega_0(y_a+\ell)) \right) , \end{aligned} \tag{A.4}$$

where $y_{0\tau}(\omega) := y^*_\tau(\tau,\ell,y_a,\omega)\ |_{\tau=0}$ is the derivative of y^* with respect to τ, evaluated at the status quo, i.e. for $\tau = 0$.

The assumption that income in the status quo is a continuous function of ω plays a role in the derivation of equation (A.4): A change of τ implies a change of $\omega_b(\tau,\ell,y_a)$ which enters both as the upper limit of the integral in the first line of (A.3) and via the term in second line of (A.3). These marginal effects exactly cancel at $\tau = 0$ if the function y_0 is continuous.

Computing the derivative of $R_\tau(0,\ell,y_a)$ with respect to ℓ and evaluating at $\ell = 0$ yields

$$R_{\tau\ell}(0,0,y_a) \;=\; T_0'(y_a)\ y_{0\tau}(\omega_0(y_a))\ f(\omega_0(y_a))\ \omega_{0\ell}(y_a) + 1 - F(\omega_0(y_a)) \ ,$$

where $\omega_{0\ell}(y_a) := \frac{d}{d\ell}\ \omega_0(y_a+\ell)\ \ |_{\ell=0}$. Note that $\omega_0(y_a+l)$ solves $y_a + l = y_0(\omega_0(y_a+l))$. Hence, $\omega_{0\ell}(y_a) = y_{0\omega}(\omega_0(y_a))^{-1}$, where, for any ω', $y_{0\omega}(\omega') := y^*_\omega(\tau,\ell,y_a,\omega)\ \ |_{\tau=0,\omega=\omega'}$. The assumption that y_0 is a strictly monotonic function plays a role here. It ensures that $y_{0\omega}(\omega_0(y_a)) \neq 0$ and hence that $\omega_{0\ell}(y_a)$ is well-defined. We can therefore write,

$$R_{\tau\ell}(0,0,y_a) \;=\; T_0'(y_a)\ f(\omega_0(y_a))\ \frac{y_{0\tau}(\omega_0(y_a))}{y_{0\omega}(\omega_0(y_a))} + 1 - F(\omega_0(y_a)) \ , \tag{A.5}$$

Given a simple reform (τ,ℓ,y_a), the first order condition characterizing $y^*(\tau,\ell,y_a,\omega)$ is given by

$$1 - T_0'(y^*(\cdot)) - \tau h'(y^*(\cdot)) - \omega^{-\left(1+\frac{1}{\varepsilon}\right)} y^*(\cdot)^{1+\frac{1}{\varepsilon}} = 0 \ .$$

For any given ℓ, we focus on ω so that $y^*(\cdot,\omega) \in [y_a + \epsilon\,\ell, y_a + (1-\epsilon)\ell]$ and $h'(y^*(\cdot) = 1$. Hence,

$$1 - T_0'(y^*(\cdot)) - \tau - \omega^{-\left(1+\frac{1}{\varepsilon}\right)} y^*(\cdot)^{1+\frac{1}{\varepsilon}} = 0 \ . \tag{A.6}$$

Starting from this equation, one can use the implicit function theorem to solve for $y^*_\tau(\cdot)$ and $y^*_\omega(\cdot)$. This allows to compute the ratio $\frac{y^*_\tau(\cdot)}{y^*_\omega(\cdot)}$. At $\tau = 0$, and for $\omega = \omega_0(y_a)$, this ratio equals

$$\frac{y_{0\tau}(\omega_0(y_a))}{y_{0\omega}(\omega_0(y_a))} = -\frac{1}{1+\frac{1}{\varepsilon}}\ \omega_0(y_a)\ \frac{1}{1 - T_0'(y_a)} \ . \tag{A.7}$$

We can now use (A.7) to substitute for $\frac{y_{0\tau}(\omega_0(y_a))}{y_{0\omega}(\omega_0(y_a))}$ in (A.5). This yields

$$R_{\tau\ell}(0,0,y_a) \quad = \quad -\tfrac{T_0'(y_a)}{1-T_0'(y_a)}\, f(\omega_0(y_a))\, \omega_0(y_a)\, \tfrac{1}{1+\frac{1}{\varepsilon}} + 1 - F(\omega_0(y_a))\,. \tag{A.8}$$

Proof of (1.). It follows from (A.4) that $R_\tau(0,0,y_a) = 0$: a small change of marginal tax rates has no effect on overall tax revenue if the change applies to a bracket with length 0. If $R_{\tau\ell}(0,0,y_a) > 0$, then a slight increase of the bracket length implies that $R_\tau(0,\ell,y_a)$ turns positive – indicating a possible to increase revenue by means of higher marginal tax rates. Analogously, $R_{\tau\ell}(0,0,y_a) < 0$ implies that revenue can be increased by means of lower marginal tax rates. Thus, if $R_{\tau\ell}(0,0,y_a) < 0$ there is a possibility of a Pareto-improving tax cut. From (A.8) it is now straightforward to verify that $R_{\tau\ell}(0,0,y_a) < 0$ holds if and only if (8) holds.

Proof of (2.). A Pareto-improving tax raise requires that $R_\tau(0,\ell,y_a) - \ell \geq 0$. Again, it follows from (A.4) that $R_\tau(0,\ell,y_a) - l = 0$ for $l = 0$. If however, $R_{\tau\ell}(0,0,y_a) - 1 > 0$ then a slight increase of the bracket length implies that $R_\tau(0,\ell,y_a) - \ell$ turns positive. From (A.8) it is now straightforward to verify that $R_{\tau\ell}(0,0,y_a) - 1 > 0$ holds if and only if (9) holds.

A.5 A characterization of welfare-improving tax reforms

The welfare implications of a generic reform (τ, h) are given by

$$W(\tau,h) := \int_{\underline{\omega}}^{\overline{\omega}} g(\omega)\; V(\tau,h,\omega) f(\omega)\; d\omega\,.$$

We assume without loss of generality that $\mathbb{E}[g(\omega)] = 1$. Using the envelope theorem, the marginal effect of a small reform is given by

$$W_\tau(0,h) = R_\tau(0,h) - \int_{\underline{\omega}}^{\overline{\omega}} g(\omega)\; h(y_0(\omega))\; f(\omega)\; d\omega\,.$$

For the special case of a simple reform (τ, ℓ, y_a) this becomes

$$\begin{aligned} W_\tau(0,\ell,y_a) \quad = \quad & R_\tau(0,\ell,y_a) \\ & - \int\limits_{\omega_0(y_a)}^{\omega_0(y_a+\ell)} g(\omega)\;\; (y_0(\omega) - y_a)\;\; f(\omega)\; d\omega \\ & -\ell\;\; (1 - F(\omega_0(y_a+\ell)))\;\; \mathcal{G}(\omega_0(y_a+\ell)) \end{aligned}\,.$$

Taking the derivative with respect to ℓ and evaluating at $\ell = 0$ yields

$$W_{\tau\ell}(0,0,y_a) = R_{\tau\ell}(0,0,y_a) - (1 - F(\omega_0(y_a)))\;\; \mathcal{G}(\omega_0(y_a))$$

Using equation (A.8) this can also be written as

$$\begin{aligned} W_{\tau\ell}(0,0,y_a) \quad = \quad & -\tfrac{T_0'(y_a)}{1-T_0'(y_a)}\; f(\omega_0(y_a))\; \omega_0(y_a)\; \left(1 + \tfrac{1}{\varepsilon}\right)^{-1} \\ & + (1 - F(\omega_0(y_a)))\;\; (1 - \mathcal{G}(\omega_0(y_a))) \end{aligned}\,.$$

Since $W_\tau(0,0,y_a)=0$, $W_{\tau\ell}(0,0,y_a)>0$ indicates that $W_\tau(0,\ell,y_a)>0$ for ℓ close to zero. Hence, when

$$\frac{T_0'(y_a)}{1-T_0'(y_a)} < \frac{1-F(\omega_0(y_a))}{f(\omega_0(y_a))\,\omega_0(y_a)}\left(1+\frac{1}{\varepsilon}\right)(1-\mathcal{G}(\omega_0(y_a))) \tag{A.9}$$

a small tax increase for incomes close to y_a yields a welfare gain. Analogously, when

$$\frac{T_0'(y_a)}{1-T_0'(y_a)} > \frac{1-F(\omega_0(y_a))}{f(\omega_0(y_a))\,\omega_0(y_a)}\left(1+\frac{1}{\varepsilon}\right)(1-\mathcal{G}(\omega_0(y_a))) \tag{A.10}$$

a small tax cut for incomes close to y_a yields a welfare gain.

B Welfare-maximizing tax schedules

B.1 Preliminaries

We use a mechanism design approach to characterize welfare-maximizing income taxes. With an appeal to the revelation principle we limit attention to direct mechanisms. Let $c:\omega\mapsto c(\omega)$ and $y:\omega\mapsto y(\omega)$ be the functions that specify the pre- and after-tax incomes of individuals as functions of their types. Let

$$u(\omega)=c(\omega)-k(y(\omega),\omega)\quad\text{with}\quad k(y(\omega),\omega)=\frac{1}{1+\frac{1}{\varepsilon}}\left(\frac{y(\omega)}{\omega}\right)^{1+\frac{1}{\varepsilon}}\ ,$$

be the utility realized by a type ω-individual under the direct mechanism.

As is well-known, such a direct mechanism is incentive compatible if and only if the following two conditions are satisfied: First,

$$u(\omega)=\underline{u}-\int_{\underline{\omega}}^{\omega}k_2(y(s),s)ds\ , \tag{B.1}$$

where $\underline{u}=u(\underline{\omega})$ is a shorthand for the utility realized by the lowest type, and k_2 is the derivative of the cost function k with respect to its second argument. With an isoelastic cost function

$$k_2(y(\omega),\omega)=-\frac{1}{\omega}\left(\frac{y(\omega)}{\omega}\right)^{1+\frac{1}{\varepsilon}}\ .$$

Second, the function y is non-decreasing.

The resource constraint requires that aggregate consumption must not exceed aggregate production

$$\mathbb{E}[c(\omega)]\leq\mathbb{E}[y(\omega)]\ ,$$

where the expectations operator $\mathbb{E}$ indicates the computation of a population average; e.g. $\mathbb{E}[c(\omega)]=\int_{\underline{\omega}}^{\overline{\omega}}c(\omega)\ f(\omega)\ d\omega$. Using that

$$\begin{aligned} c(\omega) &= u(\omega)+k(y(\omega),\omega)\\ &= \underline{u}-\textstyle\int_{\underline{\omega}}^{\omega}k_2(y(s),s)ds+k(y(\omega),\omega) \end{aligned}$$

and with an integration by parts we can write aggregate consumption also as

$$\mathbb{E}[c(\omega)] = \underline{u} + \mathbb{E}[k(y(\omega), \omega)] - \mathbb{E}\left[\frac{1 - F(\omega)}{f(\omega)}\ k_2(y(\omega), \omega)\right] .$$

Upon substituting this expression into the resource constraint, we find that resource feasibility holds provided that

$$\underline{u} \quad \leq \quad \mathbb{E}\left[y(\omega) - k(y(\omega), \omega) + \frac{1 - F(\omega)}{f(\omega)}\ k_2(y(\omega), \omega)\right] . \tag{B.2}$$

The term on the right hand side of (B.2) is also known as the virtual surplus. It is the regular surplus of aggregate output over effort costs, $\mathbb{E}[y(\omega) - k(y(\omega), \omega)]$ minus the information rents that higher types realize in the presence of incentive constraints and which are given by $-\mathbb{E}\left[\frac{1-F(\omega)}{f(\omega)} k_2(y(\omega), \omega)\right] > 0$. Thus, resource feasibility requires that the lowest type's utility does not exceed the virtual surplus.

We consider a class of additive social welfare functions

$$S = \mathbb{E}[g(\omega)\ u(\omega)]$$

and assume without loss of generality that $\mathbb{E}[g(\omega)] = 1$. Using (B.1), and after another integration by parts, welfare can be written as

$$S = \underline{u} - \mathbb{E}\left[\frac{1 - F(\omega)}{f(\omega)}\ \mathcal{G}(\omega)\ k_2(y(\omega), \omega)\right] , \tag{B.3}$$

where $\mathcal{G}(\omega) := \mathbb{E}[g(s) \mid s \geq \omega]$ is the average welfare weight among those with a type above ω. At an optimal allocation, the resource constraint (B.2) holds as an equality. Thus, welfare can also be written as

$$S = \mathbb{E}\left[y(\omega) - k(y(\omega), \omega) + \frac{1 - F(\omega)}{f(\omega)}\ (1 - \mathcal{G}(\omega))\ \ k_2(y(\omega), \omega)\right] . \tag{B.4}$$

B.2 Optimal mechanism design and optimal taxation

We can state the mechanism design problem now as one that only involves the function $y : \omega \mapsto y(\omega)$. This function has to be chosen so as to maximize the objective (B.4) subject to the constraint that its derivative y' is everywhere non-negative. This problem is also known as the *full* problem. When the monotonicity constraint is dropped, the problem is referred to as the *relaxed* problem. Obviously, if the solution to the relaxed problem satisfies the monotonicity constraint then it is also a solution to the full problem. If not, the the solution of the full problem involves bunching, i.e. subsets of types who choose the same level of income. For ease of exposition, we focus on the relaxed problem in what follows. It is well known how the resulting optimal tax formulas need to be modified if bunching is an issue, see e.g. Hellwig (2007).

Note that, once y is determined by the optimality conditions, we can use (B.2) and the fact that the resource constraint binds to solve for $\underline{u}$. We can use (B.1) to solve for the function u. And finally, we can use the fact that $c(\omega) = u(\omega) + k(y(\omega), \omega)$ to characterize the function c. Thus, we obtain a complete characterization of an optimal allocation.

A solution to the relaxed problem is obtained by a pointwise maximization of (B.4). The first order condition characterizing $y(\omega)$ is given by

$$1 - k_1(y(\omega), \omega) + \frac{1 - F(\omega)}{f(\omega)} (1 - \mathcal{G}(\omega))\, k_{21}(y(\omega), \omega) = 0, \tag{B.5}$$

where k_1 is the derivative of the cost function k with respect to its first argument and k_{21} is the cross-derivative with respect to the first and the second argument. With an isoelastic cost function

$$k_{21}(y(\omega), \omega) = -\left(1 + \frac{1}{\varepsilon}\right) \frac{1}{\omega}\, k_1(y(\omega), \omega)$$

so that the first order condition can also be written as

$$\frac{1 - k_1(y(\omega), \omega)}{k_1(y(\omega), \omega)} = \frac{1 - F(\omega)}{f(\omega)\ \omega} \left(1 + \frac{1}{\varepsilon}\right) (1 - \mathcal{G}(\omega)) \ . \tag{B.6}$$

Suppose that the welfare-maximizing allocation is decentralized by means of a non-linear income tax schedule T. Then, type ω solves the following problem:

$$max_y \quad y - T(y) - k(y, \omega) \ .$$

Denote the solution to this problem by $y^*(\omega)$. It is characterized by the first order condition

$$1 - T'(y^*(\omega)) = k_1(y^*(\omega), \omega)$$

As $y^*(\omega)$ is also the solution to the mechanism design problem, the first order condition in (B.6) can now be written as

$$\frac{T'(y^*(\omega))}{1 - T'(y^*(\omega))} = \frac{1 - F(\omega)}{f(\omega)\ \omega} \left(1 + \frac{1}{\varepsilon}\right) (1 - \mathcal{G}(\omega)) \ . \tag{B.7}$$

Equation (B.7) is also known as Diamond's formula, see Diamond (1998). It shows that marginal taxes on the income earned by type ω are increasing in the inverse hazard rate, decreasing in the elasticity ε and decreasing in the welfare weight of individuals richer than type ω.

The Rawlsian schedule. The Rawlsian schedule is the special case with $\mathcal{G}(\omega) = 0$, for all $\omega > \underline{\omega}$. In this case the, the first order condition in (B.7) becomes

$$\frac{T'(y^*(\omega))}{1 - T'(y^*(\omega))} = \frac{1 - F(\omega)}{f(\omega)\ \omega} \left(1 + \frac{1}{\varepsilon}\right) \ . \tag{B.8}$$

The Rawlsian tax schedule is also often referred to as the *maxi-min schedule*. It is the schedule that maximizes $\underline{u}$, the well-being of the worst off individual, i.e. of type $\underline{\omega}$.

B.3 The maxi-max schedule

The maxim-max schedule is the one that maximizes the well-being of the best off individual, i.e. of type $\overline{\omega}$. Since the welfare weights are now concentrated at the top, this can now longer be viewed as a special case of social welfare-maximization with weights that are higher for poorer people. This case is still of interest as it helps to interpret the lower Pareto bound for marginal tax rates in the main text, and therefore the scope for politically feasible reforms. We present a derivation of the maxi-max schedule along lines that are similar to our characterization of welfare-maximizing tax schedules above. An alternative derivation can be found in Brett and Weymark (2017).

The envelope theorem implies, that under an incentive compatible allocation,

$$u'(\omega) = -k_2(y(\omega), \omega) \ .$$

Therefore

$$u(\omega) = \overline{u} + \int_{\omega}^{\overline{\omega}} k_2(y(s), s) \ ds \ ,$$

where $\overline{u} := u(\overline{\omega})$ is a shorthand for the utility realized by the highest type.

Using $c(\omega) = u(\omega) + k(y(\omega), \omega)$ and after an integartion by parts we can write aggregate consumption as

$$\mathbb{E}[c(\omega)] = \overline{u} + \mathbb{E}[k(y(\omega, \omega))] + \mathbb{E}\left[\frac{F(\omega)}{f(\omega)} \ k_2(y(\omega), \omega)\right] \ .$$

Substituting this expression into the resource constraint and rearranging yields

$$\overline{u} = \mathbb{E}\left[y(\omega) - k(y(\omega, \omega)) - \frac{F(\omega)}{f(\omega)} \ k_2(y(\omega), \omega)\right] \tag{B.9}$$

The (relaxed) maxi-max problem is to choose the function y so as to maximize this expression. Pointwise maximization yields the following first order condition

$$1 - k_1(y(\omega), \omega) - \frac{F(\omega)}{f(\omega)} \ k_{21}(y(\omega), \omega) = 0 \ .$$

Using one more time that, with an isoelastic cost function,

$$k_{21}(y(\omega), \omega) = -\left(1 + \frac{1}{\varepsilon}\right) \ \frac{1}{\omega} \ k_1(y(\omega), \omega)$$

allows to rewrite the first order condition as

$$\frac{1 - k_1(y(\omega), \omega)}{k_1(y(\omega), \omega)} = -\frac{F(\omega)}{f(\omega) \ \omega}\left(1 + \frac{1}{\varepsilon}\right) \ . \tag{B.10}$$

Again, if this solution is decentralized by means of an income tax schedule, then

$$\frac{T'(y^*(\omega))}{1 - T'(y^*(\omega))} = -\frac{F(\omega)}{f(\omega) \ \omega}\left(1 + \frac{1}{\varepsilon}\right) \ . \tag{B.11}$$

where $y^*(\omega)$ is now the income earned by type ω under the maxi-max schedule.

C From theory to data

In our empirical analysis in Section 6, we check to what extent actual tax reforms are monotonic. We also provide an answer to the question whether the median voter actually was a beneficiary of these reforms. Here, we describe in more detail how we operationalize these questions.

Suppose that there is a set of individuals and that, for each individual i, we observe taxable income y_0^i prior to the reform. We also observe the average tax rate t_0^i and the marginal tax rate τ_0^i that are relevant for this individual prior to the reform. Finally, we observe the post-reform counterparts t_1^i and τ_1^i.

Monotonicity. Checking to what extent reforms are monotonic then amounts to checking whether, for any pair of individuals i and j, $y_0^i < y_0^j$ implies $(t_1^i - t_0^i)y_0^i < (t_1^j - t_0^j)y_0^j$. If this relation holds, then the reform is monotonic in the sense that the tax burden of richer individuals increases more than the tax burden of poorer individuals. Alternatively, if $y_0^i < y_0^j$ implies $(t_1^i - t_0^i)y_0^i > (t_1^j - t_0^j)y_0^j$, then the reform is monotonic as the additional taxes of poorer individuals exceed those of richer individuals. In Section X we report on the extent to which we find such relations in our data.

Did the median voter gain? Checking whether the median voter gained requires an assessment of whether or not the inequality

$$R(\tau, h) - \int_0^\tau h(y^*(s, h, \omega^M))\, ds \geq 0$$

holds true. Remember that $R(\tau, h)$ is the revenue (per capita) generated by the reform and $\int_0^\tau h(y^*(s, h, \omega^M))\, ds$ is the reform's effect on the median voter's indirect utility. As shown in Section 4, a sufficient condition which ensures that this inequality holds is that

$$R(\tau, h) - \max\left\{(t_1^M - t_0^M)\, y_1^M, (t_1^M - t_0^M)\, y_0^M\right\} \quad \geq \quad 0\,, \tag{C.1}$$

where t_1^M and t_0^M are, respectively, the average tax rates for the median voter after the reform and in the status quo.

Revenue effect. For the revenue effect, we compute the revenue change for each individual separately and then take an average. The revenue change due to individual i is

$$R^i = t_1^i\, y_1^i - t_0^i\, y_0^i\,, \tag{C.2}$$

where y_1^i is the individual's income after the reform. In the presence of behavioral responses y_1^i will usually be different from y_0^i. We do not observe y_1^i and hence have to come up with an estimate for this quantity.

Our assumptions on preferences imply that behavioral responses are driven entirely by changes of the marginal tax rates that individuals face. Thus, using a first order Taylor approximation,

$$y_1^i = y_0^i + (\tau_1^i - \tau_0^i)\; y_\tau^i \;,$$

where y_τ^i is the marginal effect that an infinitesimal change of the marginal tax rate has on i's taxable income (in the status quo). Using that $y_\tau^i = -y_{1-\tau}^i$, we can express this also via the marginal effect associated with a change of the net of tax rate $1-\tau$. Hence,

$$y_1^i = y_0^i - (\tau_1^i - \tau_0^i)\; y_{1-\tau}^i \;,$$

Using the definition of the ETI, $\varepsilon^i := y_{1-\tau}^i \,\frac{1-\tau_0^i}{y_0^i}$, we can rewrite this as well as

$$y_1^i = \left(1 - \frac{\tau_1^i - \tau_0^i}{1-\tau_0^i}\;\varepsilon^i\right) y_0^i \;.$$

Upon substituting this expression into (C.2) we obtain

$$R^i = \left(t_1^i - t_0^i - t_1^i \frac{\tau_1^i - \tau_0^i}{1-\tau_0^i}\varepsilon^i\right) y_0^i \;, \tag{C.3}$$

The revenue effect per capita is then given by

$$R(\tau, h) = \frac{1}{n}\sum_i R^i \;, \tag{C.4}$$

where n is the number of individuals.

Did the median voter gain? To answer this question, we check whether or not

$$R(\tau, h) - \max\left\{ (t_1^M - t_0^M)\left(1 - \frac{\tau_1^M - \tau_0^M}{1-\tau_0^M}\;\varepsilon^M\right) y_0^M, (t_1^M - t_0^M)\; y_0^M \right\} \quad \geq \quad 0\;. \tag{C.5}$$

This inequality follows from (C.1) upon replacing y_1^M by

$$\left(1 - \frac{\tau_1^M - \tau_0^M}{1-\tau_0^M}\;\varepsilon^M\right) y_0^M \;,$$

where τ_1^M and τ_0^M are, respectively, the marginal tax rates for the median voter after the reform and in the status quo, and ε^M is the median voter's elasticity of taxable income.

D Tax reforms in OECD countries

We provide more details on the descriptive statistics in the main text that document the frequency of monotonic reforms in OECD countries, see Table 2.

The OECD provides annual data on key parameters of the statutory personal income tax systems of its member countries (central governments).[1] In particular, it documents

[1]The database provided by the OECD is Table I.1. Central government personal income tax rates and thresholds accessible on $http://stats.oecd.org/Index.aspx?DataSetCode = TABLE_I1$.

personal income tax rates for wage income and the taxable income thresholds at which these statutory rates apply. The information is applicable for a single person without dependents. We use this information to construct the corresponding tax function. A reform takes place if this tax function changes from one year to the next. The OECD also reports personal allowances and tax credits, and we include these parameters in our tax functions. In many countries these allowances are equivalent to having a first bracket with a marginal tax rate of zero, see, for instance, Belgium, Estonia, Japan, Spain, the United Kingdom, or the United States. In other countries tax credits are equivalent to a first bracket with a marginal tax rate of zero, see, for instance, the Czech Republic, Italy, or the Netherlands.[2] In the supplementary material for this paper we present separate statistics for different OECD countries. More specifically, the following countries are covered: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. We excluded Slovenia because of an inconsistency in the OECD database for this country and Germany because of an incorrect representation of the German tax system in the OECD database.[3]

E Empirical analysis: Additional results

[2]Additional details on the methodology applied by the OECD is accessible on *http://www.oecd.org/ctp/tax-policy/personal-income-tax-rates-explanatory-annex.pdf*.

[3]By and large, this does not affect the overall frequency of monotonic reforms. If we include Germany and base the analysis on data from the German Federal Ministry of Finance, accessible on *https://www.bmf-steuerrechner.de/index.xhtml;jsessionid=46D8EC6083BF2573A42C23A2B03B49DF*, then 80% of the reforms in OECD countries are found to be monotonic. When Germany is excluded the number is 78%.

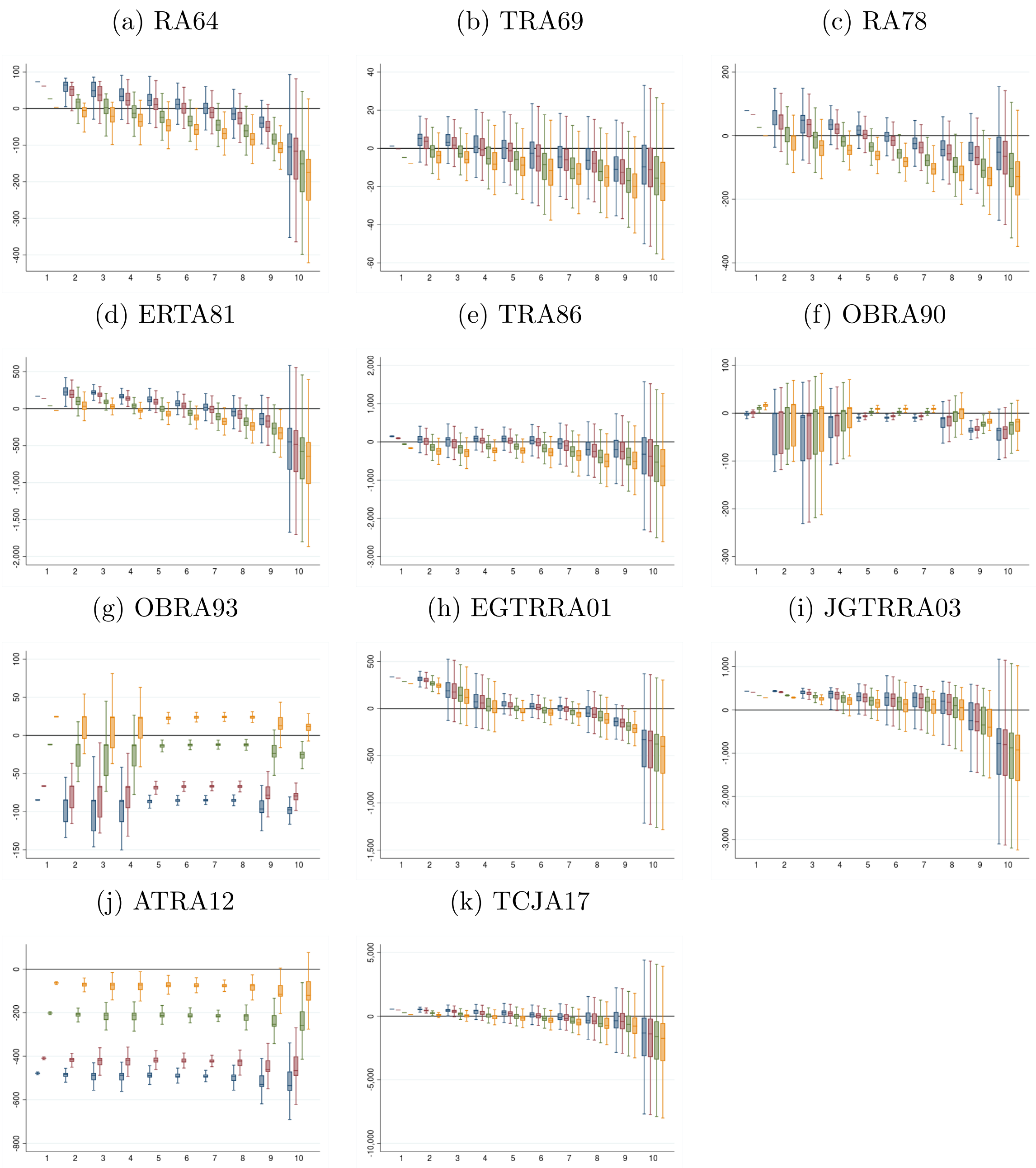


Figure E.1: Winners and losers of major US tax reforms: Heterogeneity within deciles

Notes: Figure E.1 shows the cross-sectional distribution by decile of the counterfactual change in tax liability $T_1(\hat{y}_0^i) - T_0(y_0^i) - R(\tau, h)$ for reforms of the US federal personal income tax (see Table H.1 for details) for four different values of the elasticity of taxable income (ETI): 0 (blue), 0.25 (red), 1 (green) and 1.5 (yellow), by means of box-plots. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

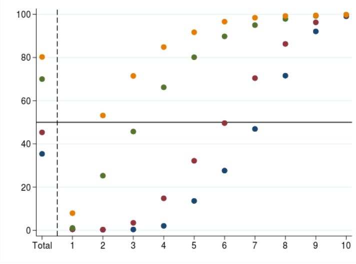
Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

Figure E.2: Shares of winners and losers by decile

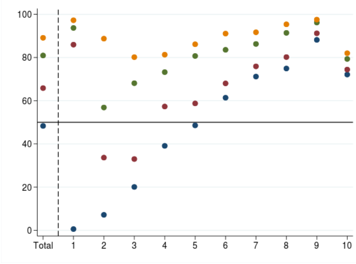
Notes: Figure E.2 shows the shares of reform winners (green) versus reform losers (losers) for major reforms of the US federal personal income tax (see Table H.1 for details), by income decile and for four different values of the elasticity of taxable income (ETI): 0, 0.25, 1 and 1.5 (from left to right). The first four bars ("Total") show the shares for the full population. The first bar shows the shares for the full population. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

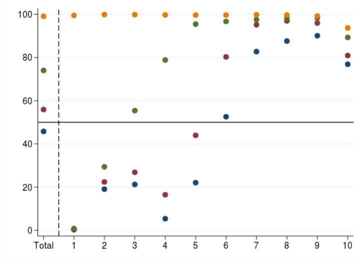
(a) RA64



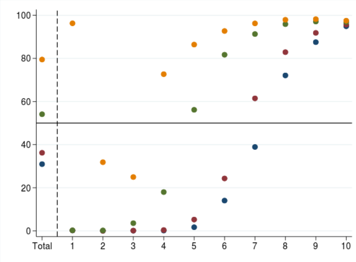
(b) TRA69



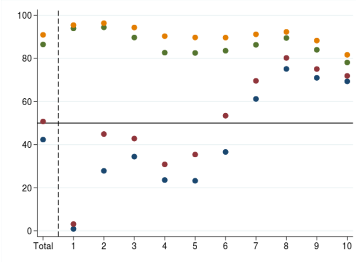
(c) RA78



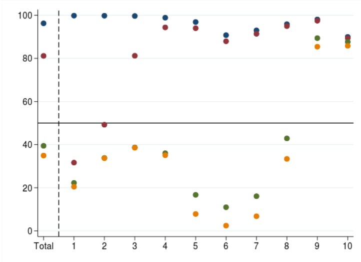
(d) ERTA81



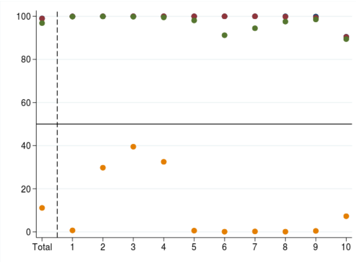
(e) TRA86



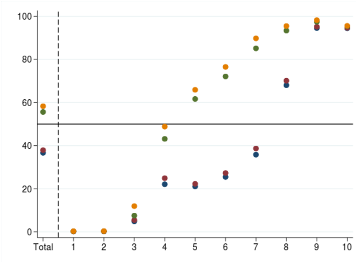
(f) OBRA90



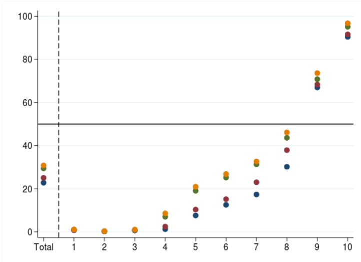
(g) OBRA93



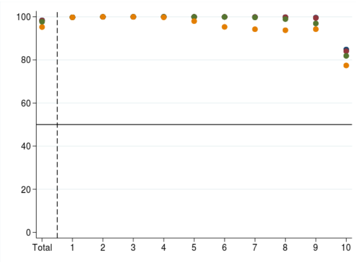
(h) EGTRRA01



(i) JGTRRA03



(j) ATRA12



(k) TCJA17

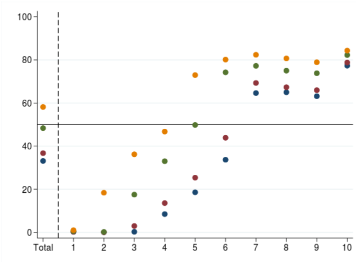


Figure E.3: Shares of winners by decile

Notes: Figure E.3 shows the shares of reform winners for major reforms of the US federal personal income tax (see Table H.1 for details), by income decile and for four different values of the elasticity of taxable income (ETI): 0 (blue), 0.25 (red), 1 (green) and 1.5 (yellow). The first four dots ("Total") show the shares for the full population. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

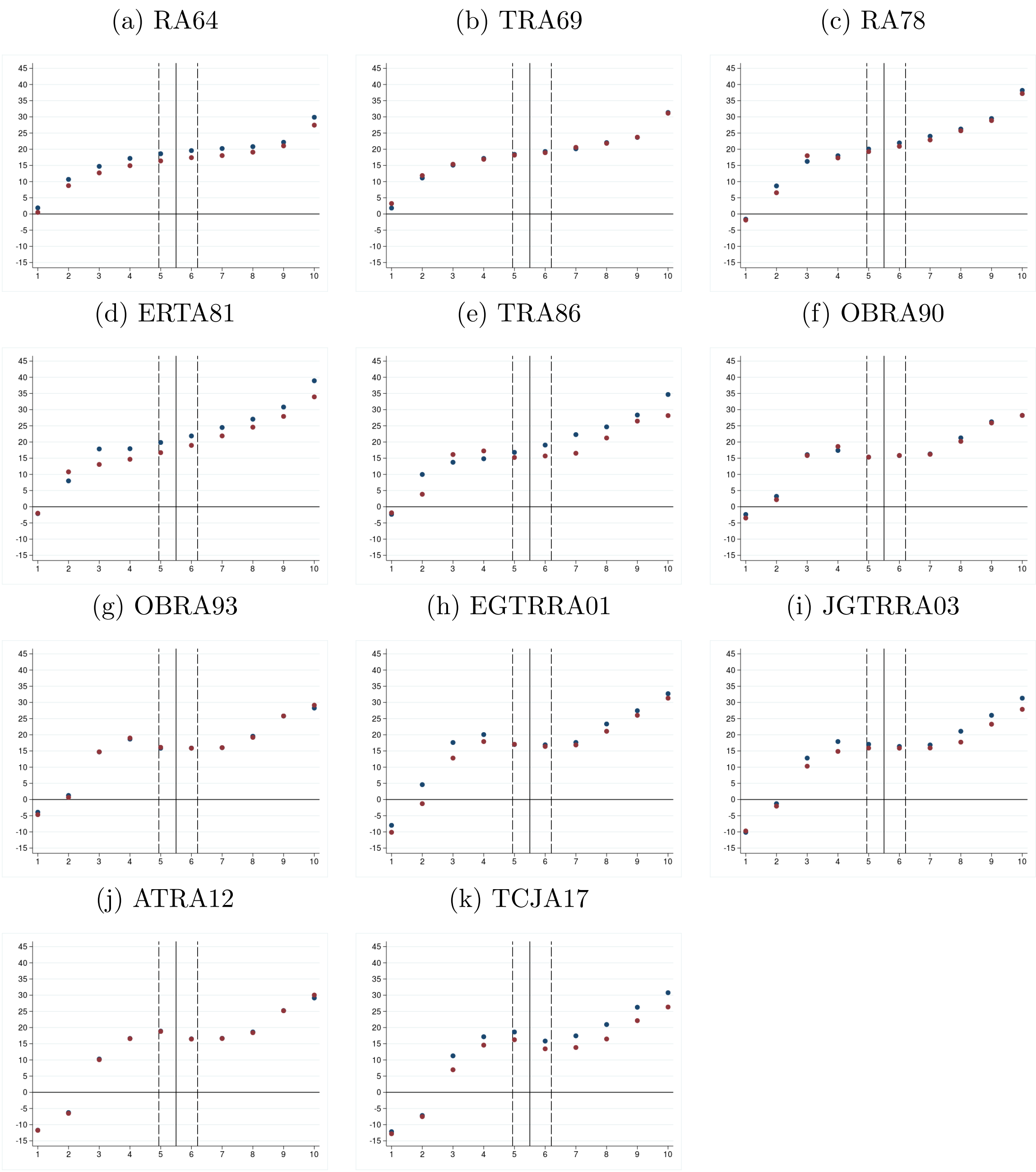


Figure E.4: Effective marginal tax rates by decile before and after each reform

Notes: Figure E.4 shows, separately for each decile effective marginal tax rates (EMTRs) T' before (blue) and after (red) major reforms of the US federal personal income tax (see Table H.1 for details). Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

F Empirical analysis: Sensitivity checks

In this section, we conduct sensitivity checks of our empirical results with respect to several choices made. More precisely, we reproduce Figure 2 with the following variations:

(i) Tax units (instead of equal split couples) – see Figure F.1;

(ii) Statutory tax rates (instead of effective tax rates) – see Figure F.2;

(iii) Different bin sizes (50 instead of 10) – see Figure F.3;

(iv) Different income definitions: gross income including capital gains (see Figure F.4) and adjusted gross income (see Figure F.5), respectively;

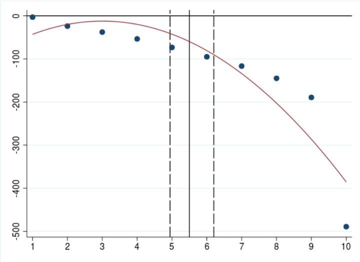
(v) Including state-level and payroll taxes – see Figure F.6.

To preview the findings below: Figures F.1 – F.6 reveal the same message as Figure 2, namely that reforms are by and large monotonic. The main differences are reported below. Given that the value of $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ depicted in these Figures is the key ingredient for all other computations, it is not surprising that these sensitivity checks also do not affect the other figures reported in the paper. For brevity reasons, we refrain from showing these variations here but they are available upon request.

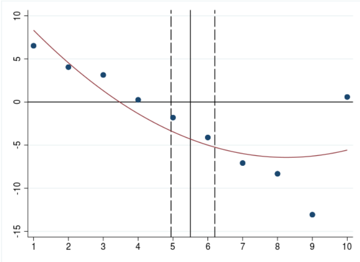
An interesting observation for TRA69 and RA78 is that the effects reported in Figure F.2 based on statutory tax rates differ from using effective tax rates instead as in Figure 2: this shows the importance of accounting for tax base changes. The same is true for other reforms albeit to a smaller extend. This shows the importance of using a micro data based microsimulation approach for the evaluation of tax reforms.

As reported in Figure F.6, the monotonicity pattern is different when we include state-level and payroll taxes for the three oldest reforms only (RA64, TRA69, RA78).

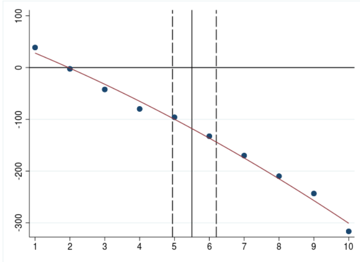
(a) RA64



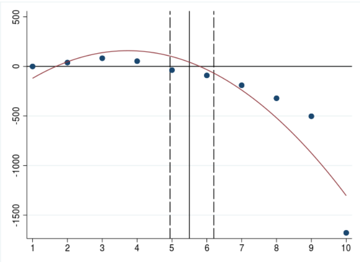
(b) TRA69



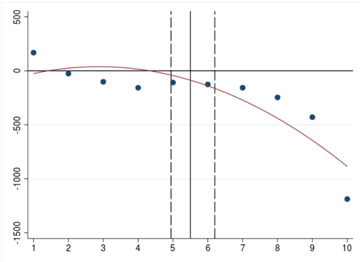
(c) RA78



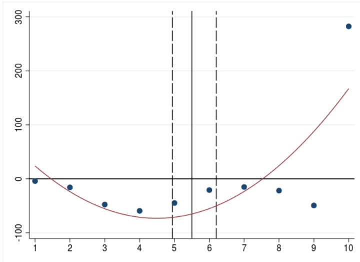
(d) ERTA81



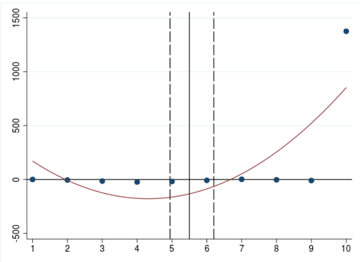
(e) TRA86



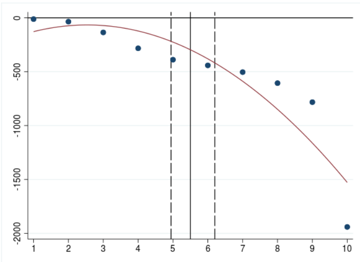
(f) OBRA90



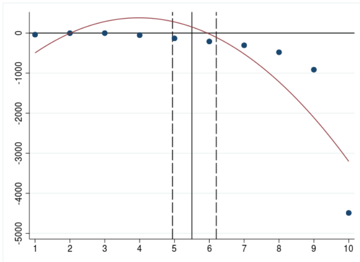
(g) OBRA93



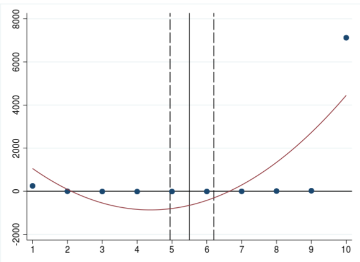
(h) EGTRRA01



(i) JGTRRA03



(j) ATRA12



(k) TCJA17

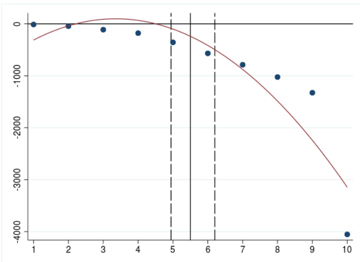


Figure F.1: Changes in tax liability: Average values per tax unit decile

Notes: Figure F.1 replicates Figure 2 with tax units instead of individual taxpayers. It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income decile. The red line represents a quadratic fit based on the underlying micro data. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the tax unit level. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

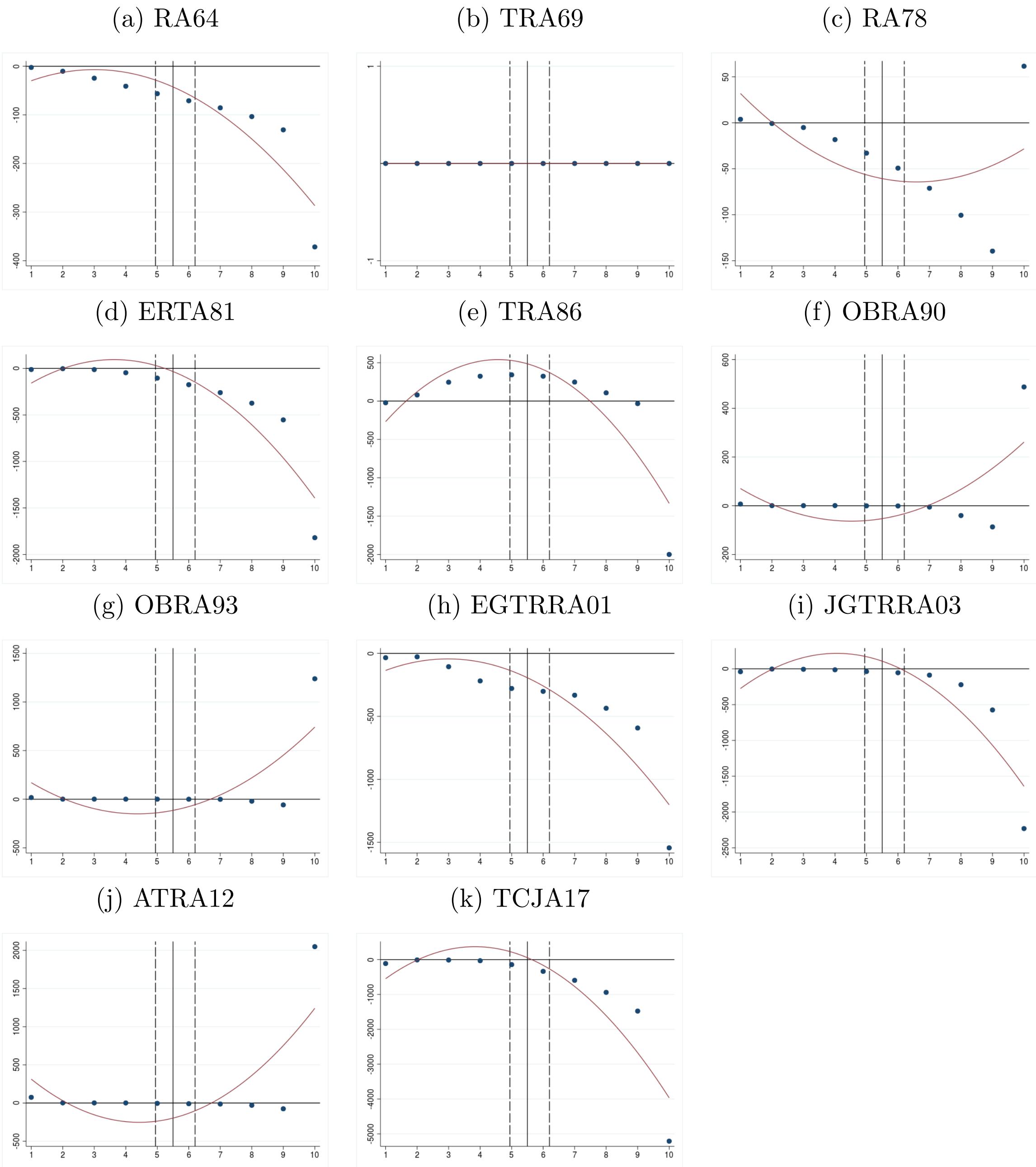


Figure F.2: Changes in statutory tax liability: Average values per decile

Notes: Figure F.2 replicates Figure 2 using statutory tax rates instead of effective tax rates. It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income decile. The red line represents a quadratic fit based on the underlying micro data. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

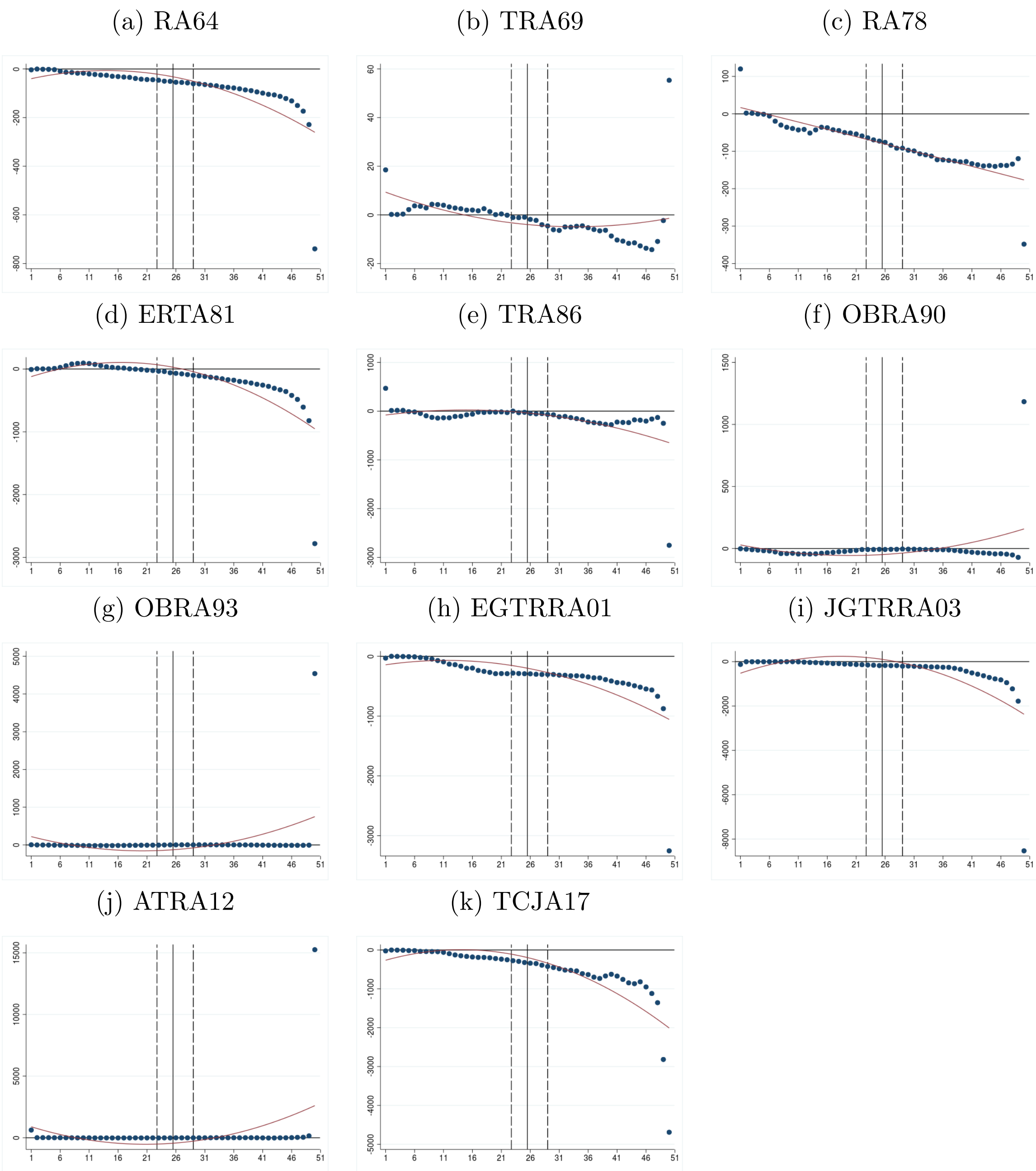


Figure F.3: Changes in tax liability: Average values per 50 income bins

Notes: Figure F.3 replicates Figure 2 using 50 income bins instead of deciles. It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income bin. The red line represents a quadratic fit based on the underlying micro data. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

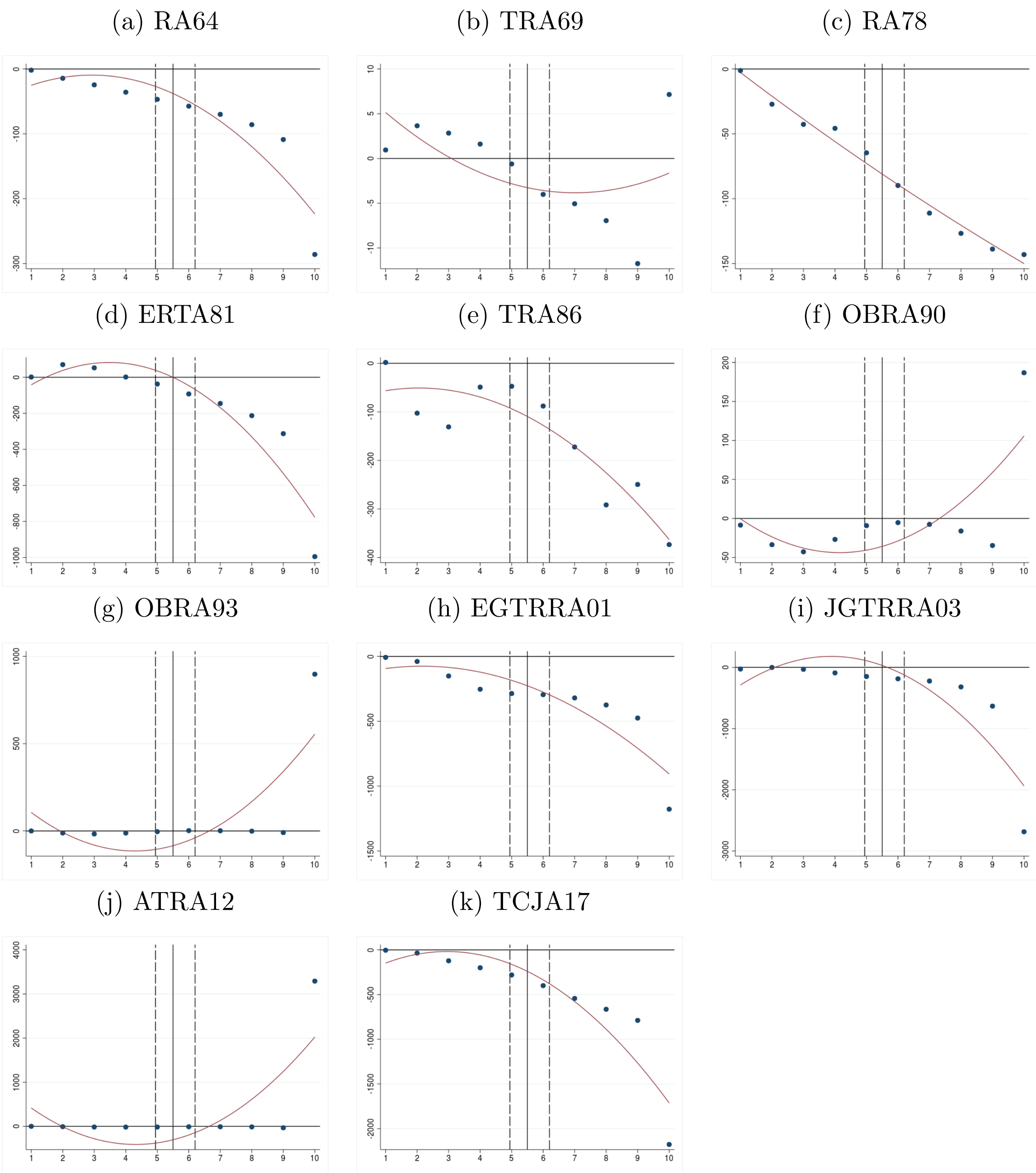


Figure F.4: Changes in tax liability including capital gains: Average values per decile

Notes: Figure F.4 replicates Figure 2 using deciles including capital gains. It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income bin. The red line represents a quadratic fit based on the underlying micro data. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

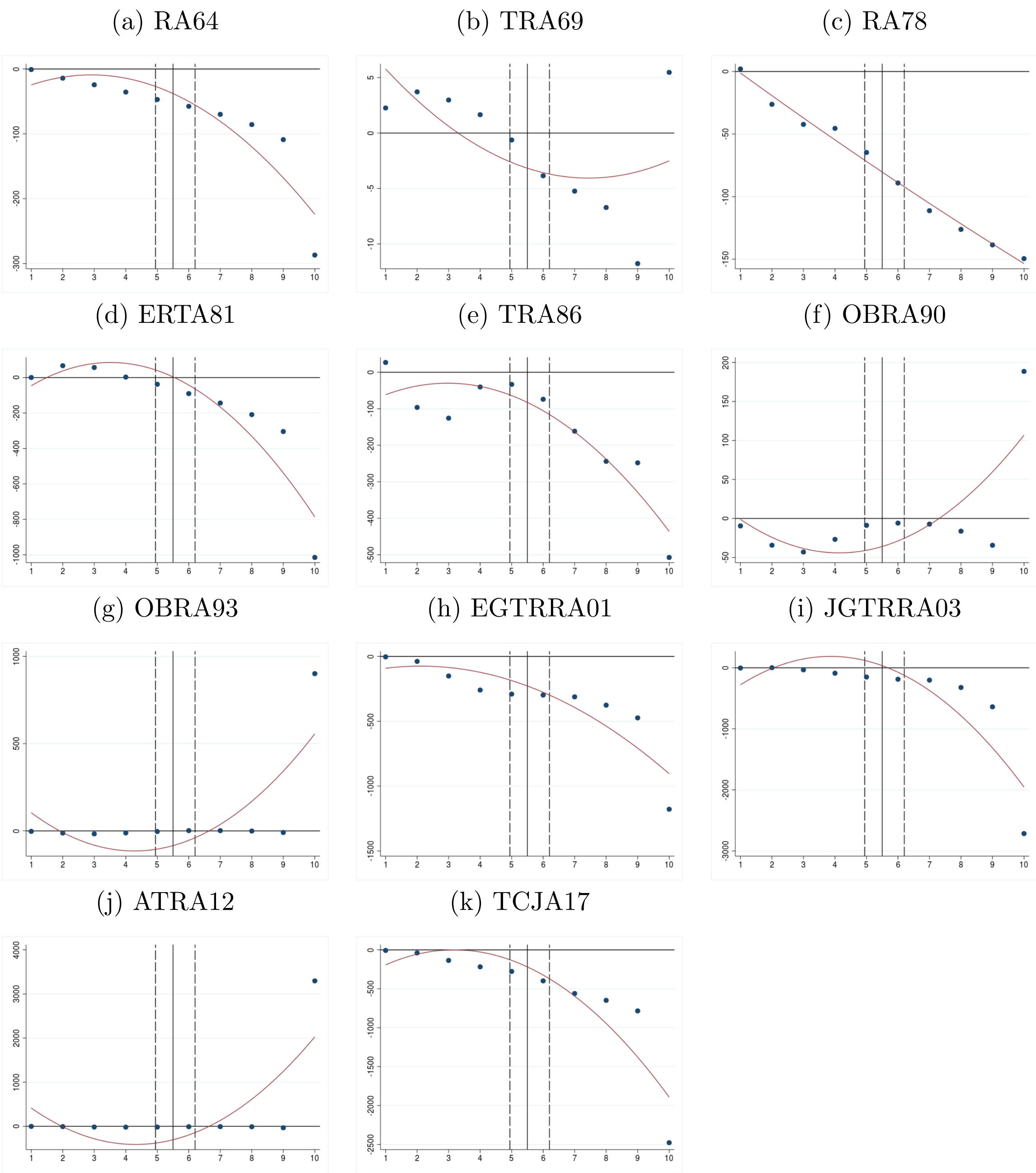


Figure F.5: Changes in tax liability: Average values per adjusted gross income decile

Notes: Figure F.5 replicates Figure 2 using deciles based on adjusted gross income (AGI). It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income bin. The red line represents a quadratic fit based on the underlying micro data. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

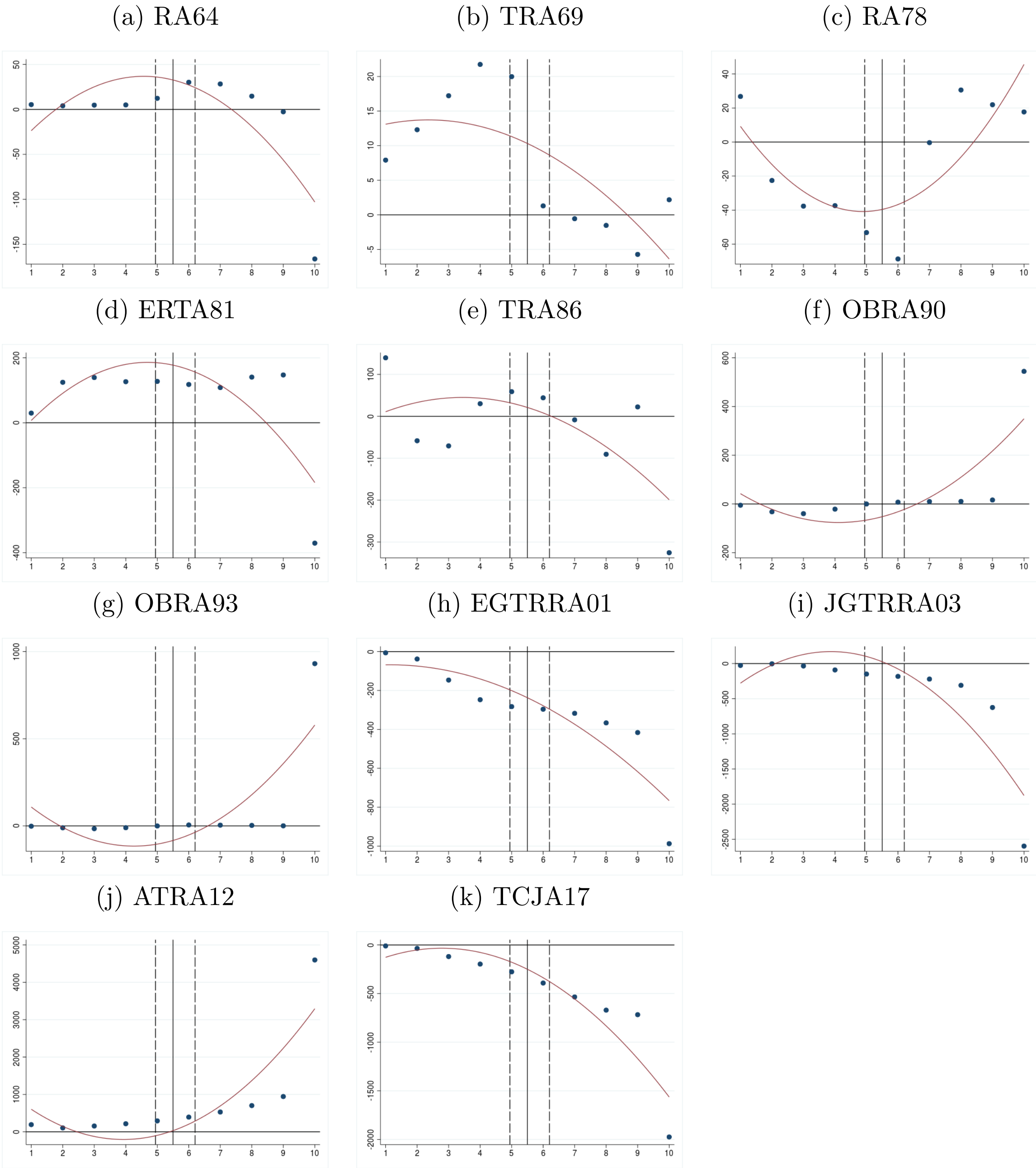


Figure F.6: Changes in tax liability including state-level and payroll taxes: Average values per decile

Notes: Figure F.6 replicates Figure 2 by including state-level and payroll taxes. It shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reforms of the US federal personal income tax (see Table H.1 for details) by income bin. The red line represents a quadratic fit based on the underlying micro data. Deciles are computed based on pre-tax income without capital gains while tax base includes capital gains. All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor. The vertical lines show different locations for the median voter: the dashed line to the left imputes non-filers to the tax return data while the dashed line to the right accounts for differential turnout by income. The solid line in the middle represents both the original median in the data as well as the one accounting for both modifications simultaneously.

Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

	Correlation	Rank Correlation
RA64	0.829	0.957
TRA69	0.270	0.765
RA78	0.318	0.716
ERTA81	0.641	0.871
TRA86	0.681	0.794
OBRA90	0.931	0.836
OBRA93	0.952	0.828
EGTRRA01	0.820	0.842
JGTRRA03	0.853	0.887
ATRA12	0.855	0.845
TCJA17	0.741	0.857

Table F.1: Monotonicity of reforms – correlation analysis

Notes: This table shows the (rank) correlation between the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ (see Figure 2) and pre-tax income for reforms of the US federal personal income tax (see Table H.1 for details). All computations are on the individual level. For this, the income of couples filing jointly is allocated equally to each spouse. In order to simulate counterfactual tax payments $T_1\left(\hat{y}_0^i\right)$, income from year 0 are inflated to year 1 using the CPI-U-RS deflator as uprating factor.
Source: Authors' calculations based on NBER TAXSIM and IRS-SOI PUF.

G Tax Reform Proposals

In order to answer the question whether the finding that tax reforms are, by and large, monotonic, extends to tax reforms proposals which are publicly debated, but not enacted, we invoke the systematic analysis of reform proposals in the US that is provided by the Tax Policy Center. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center's webpage.[4]

We identified 69 reform proposals that were made in the period 2003-2019: some proposals were made during presidential campaigns and primaries, others were proposed by the Administration during the legislative process. Figures G.1 – G.8 and Tables G.1 – G.8 below synthesize the Tax Policy Center's ex-ante analyses of the absolute (dollar) tax payment changes by income quantiles of reform proposals of the federal personal income tax between 2003 and 2019. All tables provide a code corresponding to the source document from the Tax Policy Center, the year of the projection, the type of taxes underlying the analysis and the employed baseline. The selection criteria for the

[4] See, e.g, for TCJA17 `https://www.taxpolicycenter.org/model-estimates/individual-income-tax-provisions-tax-cuts-and-jobs-act-tcja-february-2018/t18-0024`.

proposals/reforms were that (1) they concern personal income taxes, (2) they significantly impact all income percentiles and (3) they were formal proposals from the Administration, Candidates, Political Parties, or particular Congress members. In case there are several projections available for one proposal and different years, only the one that is closest to the date of the proposal is included. Estimations using different baselines are included if changing the baseline significantly affects the estimates (due to many temporary taxes).

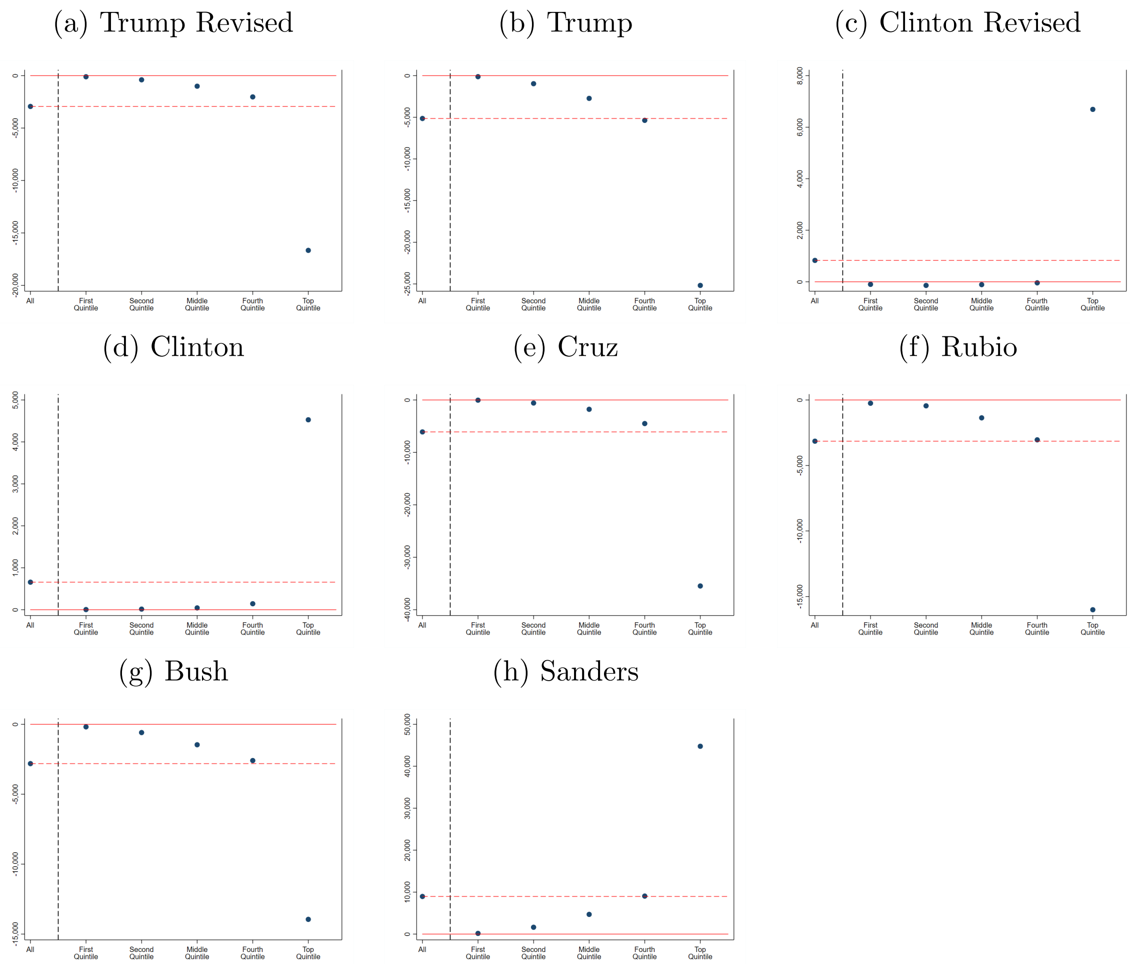
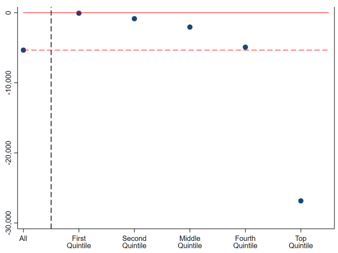


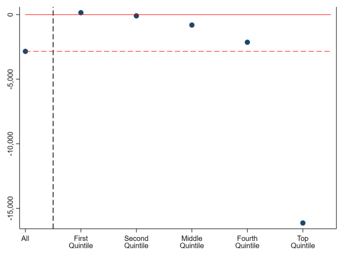
Figure G.1: Change in tax liability by quintile, 2016 US Presidential campaign

Notes: Figure G.1 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.1 for details).
Source: Authors' calculations based on Tax Policy Center.

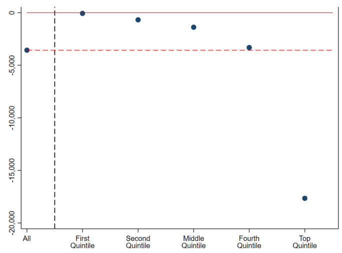
(a) Romney A



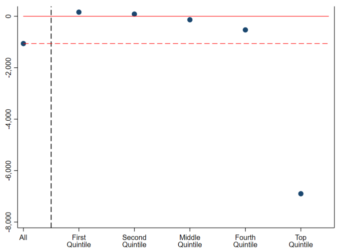
(b) Romney B



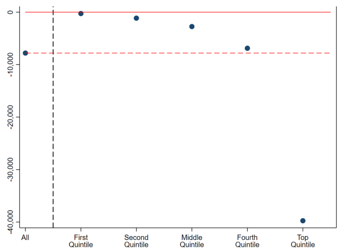
(c) Romney C



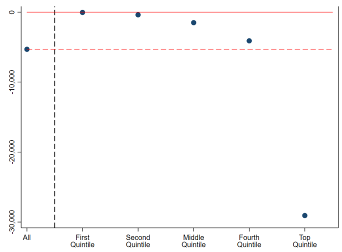
(d) Romney D



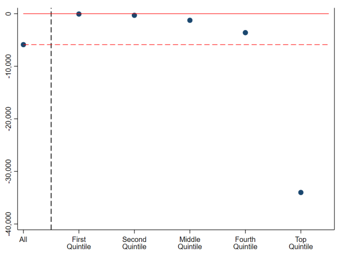
(e) Santorum A



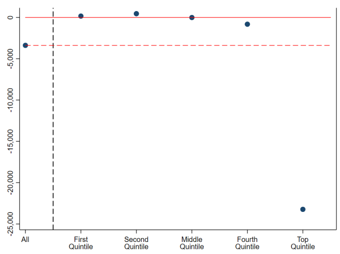
(f) Santorum B



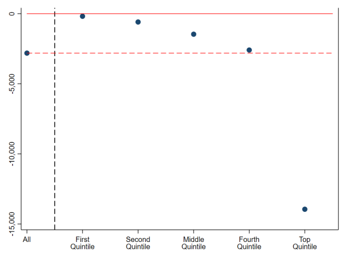
(g) Perry A



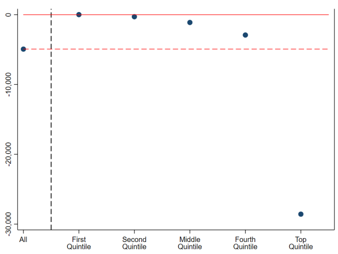
(h) Perry B



(i) Gingrich A



(j) Gingrich B



(k) Cain

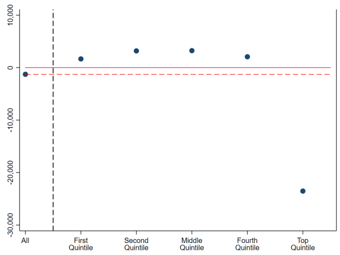


Figure G.2: Change in tax liability by quintile, 2012 US Presidential campaign

Notes: Figure G.2 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.2 for details).
Source: Authors' calculations based on Tax Policy Center.

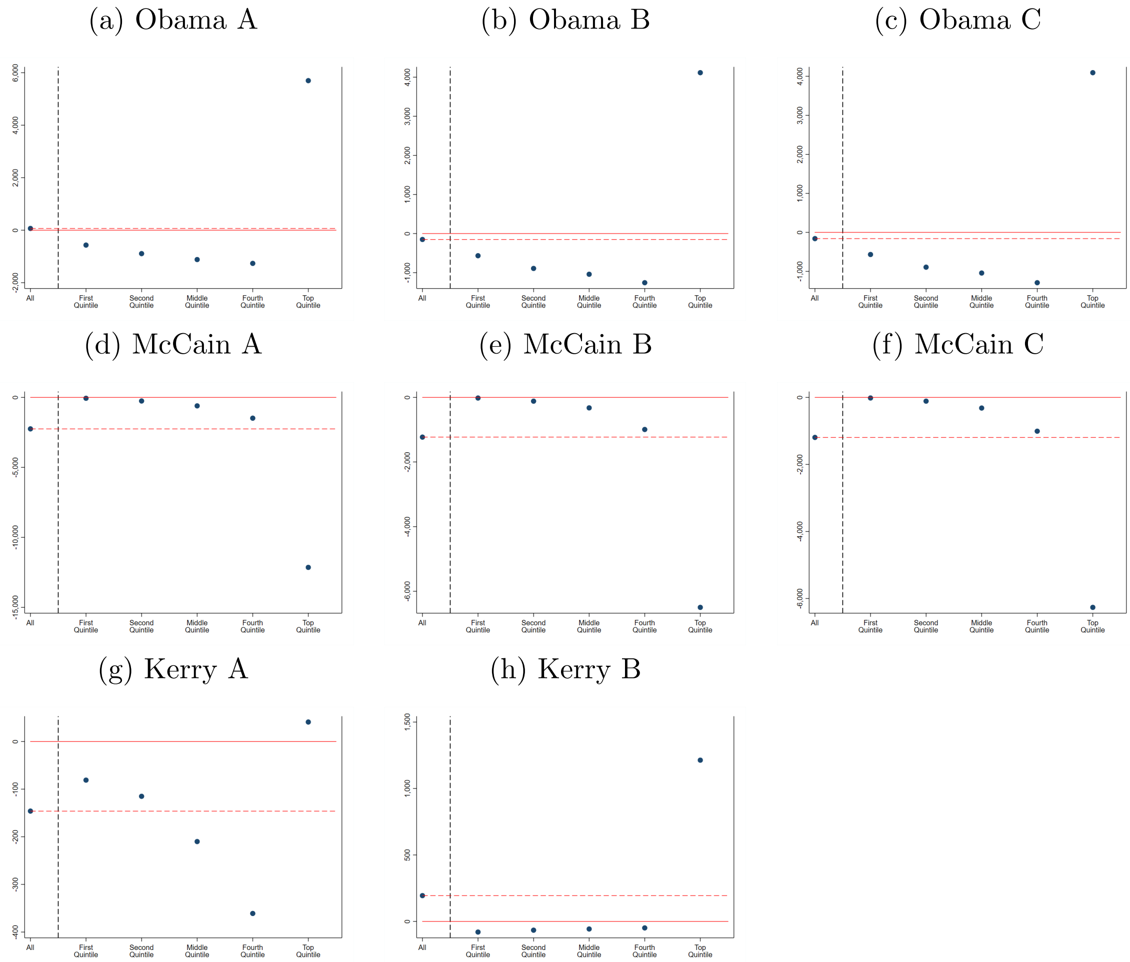


Figure G.3: Change in tax liability by quintile, 2008 and 2004 US Presidential campaigns

Notes: Figure G.3 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.3 for details).

Source: Authors' calculations based on Tax Policy Center.

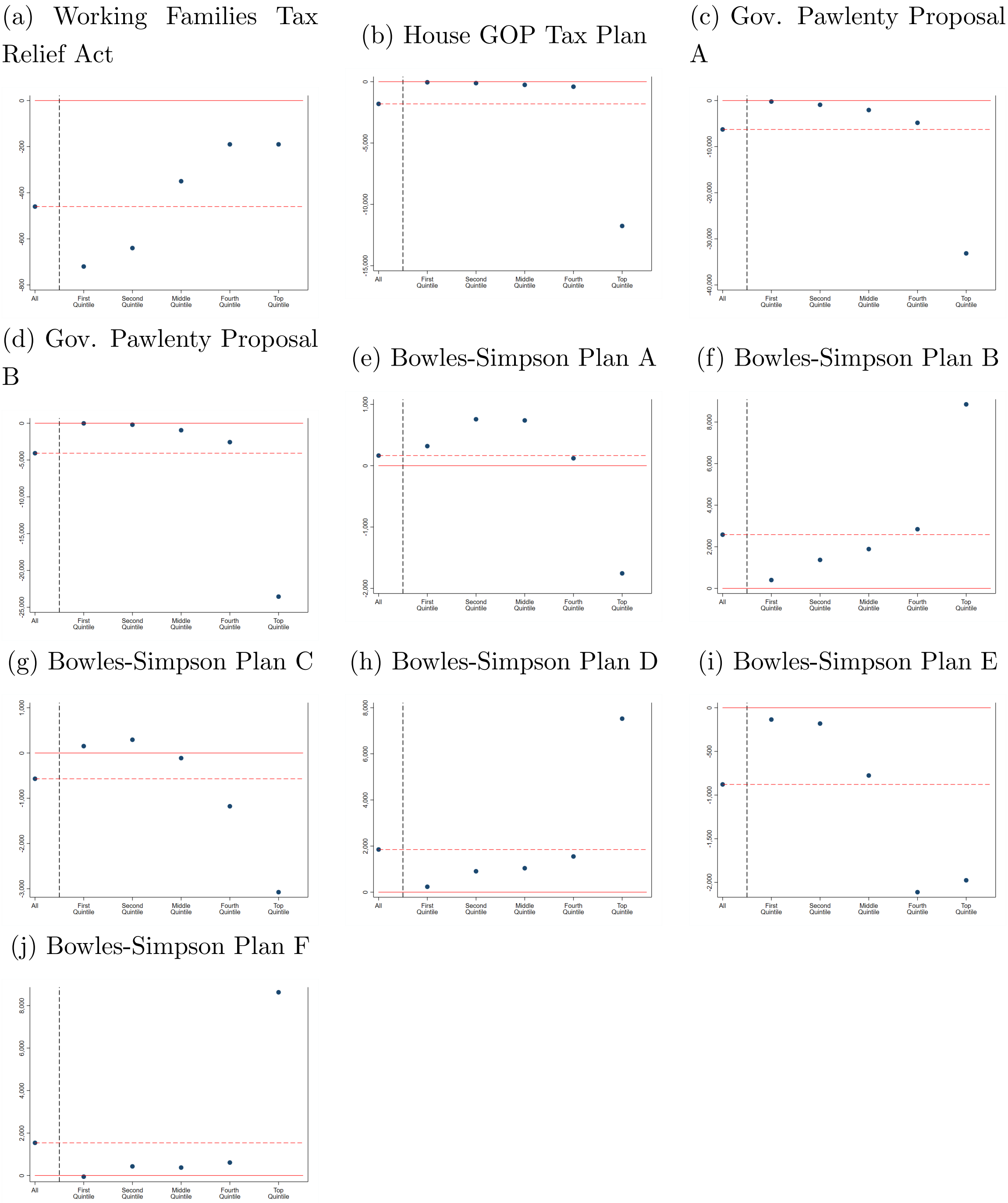
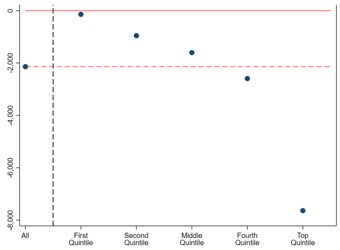


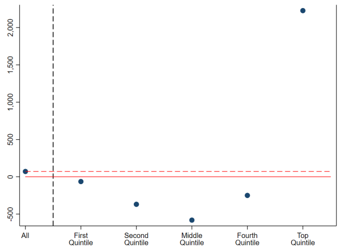
Figure G.4: Change in tax liability by quintile for reform proposals

Notes: Figure G.4 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.4 for details).
Source: Authors' calculations based on Tax Policy Center.

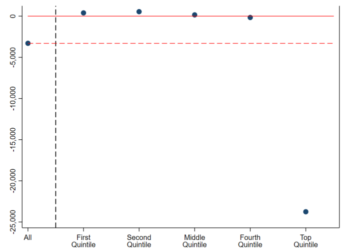
(a) Wyden-Gregg Act A



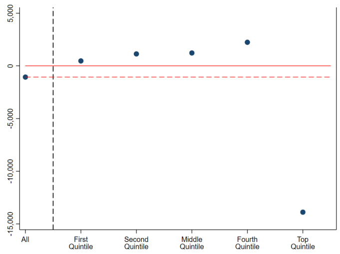
(b) Wyden-Gregg Act B



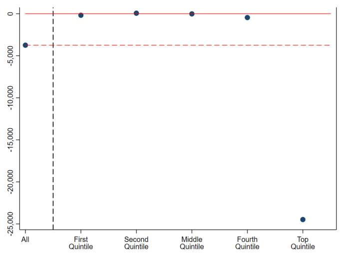
(c) Roadmap for America's Future Act A



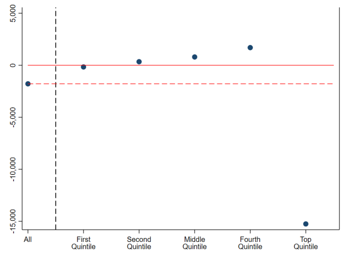
(d) Roadmap for America's Future Act B



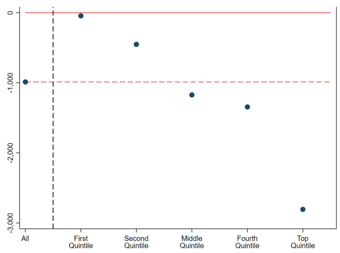
(e) Roadmap for America's Future Act C



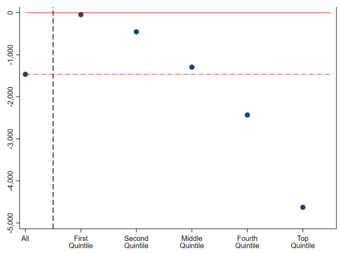
(f) Roadmap for America's Future Act D



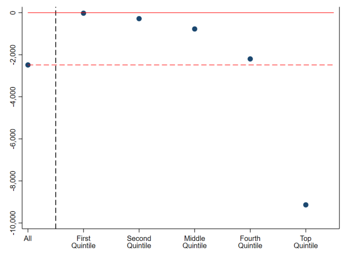
(g) House Republican Stimulus Proposal A



(h) House Republican Stimulus Proposal B



(i) Sen. Thompson's Tax Plan



(j) Democratic Stimulus Proposal

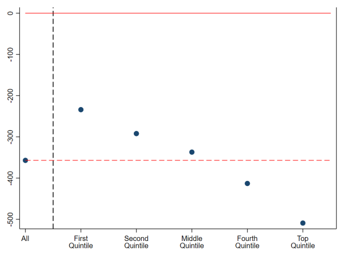
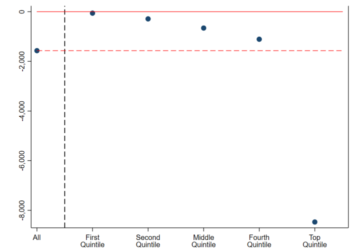


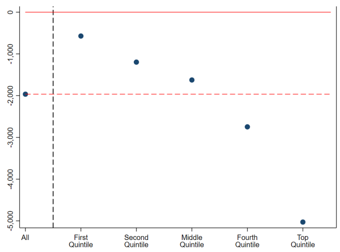
Figure G.5: Change in tax liability by quintile for reform proposals

Notes: Figure G.5 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.5 for details).
Source: Authors' calculations based on Tax Policy Center.

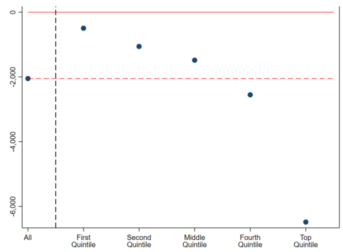
(a) Unified Framework



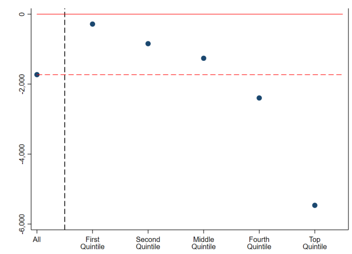
(b) Proposal for Budget FY2010 A



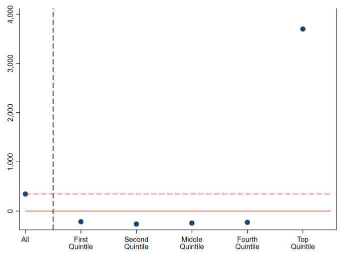
(c) Proposal for Budget FY2010 B



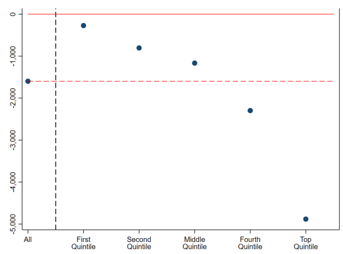
(d) Proposal for Budget FY2011 A



(e) Proposal for Budget FY2011 B



(f) Proposal for Budget FY2012 A



(g) Proposal for Budget FY2012 B

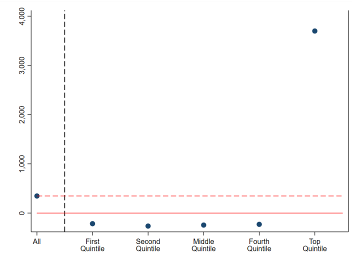
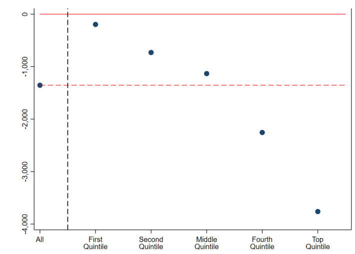


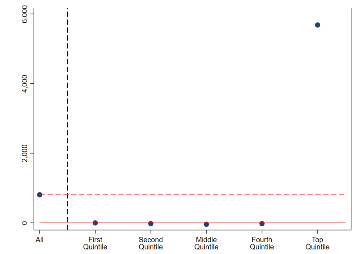
Figure G.6: Change in tax liability by quintile for reform proposals

Notes: Figure G.6 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.6 for details).
Source: Authors' calculations based on Tax Policy Center.

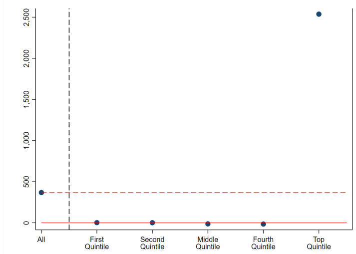
(a) Proposal for Budget FY2013 A



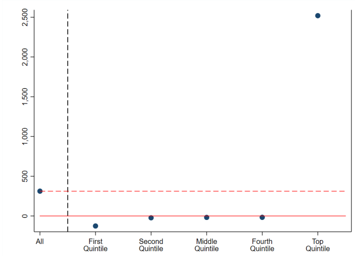
(b) Proposal for Budget FY2013 B



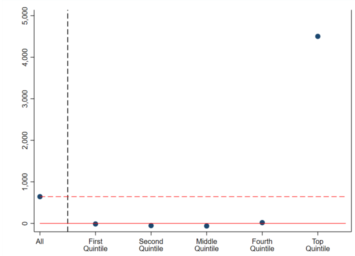
(c) Proposal for Budget FY2014



(d) Proposal for Budget FY2015



(e) Implement a Simplified Tax System



(f) Integrated Payroll Tax Plan

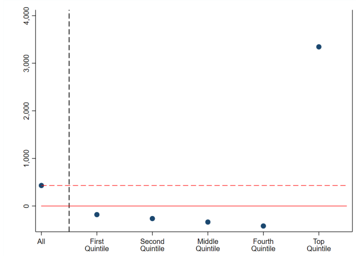
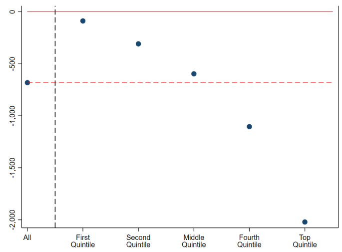


Figure G.7: Change in tax liability by quintile for reform proposals

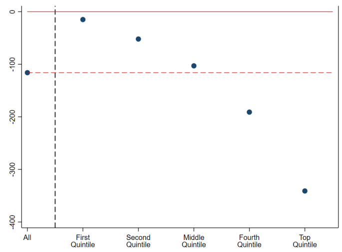
Notes: Figure G.7 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.7 for details).

Source: Authors' calculations based on Tax Policy Center.

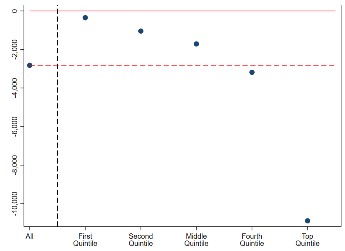
(a) Middle Class Tax Relief and Job Creation Act



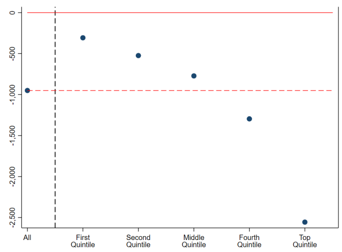
(b) Temporary Payroll Tax Cut Continuation Act



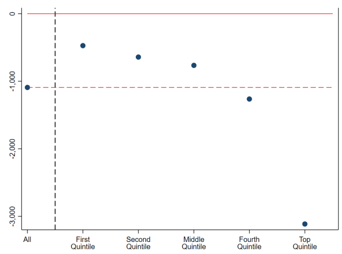
(c) Tax Relief, UI Reauthorization, and Job Creation Act A



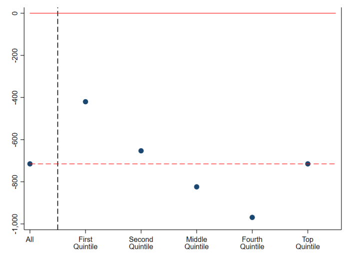
(d) Tax Relief, UI Reauthorization, and Job Creation Act B



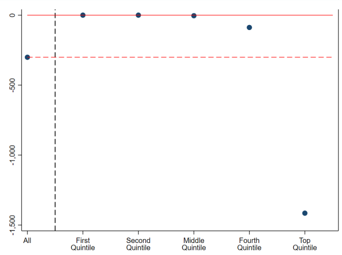
(e) American Recovery and Reinvestment Act



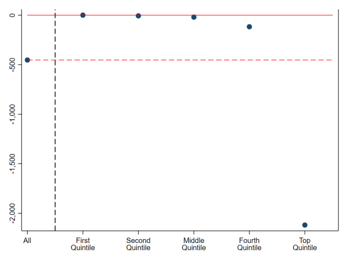
(f) Economic Stimulus Act



(g) Tax Increase Prevention Act



(h) Tax Increase Prevention and Reconciliation Act



(i) Working Families Tax Relief Act B

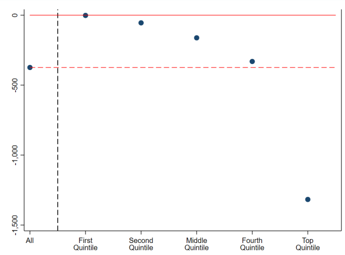


Figure G.8: Change in tax liability by quintile for reform proposals

Notes: Figure G.8 shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile. The first column shows the overall counterfactual tax change. The dashed horizontal line shows the revenue neutral benchmark (via lump sum redistribution) for an ETI of zero. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal (see Table G.8 for details).
Source: Authors' calculations based on Tax Policy Center.

Table G.1: Counterfactual change in tax liability of 2016 Presidential Campaign Tax Proposals

	Trump Revised	**Trump**	**Clinton Revised**	**Clinton**	**Cruz**	**Rubio**	**Bush**	**Sanders**
Year of projection	2017	2017	2017	2017	2017	2017	2017	2017
Party Affiliation	Republican	Republican	Democratic	Democratic	Republican	Republican	Republican	Democratic
Source	T16-0212	T15-0234	T16-0225	T16-0041	T16-0021	T16-0003	T15-0171	T16-0054
Baseline	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law
Lowest Quintile	-110	-128	-100	4	-46	-251	-185	165
Second Quintile	-400	-969	-140	15	-588	-450	-593	1625
Middle Quintile	-1010	-2732	-110	44	-1783	-1365	-1464	4692
Fourth Quintile	-2030	-5369	-40	143	-4504	-3043	-2593	9051
Top Quintile	-16660	-25180	6690	4527	-35471	-16008	-13947	44759
All	-2940	-5144	830	657	-6095	-3146	-2813	8964
Addendum								
80-89	-3270	-7731	100	246	-8907	-6059	-4258	14809
90-94	-5350	-11476	750	642	-16129	-8965	-5115	19828
95-98	-18490	-27657	4690	2673	-39352	-15364	-13256	37801
Top 1 Percent	-214690	-275257	117760	78284	-407708	-162646	-167325	525365

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.2: Counterfactual change in tax liability of 2012 Presidential Campaign Tax Proposals

	Romney A	**Romney B**	**Romney C**	**Romney D**	**Santorum A**	**Santorum B**	**Perry A**	**Perry B**	**Gingrich**	**Gingrich**	**Cain**
Year of projection	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2013
Party Affiliation	Republican	Republican	Republican	Republican	Republican	Republican	Republican	Republican	Republican	Republican	Republica
Source	T12-0039	T12-0041	T12-0002	T12-0004	T12-0012	T12-0014	T11-0377	T11-0379	T11-0403	T11-0405	T11-0373
Baseline	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy	Current Law
Lowest Quintile	-77	149	-69	157	-265	-39	-66	160	-185	6	1659
Second Quintile	-859	-97	-681	82	-1144	-383	-311	452	-593	-295	3189
Middle Quintile	-2054	-810	-1383	-138	-2744	-1502	-1258	-13	-1464	-1118	3238
Fourth Quintile	-4919	-2139	-3315	-532	-6879	-4102	-3607	-822	-2593	-2916	2071
Top Quintile	-26845	-16134	-17653	-6899	-39750	-29070	-34004	-23226	-13947	-28572	-23522
All	-5342	-2847	-3566	-1064	-7799	-5309	-5889	-3383	-2813	-4936	-1271
Addendum											
80-89	-9076	-4177	-6048	-1143	-13718	-8824	-7627	-2719	-4258	-5723	-1871
90-94	-14639	-7759	-9491	-2599	-22663	-15793	-13951	-7051	-5115	-10551	-7104
95-98	-34243	-22368	-19393	-7477	-49314	-37471	-40183	-28243	-13256	-28789	-26737
Top 1 Percent	-231971	-149997	-164719	-82188	-341447	-259865	-366739	-283903	-167325	-340179	-307473

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.3: Counterfactual change in tax liability of 2004 and 2008 Presidential Campaign Tax Proposals

	Obama A	**Obama B**	**Obama C**	**McCain A**	**McCain B**	**McCain C**	**Kerry A**	**Kerry B**
Year of projection	2009	2009	2009	2009	2009	2009	2005	2005
Party Affiliation	Democratic	Democratic	Democratic	Republican	Republican	Republican	Democratic	Democratic
Source	T08-0172	T08-0170	T08-0114	T08-0184	T08-0182	T08-0108	T04-0018	T04-0020
Baseline	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law	Current Law[1]
Lowest Quintile	-567	-567	-567	-65	-21	-19	-81	-80
Second Quintile	-892	-892	-892	-259	-118	-113	-115	-66
Middle Quintile	-1118	-1041	-1042	-608	-325	-319	-210	-57
Fourth Quintile	-1264	-1257	-1290	-1487	-994	-1009	-361	-49
Top Quintile	5697	4115	4092	-12144	-6498	-6264	41	1213
All	67	-151	-160	-2250	-1230	-1195	-146	194
Addendum								
80-89	-2132	-2130	-2204	-3736	-2584	-2614		
90-94	-2764	-2763	-2789	-6322	-4437	-4380		
95-98	799	-20	12	-15877	-8159	-7871		
Top 1 Percent	143688	115713	115974	-109214	-48862	-45361	23309	24319

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.4: Counterfactual change in tax liability of Tax Reform Proposals (not initiated by the Administration) Part 1

	Working Families Tax Relief Act	**House GOP Tax Plan**	**Gov. Pawlenty Proposal A**	**Gov. Pawlenty Proposal B**	**Bowles-Simpson Plan A**	**Bowles-Simpson Plan B**	**Bowles-Simpson Plan C**	**Bowles-Simpson Plan D**	**Bowles-Simpson Plan E**	**Bowles-Simpson Plan F**
Year of projection	2019	2017	2013	2013	2015	2015	2015	2015	2015	2015
Year of proposal	2019	2016	2011	2011	2010	2010	2010	2010	2010	2010
Originator	Senate Democrats	House of Representatives GOP	Gov. Pawlenty	Gov. Pawlenty	Bowles-Simpson Deficit Commission	Bowles-Simpson Deficit Commission	Bowles-Simpson Deficit Commission	Bowles-Simpson Deficit Commission	Bowles-Simpson Deficit Commission	Bowles-Simpson Deficit Commission
Source	T19-0053	T16-0197	T11-0169	T11-0171	T10-0247	T10-0248	T10-0251	T10-0252	T10-0253	T10-0254
Baseline	Current Law	Current Law	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy
Lowest Quintile	-720	-50	-218	-23	319	402	152	234	-135	-53
Second Quintile	-640	-120	-919	-205	757	1370	293	906	-181	432
Middle Quintile	-350	-260	-2057	-955	738	1890	-113	1039	-776	376
Fourth Quintile	-190	-410	-4825	-2572	121	2845	-1177	1548	-2112	612
Top Quintile	-190	-11760	-33149	-23557	-1755	8848	-3075	7527	-1976	8626
All	-460	-1810	-6267	-4078	165	2583	-569	1850	-878	1540
Addendum										
80-89	-220	-310	-10051	-5672	-602	4020	-2084	2538	-2824	1798
90-94	-190	-370	-15495	-9654	-1690	5161	-3013	3838	-3846	3005
95-98	-160	-7690	-36403	-25796	-3348	8210	-4390	7168	-5321	6238
Top 1 Percent	0	-212660	-337439	-261433	-7322	77409	-8118	76613	28704	113434

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.5: Counterfactual change in tax liability of Tax Reform Proposals (not initiated by the Administration) Part 2

	Wyden-Gregg Act)	**Wyden-Gregg Act)**	**Roadmap for America's Future Act A**	**Roadmap for America's Future Act B**	**Roadmap for America's Future Act C**	**Roadmap for America's Future Act D**	**Republican Stimulus Proposal A**	**Republican Stimulus Proposal B**	**Sen. Thompson's Tax Plan**	**Democratic Stimulus Proposal**
Year of projection	2014	2014	2014	2014	2014	2014	2009	2009	2009	2003
Year of proposal	2010	2010	2010	2010	2010	2010	2009	2009	2007	2003
Originator	Sen. Wyder and Sen. Gregg	Sen. Wyder and Sen. Gregg	Rep. Ryan	Rep. Ryan	Rep. Ryan	Rep. Ryan	House of Representatives GOP	House of Representatives GOP	Sen. Thompson	House of Representatives Democrats
Source	T10-0122	T10-0119	T10-0087	T10-0091	T10-0089	T10-0093	T09-0046	T09-0048	T07-0334	T03-0005
Baseline	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Law	Current Law	Current Law
Lowest Quintile	-142	-64	393	472	-180	-164	-45	-45	-25	-234
Second Quintile	-957	-369	541	1137	62	339	-452	-455	-284	-292
Middle Quintile	-1603	-581	152	1227	-17	794	-1173	-1295	-774	-337
Fourth Quintile	-2594	-250	-165	2242	-454	1694	-1345	-2432	-2199	-413
Top Quintile	-7638	2227	-23756	-13885	-24478	-15250	-2806	-4627	-9138	-509
All	-2140	71	-3298	-1063	-3742	-1786	-988	-1465	-2485	-357
Addendum										
80-89	-4068	196	-1701	2609	-2079	1929	-1242	-3568	-4262	-501
90-94	-4391	1622	-3022	3195	-3618	1972	-1734	-3793	-8140	-516
95-98	-7579	2594	-20931	-10296	-21977	-12553	-3601	-4278	-12626	-520
Top 1 Percent	-58990	23861	-353891	-274171	-357376	-279521	-20412	-20559	-48933	-518

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.6: Counterfactual change in tax liability of Tax Reform Proposals (initiated by the Administration) Part 1

	Unified Framework	**Proposal for Budget FY2010 A**	**Proposal for Budget FY2010 B**	**Proposal for Budget FY2011 A**	**Proposal for Budget FY2011 B**	**Proposal for Budget FY2012 A**	**Proposal for Budget FY2012 B**
Year of projection	2018	2012	2011	2012	2012	2013	2013
Year of proposal	2017	2009	2009	2010	2010	2011	2011
Source	T17-0225	T09-0132	T09-0501	T10-0037	T10-0039	T11-0027	T11-0029
Baseline	Current Law	Current Law	Current Law	Current Law	Current Policy	Current Law	Current Policy
Lowest Quintile	-60	-572	-496	-284	-216	-272	-216
Second Quintile	-290	-1197	-1059	-844	-264	-805	-264
Middle Quintile	-660	-1625	-1484	-1261	-244	-1166	-244
Fourth Quintile	-1110	-2747	-2553	-2396	-229	-2297	-229
Top Quintile	-8470	-5028	-6483	-5465	3698	-4882	3698
All	-1570	-1965	-2051	-1729	347	-1599	347
Addendum							
80-89	-1140	-4672	-4690	-4439	-273	-4184	-273
90-94	-1500	-5790	-5900	-5820	-222	-5654	-222
95-98	-7620	-6223	-8579	-7994	1857	-6881	1857
Top 1 Percent	-129030	-138	-18755	-3966	68906	-205	68906

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.7: Counterfactual change in tax liability of Tax Reform Proposals (initiated by the Administration) Part 2

	Proposal for Budget FY2013 A	**Proposal for Budget FY2013 B**	**Proposal for Budget FY2014 A**	**Proposal for Budget FY2015 B**	**Implement a Simplified Tax System**	**Integrated Payroll Tax Plan**
Year of projection	2014	2014	2015	2016	2010	2008
Year of proposal	2012	2012	2013	2014	2010	2007
Source	T12-0043	T12-0045	T13-0134	T14-0057	T10-0077	T07-0209
Baseline	Current Law	Current Policy	Current Law	Current Policy	Current Law	Current Law
Lowest Quintile	-196	-2	2	-126	-13	-181
Second Quintile	-731	-22	1	-23	-53	-264
Middle Quintile	-1133	-40	-13	-18	-62	-337
Fourth Quintile	-2255	-22	-15	-17	19	-420
Top Quintile	-3762	5683	2537	2519	4502	3345
All	-1355	807	368	312	644	431
Addendum						
80-89	-4279	68	29	14	132	7108
90-94	-5659	120	65	93	127	13410
95-98	-5743	4495	2652	2677	2707	43126
Top 1 Percent	18519	93707	39739	38264	76558	65689

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

Table G.8: Counterfactual change in tax liability of Further Amended Tax Reforms

	Middle Class Tax Relief and Job Creation Act	**Temporary Payroll Tax Cut Continuation Act**	**Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act A**	**Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act B**	**American Recovery and Reinvestment Act**	**Economic Stimulus Act**	**Tax Increase Prevention Act**	**Tax Increase Prevention and Reconciliation Act**	**Working Families Tax Relief Act**
Year of projection	2012	2012	2011	2011	2009	2008	2007	2006	2005
Year of proposal	2012	2011	2010	2010	2009	2008	2007	2005	2004
Source	T12-0034	T12-0006	T10-0273	T10-0275	T09-0113	T08-0062	T07-0343	T06-0086	T04-0154
Baseline	Current Law(1) ()	Current Law(1)	Current Law	Current Policy	Current Law	Current Law	Current Law	Current Law	Current Law
Lowest Quintile	-89	-15	-351	-307	-473	-420	0	0	-2
Second Quintile	-309	-52	-1047	-524	-642	-653	0	-7	-55
Middle Quintile	-597	-103	-1713	-772	-765	-824	-4	-20	-162
Fourth Quintile	-1105	-191	-3186	-1296	-1263	-969	-88	-117	-331
Top Quintile	-2021	-341	-10887	-2556	-3113	-715	-1415	-2119	-1317
All	-682	-116	-2823	-950	-1092	-715	-301	-453	-374
Addendum									
80-89	-1780	-302	-5906	-2068	-2470	-975	-704		
90-94	-2226	-376	-7759	-2544	-3732	-688	-1514		
95-98	-2278	-380	-11983	-2903	-4642	-268	-3253		
Top 1 Percent	-2407	-396	-70836	-6095	-514	-38	-684	-14094	-2390

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for reform proposals of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The data is taken from the Tax Policy Center's ex ante analysis of each reform proposal. Details on the underlying data, methods and simulation model can be found here: `https://www.taxpolicycenter.org/resources/brief-description-tax-model`. For each proposal, there is a code ("Source") corresponding to the source document from the Tax Policy Center. The table also contains information on the year of the proposal, the year of the projection and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on Tax Policy Center.

H Details on US Tax Reforms

In this section, we briefly outline the major changes in the US personal income tax system from 1964 until 2017. Table H.1 provides an overview of the 11 reforms that we identified and analyze. We concentrate on large legislative changes which drive the tax policy effect. Reforms of interest are the Revenue Act of 1964 (RA64), the Tax Reform Act of 1969 (TRA69), the Revenue Act of 1978 (RA78), the Economic Recovery Tax Act of 1981 (ERTA81), the Tax Reform Act of 1986 (TRA86), the Omnibus Budget Reconciliation Act of 1990 and 1993 (OBRA90 and OBRA93), the Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA01), the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA03), the American Taxpayer Relief Act of 2012 (ATRA12) and the Tax Cuts and Jobs Act of 2017 (TCJA17).

Tax reform	pre	post	key features of the reform
RA64	1962	1966	Tax cut (top rate from 91% to 70%)
TRA69	1968	1970	Introduction of Alternative Minimum Tax and new tax schedule for single taxpayers
RA78	1978	1979	Widening of tax brackets (and reducing their number)
ERTA81	1980	1984	Tax cut (top rate from 70% to 50%)
TRA86	1985	1988	Broadening of tax base and reductions in MTRs (top rate from 50% to 28%)
OBRA90	1990	1991	Increase of top tax rate from 28% to 31%
OBRA93	1992	1993	Expansion of EITC and increase of top tax rate from 31% to 39.6%
EGTRRA01	2000	2002	Reductions in marginal tax rates
JGTRRA03	2002	2003	Reductions in marginal tax rates
ATRA12	2012	2013	Increase of tax rates for high income earners
TCJA17	2016	2018	Tax cuts (top rate from 39.6% to 37%)

Table H.1: Overview of US reforms

Notes: Table H.1 lists the major reforms of the federal income tax in the US after WWII: the Revenue Act of 1964 (RA64), the Tax Reform Act of 1969 (TRA69), the Revenue Act of 1978 (RA78), the Economic Recovery Tax Act of 1981 (ERTA81), the Tax Reform Act of 1986 (TRA86), the Omnibus Budget Reconciliation Act of 1990 and 1993 (OBRA90 and OBRA93), the Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA01), the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA03), the American Taxpayer Relief Act of 2012 (ATRA12) and the Tax Cuts and Jobs Act of 2017 (TCJA17). The pre reform year is always the last year before any change was implemented while the post reform year is the one after all changes are phased in (except for RA64 due to only bi-annual data availability of SOI PUF before 1966).

The key features of these reforms as well as distributional ex ante analyses of these reforms are summarized in the following.

RA64: RA64 was proposed by President Kennedy, thus often referred to as "Kennedy tax cuts", but came into effect only after his assassination in 1964. Individual tax rates were reduced considerably, with the marginal rate at the top dropping from 91% to 70%. The tax revenue effect was negative (Tempalski (2006)). To the best of our knowledge, there is no retrievable distributional analysis for this reform and we provide such an analysis in Figure 2 .

TRA69: The main goal of TRA69 was to tax high-income earners who had previously avoided paying taxes due to various exemptions and deductions by creating the Alternative Minimum Tax (AMT). There were also some tax rate and bracket changes (mostly for single taxpayers) and some changes to standard deductions and personal exemptions. The tax revenue effect was negative (Tempalski (2006)). To the best of our knowledge, there is no retrievable distributional analysis for this reform and we provide such an analysis in Figure 2 .

RA78: RA78 reduced individual income taxes by widening tax brackets, reducing the number of tax rates, increasing the personal exemption, increasing the standard deduction and reducing the effective tax rate on realized capital gains. The tax revenue effect was negative (Tempalski (2006)). To the best of our knowledge, there is no retrievable distributional analysis for this reform and we provide such an analysis in Figure 2 .

ERTA81: ERTA81 introduced the indexation of individual income tax parameters which became effective in 1985. Tax cuts were phased in over the years 1982–1984, with a reduction of top marginal tax rates from 70% to 50% in 1982 and of other tax rates by 23% in three annual steps. Further, the income threshold for the top rate substantially increased from $85,600 in 1982 to $109,400 (1983) and $162,400 (1984) for married couples filing jointly. Similarly, thresholds were increased for couples filing separately and for singles. The Joint Committee on Taxation (1981) conducted an ex ante analysis of the anticipated distributional effects. Estimates for the year 1982 show that all income classes are expected to pay less taxes (see Table H.3).

TRA86: Key aspects of TRA86 were the broadening of the tax base and reductions in marginal tax rates.[5] TRA86 further lowered the top marginal rate to 38.5% in 1987 and to 28% in 1988, reduced the number of tax brackets from 15 in 1986 to two in 1988, but also substantially expanded the EITC with financial benefits for low–income households. The Joint Committee on Taxation (1986) conducted an ex ante analysis of the anticipated distributional effects. The prediction was that all taxpayers would gain (see Table H.3).

[5] As part of the tax burden was effectively shifted from the individual to the corporate sector which is not part of our analysis, TRA86 constitutes a tax cut in the context of this paper.

OBRA90 & OBRA93: OBRA90 contained increases in income taxes as well as expansions of the EITC and other low–income credits. Furthermore, payroll taxes were increased by lifting the taxable maximum for Medicare which was finally abolished in 1994. OBRA93 then led to the largest single expansion of the EITC (cf. Eissa and Hoynes (2011), and further increases in income tax rates were implemented, e.g. the top rate rose from 31% to 39.6% in 1993. The EITC became much more generous in 1994 with higher maximum credits and an expansion to single workers with no children. The EITC was further expanded in the following years. Joint Committee on Taxation (1990) and Congressional Budget Office (1991) conducted ex ante analyses of the anticipated distributional effects of OBRA90, while Congressional Budget Office (1993) analyzed OBRA93. Both reforms were overall tax increases for most taxpayers except for those at the bottom of the distribution (see Tables H.2 and H.3).

EGTRRA01 & JGTRRA03: EGTRRA01 and JGTRRA03 were characterized by reductions in marginal tax rates, both for low– and high–income families, expansions of the child tax credits, and reductions in taxes on dividends. In 2003, JGTRRA accelerated those provisions of EGTRRA which were not set to become effective until 2006. Ex ante analyses of the anticipated distributional effects of both EGTRRA01 (Tax Policy Center, 2002; Joint Committee on Taxation, 2001) and JGTRRA03 (Tax Policy Center, 2003b,c) show that both reforms were tax cuts and that the absolute dollar change in income tax payments increases with each household income quintile (see Tables H.2 and H.3).

ATRA12: ATRA12 made the changes introduced with EGTRRA01 and JGTRRA03 permanent with the exception of high-income taxpayers. For individuals with earnings in excess of $400,000 ($450,000 for jointly filing married couples), the lowered rates expired as scheduled and the previous marginal rate of 39.6% was brought back. Additionally, these individuals saw an increase in the taxation of long-term capital gains and dividends, with the rate raising from 15 to 20%. Tax Policy Center (2012k,l) conducted ex ante analyses of the anticipated distributional effects of ATRA12 assuming either current law as baseline (i.e., temporary tax changes are considered to expire once finished) or current policy as baseline (i.e., temporary tax changes are assumed to remain in place after they expire) (see Tables H.2 and H.3). When using the current law baseline, the reform is a tax cut for all taxpayers while it is an increase for the top of the distribution when using current policy as the baseline. We refer to Saez (2016) for a detailed analysis ex post of ATRA12.

TCJA17: TCJA17 made several significant changes to individual tax rates as well as to the calculation of taxable income. Tax rates were reduced for all income brackets but the lowest by one to four percentage points. The top rate was brought down from 39.6% to 37%. Furthermore, both the standard deduction and the child tax credit were roughly doubled. Joint Committee on Taxation (2017); Tax Policy Center (2018b,a) conducted ex ante analyses of the anticipated distributional effects (see Tables H.2 and H.3).

Table H.2: Distributional effects of major US Tax Reforms from 1981 to 2017, by Income Percentiles

	TCJA17	**ATRA12**	**ATRA12**	**JGTRRA03**	**EGTRRA01**	**OBRA93**	**OBRA90**	**TRA86**	**ERTA81**
Year of projection	2018	2013	2013	2003	2002	1994	1991	(n.a.)	(n.a.)
Source	Tax Policy Center (2018b)	Tax Policy Center (2012b)	Tax Policy Center (2012d)	Tax Policy Center (2003b)	Tax Policy Center (2002b)	CBO (1993)	CBO (1991)		
Baseline		Current Law	Current Policy						
Lowest Quintile	-190	-265	0	-1	-26	-166	-109		
Second Quintile	-550	-795	1	-72	-283	-35	73		
Middle Quintile	-1,050	-1184	0	-245	-469	64	290		
Fourth Quintile	-1,810	-2170	-2	-475	-601	110	414		
Top Quintile	-7,170	-6845	2,483	-2,666	-1,287	1,884	1389		
All	-2,180	-1847	364	-692	-534	382	411		
Addendum									
80-89	-2,950	-4275	-1	-1,253	-871	239			
90-94	-4,100	-5494	-1	-2,110	-1,081	388			
95-98	-12,130	-10359	-71	-3,173	-1,418	1,177			
Top 1 Percent	-51,310	-25672	50,508	-17,540	-5,950	29,417			
Top 0.1 Percent	-247,020	-71885	322,528						

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for implemented reforms of the US federal personal income tax by income quintile as well as a decomposition for the top quintile. The table also contains information on the year of the proposal, the year of the projection, the source and the employed baseline (current law vs. current policy).
Source: Authors' calculations based on the "Source".

Table H.3: Distributional effects of major US Tax Reforms from 1981 to 2017, by Income Class

	TCJA17	**ATRA12**	**ATRA12**	**JGTRRA03**	**EGTRRA01**	**OBRA93**	**OBRA90**	**TRA86**	**ERTA81**
Year of projection	2018	2013	2013	2003	2002	1994	1991	1986	1982
Source	Tax Policy Center (2018a)	Tax Policy Center (2012a)	Tax Policy Center (2012c)	Tax Policy Center (2003a)	Tax Policy Center (2002a)	CBO (1993)	JCT (1990)	JCT (1986)	JCT (1981)
Baseline		Current Law	Current Policy						
Less than 10	-10	-131	0	-2	-27	-68	-6	-39	-92
10-20	-50	-351	0	-97	-270	-86	-83	-200	-284
20-30	-180	-709	2	-225	-448	-41	103	-220	-498
30-40	-360	-891	0	-324	-495	50	183	-273	-782
40-50	-570	-1047	0	-445	-549	105	205	-486	-1135
50-75	-870	-1428	-1	-688	-687	192	234	-150	-1934
75-100	-1310	-2253	-2	-1597	-924	312	453	-176	-3275
100-200	-2260	-4436	-1	-2497	-1159	649	940	-612	-13282
200-500	-6560	-10203	-70	-4997	-2020				-58250
500-1,000	-21240	-17585	6689	-15452	-4769				
More than 1,000	-69660	-38947	122560	-3	-18604	23521	9323	-3362	-135249
All	-1610	-1847	364	-692	-534	382			

Notes: This table shows the average value of the counterfactual change in tax liability $T_1\left(\hat{y}_0^i\right) - T_0\left(y_0^i\right)$ for implemented reforms of the US federal personal income tax by income classes. The table also contains information on the year of the proposal, the year of the projection, the source and the employed baseline (current law vs. current policy).

Source: Authors' calculations based on the "Source".

I Extensions

In this section we show that the median voter theorem for small monotonic reforms (Theorem 1) applies to models with more than one source of heterogeneity among individuals. Again, we show that a small tax reform is preferred by a majority of taxpayers if and only if it is preferred by the taxpayer with median income. Throughout, we stick to the assumption that individuals differ in their productive abilities ω. We introduce a second consumption good and the possibility of heterogeneity in preferences over consumption goods in Section I.1. We use this framework to discuss whether the introduction of distortionary taxes on savings is politically feasible. In Section I.2 we consider fixed costs of labor market participation as an additional source of heterogeneity.[6] In Section I.3 we assume that individuals differ in their valuation of increased public spending.[7] Finally, in Section I.4, individuals differ by how much of their income is due to luck as in Alesina and Angeletos (2005).

I.1 Political support for taxes on savings

We now suppose that there are two consumption goods. We refer to them as food and savings, respectively. An individual's budget constraint now reads as

$$c_f + c_s + T_{0s}(c_s) + \tau_s h_s(c_s) \leq c_0 + y - T_0(y) - \tau h(y) \ . \tag{I.1}$$

The variables on the right-hand side of the budget constraint have been defined before. On the left-hand side, c_f denotes food consumption and c_s savings. In the status quo savings are taxed according to a possibly non-linear savings-tax function T_{0s}. A reform replaces both the status quo income tax schedule T_0 by $T_1 = T_0 + \tau h$ and the status quo savings tax schedule T_{0s} by $T_{1s} = T_{0s} + \tau_s h_s$. We maintain the assumption that the functions h and h_s are non-decreasing and focus on revenue neutral reforms so that either $\tau > 0$ and $\tau_s < 0$ or $\tau < 0$ and $\tau_s > 0$.

Preferences of individuals are given by a utility function $u(v(c_f, c_s, \beta), y, \omega)$, where v is a subutility function that assigns consumption utility to any consumption bundle (c_f, c_s). The marginal rate of substitution between food and savings depends on a parameter β. We do not assume a priori that β is the same for all individuals. Under this assumption, however, the utility function u has the properties under which an efficient tax system does not involve distortionary commodity taxes, see Atkinson and Stiglitz (1976), or Laroque (2005) for a more elementary proof. Distortionary taxes on savings are then undesirable from a welfare-perspective.

Individuals choose c_f, c_s and y to maximize utility subject to the budget constraint above. We denote the utility maximizing choices by $c_f^*(\tau_s, \tau, \beta, \omega)$, $c_s^*(\tau_s, \tau, \beta, \omega)$ and $y^*(\tau_s, \tau, \beta, \omega)$ and the corresponding level of indirect utility by $V(\tau_s, \tau, \beta, \omega)$. The slope of

[6]See Saez (2002), Choné and Laroque (2011), and Jacquet et al. (2013).

[7]See Boadway and Keen (1993), Hellwig (2004), Bierbrauer (2014), or Weinzierl (2018).

an indifference curve in a τ-τ_s diagram determines the individuals' willingness to accept higher savings taxes in return for lower taxes on current earnings. The following Lemma provides a characterization of this marginal rate of substitution in a neighborhood of the status quo. Let

$$s(\tau, \tau^s, \beta, \omega) = -\frac{V_\tau(\tau_s, \tau, \beta, \omega)}{V_{\tau_s}(\tau_s, \tau, \beta, \omega)}$$

be the slope of an individual's indifference curve in a τ-τ_s diagram. The slope in the status quo is denoted by $s^0(\omega, \beta)$. We denote the individual's food consumption, savings and earnings in the status quo by $\tilde{c}_f^0(\omega, \beta)$, $\tilde{c}_s^0(\omega, \beta)$ and $\tilde{y}^0(\omega, \beta)$, respectively.

Lemma I.1 *In the status quo the slope of a type (ω, β)-individual's indifference curve in a τ-τ_s diagram is given by*

$$s^0(\omega, \beta) = -\frac{h(\tilde{y}^0(\omega, \beta))}{h_s(\tilde{c}_s^0(\omega, \beta))} .$$

The Lemma provides a generalization of Roy's identity that is useful for an analysis of non-linear tax systems. As is well known, with linear tax systems, the marginal effect of, say, an increased savings tax on indirect utility is equal to $-\lambda^* c_s^*(\cdot)$, where λ^* is the multiplier on the individual's budget constraint, also referred to as the marginal utility of income. Analogously, the increase of a linear income tax affects indirect utility via $-\lambda^* y^*(\cdot)$ so that the slope of an indifference curve in a τ_s-τ-diagram would be equal to the earnings-savings-ratio $-\frac{y^*(\cdot)}{c_s^*(\cdot)}$. Allowing for non-linear tax systems and non-linear perturbations implies that the simple earnings-savings-ratio is replaced by $-\frac{h(y^*(\cdot))}{h_s(c_s^*(\cdot))}$.

Consider a reform that involves an increase in the savings tax rate $d\tau_s > 0$ and a reduction of taxes on income $d\tau < 0$. We say that a type (ω, β)-individual strictly prefers a small reform with increased savings taxes over the status quo if

$$V_{\tau_s}(0, 0, \beta, \omega)\ d\tau_s + V_\tau(0, 0, \beta, \omega)\ d\tau > 0 ,$$

or, equivalently, if

$$\frac{d\tau_s}{d\tau} > s^0(\omega, \beta) = -\frac{h(\tilde{y}^0(\omega, \beta))}{h_s(\tilde{c}_s^0(\omega, \beta))} . \tag{I.2}$$

Since h_s is an increasing function, this condition is, ceteris paribus, easier to satisfy if the individual has little savings in the status quo.[8]

[8] The ratio $\frac{d\tau_s}{d\tau}$ on the left-hand side of inequality (I.2) is determined as follow: Let $R^s(\tau_s, \tau)$ be the change of revenue from savings taxes and $R(\tau_s, \tau)$ the change of revenue from income taxation due to the reform. Revenue-neutrality requires that

$$R^s_{\tau_s}(\tau_s, \tau) d\ \tau_s + R^s_\tau(\tau_s, \tau)\ d\tau + R_{\tau_s}(\tau_s, \tau)\ d\tau_s + R_\tau(\tau_s, \tau)\ d\tau = 0 ,$$

or, equivalently, that

$$\frac{d\tau_s}{d\tau} = -\frac{R_\tau(\tau_s, \tau) + R^s{}_\tau(\tau_s, \tau)}{R^s_{\tau_s}(\tau_s, \tau) + R_{\tau_s}(\tau_s, \tau)} ,$$

which has to be evaluated for $(\tau_s, \tau) = (0, 0)$. We assume that this expression is well-defined and takes a finite negative value.

Different types will typically differ in their generalized earnings-savings-ratio $s^0(\omega, \beta)$ and we can order types according to this one-dimensional index. Let $(\omega, \beta)^{0M}$ be the type with the median value of $s^0(\omega, \beta)$. The following proposition extends Theorem 1. It asserts that a small reform is politically feasible if and only if it is supported by the median type $(\omega, \beta)^{0M}$.

Proposition I.1 *For a given status quo tax policy and a given pair of non-decreasing functions h and h_s, the following statements are equivalent:*

1. *Type $(\omega, \beta)^{0M}$ prefers a small reform with increased savings taxes over the status quo.*

2. *There is a majority of individuals who prefer a small reform with increased savings taxes over the status quo.*

As Theorem 1, Proposition I.1 exploits the observation that individuals can be ordered according to a one-dimensional statistic that pins down whether or not they benefit from a tax reform. This makes it possible to prove a median-voter theorem for reforms that remain in a neighborhood of the status quo. There is also an important difference to Theorem 1. With only one-dimensional heterogeneity, there is a monotonic relation between types and earnings so that the identity of the type with median income does not depend on the status quo. Whatever the tax system, the person with the median income is the person with the median type ω^M. Here, by contrast, we allow for heterogeneity both in productive abilities and in preferences over consumption goods. The type with the median value of the generalized earnings-savings-ratio $s^0(\omega, \beta)$ will then typically depend on the status quo tax system. This does not pose a problem if we focus on small reforms. In this case, preferences over reforms follow from the generalized earnings-savings-ratios in the status quo, and a small reform is preferred by a majority of individuals if and only if it is preferred by the individual with the median ratio.

I.2 Fixed costs of labor market participation

With fixed costs of labor market participation individuals derive utility $u(c - \theta\, \mathbf{1}_{y>0}, y, \omega)$ from a (c, y)-pair. Fixed costs θ absorb some of the individual's after-tax income if the individual becomes active on the labor market, e.g. because of additional child care expenses. As before, there is an initial status quo tax schedule under which earnings are transformed into after-tax income according to the schedule C_0 with $C_0(y) = c_0 + y - T_0(y)$. After a reform, the schedule is

$$C_1(y) = c_0 + R + y - T_0(y) - \tau\, h(y) \ ,$$

where h is a non-decreasing function of y. We denote by $y^*(R, \tau, \omega, \theta)$ the solution to

$$\max_y \ u(C_1(y) - \theta\, \mathbf{1}_{y>0}, y, \omega),$$

and the reform-induced change in indirect utility by $V(R,\tau,\omega,\theta)$. We proceed analogously for other variables: what has been a function of ω in previous sections is now a function of ω and θ.

For a given function h, the marginal gain that is realized by an individual with type (ω,θ) if the tax rate τ is increased, is given by the following analogue to equation (2),

$$V_\tau(\omega,\theta \mid \tau,h) = \tilde{u}_c^1(\omega,\theta)\left(R_\tau(\tau,h) - h(\tilde{y}^1(\omega,\theta))\right) , \tag{I.3}$$

where $\tilde{u}_c^1(\omega,\theta)$ is the marginal utility of consumption realized by a type (ω,θ)-individual after the reform, and $\tilde{y}^1(\omega,\theta)$ are the individual's post-reform earnings. At $\tau=0$, we can also write

$$V_\tau(\omega,\theta \mid 0,h) = \tilde{u}_c^0(\omega,\theta)\left(R_\tau(0,h) - h(\tilde{y}^0(\omega,\theta))\right) , \tag{I.4}$$

where $\tilde{u}_c^0(\omega,\theta)$ and $\tilde{y}^0(\omega,\theta)$ are, respectively, marginal utility of consumption and earnings in the status quo.

For a given status quo tax policy and a given function h we say that type (ω,θ) strictly prefers a small tax reform over the status quo if $V_\tau(\omega,\theta \mid 0,h) > 0$. The status quo median voter strictly prefers a small reform if $V_\tau\left((\omega,\theta)^{0M} \mid 0,h\right) > 0$, where $\tilde{y}^{0M}$ is the median of the distribution of earnings in the status quo and $(\omega,\theta)^{0M}$ is the corresponding type; i.e. $\tilde{y}^0\left((\omega,\theta)^{0M}\right) = \tilde{y}^{0M}$.

Proposition I.2 *For a given status quo tax policy and a monotonic function h, the following statements are equivalent:*

1. *Type $(\omega,\theta)^{0M}$ prefers a small reform over the status quo.*

2. *There is a majority of individuals who prefer a small reform over the status quo.*

Proposition I.2 exploits that the slope of a type (ω,θ) individual's indifference curve through a point (τ,R),

$$s(\tau,R,\omega,\theta) = h(y^*(R,\tau,\omega,\theta)) \; .$$

is a function of the individual's income. As in the basic Mirrleesian setup, the interpretation is that individuals with a higher income are more difficult to convince that a reform that involves tax increases ($\tau > 0$) is worthwhile. A difference to the Mirrleesian setup is, however, that there is no monotonic relation between types and earnings. In the presence of income effects, and for a given level of ω, y^* will increase in θ as long as θ is below a threshold $\hat{\theta}(\omega)$ and be equal to 0 for θ above the threshold. Moreover, the threshold is affected by tax policy. This implies that there is no longer a fixed type whose income is equal to the median income whatever the tax schedule. As in Proposition I.1, this does not pose a problem if we focus on small reforms, i.e. on small deviations from $(\tau,R) = (0,0)$. In this case, preferences over reforms follow from the relation between types and earnings in the status quo, and a small reform is preferred by a majority of individuals if and only if it is preferred by the individual with the median level of income in the status quo.

I.3 Public-goods preferences

Suppose that the change in revenue R is used to increase or decrease spending on publicly provided goods. The post-reform consumption schedule is then given by

$$C_1(y) = c_0 + y - T_0(y) - \tau\, h(y) \ ,$$

We assume that individuals differ with respect to their public-goods preferences. Now the parameter θ is a measure of an individual's willingness to give up private goods consumption in exchange for more public goods. More specifically, we assume that individual utility is

$$u(\theta(R^0 + R) + C_1(y), y, \omega) \ ,$$

where R^0 is spending on publicly provided goods in the status quo. Again, we denote by $y^*(R, \tau, \omega, \theta)$ the solution to

$$\max_y \ u(\theta(R^0 + R) + C_1(y), y, \omega)$$

and the reform-induced change in indirect utility by $V(R, \tau, \omega, \theta)$. By the envelope theorem, the slope of a type (ω, θ) individual's indifference curve through point (τ, R) is now given by

$$s(\tau, R, \omega, \theta) = \frac{h(y^*(R, \tau, \omega, \theta))}{\theta} \ .$$

This marginal rate of substitution gives the increase in public-goods provision that an individual requires as a compensation for an increase of marginal tax rates. Ceteris paribus, individuals with a lower income and individuals with a higher public-goods preference require less of a compensation, i.e. they have a higher willingness to pay higher taxes for increased public-goods provision. If we focus on small reforms we observe, again, that if a type (ω, θ)-individual benefits from a small tax-increase, then the same is true for any type (ω', θ') with

$$\frac{h(\tilde{y}^0(\omega, \theta))}{\theta} \geq \frac{h(\tilde{y}^0(\omega', \theta'))}{\theta'} \ .$$

By the arguments in the proof of Proposition I.2, a small reform with $\tau > 0$ is preferred by a majority of individuals if and only if

$$\left(\frac{h(\tilde{y}^0(\omega, \theta))}{\theta} \right)^{0M} < R_\tau(0, h) \ ,$$

where $\left(\frac{h(\tilde{y}^0(\omega, \theta))}{\theta} \right)^{0M}$ is the median willingness to pay higher taxes for increased public spending in the status quo.

I.4 Fairness and politically feasible reforms

The validity of our approach does not dependent on the assumption that voting behavior is driven by narrow self-interest. To illustrate this insight, we analyze politically feasible reforms in the context of a model in which social preferences determine political support for redistributive taxation. Specifically, we adopt the framework of Alesina and Angeletos (2005). Alesina and Angeletos assume that individual incomes can be due to luck or effort and that preferences over tax policies include a motive to tax income that is due to luck more heavily than income that is due to effort. Alesina and Angeletos focus, however, on linear tax systems.

There are two periods. When young individuals choose a level of human capital k. When old individuals choose productive effort or labor supply l. Pre-tax income is determined by

$$y = \pi(l, k) + \eta \ ,$$

where π is a production function that is increasing in both arguments and η is a random source of income, also referred to as luck. An individual's life-time utility is written as $u(c, l, k, \omega)$. Utility is increasing in the first argument. It is decreasing in the second and third argument to capture the effort costs of labor supply and human capital investments, respectively. Effort costs are decreasing in ω. More formally, lower types have steeper indifference curves both in a (c, l)-space and in a (c, k)-space. We consider reforms that lead to a consumption schedule

$$C_1(y) = c_0 + R + y - T_0(y) - \tau \ h(y) \ .$$

We assume that individuals first observe how lucky they are and then choose how hard they work, i.e. given a realization of η and given the predetermined level of k, individuals choose l so as to maximize

$$u(C_1(\pi(l, k) + \eta), l, k, \omega) \ .$$

We denote the solution to this problem by $l^*(R, \tau, \omega, \eta, k)$. The reform-induced change in indirect utility is denoted by $V(R, \tau, \omega, \eta, k)$. As of $t = 1$, there is multi-dimensional heterogeneity among individuals: they differ in their type ω, in their realization of luck η and possibly also in their human capital k.

In Alesina and Angeletos (2005) preferences over reforms have a selfish and fairness component. The indirect utility function V shapes the individuals' selfish preferences over reforms. The analysis of these selfish preferences can proceed along similar lines as the extension that considered fixed costs of labor market participation. Selfish preferences over small reforms follow from the relation between types and earnings in the status quo, and a small reform makes a majority better off if and only if it is beneficial for the individual with the median level of income in the status quo. More formally, let

$\tilde{y}^0(\omega, \eta, k) := y^*(0, 0, \omega, \eta, k)$ be a shorthand for the earnings of a type (ω, η, k)-individual in the status quo and recall that the sign of

$$s(0, 0, \omega, \eta, k) = h(\tilde{y}^0(\omega, \eta, k))$$

determines whether an individual benefits from a small tax reform. Specifically, suppose that h is a non-decreasing function and denote by y^{0M} the median level of income in the status quo and by $(\omega, \eta, k)^{0M}$ the corresponding type. A majority of individuals is – according to their selfish preferences – made better off if and only if the median voter benefits from the reform,

$$s^0\left((\omega, \eta, k)^{0M}\right) = h\left(\tilde{y}^{0M}\right) < R_\tau(0, h) \ .$$

In their formalization of social preferences, Alesina and Angeletos (2005) view $\pi(l, k)$ as a reference income. It is the part of income that is due to effort as opposed to luck. A tax reform affects the share of $y = \pi(l, k) + \eta$ that individuals can keep for themselves. After the reform, the difference between disposable income and the reference income is given by[9]

$$C_1(y) - \pi(l, k) = \eta - T_0(\pi(l, k) + \eta) - \tau h(\pi(l, k) + \eta) \ .$$

A social preferences for fair taxes is then equated with a desire to minimize the variance of $\eta - T_0(\pi(l, k) + \eta) - \tau h(\pi(l, k) + \eta)$ taking into account that k and l are endogenous variables.[10] Denote this variance henceforth by $\Sigma(R, \tau)$. Any one individual is assumed to evaluate a tax reform according to

$$V(R, \tau, \omega, \eta, k) - \rho\, \Sigma(R, \tau) \ ,$$

where ρ is the weight on fairness considerations which is assumed to be the same for all individuals. Therefore, heterogeneity in preferences over reforms is entirely due to heterogeneity in selfish preferences. Consequently, the finding that a small reform is preferred by a majority of taxpayers if and only if it is preferred by the voter with median income in the status quo is not affected by the inclusion of a demand for fair taxes.

[9]The analysis in Alesina and Angeletos (2005) looks at a special case of this. They focus on a status quo equal to the laissez-faire schedule so that $T_0(y) = 0$, for all y, and a reform that introduces a linear tax schedule, i.e. $h(y) = y$, for all y. Under these assumptions, we have $\eta - T_0(\pi(l, k) + \eta) - \tau h(\pi(l, k) + \eta) = (1 - \tau)\eta + \tau\pi(l, k)$.

[10]Human capital investment is a function of effort costs ω and the expectations (R^e, τ^e) of the young on the tax reforms that will be adopted when they are old.

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