Self-Financing Tax Cuts Around the World: New Theoretical Results and Applications to 33 Countries*

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PRELIMINARY

Abstract

This paper studies whether tax-transfer systems are inefficient in the sense of allowing for self-financing tax cuts. In the first part, we combine household micro data from representative surveys with tax-transfer calculators for 33 countries around the world. We show that, with standard labor supply elasticities, self-financing tax cuts exist for all 29 countries in which the effective marginal tax rates (EMTR) exhibit sudden drops. In the second part, we show analytically that sudden drops in EMTRs give rise to inefficiencies whenever (a) taxpayers are rational and have additively separable preferences, or (b) taxpayers use the ironing heuristic and EMTRs are above some threshold. In the third part, we characterize discrete tax reforms that bring inefficient tax-transfer systems to the Pareto frontier. For this purpose, we focus on a canonical model with iso-elastic and quasi-linear preferences and consider both rational and non-rational taxpayers. Thereby, we provide an empirically applicable recipe how to design tax reforms that raise tax revenue without making any individual in society worse off.

Keywords: Non-linear income taxation; Tax reforms; Efficiency; Behavioral public economics
JEL classification: H21, H24, H31, D90

*__Hansen__: LMU Munich and CESifo (emanuel.hansen@econ.lmu.de); __Weishaar__: LMU Munich (daniel.weishaar@econ.lmu.de). This paper uses EUROMOD (model version I6.0+) and OECD TaxBEN, the OECD tax-benefit model (version 2.4.0). Results and their interpretation are the sole responsibility of the authors. In particular, the OECD and its member countries are not responsible for any errors, omissions, or inaccuracies. Special thanks go to Felix Bierbrauer, Andreas Peichl, and Dominik Sachs for many fruitful discussions and exchanging ideas. We also thank Herwig Immervoll for helpful instructions to access OECD TaxBEN. Rafael Pfeiffer and Helene Wagner provided excellent research assistance. Support by Deutsche Forschungsgemeinschaft through CRC TRR 190 (project number 280092119) is gratefully acknowledged.

1 Introduction

This paper provides a systematic analysis of tax-transfer systems around the world. In particular, we build on Bierbrauer et al. (2023) to analyze whether modern tax systems are second-best Pareto-efficient. If they are, then any tax reform creates winners and losers. For instance, higher transfer payments can then improve the living standards of the poor only at the expense of higher tax liabilities for others. Conversely, if tax systems are inefficient, there are self-financing tax reforms that make some individuals better off without harming anyone else. Such tax reforms are also of particular interest for policymakers, since they allow to raise revenue at minimal political cost, and thereby to ease fiscal pressures arising from contemporaneous challenges like aging populations, climate change, and geopolitical instability.

This paper provides three contributions. First, in our empirical part, we provide the first systematic assessment of inefficiencies in tax-transfer system in 33 countries around the world. Second, we provide novel theoretical results under weaker assumptions than those imposed by Bierbrauer et al. (2023). In particular, we show that a tax-transfer system is inefficient if it features a sudden drop in effective marginal tax rates (EMTRs) whenever (i) taxpayers are rational and have separable preferences or (ii) taxpayers use the ironing heuristic (i.e., misperceive average tax rates as marginal tax rates) and EMTRs are sufficiently high. Third, we are the first to provide analytical results on discrete tax reforms that eliminate inefficiencies in a tax-transfer system, i.e., bring the system to the Pareto frontier. As a benchmark, we focus on a canonical model with quasi-linear and iso-elastic preferences but consider both rational taxpayers and non-rational taxpayers using the ironing heuristic.

Detecting Inefficiencies In the first part, we use the sufficient-statistics tools developed by Bierbrauer et al. (2023) to investigate tax-transfer systems in 33 countries around the world, including the ones of Australia, Canada, Finland, Germany, Italy, Japan, South Korea, the United Kingdom, and the United States. The analysis is based on the common assumptions that (a) taxpayers are rational and perfectly informed about the tax code, and (b) that taxpayer preferences are quasi-linear and iso-elastic. It requires empirical estimates of income distributions, labor supply elasticities at the intensive and extensive margin, and tax rates. To conduct the analysis for our set of 33 countries, we combine country-specific household micro data on the distribution of incomes with information from the tax-benefit microsimulation model for the European Union (EUROMOD) and the OECD calculator of taxes and benefits (OECD TaxBEN).

Our analysis reveals two consistent patterns in the marginal tax rate schedules. First, marginal tax rates are particularly high at the lower end of the income distribution. This phenomenon can be attributed to the phase-out of transfers, such as social assistance or in-work benefits, which often occurs at rates exceeding 60 percent. Second, once these transfers are fully phased out, marginal tax rates drop discontinuously and substantially. These sudden drops arise because statutory marginal tax rates are relatively moderate at the income levels where individuals no longer qualify for transfers. Using standard assumptions about labor supply elasticities from the literature, we identify inefficiencies in all tax-transfer systems that involve discontinuous drops in marginal tax rates.

General Preferences and Non-Rational Behavior In the second part of the analysis, we derive new and simple conditions for tax-transfer systems to be inefficient that go in two ways beyond previous results. First, the approach suggested by Bierbrauer et al. (2023) requires to study the properties of a test function – called "revenue function" – that depends on income distributions, labor supply elasticities, and tax rates. Second, their analysis is based on the assumption that taxpayers are rational and perfectly

informed about the tax function. By contrast, we show that inefficiencies can be detected based on the EMTRs alone, once the researcher is willing to impose one of the two following assumptions: Either taxpayers are rational and their preferences are additively separable between consumption and labor supply as in the context of the Atkinson-Stiglitz Theorem; or they are non-rational and misperceive the tax-transfer system using the "ironing heuristic" (Liebman and Zeckhauser, 2004). In the latter case, they misinterpret their true average tax rate as a (constant) marginal tax rate. Empirically, many taxpayers seem to rely on this heuristic (Rees-Jones and Taubinsky, 2020).

Specifically, our first theoretical result shows that discontinuous drops in marginal tax rates give rise to an inefficiency whenever taxpayers are rational and have additively separable preferences. This insight directly relates to our empirical finding that tax-transfer systems involve inefficiencies exactly at the income levels where transfer payments are phased out completely and EMTRs drop substantially. It clarifies that this empirical result does not depend on the specific assumptions we imposed on labor supply elasticities, but is more general.

The second theoretical result extends this insight to scenarios in which taxpayers misperceive the tax schedule in line with the ironing heuristic and marginal tax rates are above some threshold.[1] In this case as well, tax-transfer systems allow for self-financing tax cuts whenever they feature sudden drops in EMTRs and, in addition, the EMTRs are above some threshold level below the drop. Note that, in this scenario, the envelope theorem does not hold, so we need to account for the first-order utility effects of taxpayers' labor supply responses. We then implement our efficiency conditions for the scenario with non-rational taxpayers empirically for the set of 33 countries studied in part one. We find that the potential for Pareto-improving tax reforms persists in many, but not all countries.

Discrete Reforms In the third part of the analysis, we go beyond the existing literature which has focused on the existence of self-financing tax cuts or, put differently, Pareto-improving tax reforms. For this purpose, the literature relies on marginal reforms that perturb the tax-transfer system in a small environment around the status-quo policy. By construction, such reforms cannot eliminate existing inefficiencies but only (marginally) reduce them. In this part, by contrast, we study how to design a discrete reform that fully eliminates an existing inefficiency and brings the economy to the Pareto frontier. Specifically, we follow Werning (2007) and solve for the tax reform that maximizes the gain in tax revenue subject to the constraint that no agents are made worse off. The analysis of discrete reforms requires structural assumptions about preferences and type distributions, since we must track individual behavior in regions that are no longer close to the status quo tax system. In a first step, we focus on the canonical optimal tax model with quasi-linear and iso-elastic preferences as used by Diamond (1998). For this model, we provide analytical characterizations of the revenue-maximizing tax cuts for both scenarios with rational and non-rational taxpayers.

We find that, in the scenario with rational taxpayers, the optimal tax reform eliminates the inefficiencies by smoothing the EMTRs so that the post-reform tax rates fall gradually over longer income ranges instead of dropping discontinuously. In the scenario with non-rational taxpayers, the optimal reform may involve smaller discontinuities in EMTRs but smooths and reduces average tax rates. In both scenarios, the optimal reforms require to reduce excessively high transfer phase-out rates and to raise the transfer eligibility threshold. Again, we also bring our analytical results to the data and estimate the associated post-reform marginal tax rate schedule for the covered countries. Summing up, our third set of results

[1] We focus on the ironing heuristic, since this form of misperceptions has been found to be particularly prevalent in empirical studies (see, e.g., Rees-Jones and Taubinsky, 2020).

offers concrete and simple instructions on how to reform tax-transfer systems around the world in a way that does not require hard tradeoffs, but makes everybody better off.

Related Literature Our paper relates to three strands of the literature. First, we contribute to the literature on Pareto-efficient income taxation (Bierbrauer et al., 2023; Bierbrauer et al., 2021; Lorenz and Sachs, 2016; Werning, 2007). Our empirical analysis applies the test for inefficiencies suggested by Bierbrauer et al. (2023) to current tax-transfer systems. Our theoretical results then extend this literature by (i) considering scenarios with non-rational taxpayers and (ii) characterizing discrete reforms that bring tax-transfer systems to the Pareto frontier. By contrast, the previous literature focused on rational taxpayers and marginal reforms.

Second, we contribute to the theoretical literature on income taxation with non-rational taxpayers. The seminal paper by Liebman and Zeckhauser (2004) discusses misperceptions of tax schedules, labeled *schmeduling*. Incomplete knowledge of the tax system and, in particular, the ironing heuristic have been found to be empirically relevant for the behavior of individuals, both in lab experiments (Rees-Jones and Taubinsky, 2020; Abeler and Jäger, 2015) and in the field (Chetty et al., 2013; Chetty et al., 2009).[2] Theoretical work on optimal taxation under non-rational behavior includes Craig and Slemrod (2023) and Farhi and Gabaix (2020). Our theoretical analysis differs from their work in that we are interested in the effect of tax reforms starting from an arbitrary status quo and in our focus on Pareto improvements and self-financing tax cuts. To the best of our knowledge, our work is the first to empirically assess the effect of tax reforms under non-rational behavior.

Finally, we contribute to the literature employing micro-simulation models to evaluate actual and hypothetical tax reforms with respect to tax revenue, labor supply, and political feasibility (see, e.g., Bierbrauer et al., 2021; Bargain et al., 2015; Eissa et al., 2008). Our analysis thereby demonstrates how integrating rigorous theoretical frameworks with applied policy evaluation tools can yield robust and actionable findings.

Outline The remainder of the paper is organized as follows. Section 2 describes the general theoretical framework for our analysis. Section 3 conducts our empirical analysis of tax-transfer systems, applying sufficient-statistics formulas to identify the existence of inefficiencies. In Section 4, we generalize the conditions for the identification of a Pareto inefficient tax system and extend them to non-rational behavior. Section 5 discusses the optimal design of discrete reforms, and Section 6 concludes.

2 Theoretical Framework

Environment. There is a continuum of individuals who value consumption c and generate earnings y. The generation of earnings comes with effort costs that depend on a vector of individual, potentially multidimensional, characteristics $\theta = (\theta_1, \theta_{-1}) \in \Theta \subset \mathbb{R}^k$ with $k \geq 1$. The cross-section distribution of θ is atomless and represented by a cumulative distribution function F, with continuous density f. Preferences are represented by the utility function $u : (c, y, \theta) \mapsto u(c, y, \theta)$ that is twice continuously differentiable in the first two arguments with $u_c > 0$, $u_{cc} \leq 0$, $u_y < 0$, and $u_{yy} < 0$ for any $y > 0$. Finally, we assume that u is continuously differentiable in θ and that u_y (u_c) is strictly (weakly) increasing in θ_1. Hence, a

[2] For recent evidence of behavior that is consistent with the spotlighting heuristic, see Gelber et al. (2025).

single-crossing condition holds with respect to the first type dimension: The MRS, $-u_y(c,y,\theta)/u_c(c,y,\theta)$, is continuous and strictly decreasing in θ_1. We will refer to this type dimension as the skill type θ_1.

The Tax System. The status-quo tax system (c_0, T_0) is represented by a parameter c_0 and a function T_0, which jointly define the budget set $C_0(y) = c_0 + y - T_0(y)$. Parameter c_0 is a base transfer paid to people with zero income. T_0 is a tax function normalized to satisfy $T_0(0) = 0$. Hence, $T_0(y)$ is the difference between the (net) tax payments at income y and at zero income. In the literature, it is often referred to as the participation tax. A *tax reform* is characterized by a function h that defines the direction of reform and a scalar τ that defines the magnitude of reform. Reform (τ, h) implements a new tax function $T_1 = T_0 + \tau h$ and a new base transfer c_1. We denote by $y^*(\tau, h, c_1, \theta)$ the income chosen by a θ type after reform (τ, h), and use $y_0(\theta) = y^*(0, h, c_0, \theta)$ as a shorthand for income in the status quo. We assume that the base transfer c_1 is adjusted so to make the reform budget-neutral. Formally, this implies that $c_1 = c_0 + R(\tau, h)$, where the net revenue gain $R(\tau, h)$ solves the fixed point equation

$$R(\tau,h) \quad = \quad \int_{\theta\in\Theta} f(\theta) T_1\left(y(\tau,h,c_0+R(\tau,h),\theta)\right) d\theta - \int_{\theta\in\Theta} f(\theta) T_0\left(y_0(\theta)\right) d\theta \; . \tag{1}$$

Revenue Implications. Our goal is to investigate the existence of tax reforms that are Pareto-improving, i.e., that allow to make all θ types better off. For this purpose, we first need to determine the revenue implications of tax reforms. By Proposition 3 in Bierbrauer et al. (2023), the effect of a small tax reform in direction h on net tax revenue is given by

$$R_\tau(0,h) = \int_0^\infty h'(y)\mathcal{R}_0(y)dy \; , \tag{2}$$

where $\mathcal{R}_0(y)$ is referred to as the *revenue function* under status quo tax policy (c_0, T_0). It captures the revenue effects of a small single-bracket tax reform with direction

$$h^s(\tilde{y}) = \begin{cases} 0 & \text{if} \quad \tilde{y} \leq y \; , \\ \tilde{y} - y & \text{if} \quad \tilde{y} \in (y, y+\ell) \; , \\ \ell & \text{if} \quad \tilde{y} \geq y + \ell \end{cases} \tag{3}$$

for the threshold income level y. Formally, $\mathcal{R}_0$ is the cross-derivative of the net revenue gain R with respect to τ and ℓ, evaluated at $(\tau, \ell) = (0, 0)$. Intuitively, it captures the revenue implications of a Saez-type reform that slightly increases the effective marginal tax rate T' in a small income range around y. Below, we will use formulas that express $\mathcal{R}_0$ either in terms of empirically estimable objects (sufficient statistics) such as income distributions and labor supply elasticities, or in terms of the model's primitives such as type distributions and parameters of the utility function.

To evaluate discrete (non-marginal) tax reforms, we note that the revenue function is an endogenous object that is affected by a tax reform (τ, h). In particular, letting $\mathcal{R}_1(y, \tau, h)$ denote the revenue function after the reform (τ, h), the change in net tax revenue due to a discrete reform is given by

$$R(\tau,h) = \int_{\tau'=0}^{\tau} \int_0^\infty h'(y)\mathcal{R}_1(y,\tau',h)dyd\tau' \; . \tag{4}$$

In the following section, we will investigate whether modern tax-transfer systems in 33 countries allow for self-financing tax cuts, i.e., tax reforms that reduce the tax burden for a non-empty set of θ types

without making any other agents worse off or reducing the government's net tax revenue. We build on Theorem 1 in Bierbrauer et al. (2023) according to which a self-financing tax cut exists if (i) the revenue function $\mathcal{R}_0$ attains a value below 0 or above 1, or (ii) if $\mathcal{R}_0$ is increasing between two income levels $y_a > 0$ and $y_b > y_a$. They also show that any self-financing tax cut constitutes a Pareto improvement if taxpayers are rational, i.e., each θ type chooses income y to maximize their utility function $u(c, y, \theta)$.

3 Investigating Tax-Transfer Systems in 33 Countries

In the following section, we investigate whether observed tax-transfer systems are inefficient in the sense of allowing for Pareto-improving tax reforms. We focus on a set of benchmark assumptions on preferences and taxpayer behavior. In particular, we assume that taxpayers are rational and are heterogeneous in two dimensions: skills θ_1 and fixed costs of labor market participation θ_2. Their preferences are captured by a utility function of the form

$$u(c, y, \theta_1, \theta_2) = c - \frac{1}{1 + \frac{1}{\sigma}} \left(\frac{y}{\theta_1}\right)^{1+\frac{1}{\sigma}} - \mathbb{1}_{y>0}\, \theta_2 \,. \tag{5}$$

The quasi-linearity in consumption implies that there are no income effects in labor supply. Also, preferences are iso-elastic: the intensive-margin elasticity of income with respect to the retention rate $1 - T'$ is given by $\sigma > 0$ (on a linear budget). We assume that, for each skill level θ_1, there is heterogeneity in the fixed cost of working θ_2. This creates labor supply responses at the extensive margin; the agents with the highest fixed costs are best off with zero earnings, i.e., non-employed.

Under these assumptions, as shown by Bierbrauer et al. (2023), the revenue function $\mathcal{R}_0$ is given by

$$\mathcal{R}_0(y) \quad = \quad \underbrace{1 - F_y(y)}_{\text{Mechanical Effect}} \quad \underbrace{- \varepsilon_0(y)\; y\; f_y(y)\; \frac{T_0'(y)}{1 - T_0'(y)}}_{\text{Intensive Margin}} \underbrace{- \int_y^\infty f_y(y')\eta_0(y') \frac{t_0(y')}{1 - t_0(y')} dy}_{\text{Extensive Margin}} \,, \tag{6}$$

where f_y and F_y are the probability density function (pdf) and the cumulative distribution function (cdf) of the income distribution under the status quo tax system; $T_0'(y)$ and $t_0(y) = T_0(y)/y$ are the effective marginal tax rate and the participation tax rate at income level y, respectively; $\varepsilon_0(y)$ is the intensive-margin elasticity at income level y; and $\eta_0(y)$ is the participation elasticity at income level y. As explained before, the revenue function (6) provides an estimate of the effects of a small single-bracket reform on net tax revenue: The first term captures mechanical effects, the second term behavioral effects related to intensive-margin responses, and the third term behavioral effects related to extensive-margin (participation) responses.

Below, we also use the approach suggested by Bierbrauer et al. (2023) to measure the size of inefficiencies in status quo tax-transfer systems. In particular, this approach requires, in the first step, to identify the reform direction h_R that maximizes the gain in net tax revenue conditional on making no agent worse off and, in the second step, to evaluate the Gateaux differential related to this reform direction,

$$I(T_0, c_0) = R_\tau(0, h_R) - \max_y h_R(y) \,. \tag{7}$$

3.1 Data

The empirical assessment of the tax-transfer system in a given country and year requires, as indicated by equation (6), information on (i) the marginal tax rates and participation tax rates, (ii) the pdf and the cdf of the earnings distribution, as well as (iii) assumptions about behavioral responses to taxation in the form of intensive margin elasticities and participation elasticities.

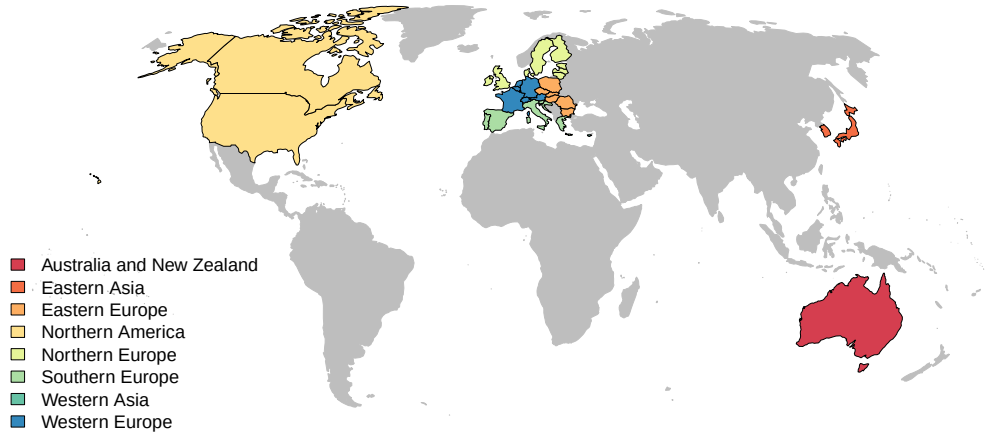
Based on the availability of these inputs, our empirical analysis includes 33 countries around the world (see Table 1 and Figure 1). While most of the selected countries are located in Europe, we also provide results for some countries in North America, Asia, and the Pacific region. Our selection fully captures the group of the major advanced economies (G7), more than 75 percent of all OECD member countries, and 26 out of 27 European Union member states. While our sample is globally centered around advanced economies, we also capture countries on the European continent that are classified as emerging economies like Bulgaria and Romania.[3]

Table 1: Country List for Empirical Analysis

Region	Countries
Northern Europe	Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden, United Kingdom
Western Europe	Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland
Southern Europe	Croatia, Greece, Italy, Portugal, Slovenia, Spain
Eastern Europe	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic
Northern America	Canada, USA
Asia and Australia	Australia, Cyprus, Japan, South Korea

Note: This table lists the countries included in our empirical analysis. Regional classifications are based on the sub-regions used by the United Nations Statistics Division.

Figure 1: Country Coverage



Note: This figure displays the selection of countries. Regional classifications are based on the sub-regions used by the United Nations Statistics Division.

Tax Rates We obtain marginal tax rates and participation tax rates from two micro-simulation models for the policy year 2018. For European countries, we use EUROMOD (version I.6.0+), a tax-benefit

[3]For details, see country classification by the International Monetary Fund (IMF).

microsimulation model for the European Union. For other countries, we use OECD TaxBEN (version 2.4.0), the cross-country tax and benefit simulation model developed and maintained by the OECD.[4] We use these models to determine tax liabilities, effective marginal tax rates and effective participation tax rates for two types of households: (i) childless singles and (ii) single parents with two children.[5] For the baseline results, we consider the combination of income taxes, social insurance contributions, and transfer programs when calculating effective tax rates. For now, we further assume that individuals take up all transfers that they are eligible for.[6] In particular, we use the microsimulation models to simulate the budget sets available to both household types. Then, we calculate marginal tax rates T_0' and participation tax rates t_0 from these budget sets.

Figure 2 displays the resulting tax rates for single individuals without children for a selection of nine countries from three continents: Australia, Canada, Finland, Germany, Hungary, Italy, Japan, the United Kingdom, and the United States. Results for the full set of countries are shown in Appendix Figure A2 (A3) for singles without (with) children. While details in the magnitude and shape of tax rates differ, there are some common features of EMTR schedules across countries. First, in all countries except Hungary, effective marginal tax rates are very high at the bottom of the income distribution. For Canada, Italy, and the US, they exceed 70% at low incomes, for the other five countries even 80%. Second, in the same set of eight countries, EMTRs drop discontinuously and substantially – between 30 and more than 70 percentage points – at the income level where the transfer programs are phased out completely.[7]

These features are not specific to our selection of countries. Table 2 summarizes the information about discontinuous drops for the full set of 33 countries. It shows that the effective marginal tax rate schedule for singles without (with) children features downward discontinuities of at least 25 percentage points in 29 (31) out of 33 covered countries. When abstracting from transfer phaseout rates in the calculation of marginal tax rates, only three countries feature such a discontinuous drop. The median size of the drop in marginal tax rates is substantial and lies at almost 70 (60) percentage points for singles without children in countries covered in EUROMOD (OECD TaxBEN). Appendix Tables A5 and A6 present the exact location and size of the downward discontinuities of marginal tax rates for all countries.

Income Distributions To obtain income distributions, we use data from the European Survey of Income and Living Conditions (EU-SILC) and six other household surveys for Australia (HILDA), Japan (JHPS), Canada (CIS), the United States (PSID), the United Kingdom (HLS), and Switzerland (SHP). For each country, we focus on the survey wave closest to the policy year 2018 and restrict the sample to single individuals of age 25 to 60 with non-negative gross earnings.[8]

[4]For detailed information on EUROMOD, see Sutherland and Figari (2012) and Sutherland (2017). For detailed information on OECD TaxBEN, see OECD (2024). For an overview of the different tax and transfer programs that are (not) simulated by the models in the respective countries, see Appendix Table A2.

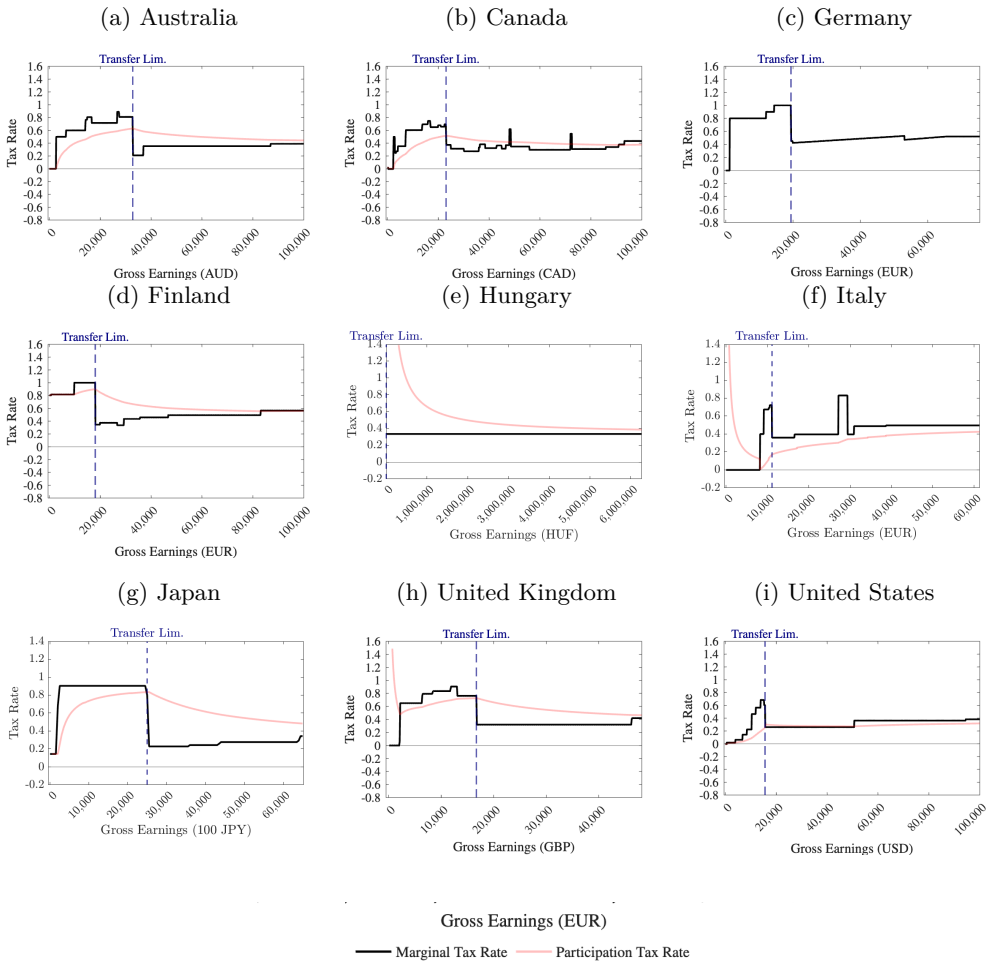
[5]The exact characteristics of hypothetical households in both groups are shown in Appendix Table A4. We abstract from the tax treatment of married couples. For recent insights on Pareto improving tax reforms and the taxation of couples, see Bierbrauer et al. (2024).

[6]We can relax this assumption by imposing exogenous propensities for taking up transfers that potentially vary across the income distribution. We abstract, however, from the endogeneity of take-up decisions to the tax and transfer system. For recent work on the integration of endogenous transfer take-up into the analysis of Pareto improving tax reforms, see Bastani et al. (2024).

[7]In Hungary, the pattern looks very different. In particular, the Hungarian tax and transfer system features a constant marginal tax rate paired with a transfer that is completely phased out as soon as the first Hungarian Forint is earned. As a result, although the marginal tax rate remains flat, the participation tax rate is extremely high for those with lower incomes.

[8]The age restriction is warranted, since our model abstracts from education and retirement decisions and because the elasticities used in the analysis are plausibly only valid for people with strong labor force attachment. For details on the data sources and particularities of the data preparation, see Appendix Table A1. Appendix Table A3 presents summary statistics for the sample of singles with and without children.

Figure 2: Tax Rates, Selected Countries, 2018



Note: This figure displays for nine selected countries the marginal tax rates (black lines) and participation tax rates (red lines) for single individuals without children. Tax rates are calculated from budget sets using EUROMOD and the OECD calculator of taxes and benefits. The vertical dashed line indicates the income level at which the major transfer programs (social assistance, unemployment benefits, housing and in-work benefits) are completely phased out. Results for the full set of countries is shown Appendix Figure A2 (A3) for singles without (with) children.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Table 2: Downward Discontinuities, Summary

		EUROMOD			OECD TaxBEN		
Household Type	MTR Type	N	N_D	Median Disc.	N	N_D	Median Disc.
Singles without Children	Tax + SIC + Benefit	26	23	0.50	7	7	0.34
	Tax + Benefit	26	23	0.47	7	7	0.28
	Tax + SIC	26	4	7.07	7	2	0.44
	Tax	26	3	0.36	7	1	0.55
Singles with Children	Tax + SIC + Benefit	26	25	0.62	7	7	0.44
	Tax + Benefit	26	25	0.53	7	7	0.44
	Tax + SIC	26	5	8.53	7	2	0.44
	Tax	26	2	0.33	7	1	0.55

Note: This table shows for all countries whether countries' tax and benefit systems incorporate a downward discontinuity of more than 25 pecentage points in the marginal tax rate schedule for singles without and singles with children. The table distinguishes between countries covered in EUROMOD (columns 3-5) and countries covered in OECD TaxBEN (6-8), as well as between different types of marginal tax rates. The table displays the total number of countries, the number of countries with a downward discontinuity, as well as the median downward discontinuity among those countries that have a discontinuity. Appendix Table A5 (A6) shows details regarding the location of downward discontinuities associated with the full effective marginal tax rate schedule for singles without (with) children.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

We estimate the income distributions separately for singles with and without children using an adjusted kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution.[9] All estimations are weighted if survey weights are available. Figure 3 displays the estimated distribution for singles without children for our set of selected countries. Estimates for the distributions of all other countries are relegated to Appendix Figure A4 (A5) for the sample of singles without (with) children.[10]

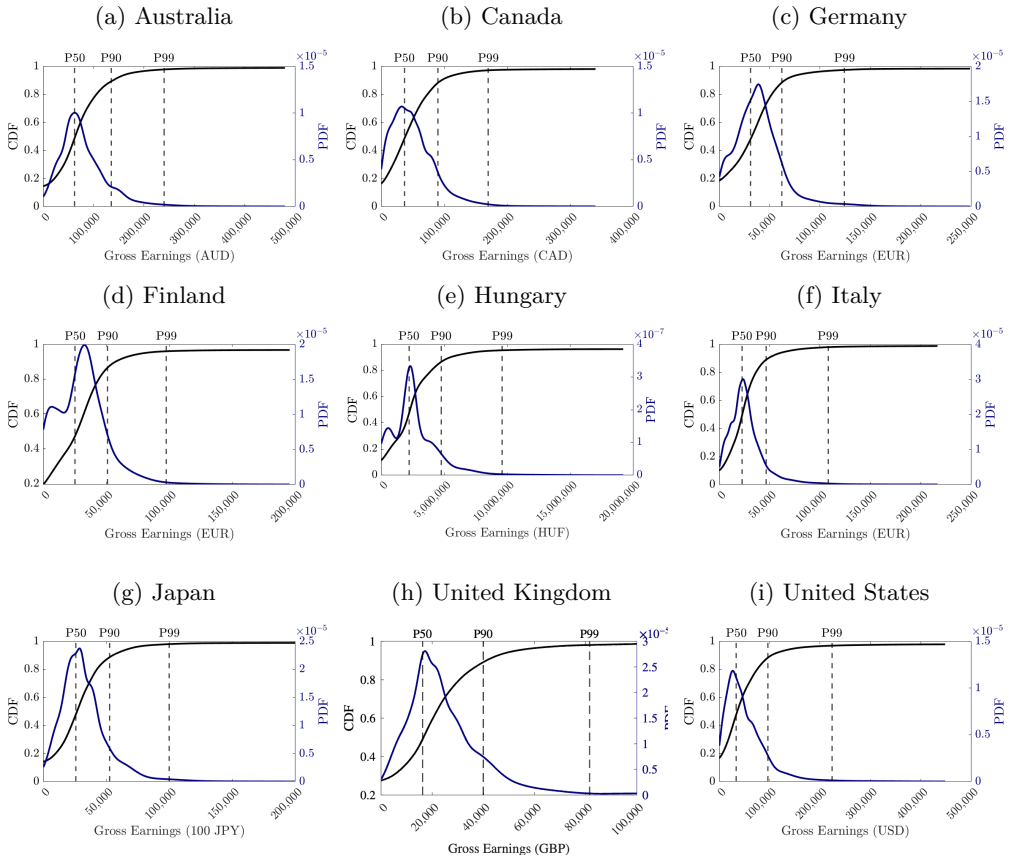
Behavioral Responses to Taxation We consider both intensive and extensive margin responses. For intensive-margin responses, we use a baseline elasticity of income with respect to the rentention rate of 0.5. Thereby, our assumption follows the range of estimates in the literature, see e.g. Blundell and Macurdy (1999), Saez et al. (2012), Bargain et al. (2014), and Neisser (2021). For extensive-margin responses, we assume that participation elasticities decrease with income. In the baseline, the participation elasticity decreases from 0.35 to 0.025 between zero and the 90th percentile of the sample-specific income distribution. For now, moreover, we assume that there are no income effects in labor supply.

3.2 Revenue Functions and Inefficiencies

Based on the set of inputs described in the previous section, we use equation (6) to estimate revenue functions under rational behavior and iso-elastic preferences, assuming no income effects in labor supply. Figure 4 displays the resulting revenue functions for singles without children in each of our nine selected countries. Specifically, the solid lines display the resulting revenue functions in the benchmark scenario with labor supply responses at the intensive and extensive margins. By contrast, the dashed lines depict the revenue functions in an alternative scenario without extensive-margin responses. While the consideration of extensive margin responses decreases revenue functions throughout, it does not alter our qualitative results for most countries.

[9]The sample sizes of the household micro data prevent separate estimations by the exact number of children.
[10]In the appendix, we also provide a robustness check by estimating income distributions using a kernel density function with fixed bandwidth (Figures A6 and A7). For the German case, we also assess the quality of survey data against a second data source (Figures A8 and A9), and provide insights on how distributions vary by transfer take-up (Figure A10).

Figure 3: Distribution, Singles without Children



Note: This figure displays in the cumulative distribution function (cdf) and the probability density function (pdf) for countries in the sample as black and blue lines. All information refers to the reference year 2018. Vertical dashed lines indicate selected percentiles of the distribution. The distributions are estimated for gross earnings consisting of income from employment and self-employment. We estimate the distribution by means of an adjusted kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. All estimations are weighted using survey weights if available. The sample consists of unmarried single households of age 25 to 60 without children. Descriptive statistics for the sample are shown in Table A3. Results for the full set of countries are shown in Appendix Figure A4 (A5) for singles without (with) children.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

As shown by Bierbrauer et al. (2023), a tax-transfer system is inefficient whenever (a) the revenue functions attain levels below zero, or (b) the revenue functions are increasing over some income range. In the first case, a one-bracket tax reform that *decreases* marginal tax rates in this income range would be Pareto-improving. For instance, considering the German case (Figure 4c), one could decrease marginal tax rates between 14,000 EUR and 20,000 EUR. This inefficiency can be interpreted as a local Laffer curve argument. Marginal tax rates are inefficiently high between 14,000 EUR and 20,000 EUR. Decreasing the marginal tax in this income range leads to a positive behavioral effect in net tax revenue (due to higher labor supply) that is large enough to outweigh the negative mechanical effect. Similarly, the revenue functions for Finland, Italy, Japan, and the United Kingdom also attain negative values, indicating excessively high marginal taxes.

In the second case where the revenue function is increasing over some income range, a two-bracket tax reform that *decreases* marginal tax rates for incomes in a lower bracket, *increases* marginal tax

rates for incomes in a higher bracket, and leaves tax levels constant above the second bracket would be Pareto-improving. For instance, the revenue function for childless singles in Australia increases sharply at around 32,200 AUD. Consider a tax reform that decreases the EMTR by one percentage point between 30,000 and 32,200 AUD, and increases the EMTR by one percentage point between 32,200 and 34,400 AUD. This reform mechanically reduces the net tax liability for all agents with income between 30,000 and 34,400 AUD. Moreover, it generates labor supply responses at the intensive and extensive margins that give rise to a behavioral effect on net tax revenue. As the revenue function attains higher levels in the upper bracket, the behavioral effect is positive and large enough to dominate the negative mechanical effect: the reform is a self-financing tax cut and allows to realize a Pareto improvement. The main insight from Figure 4 is that the revenue functions for all nine selected countries involve such non-monotonicities. Hence, all corresponding tax-transfer systems are inefficient. For one country, Hungary, the non-monotonicity is only present under the consideration of extensive margin responses.

The revenue functions for all other countries are depicted in Appendix Figures A11 (childless singles) and A12 (single parents). We find that most revenue functions involve non-monotonicities, implying that a large majority of tax-transfer systems is inefficient. In particular, whenever the effective marginal tax rate in a country drops discontinuously, the corresponding revenue function increases at the same income level.

Revenue-Maximizing Reform Directions Bierbrauer et al. (2023) also suggest an approach to measure the size of inefficiencies in tax-transfer systems. Specifically, they suggest to proceed in two steps: (a) to identify the reform direction that yields the largest net revenue gain in excess of what is needed to compensate the agents facing the largest tax increase, and (b) to approximate the net revenue gain from a reform in this direction that changes marginal tax rates at each income by at most 1 percentage point.[11] For a revenue function that involves a single non-monotonicity, the *revenue-maximizing reform direction* h_R is a two-bracket tax cut. It is defined by two income levels y_s and y_t such that the revenue function attains the same value at y_s and y_t but lower values in (y_s, y_m) and higher values in (y_m, y_t), where $y_m = (y_s + y_t)/2$. Direction h_R reduces the marginal tax rate in the former bracket and increases it in the latter bracket. The revenue gain from a one-percentage points step in this direction is approximated by

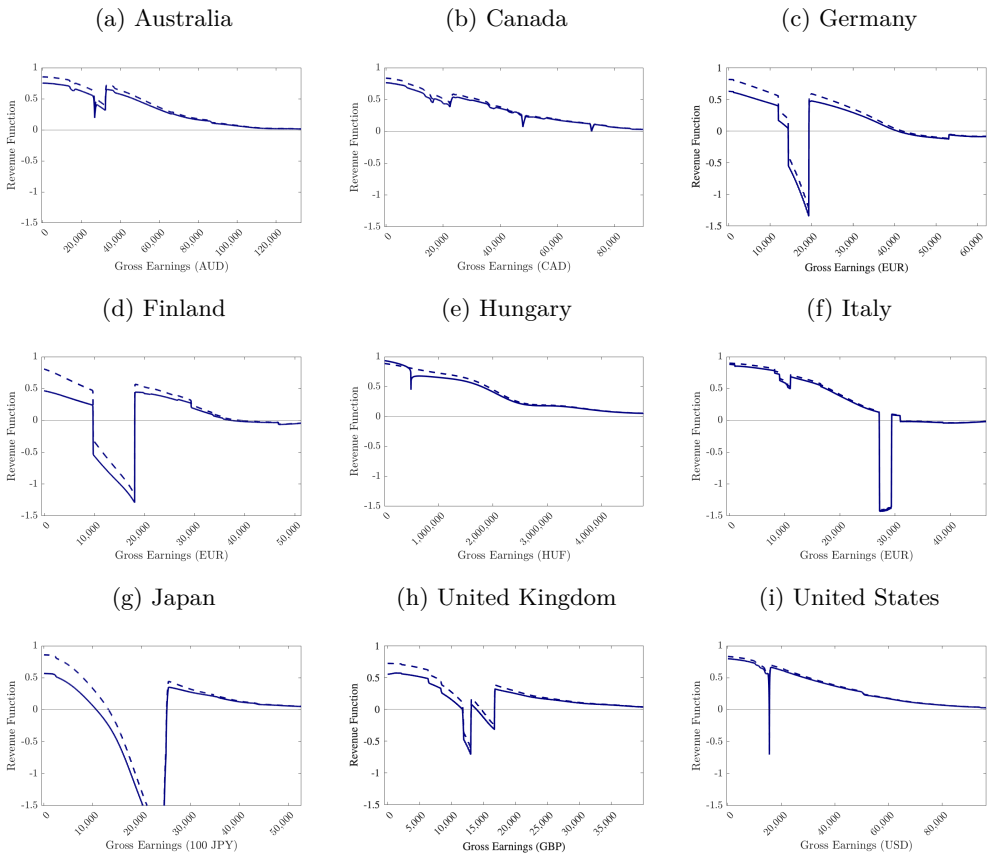
$$I(T_0, c_0) = 0.01 \cdot \left[\int_{y_m}^{y_t} \mathcal{R}(y) dy - \int_{y_s}^{y_m} \mathcal{R}(y) dy \right] , \tag{8}$$

see Bierbrauer et al. (2023), Proposition B.1. Equation (8) approximates the revenue gain per household in the population group under consideration (i.e., per childless single or single parent).

Figure 5 depicts the revenue-maximizing tax cuts for the nine selected countries. For each country, it focuses on the most substantial non-monotonicity, i.e., the most inefficient parts of the tax-transfer schedule. In each panel, the horizontal red line illustrates the income brackets tackled by the revenue-maximizing reform direction h_R. The gray area between this red line and the revenue function represents the corresponding inefficiency measure $I(T_0, c_0)$, i.e., it is proportional to the net revenue gain resulting from a small reform in direction h_R. Each panel of Figure 5 also reports the income levels y_s, y_m and y_t at which the marginal tax should be varied, and the implied net revenue gain. For instance, considering the case of Finland, a one percentage point decrease of marginal tax rates between 8,100 EUR and 18,150 EUR combined with a one percentage point increase of marginal tax rates between 18,150 EUR and

[11] See Appendix B in Bierbrauer et al. (2023) for formal details.

Figure 4: Revenue Functions under Rational Behavior, Singles without Children



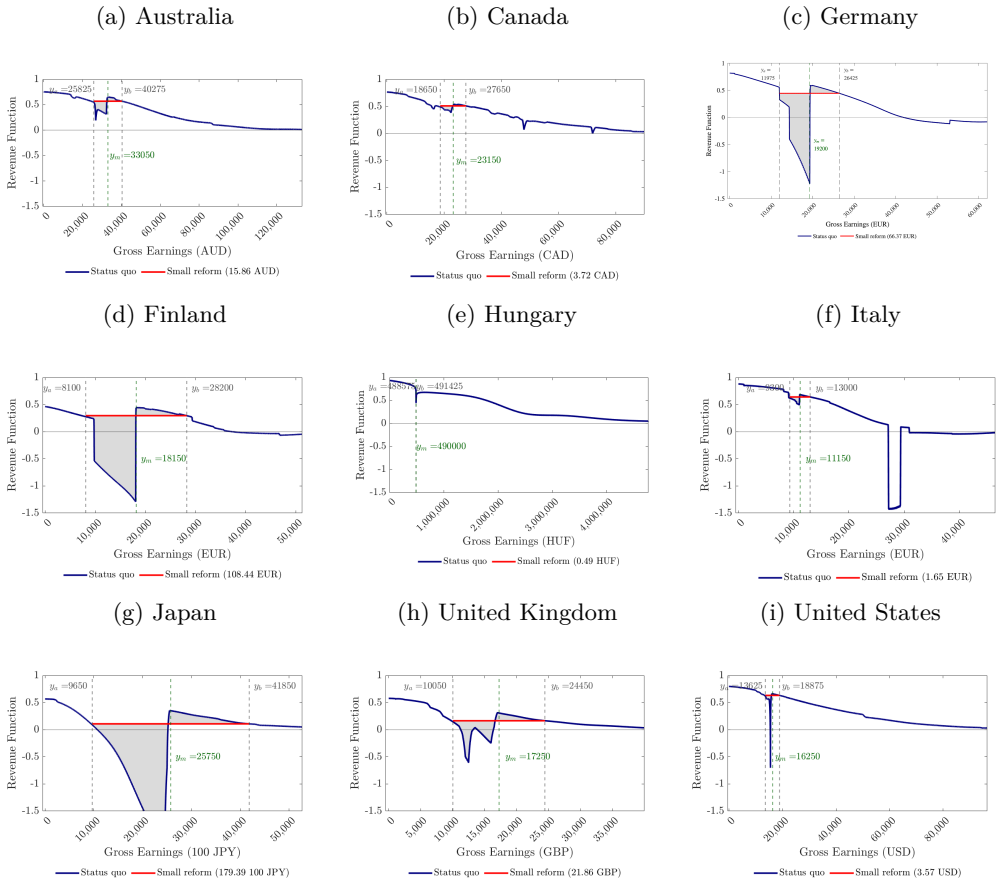
Note: This figure displays the revenue function under rational behavior for selected countries for the group of singles with children including (excluding) extensive margin responses as solid (dashed) blue lines. Results for the full set of countries are shown in Appendix Figure A11 (A12) for singles without (with) children.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

28,200 EUR would yield a non-negligible revenue gain of around 105 EUR for each childless single without making anyone worse off. According to this measure, tax-transfer systems in Finland, Germany, and Japan are more inefficient than the one in Australia and the United Kingdom. For Canada, Hungary, Italy, and the United States, the size of the inefficiency is the least pronounced. In these countries, moving one percentage point into the revenue maximizing reform direction would generate less than 4 USD respectively.[12]

It is important to note that this measure relies on comparing marginal (small) reforms or, more technically, Gateau differentials at a given status quo away from the Pareto frontier. The analysis does not allow to identify discrete reforms that eliminate inefficiencies and bring a tax-transfer system to the Pareto frontier. Solving for such discrete reforms requires specifying more structure instead of relying on sufficient statistics. We address discrete reforms in Section 5.

[12]In 2018 USD, the estimated revenue gains per head are: Japan 162.59, Finland 124.03, Germany 79.68, UK 27.74, Australia 11.15, USA 3.57, Canada 2.73, Italy 1.89, Hungary < 0.01 (exchange rates as of December 31, 2018).

Figure 5: Optimal Reform Directions under Rational Behavior, Singles without Children



Note: This figure displays the revenue function for selected countries for the group of singles with children including extensive margin responses as solid lines. The figures also show the midpoint (green vertical dashed line), as well as lower and upper thresholds of the reform (gray dashed lines). The gray area represents the approximate per capita revenue generated from a reform that decreases marginal tax rates between the lower threshold and the midpoint, and increases marginal tax rates between the midpoint and the upper threshold. The amount of tax revenue generated is also shown in each of the respective legends.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

4 Generalizations

In the previous section, we studied the existence of self-financing tax cuts under a set of common, but very restrictive assumptions: In particular, we assumed rational and fully informed agents, no income effects, and specific labor supply elasticities at both margins. Under these assumptions, we found that, in 2018 there existed self-financing tax cuts that allowed to make anybody better off in all our selected nine countries and, more generally, inmost countries we consider. One way to test the robustness of these results is to vary the assumptions on labor-supply responses at the intensive and the extensive margins and to allow for income effects. Similarly, we could vary the way we estimate income distributions.[13] In the following, we take two different avenues.

First, we establish a novel result on the existence of Pareto-improving tax reforms for rational taxpayers given a large class of preferences. Second, we derive novel results on the existence of Pareto-improving reforms under ironing, a well-documented type of non-rationality where taxpayers mistakenly perceive their average tax rate they face as their marginal tax rate.

[13]See Bierbrauer et al. (2023) for a large set of robustness checks.

4.1 Rational Taxpayers and Discontinuous Drops in Marginal Tax Rates

In this subsection, we show that, if taxpayers are rational and have preferences that satisfy a weak regularity condition, there exists a self-financing tax cut whenever the tax-transfer system involves a discontinuous drop in marginal tax rates, i.e., a concave kink in the tax schedule T_0. The following assumption ensures that there is such a concave kink that is relevant in the sense that some agents choose incomes in the adjacent tax brackets to the left and to the right.

Assumption 1 *There are three income levels $y_R > \hat{y} > y_L > 0$ such that*

- $\lim_{\varepsilon \to 0, \varepsilon > 0} T_0'(\hat{y} - \varepsilon) - T_0'(\hat{y} + \varepsilon) > 0$,
- $T_0'(y) > T_0'(z)$ *for each* $y \in [y_L, \hat{y})$ *and* $z \in (\hat{y}, y_R]$,
- $T_0''(y) \geq 0$ *for all* y *in* $[y_L, \hat{y})$ *and* $(\hat{y}, y_R]$,
- $F_y(y_R) > F_y(\hat{y}) > F_y(y_L)$ *and* $f_y(y) > 0$ *for* $y \in \{y_L, y_R\}$.

Assumption 1 is satisfied, for example, if the tax system is piecewise linear with a lower marginal tax above than below an income $\hat{y}$ such that $F_(\hat{y}) \in (0, 1)$.

The next assumption imposes a weak regularity condition on individual preferences. In particular, it puts a restriction on the relation between skill θ and the marginal rate of substitution between income and consumption $MRS(c, y, \theta) = -u_y(c, y, \theta)/u_c(c, y, \theta)$. By the single-crossing condition, the MRS is decreasing in skill θ.

Assumption 2 *Let $\Theta \in \mathbb{R}$. Consider two bundles (c_1, y_1) and $(c_2, y_2) > (c_1, y_1)$ such that $u(c_1, y_1, \theta) = u(c_2, y_2, \theta)$ for some $\theta \in \Theta$. Then,*

$$MRS(c_2, y_2, \theta) > MRS(c_1, y_1, \theta) \text{ and} \tag{9}$$

$$\frac{\partial MRS\,(c_2, y_2, \theta)}{\partial \theta} \leq \frac{\partial MRS\,(c_1, y_1, \theta)}{\partial \theta}\,. \tag{10}$$

The assumption implies that, first, indifference curves are strictly convex and, second, $dMRS/d\theta$ is non-increasing along any indifference curve. It is satisfied, for example, if preferences are additively-separable with $u_{cy} = u_{c\theta} = 0$, $u_{cc} \leq 0$, and $u_{yy\theta} \geq 0$. In this case, we have $\partial MRS(c, y, \theta')/\partial\theta = -u_{y\theta}(c, y, \theta')/u_c(c, y, \theta)$, which is weakly decreasing along the indifference curve.

The following proposition implies that, if Assumption 2 is satisfied, a discontinuous drop in EMTRs is a smoking gun. Once there is such a discontinuity, we have a direct evidence of an inefficiency. We do not have to estimate and evaluate revenue functions to arrive at this conclusion.

Proposition 1 *If Assumptions 1 and 2 are satisfied, there exists a Pareto-improving tax reform.*

The proof of Proposition 1 shows that, under Assumptions 1 and 2, the revenue function attains a lower value at some income y_a below the kink at $\hat{y}$ than at another value y_b above the kink. Intuitively, two small tax reforms that increase the marginal tax at incomes (i) just below or (ii) just above the kink give rise to (almost) the same mechanical effects and income effects. But, with $\tau_1 > \tau_2$, the reform (i) below the kink gives rise to a strictly larger (negative) revenue loss due to substitution effects in labor supply than the one (ii) above the kink. The reason is that a higher marginal tax implies that a given response in earned incomes comes with a larger fiscal externality. We can then invoke the results from Bierbrauer

et al. (2023): If the revenue function is increasing in some income range, there exists a two-bracket tax cut that is self-financing and makes all agents better off.

Proposition 1 holds under quite general assumptions on preferences and the status-quo tax. We can further generalize it by allowing for fixed cost of work that are additively separable such that $u(c, y, \theta_1, \theta_2) = \tilde{u}(c, y, \theta_1) - \mathbb{1} \cdot \theta_2$. As long as the subutility function $\tilde{u}$ satisfies Assumption 2, the proposition remains valid.

4.2 Pareto-Improving Tax Reforms under Ironing: Theory

The previous section discussed the potential for Pareto improving reforms under the assumption of rational behavior, in particular under the assumption that individuals correctly assess their marginal and average tax rates. Our framework allows us to test whether the potential for Pareto improving reforms is also present in case of misperceptions. In particular, under the ironing heuristic, taxpayers misinterpret their (true) average tax rate as a constant marginal tax rate they would face.

Liebman and Zeckhauser (2004) introduce a heuristic termed ironing that behavioral agents may use. Agents using this heuristic – henceforth, ironers – are not aware of the difference between marginal tax rates and average tax rates, which results from non-linearities in T_0. An ironer with type θ observes the tax payment $T_0(y_0)$ associated with her current earning levels y_0, and misinterprets it as resulting from a linear tax function with a *perceived* marginal tax rate of

$$T^{p\prime}{}_0(y \mid y_0) = t_0(y_0) = \frac{T_0(y_0)}{y_0} \,. \tag{11}$$

This implies a *perceived* budget set

$$C_0^p(y \mid y_0) \coloneqq c_0 + y\,[1 - t_0(y_0)] \,. \tag{12}$$

We follow Liebman and Zeckhauser (2004) by assuming that agents only misperceive the tax function (through ironing), but do not misperceive their utility function. In the following, we also focus on a utility function that is quasi-linear in consumption and does not involve fixed costs of working such that $u(c, y, \theta) = u\,(c - v(y, \theta))$ with an increasing and strictly convex effort cost function v.

Ironing Behavior. An ironer with type θ chooses income $y_0^i(\theta)$ to maximize $u(C_0^p(y \mid y_0), y, \theta)$ over y and, equivalently, satisfy the *perceived* first-order condition

$$1 - t_0(y_0^i(\theta)) - v_y(y_0^i(\theta), \theta) = 0 \,. \tag{13}$$

Assume that this condition holds. Then, the behavioral bias is given by

$$\phi_b(\theta) = t_0(y_0^i(\theta)) - T_0'(y_0^i(\theta)) \,, \tag{14}$$

which is strictly positive if $T_0'(y_0^i(\theta)) < t_0(y_0^i(\theta))$, and strictly negative if $T_0'(y_0^i(\theta)) > t_0(y_0^i(\theta))$. Put differently, ironers work more than individually optimal if they face a (locally) progressive tax schedule and less than individually optimal if they face a (locally) regressive tax schedule.

Labor Supply Responses. Ironers do not change their earnings choice in response to variations in the marginal tax, but in the average tax at their current earnings level $y_0^i(\theta)$. Specifically, assume that a reform implements $t_1(y) = t_0(y) + \gamma$ at each income level. From differentiating the first-order condition (13) with respect to γ, the marginal change in $y^i(\theta)$ results as

$$\frac{dy^i(\theta)}{d\gamma} = -\frac{1}{v_{yy}(y_0^i(\theta), \theta) + t_0'(y_0^i(\theta))} \ .$$

The corresponding elasticity of earnings with respect to the perceived retention rate, $1 - T^{p\prime}_0 = 1 - t_0$, is given by

$$\varepsilon^i_{y,1-t} = -\frac{dy^i(\theta)}{d\gamma} \ \frac{1 - t_0(y_0^i(\theta))}{y_0^i(\theta)} = \frac{1}{y_0^i(\theta)} \ \frac{v_y(y_0^i(\theta), \theta)}{v_{yy}(y_0^i(\theta), \theta) + t_0'(y_0^i(\theta))} \ . \tag{15}$$

Reform Effects on Tax Revenue. Bierbrauer et al. (2022) show that, in the standard model with rational taxpayers, the existence of Pareto-improving tax reforms can be determined based on the revenue function $\mathcal{R}_0$, which associates to each income level y the revenue gain or loss associated with a tax reform that slightly increases the marginal tax in a small interval around y. We proceed by deriving the revenue function with ironing behavior. This requires, in particular, to determine the marginal effect $m_0(y, h) = \frac{dt_0(y)}{d\tau}$ of a reform in direction h on the perceived tax rate $T^{p\prime}$. For a single-bracket reform that increases the marginal tax between incomes $\hat{y}$ and $\hat{y} + \ell$, this marginal effect is given by

$$m_0(y, h^s) = \begin{cases} 0 & \text{for} \quad y \leq \hat{y} \ , \\ \frac{y - \hat{y}}{y} & \text{for} \quad y \in (\hat{y}, \hat{y} + \ell) \ , \\ \frac{\ell}{y} & \text{for} \quad y \geq \hat{y} + \ell \ . \end{cases} \tag{16}$$

The marginal effect of this reform on net tax revenue follows as

$$R^i_\tau(0, h^s) = \int_{\theta_0(\hat{y})}^{\bar{\theta}} f(\theta) \left[h^s \left(y_0^i(\theta) \right) + \frac{dy^i(\theta)}{d\gamma} m_0(y, h^s) T_0'(y_0^i(\theta)) \right] d\theta \ . \tag{17}$$

The following proposition identifies the revenue function – the cross-derivative of net tax revenue with respect to τ and ℓ – under the assumptions that all agents are ironers.

Proposition 2 *With a population of ironing agents, the revenue function is given by*

$$\mathcal{R}_0^i(\hat{y}) = \int_{\hat{y}}^{\infty} f_y(y) \left[1 - \varepsilon^i_{y,1-t}(y) \ \frac{T_0'(y)}{1 - t_0(y)} \right] dy \ , \tag{18}$$

where F_y is the cdf of the income distribution, $f_y(y)$ is the corresponding pdf, and $\varepsilon^i_{y,1-t}$ is the elasticity of income with respect to one minus the average tax rate t_0 along the non-linear budget set C_0.

For comparison, the revenue function with rational agents is given by

$$\mathcal{R}_0(\hat{y}) = \int_{\hat{y}}^{\infty} f_y(y) \ dy - \varepsilon_{y,1-T'}(\hat{y}) \ \hat{y} \ f_y(\hat{y}) \ \frac{T_0'(\hat{y})}{1 - T_0'(\hat{y})} \ ,$$

where $\varepsilon_{y,1-T'}$ is the elasticity of income of rational agents with respect to the retention rate $1 - T'$ along the nonlinear budget $C - 0$.

We can also generalize the following insights to allow for extensive-margin responses. Denote by $\pi_0(y)$ the participation elasticity of ironing agents choosing income y if they participate in the labor market. Then, the revenue function reads

$$\mathcal{R}_0^i(\hat{y}) = \int_{\hat{y}}^{\infty} f_y(y) \left[1 - \varepsilon_{y,1-t}^i(y) \, \frac{T_0'(y)}{1-t_0(y)} - \pi_0(y) \frac{t_0(y)}{1-t_0(y)}\right] dy \, . \tag{19}$$

Note that we do not assume any misperception in $t_0(y)$, the tax rate that matters for the extensive-margin choice of whether or not to participate on the labor market. For this decision, the agents just needs information about the tax levels at her preferred income y and at zero income; potential non-linearities in the tax schedule are irrelevant.

Reform Effects on Utility. For a reform in direction h, the effect of a marginal increase in the reform magnitude τ on utility is given by

$$v_\tau^i(0,h,\theta) \quad = \quad R_\tau^i(0,h) - h(y_0^i(\theta)) + \left[t_0(y_0^i(\theta)) - T_0'(y_0^i(\theta))\right] m_0(y_0^i(\theta),h) \frac{dy^i(\theta)}{d\gamma} \, . \tag{20}$$

Thus, the envelope theorem does not hold for ironing agents such that two conditions are simultaneously satisfied at their chosen income level: (i) the marginal and average taxes differ, and (ii) the reform affects the average tax. This implies that a small reform in direction h is (only) Pareto-improving if

$$R_\tau^i(0,h) > \max_\theta \left[h(y_0^i(\theta)) - \left[t_0(y_0^i(\theta)) - T_0'(y_0^i(\theta))\right] m_0(y_0^i(\theta),h) \frac{dy^i(\theta)}{d\gamma}\right] \, , \tag{21}$$

which can in general be more or less hard to satisfy than the corresponding condition with rational agents, $R_\tau(0,h) > \max_y h(y)$. We continue by focusing on the effects of two-bracket tax cuts.[14]

Two-Bracket Reforms. Consider a two-bracket tax cut such that marginal taxes are reduced by τ_1 in a lower bracket $(\hat{y}_1, \hat{y}_1 + \ell)$ and increased by τ_2 in an upper bracket $(\hat{y}_2, \hat{y}_2 + \ell)$ such that $\tau_1 = -\tau_2 < 0$. This reform reduces average tax rates between $\hat{y}_1$ and $\hat{y}_2 + \ell_2$ and, hence, induces an increase in labor supply by taxpayers in this range. The reform does not affect the average taxes outside of this interval.

As a result, taxpayers with pre-reform earnings below $\hat{y}_1$ or above $\hat{y}_2 + \ell$ do not change their labor supply decision. Their utility is only affected by the adjustment in the base transfer, $V_\tau(0,h,\theta) = R_\tau^i(0,h)$. Taxpayers with pre-reform earnings between $\hat{y}_1$ and $\hat{y}_2 + \ell$ are also affected by the adjusted base transfer, but they also benefit mechanically from the reduced tax liability. In addition, their labor supply response has a first-order effect on their *experienced* utility whenever the behavioral bias $\phi_b(\theta)$ does not equal zero.

The following proposition provides two jointly sufficient conditions for the existence of a Pareto-improving two-bracket tax cut.

Proposition 3 *With ironing, there exists a Pareto-improving two-bracket tax cut if there is a pair of income levels y_a, $y_b > y_a$ such that*

(i) $\mathcal{R}_{i0}(y_a) < \mathcal{R}_{i0}(y_b)$, *and*

(ii) $T_0'(y) \leq t_0(y)$ *for all* $y \in [y_a, y_b]$.

[14] Besides, we can also provide conditions under which there are Pareto-improving one-bracket reforms.

Condition (i) is both necessary and sufficient for the existence of a two-bracket tax cut that is self-financing. Such a self-financing tax cut also strictly increases the budget set available to all taxpayers, and hence their *decision* utility. Due to the behavioral bias, which implies that labor supply responses may have first-order utility effects, their *experienced* utility may go down, nevertheless. Condition (ii) ensures that this additional utility effect is non-negative, so that the two-bracket tax cut is also Pareto-improving in a strict sense.

We can go one step further by introducing $\tilde{\varepsilon}_{y,1-t}$, the elasticity of income with a constant average tax rate t_0'. It is related to the unconditional elasticity by

$$\varepsilon^i_{y,1-t}(\theta) \quad = \quad \frac{1}{y_0^i(\theta)} \, \frac{v_y(y_0^i(\theta),\theta)}{v_{yy}(y_0^i(\theta),\theta) + t_0'(y_0^i(\theta))} = \frac{\tilde{\varepsilon}_{y,1-t}}{1+\tilde{\varepsilon}_{y,1-t}\frac{T_0'(y_0^i(\theta))-t_0(y_0^i(\theta))}{1-t_0(y_0^i(\theta))}} \, , \tag{22}$$

where the last equality sign follows because $yt_0'(y) = T_0'(y) - t_0(y)$. The more decreasing the average tax is, the larger the elasticity is. Plugging this expression into the revenue function, we get

$$\mathcal{R}_0^i(\hat{y}) \quad = \quad \int_{\hat{y}}^{\bar{y}} f_y(y) \, \frac{1-(1+\tilde{\varepsilon}_{y,1-t})t_0(y)}{1-(1+\tilde{\varepsilon}_{y,1-t})t_0(y)+\tilde{\varepsilon}_{y,1-t}T_0'(y)} \, dy \, , \tag{23}$$

where the denominator is strictly positive at each perceived-optimal earnings level y. Combining this insight with Proposition 3, we get a strikingly simple condition for inefficient taxes.

Proposition 4 *Let $T_0'(y) \in (0,1)$ for all $y > 0$ and let all agents use the ironing heuristic. There is a Pareto-improving tax reform with two brackets if some agents choose an income level $y > 0$ at which*

$$T_0'(y) < t_0(y) < \frac{1}{1+\tilde{\varepsilon}_{y,1-t}} \, . \tag{24}$$

This implies an upper bound on the marginal tax. For an elasticity of $\tilde{\varepsilon}_{y,1-t} = 0.33$, for example, the average tax must not be larger than 75% at any income level to be consistent with Pareto efficiency. For $\tilde{\varepsilon}_{y,1-t} = 0.5$, we have an upper bound of 66.7%, etc. If the average tax is above this bound, but below the marginal tax $T_0'(y)$, then the revenue function is strictly increasing, but a tax reform might aggravate the loss in experienced utility that ironers incur due to misperceptions. For the iso-elastic preferences considered by Diamond (1998), the constant-tax-rate elasticity $\tilde{\varepsilon}_{y,1-t}$ is equal to parameter σ.

With extensive-margin responses, the revenue function can correspondingly be written as

$$\mathcal{R}_0^i(\hat{y}) = \int_{\hat{y}}^{\bar{y}} f_y(y) \left[1 - \frac{\tilde{\varepsilon}_{y,1-t}}{1+\tilde{\varepsilon}_{y,1-t}\frac{T_0'(y)-t_0(y)}{1-t_0(y)}} \, \frac{T_0'(y)}{1-t_0(y)} - \pi_0(y)\frac{t_0(y)}{1-t_0(y)} \right] dy \, . \tag{25}$$

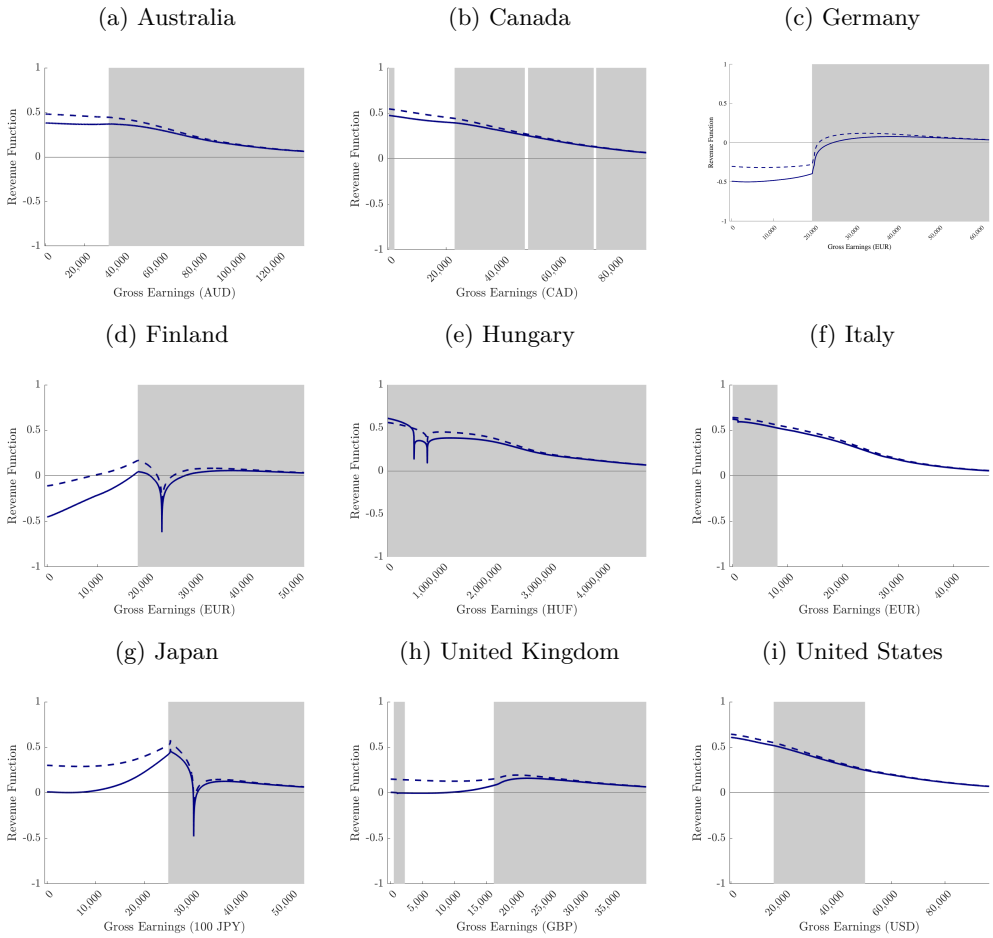
4.3 Pareto-Improving Tax reforms under Ironing: Applications

We use equation (25) to estimate the revenue function under the ironing heuristic empirically and thereby identify inefficiencies under the assumption that individuals misperceive the tax code. For this purpose, we use the same ingredients as in Section 3: Marginal and participation tax rates as simulated with EUROMOD and OECD TaxBen, and income distributions estimated based on EU SILC and other representative surveys. Under the ironing heuristic, a Pareto-improving two-bracket tax reform exists if the revenue function is increasing over an income range where the tax system is regressive, i.e., where the participation tax rate is larger than the marginal tax rate.

Figure 6 shows the results for our set of nine selected countries. In each panel, the solid line depict the revenue function with labor supply responses at both margins, while the dashed line shows the revenue function for intensive-margin responses only. The gray areas mark income ranges in which the marginal tax rate is below the participation tax rate, i.e., condition (ii) in Proposition 3 is satisfied.

We find that this condition in indeed satisfied for substantial income ranges in each selected country. In addition, we find that the revenue functions are increasing in five out of the selected nine countries (Germany, Finland, Hungary, Japan, United Kingdom). In each case, there is an overlap between the income ranges in which both conditions are satisfied. This suggests, for instance, that there exists a Pareto-improving two bracket tax reform around a midpoint slightly above 20,000 EUR in Germany and around 23,000 EUR for Finland. For the United Kingdom (Japan), a Pareto-improving two-bracket tax cut exists around income levels of 17,000 GBP (3,000,000 JPY). In contrast, for the tax-transfer systems of Australia, Canada, Italy, and the United States, we do not detect inefficiencies under ironing. This insight seems related to the previous finding that these countries showed smaller inefficiencies under rational behavior.

Figure 6: Revenue Functions under Ironing, Singles without Children



Note: This figure displays the revenue function under the ironing heuristic for selected countries for the group of singles with children including (excluding) extensive margin responses as solid (dashed) blue lines. The gray area visualizes income ranges for which the tax system is progressive, i.e., income levels for which the participation tax rates are larger than the marginal tax rates (see also Figure 2).
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

5 Discrete Tax Reforms towards the Pareto Frontier

In the previous sections, we studied whether a tax-transfer system is inefficient in the sense that there exists a Pareto-improving tax reform. Our analysis was local in nature: It focused on marginal steps away from the current status quo policy in some reform direction. We also identified optimal reform directions and measured inefficiencies by the tax revenue gain that can be achieved by taking a small step in the optimal direction. The same approach is also taken in Bierbrauer et al. (2023).

In the following section, we instead consider *discrete (large) tax reforms* and ask how such a reform needs to be designed to restore second-best efficiency, i.e., to move from an inefficient status quo system (c_0, T_0) to an efficient tax system (c_1, T_1) that implements an allocation on the Pareto frontier. Generically, if there is an inefficiency, then there exist infinitely many tax reforms that establish different Pareto-superior allocations on the Pareto frontier. In this chapter, we solve for the revenue-maximizing tax cut, i.e., the discrete reform that maximizes net tax revenue conditional on making no agent worse off.[15] For this purpose, we cannot rely on the sufficient-statistics approach applied by Bierbrauer et al. (2023). Instead, we need to specify a structural model that also allows to determine optimal behavior and behavioral responses under counterfactual tax systems away from the status quo. As a benchmark, we focus on the workhorse model of optimal taxation used by Diamond (1998) with quasi-linear, iso-elastic preferences and labor supply responses at the intensive margin only. We start by solving for the revenue-maximizing tax cut with rational taxpayers. In the second step, we identify revenue-maximizing tax cuts for taxpayers that have the same preferences but rely on the ironing heuristic. In the final step, we then apply our formal results to study the optimal tax reforms under both scenarios in Germany.

It should be noted that we do not compute welfare-maximizing tax-transfer systems. Instead, we characterize those tax-transfer systems among all Pareto-efficient systems that yields the largest gain in tax revenue relative to the status-quo system. As such, the tax-transfer systems we characterize depend on the starting point of our algorithm, i.e., the status-quo system (c_0, T_0).

5.1 Discrete Reforms under Rational Behavior

Consider a tax system (c_0, T_0) such that the corresponding revenue function $\mathcal{R}^0$ is non-monotonic, implying the existence of a Pareto-improving tax reform with two brackets. Assume moreover that preferences are quasi-linear and iso-elastic (but agents are fully rational). We now note that the revenue function will be endogenous to the tax reform (τ, h). In particular, let $\mathcal{R}_1(\cdot, \tau, h)$ denote the revenue function after implementation of (τ, h). We can write this revenue function as a function of skill types θ rather than income levels y.

The revenue-maximizing tax cut (τ_R, h_R) maximizes

$$\Pi(\tau, h) = R(\tau, h) - \tau \max_y h(y) = \int_0^{\tau} \int_0^{\bar{y}} h'(y) \mathcal{R}_1(y, \tau', h) dy d\tau' - \tau \max_y h(y) \tag{26}$$

over $\tau > 0$ and h.

We first provide a preliminary result on the relation between a tax reform (τ, h) and the post-reform revenue function $\mathcal{R}_1$. For this purpose, we denote by $\mathcal{Y}$ the set of income levels that are chosen by some agents.

[15] Thereby, we follow the ideas in Werning (2007).

Lemma 1 *For all $y, \tilde{y} \in \mathcal{Y}$ and $\tau > 0$, we have $\frac{d\mathcal{R}_1(y,\tau,h)}{dh'(\tilde{y})} \leq 0$. For all $y_1 < \tilde{y}$, $y_2 > \tilde{y}$, and $\tilde{y} \in \mathcal{Y}$, we have $\frac{d\mathcal{R}_1(y_1,\tau,h)}{dh'(\tilde{y})} = \frac{d\mathcal{R}_1(y_2,\tau,h)}{dh'(\tilde{y})} = 0$.*

Hence, an increase in marginal tax rates for incomes in (y_a, y_b) only reduces the value of the revenue function at these income levels, but does not affect its value at other income levels.

We now present a proposition that characterizes the revenue-maximizing discrete tax cut (τ, h) and the tax system (T_1, c_1) with $T_1 = T_0 + \tau_R h_R$ and $c_1 = c_0 + R(\tau_R, h_R)$ it implements.

Proposition 5 *Let $\mathcal{R}_0$ be increasing on a unique interval (y_a, y_b), decreasing at all other income levels and let $\mathcal{R}_0(y) \in (0,1)$ for all $y \in y_0(\underline{\theta}), \bar{\theta})$. Define the auxiliary function*

$$Z(\theta, z) = \frac{1 - F(\theta) - z}{\theta \ f(\theta)} \ \frac{1+\sigma}{\sigma} \ . \tag{27}$$

The revenue-maximizing tax cut (τ_R, h_R) involves a unique vector (y_s, y_m, y_t, z) with $y_s < y_a < y_m < y_b < y_t$ such that

$$\begin{aligned}
\mathcal{R}_0(y_s) &= \mathcal{R}_0(y_m) = \mathcal{R}_0(y_t) = z \ , \\
\mathcal{R}_1(y, \tau_R, h_R) &= z \text{ for all } y \in (y_s, y_t) \ , \\
T_1'(y_1(\theta)) &= \frac{Z(\theta, z)}{1 + Z(\theta, z)} \text{ for all } y \in (y_s, y_t) \ , \\
y_1(\theta) &= \theta^{1+\sigma} \left[1 + Z(\theta, z)\right]^{-\sigma} \text{ for all } y \in (y_s, y_t) \ , \\
\mathcal{R}_1(y, \tau_R, h_R) &= \mathcal{R}_0(y) \text{ for all } y \notin (y_s, y_t) \text{ , and} \\
\tau_R h_R(y) &= T_1(y) - T_0(y) = 0 \text{ for all } y \notin (y_s, y_t) \ .
\end{aligned} \tag{28}$$

The formal proof takes into account the effects of any reform (τ, h) on the revenue function. Intuitively, the optimal reform smooths the marginal tax rates in the income range (y_s, y_t) to eliminate any non-monotonicities in the revenue function. The post-reform revenue function attains a constant value $z \in (0,1)$ at all income levels in this range. Further variations in the marginal tax that make $\mathcal{R}_1$ strictly decreasing in this range would also restore a Pareto-efficient tax system, but they would raise less net tax revenue and, potentially, make only a subset of agents strictly better off.

5.2 Discrete Reforms under Ironing

We proceed by characterizing the discrete tax reform (τ_R, h_R) that maximizes tax revenue gains without making anyone worse off under the assumption that all taxpayers use the ironing heuristic. For this purpose, consider again some tax system (T_0, c_0) that is not Pareto-efficient under ironing.

Assumption 3 *Tax system (T_0, c_0) involves*

$$t_0(y) > \frac{1}{1+\sigma} \text{ if and only if } y \in (y_a, y_b). \tag{29}$$

By Proposition 4, this condition implies that $\mathcal{R}$ is increasing between y_a and y_b only.

Proposition 6 *Let Assumption 3 hold. The tax cut* (τ_{Ri}, h_{Ri}) *that maximizes* $R^i(\tau, h) - \max_y \tau h(y)$ *implements a tax system* $(T_1, c_0 + R(\tau_{Ri}, h_{Ri}))$ *such that*

$$\begin{aligned} T_1'(y) \ = t_1(y) = & \quad \tfrac{1}{1+\sigma} \quad \textit{for all } y \in (y_a, y_b) \ , \\ T_1(y) \ = & \quad \tfrac{y}{1+\sigma} \quad \textit{for all } y \in (y_a, y_b) \ , \\ T_1(y) \ = & \quad T_0(y) \quad \textit{for all } y \notin (y_a, y_b) \ . \end{aligned}$$

This result is strikingly simple. If all agents use the ironing heuristic and have the same preference parameter σ, then a tax system is inefficient if and only $t_0(y)$ exceeds the value $1/(1+\sigma)$ at some income levels. To maximize tax revenue gains without making any agent worse off, the government simply needs to reduce the marginal tax rate to the threshold $1/(1+\sigma)$ at these income levels but leave it unchanged at all income levels where $t_0(y)$ was below this critical value. Again, the revenue-maximizing reform is a two-bracket tax cut.

We can characterize both the revenue-maximizing reform and the post-reform revenue function. The reform is given by

$$\tau h'(y) = \begin{cases} \frac{1}{1+\sigma} - T_0'(y) & \text{for all} \quad y \in (y_a, y_b) \ , \\ 0 & \text{for all} \quad y \notin (y_a, y_b) \ . \end{cases} \tag{30}$$

The post-reform revenue function $\mathcal{R}_1^i$ is given by

$$\mathcal{R}_1^i(y, \tau_{Ri}, h_{Ri}) = \begin{cases} \mathcal{R}_0(y) + [\mathcal{R}_0(y_b) - \mathcal{R}_0(y_a)] & \text{for} \quad y < y_a \ , \\ \mathcal{R}_0(y_b) & \text{for} \quad y \in [y_a, y_b] \ , \\ \mathcal{R}_0(y) & \text{for} \quad y > y_b \ . \end{cases} \tag{31}$$

Finally, the tax revenue gain due to the reform is given by

$$R^I(\tau_{Ri}, h_{Ri}) \quad = \quad \frac{\sigma^\sigma}{(1+\sigma)^{1+\sigma}} \int_{\theta_0(y_a)}^{\theta_0(y_b)} f(\theta) \ \theta^{1+\sigma} d\theta - \int_{y_a}^{y_b} f_y(y) T_0(y) dy \ , \tag{32}$$

where $f(\theta)$ can be computed according from the income distribution $f_y(y)$.

5.3 Discrete Reforms: Application to the German Tax-Transfer System

We now describe the properties of the discrete reform empirically for the case of the German tax-transfer system. For this purpose, we first estimate the skill distribution. While skill is not directly observed in the data, we observe income choices under the status quo tax system. Assuming that individuals behave optimally under the status quo tax system, we can identify the skill-income relationship by inverting the first order conditions.

Rational Behavior Under rational behavior, the inverted first order condition of individuals reads

$$\theta^0(y) = y^{\frac{1}{1+\sigma}} \left[1 - T_0'(y)\right]^{-\frac{\sigma}{1+\sigma}} . \tag{33}$$

However, since the marginal tax rate schedule features both upward and downward jumps, the first order condition governing local optimality might not determine a global optimum. We take respective corner solutions into account when determining the skill-income relationship.

The black line in Figure 7a shows the result. Unsurprisingly, the skill-income relationship exhibits bunching and gaps due to discrete changes in marginal tax rates. Specifically, increases in marginal tax rates cause individuals with different skill levels to bunch at the same income level, while decreases in marginal tax rates create dominated income ranges that are never chosen by individuals.

The existence of bunching and missing masses does not invalidate our results on the possibilities of Pareto-improving tax reforms. In Appendix Figure A13, we illustrate in a stylized example of a tax system with two brackets that upward jumps of marginal tax rates also imply inefficiencies when the downward jump in marginal tax rates leads to missing masses in the income distribution. In contrast, even though upward jumps in marginal tax rates lead to bunching at certain income levels, upward jumps are still not a sign of an inefficient tax system (see Appendix Figure A14).

For the empirical application, since we neither observe bunching nor missing masses in the income distribution (see Figure 3c), we approximate the income skill relationship with a polynomial through the origin that secures a monotonic and smooth relationship between the skill level and the chosen income. The red line in Figure 7a displays the approximated relationship used for the further analyses, and Figure 7c shows the resulting skill distribution.

Ironing Heuristic Under the ironing heuristic, we follow the same approach, inverting the first order condtion, i.e.,

$$\theta^0(y) = y^{\frac{1}{1+\sigma}} \left[1 - t_0(y)\right]^{-\frac{\sigma}{1+\sigma}}, \tag{34}$$

and validating that the associated local optimum is also the globally optimal solution. In contrast to the situation under rational behavior, the original relationship between skill level and chosen incomes is smooth and monotonic. However, to be consistent with the estimation of the skill-income relationship under rational behavior, we also approximate the original relationship with a polynomial through the origin (see Figure 7b). Figure 7d displays the resulting skill distribution.

Optimal Discrete Reform Equipped with the skill distribution, we can apply the closed-form solutions provided in Propositions 5 and 30 to solve for the optimal discrete reform that brings the tax system to the Pareto frontier under rational behavior and under the ironing heuristic.

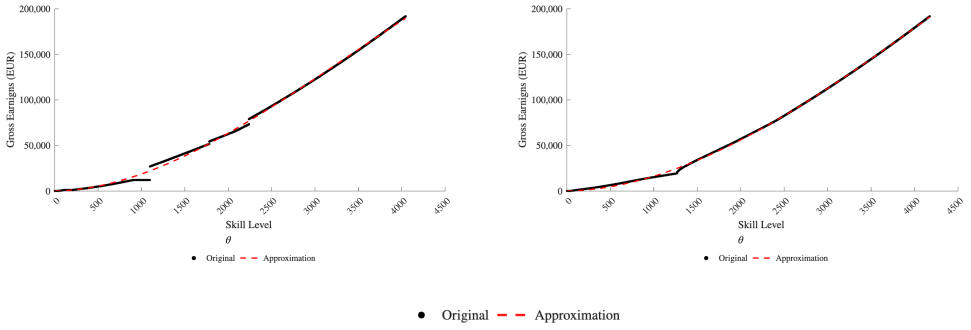
Figure 8 displays the pre- and post reform revenue functions and marginal tax rate schedules. Under rational behavior, the optimal reform transforms the discrete drop in marginal tax rates into a smooth decline that spans from around 12,000 EUR to around 25,000 EUR. Under the ironing heuristic, the marginal tax rate is reduced to 0.67 at those income levels where t_0 exceeded this value prior to the reform. In this case, marginal tax rate are not fully smoothed, but the reform again dampens their initial variation in a piecewise linear way.

6 Conclusion

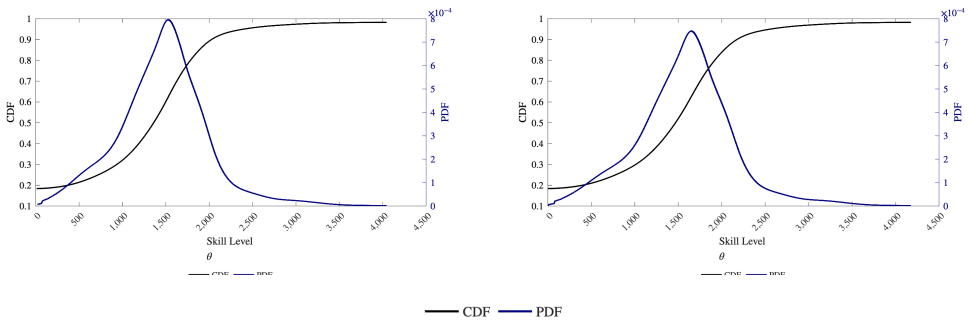
This paper provides a comprehensive theoretical and empirical analysis of self-financing tax cuts across 33 countries around the world. Using microsimulation models, such as EUROMOD and OECD TaxBEN, combined with robust data from EU-SILC and national surveys, we identify widespread inefficiencies in tax-transfer systems. These inefficiencies commonly occur at the phase-out points of social transfers, where marginal tax rates exhibit discrete drops.

Figure 7: Skill Level — Germany , 2018

(a) Skill/Income Relation — Rational Behavior (b) Skill/Income Relation — Ironing Heuristic



(c) Skill Distribution — Rational Behavior (d) Skill Distribution— Ironing Heuristic



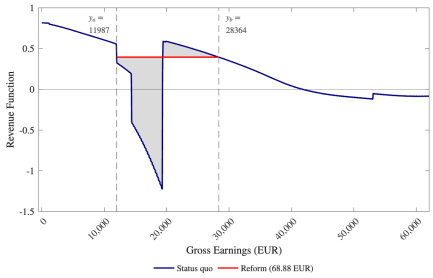
Note: This figure displays the skill income relationship under rational behavior (Figure 7a) and under the ironing heuristic (Figure 7b) based on equations 33 and 34 respectively. The original relationship is approximated by a third order polynomial through the origin. The skill distributions based on the approximated relationship are shown in Figure 7c and Figure 7d respectively.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

We further provide novel theoretical insights, demonstrating that such discrete drops in effective marginal tax rates (EMTRs) are strong indicators of inefficiency both under both rational behavior and with common misperceptions of the tax code such as the "ironing" heuristic.

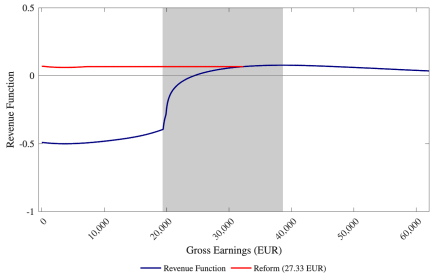
Finally, we propose discrete tax reforms to eliminate inefficiencies and move tax systems to the Pareto frontier. These reforms offer policymakers actionable solutions to repair inefficient systems. As self-financing measures, they enable governments to raise additional revenue for public goods, investments, or social programs without imposing additional costs on citizens.

Figure 8: Discrete Two-Bracket Tax Reforms, Singles without Children, Germany

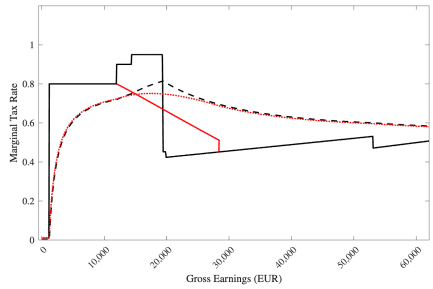
(a) Rational Behavior — Discrete Reform



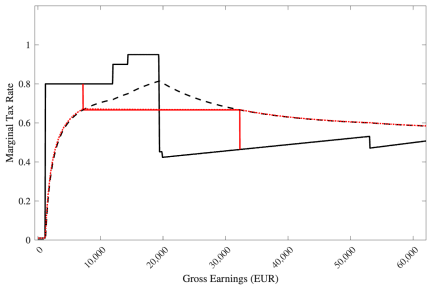
(b) Ironing Heuristic — Discrete Reform

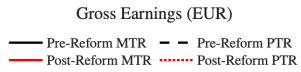


(c) Rational Behavior — MTR Pre/Post



(d) Ironing Heuristic — MTR Pre/Post





Note: This figure displays, how we identify discrete two-bracket tax reforms for singles without children in Germany as an example. Figure 8a (8b) displays the pre and post reform revenue functions under rational behavior (ironing heuristic), including extensive margin responses. Pre- and post reform marginal tax rates under rational behavior (ironing) are shown in Figure 8c (8d).
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

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A Supplementary Material — Empirics

Table A1: Country Overview, Micro Data

Country	EU	OECD	G7	Ref. Year	Pol. Year	Currency	Source	Remarks, Earnings	Remarks, Children
Australia & New Zealand (2)									
Australia	-	Yes	-	2018	2018	AUD	HILDA	Total annual salary and wages, and business income.	All dependent children in family. Can be older than 18. Non-dependent children, other family members, members of household unrelated to all household members are dropped.
New Zealand	-	Yes	-	2014	2018	NZD	PIAAC	Income from employment and income from self-employment and independent work.	All own children below age 18.
Eastern Asia (2)									
Japan	-	Yes	Yes	2018	2018	JPY	JHPS	Income from main job last year before deductions for taxes and social insurance. Includes income from self employment.	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
South Korea	-	Yes	-	2018	2018	KRW	KLIPS	Income received in return for labor (work), including wages received from the workplace or income earned by the self-employed. Excludes revenue earned by the business for which you worked as an unpaid family worker.	All children in household that are either in education up to high school or in college education
Eastern Europe (7)									
Bulgaria	Yes	-	-	2018	2018	BGN	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Czech Republic	Yes	Yes	-	2018	2018	CZK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Hungary	Yes	Yes	-	2018	2018	HUF	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Poland	Yes	Yes	-	2018	2018	PLN	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Romania	Yes	-	-	2018	2018	RON	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Russia	-	-	-	2018	2018	RUB	RLMS	Income from all jobs (jobs can refer to dependent employment and self-employment)	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Slovak Republic	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)

Note: Continues on next page.

Table A1: Country Overview, Micro Data (cont.)

Country	EU	OECD	G7	Ref. Year	Pol. Year	Currency	Source	Remarks, Earnings	Remarks, Children
Latin America & the Caribbean (5)									
Brazil	-	-	-	2019	2019	BRL	PNADc	Income from employment (primary and secondary jobs) and income from self-employment (primary and secondary jobs).	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Chile	-	Yes	-	2014	2015	CLP	PIAAC	Income from employment and income from self-employment and independent work.	All own children below age 18.
Ecuador	-	-	-	2019	2019	USD	ENEMDU	Income from employment and income from self-employment and independent work.	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Mexico	-	Yes	-	2018	2018	MXN	ENIGH	Income from employment and income from self-employment.	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Peru	-	-	-	2019	2019	PEN	ENAHO	Income from employment and income from self-employment (primary job only).	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Northern America (2)									
Canada	-	Yes	Yes	2018	2018	CAD	CIS	Wages and salaries before deductions, and self-employment income.	Own children under age 18 living in the economic family, and children aged 18–24 who are still in education.
United States	-	Yes	Yes	2018	2018	USD	PSID	Wages and salaries, any separate reports of bonuses, overtime, tips, commissions, professional practice or trade, additional job income, and miscellaneous labor income and the labor portion of business income.	Children of the reference person under age 18 living in the household, and children aged 18–24 who are still in education.
Northern Europe (10)									
Denmark	Yes	Yes	-	2018	2018	DKK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Estonia	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Finland	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Iceland	-	Yes	-	2017	2018	ISK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Ireland	Yes	Yes	-	2017	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)

Note: Continues on next page.

Table A1: Country Overview, Micro Data (cont.)

Country	EU	OECD	G7	Ref. Year	Pol. Year	Currency	Source	Remarks, Earnings	Remarks, Children
Latvia	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Lithuania	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Norway	-	Yes	-	2018	2018	NOK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Sweden	Yes	Yes	-	2018	2018	SEK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
United Kingdom	-	Yes	Yes	2018	2018	GBP	HLS	Gross usual pay, gross self-employment income and gross pay in second job.	All own dependent children that live in the same household.
Southern Europe (7)									
Croatia	Yes	-	-	2018	2018	HRK	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Greece	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Italy	Yes	Yes	Yes	2017	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Malta	Yes	-	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Portugal	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Slovenia	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Spain	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Sub-Saharan Africa (1)									
South Africa	-	-	-	2017	2018	ZAR	NIDS	Income from employment and income from self-employment.	Own children under age 18 living in the household, and children aged 18–24 who are still in education.
Western Asia (3)									
Cyprus	Yes	-	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Israel	-	Yes	-	2014	2018	ILS	PIAAC	Income from employment and income from self-employment and independent work.	All own children below age 18.
Turkey	-	Yes	-	2018	2018	TRY	TSILC	Income from employment and income from self-employment and independent work.	Own children under age 18 living in the household, and children aged 18–24 who are still in education or are fullfilling domestic tasks.

Note: Continues on next page.

Table A1: Country Overview, Micro Data (cont.)

Country	EU	OECD	G7	Ref. Year	Pol. Year	Currency	Source	Remarks, Earnings	Remarks, Children
Western Europe (7)									
Austria	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Belgium	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
France	Yes	Yes	Yes	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Germany	Yes	Yes	Yes	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Luxembourg	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Netherlands	Yes	Yes	-	2018	2018	EUR	SILC	Employee cash and noncash income, cash benefits and losses from self-employment.	Dependent children (under age 18, and aged 18–24 who are inactive)
Switzerland	-	Yes	-	2018	2018	CHF	SHP	Income from employment and income from self-employment and independent work.	Own children under age 18 living in the household, and children aged 18–24 who are still in education.

Note: This table presents information on the country coverage and the micro data sources used to estimate income distributions. Countries are ordered according to the sub regional classification by the United Nations. Column 2-3 indicate membership of the respective country in the European Union (EU), the Organisation for Economic Co-operation and Development (OECD), and the G7 group of industrial countries. Column 4 display the original reference year to which income values refer to and Column 5 displays the policy year to which tax and transfer systems refer to. Column 6 displays the currency in which the income variable is measured and Column 7 indicates the data source for the income distribution. Columns 8 and 9 describe the earnings variable and definition of children.

Table A2: Country Overview, Micro-Simulation Model

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Austria	EUROMOD	Personal income tax[1] Health SIC Pension SIC Unemployment SIC Housing benefit contribution Union contribution	Co-insurance relatives in health insurance	Minimum income benefit (only Vienna)[2] Family allowance Child (maintenance) tax credit[3]	Maintenance payment state Housing benefits	[3]treated like a universal benefit in reality
Australia	OECD TaxBEN	Personal income tax Medicare levy Median school fee for centre-based care		Newstart allowance[2] Youth allowance[2] Parenting payment[2] Family tax benefit[2] Housing benefit	Working credit Language, literacy and numeracy supplement Approved programme of work supplement Special benefit Single income family supplement	There are no SIC paid by employees in AU
Belgium	EUROMOD	Personal income tax[1] Medical care SIC Pension SIC Unemployment SIC Disability SIC Special SIC Work bonus (credited SIC)[3] Lump sum tax deduction for professional expenses	Flemish care insurance contribution	Income support (social assistance)[2] Child allowance (including supplements)	Education-related allowances (simulated in 2019) Housing benefits	[3]only white-collar simulated
Bulgaria	EUROMOD	Personal income tax Health SIC Pension SIC Unemployment fund General sickness SIC		Social assistance allowance[2] Child allowance Heating allowance[3]	Lump sum social assistance allowance Rent allowance for municipal lodging	[3]based on a number of assumptions

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Canada	OECD TaxBEN	Federal income tax		Social assistance[3]	Extended health benefits	[3]varies on regional level; only Ontario described in report
		Local income tax[3]		Federal child benefit	Housing benefit	
		Health premium[3]		Regional family benefit[3]		
		Pension SIC		Child care fee discount[3]		
		Unemployment SIC		Workers benefit		
		Ontario-specific tax credits				
Switzerland	OECD TaxBEN	Federal income tax[1]	Church tax	Guaranteed minimum income (incl. housing and medical benefits)[2,3]	Integration supplement (part of GMI)	[3]varies on regional level; only Zurich simulated
		Local income tax[1,3]		Family benefit		
		Child expenditure tax concession				
		Health fund (avg. value)[3]				
		Pension SIC				
		Unemployment SIC				
		Pillar II pension contribution (avg. value)				
Cyprus	EUROMOD	Personal income tax[1]	Optional flat-rate SIC	General minimum income[2,3,4]	Other benefits for parents	[3]some minor cash and non-cash benefits not simulated; includes housing allowance with region-specific rates: weighted average is applied
		General SIC for employees	Credited SIC	Child benefit[2]		[4]after certain income threshold, this is no longer paid, which leads to a drop in disp. income under the level at zero gross income; according to TaxBEN, however, there is a smooth phase-out
		General health fund (only from 2019)	Provident fund contributions	Single parent benefit		
			Tax credits for double taxation of foreigners			

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Czech Republic	EUROMOD	Income tax[1]	Kindergarten tax credit	Social assistance	Education-related allowances	[3]there is a minimum contribution to health insurance; if wage is lower than min. wage, EUROMOD wrongly models the difference as employee SIC; in fact, employees pay 4.5% health insurance at all times and rest is covered by employer or state;
		Health SIC		Child allowance	Other minor social benefit programmes	
		Pensions[3]		Supplement for housing	Housing benefit	
				Income tax bonus		
Germany	EUROMOD	Income tax[1]	Church tax	Unemployment benefit II[2],[3]	Lump-sum unemployment benefits	[3]nation-wide averages are applied
		Solidarity surcharge		Social benefits (Sozialgeld)	Advances on alimony payments	[4]partly; in-kind benefits are not simulated
		Tax exemption for 'Minijobs'		Child benefit		
		Deductions for income-related expenses and lone parents (lump-sum)		Additional child benefit[2]		
		Deduction for special expenses		Educational allowance[4]		
		Child tax allowance		Housing benefits[2],[3]		
		Health SIC				
		Pension SIC				
		Unemployment SIC				
		Long-term care SIC				

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Denmark	EUROMOD	Bottom bracket income tax Top bracket income tax Income tax credit Municipality tax[3] Church tax[3] Labour market contribution[4] Supplementary labour market pension (only monthly contracts) Unemployment insurance[5] Health contribution[4] (abolished 2019)		Social assistance[2],[6] Green check	Child family grant Ordinary child allowance and lone-parent supplement Child support (alimony payment) Housing benefit	[3]regional differences; average values applied [4]counts as tax in EUROMOD [5]payment depends on insurance provider; averages are applied; nevertheless, EUROMOD models contribution only after certain income threshold, which leads to a discrete drop in disp. income [6]no longer paid after certain income threshold, which leads to a sudden deep drop in disp. Income
Estonia	EUROMOD	Income tax[1] Pillar II pension SIC Unemployment SIC	Pillar III (voluntary) pension contributions	Subsistence benefit[3] Child allowance	Single parent child allowance Local (family) benefits	[3]assumptions made on housing costs
Greece	EUROMOD	Personal income tax[1] Solidarity contribution Sickness SIC[3] Pension SIC[3] Unemployment SIC[3] Other SIC[3]	Regional and municipal taxes	Guaranteed minimum income[2] Social dividend (2018) Child benefit Housing benefit[2] (2019)	Unemployment assistance for long-term unemployed Other minor benefit programmes	[3]non-hazardous occupations only

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Spain	EUROMOD	Personal income tax	Several (regional) tax credits	Minimum income support[5]	Unemployment assistance	[3]differences for certain jobs (housemaids, sea workers, etc.) are not modelled
		General regime SIC for employees[1],[3], [4]		Child benefit	Active insertion allowance	[4]singles w/o children: since SIC are paid from first positive income, low gross income may lead to less disp. income than at zero gross income
				Refundable lone parent tax credit	Other unemployment programmes (e.g. PREPARA and PAE) Regional child benefits Housing benefits	[5]regional differences; Madrid is modelled
Finland	EUROMOD	National income tax	Medical care contributions	Local authority income support[2]	Labour market subsidy	[3]average rate applied
		Municipal income tax[3]	Church tax	Child benefit	State child maintenance allowance	[4]assumption that household owns their house and does not rent
		Broadcasting tax	Several minor tax credits (e.g. deficit credit)	Housing allowance[4]		
		Medical care SIC Pension SIC Unemployment SIC Daily allowance SIC				
France	EUROMOD	Personal income tax[1]	Exceptional contribution on high incomes	Solidarity labour income[2]	Family support allowance (ASF)	[3]includes sickness, pension, unemployment, and outstanding contribution; non-white collar only
		General Social contribution	Several minor tax credits	Family allowance	Energy bonus	
		Social security debt repayment contribution		Education benefit		
		General employee SIC (régime général)[3]		Activity bonus		
				Housing benefit (tenants only)[2]		

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Croatia	EUROMOD	Personal income tax[1]	Credited SIC	Subsistence benefit[2]	Several minor benefits (e.g. foster-parent benefit, one-time benefits for households in need)	[3]rate varies on the local level; average values applied
		Surtax[3]		Child benefit	Several minor benefits on local level	
		Pension B1 and B2 SIC			Compensation for electricity costs	
Hungary	EUROMOD	Personal income tax[1] (only family tax credit is modelled)	Local taxes	Stand-by allowance	Out-of-work allowance	High participation tax for low incomes because social assistance being is cancelled for positive income
		Health SIC		Family allowance	Home maintenance support	
		Pension SIC		Regular child protection benefit	Several social benefits by local governments	
		General insurance SIC			Advance on maintenance payments	
					Irregular child protection benefit	
					Debt management benefit	
					Public health benefit card	
Ireland	EUROMOD	Personal income tax[1]		Basic supplementary welfare allowance[2]	Jobseeker's allowance	[3]this benefit can lead to negative PTR if benefit receipt is larger than at zero income
		Universal social charge		One-parent family payment	Back to work family dividend	
		Employee SIC (only Class A)		Child benefit	Community employment programme and tús	
				Working family payment[3]	Housing assistance payment	
					Part-time job incentive scheme	
					Fuel allowance	

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Italy	EUROMOD	National income tax[1]		Minimum income[2]	Housing benefit	[3]varies slightly across regions
		Regional income tax[1],[3]		Family allowance [5]	State and municipality dependency benefits	[4]contribution rate varies slightly across (among others) occupation, size of firm, sector; industrial firm with 50 employees is simulated; also, daily minimum wage contribution is paid by employer if income is too low, but EUROMOD counts this as employee SIC (OECD TaxBEN)
				Bonus 80 Euro	Minimum insertion income	[5]no reduction for part-time workers;
		Tax credit for employment income			Basic needs debit card	Also: paid only after certain income threshold, which leads to negative PTR if benefit receipt is larger than at zero income
		Tax credit for dependent family members				
		Regional additional tax				
		Employee SIC[4]				
Japan	OECD TaxBEN	Personal income tax[1]		Livelihood assistance		[3]varies on regional level; only Tokyo simulated
		Local income tax (national avg. rates)[1]		Child allowance		
		Health SIC		Child rearing allowance		
		Pension SIC		Child assistance supplement[2]		
		Unemployment SIC		Lone parent assistance[2]		
				Housing assistance[3]		
				Re-employment allowance		

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
South Korea	OECD TaxBEN	Personal income tax[1] Local income tax Health SIC Pension SIC Unemployment SIC		National basic livelihood security[2] Housing benefit for rented accommodation[3] Lone-parent support subsidy Early re-employment allowance Earned income tax credit[2] Child care tax credit[2]	Hope growing account	[3]Seoul vales applied
Lithuania	EUROMOD	Personal income tax[1] Health SIC Pension SIC Sickness SIC (since 2019) Credited social contributions	Pillar II pension contributions (voluntary)	Social benefit[2],[3] Universal child benefit Additional child benefit	Heating benefit Compensation for special working conditions State social assistance benefits Municipal support	[3]not simulated for singles w/o children
Luxembourg	EUROMOD	Personal income tax[1] Health SIC (cash and in-kind insurance)[3] Pension SIC Unemployment fund Long-term care SIC, Credited health SIC for social assistance		Guaranteed minimum income (until 2018)[2] Social inclusion income (from 2019)[2] Child benefit Rent allowance (part of GMI)[2] Expensive life allowance New school year allowance Tax credits: employees, lone parents[4]		[3]rate varies across occupations; average value applied [4]the employee tax credit can lead to negative PTRs if negative tax is larger (in absolute terms) than benefit receipt at zero income

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Latvia	EUROMOD	Personal income tax[1]		Guaranteed minimum income[2],[3]	Municipal benefit in extraordinary situations	[3]some municipalities give in-kind transfers instead of cash (case-by-case basis); cash is modelled
		Solidarity tax Health SIC Pension SIC, Unemployment SIC Disability SIC Accident SIC Maternity and sickness SIC Parents' insurance		Family state benefit Housing allowance[2],[3]		
Malta	EUROMOD	Personal income tax[1]	Credited SIC	Social assistance[2]	Unemployment assistance	
		Employment tax rebate		Social assistance for single unmarried parents[2]	Housing benefit	
		Class I employee SIC		Supplementary assistance (for childless) Child allowance (means-tested and flat rate) In-work benefit Bonuses on social assistance	Tapering of benefits	
Netherlands	EUROMOD	Personal income tax[1]		General social assistance[2]	Rent allowance	[3]partial compensation for the obligatory private health insurance
		Health SIC People insurance SIC (pension, survivor benefits, care) Tax and SIC credits (general credit, work credit, income-related combination credit)		Child benefit Child related budget[2] Care allowance[3]		

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Poland	EUROMOD	Personal income tax[1]		Family allowance	Supplement for lone parents	[3]only based on income test; in reality, household benefit officers additionally visit applying families to assess their neediness
		Health SIC		Family 500 plus programme	Temporary social assistance	
		Pension SIC		Supplement for starting school year		
		Disability SIC		Good start benefit		
		Sickness SIC		Housing benefits[3]		
Portugal	EUROMOD	Personal income tax[1]		Social integration income[2]	Housing benefits	[3]minor occupation-related details are not simulated
		Employee SIC[3]		Child benefit	Education benefits Other family benefits Other social assistance benefits	
Romania	EUROMOD	Personal income tax[1]	Credited health insurance	Guaranteed minimum income[2]	Heating aid	
		Health SIC	No tax credit is simulated	Universal child benefit	Financial aid	
		General contribution		Family benefits (means-tested)[2]	Aid for purchasing a computer Money for high school	
Sweden	EUROMOD	Personal income tax[3]	Public media fee	Social assistance[2],[3]	Maintenance support	[3]nation-wide average values applied
		Funeral fee[3]		Child benefit		[4]given assumptions about housing costs
		Employee SIC		Housing allowance[2],[3],[4]		

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. Continues on next page.

Table A2: Country Overview, Micro-Simulation Model (cont.)

Country	Tax Model	Taxes/SIC		Benefits		Notes
		Simulated	Not Simulated	Simulated	Not Simulated	
Slovenia	EUROMOD	Personal income tax Health SIC Pension SIC Unemployment SIC Maternity leave SIC	Minimum base condition for SIC	Social assistance[2] Child benefit[2] Housing benefit[2],[3]		[3]based on assumptions about flat size
Slovak Republic	EUROMOD	Personal income tax Health SIC Pension SIC Unemployment SIC Disability SIC Sickness SIC		Material needs benefit (incl. housing allowance) Child benefit Additional child benefit	Alimony payments	
United Kingdom	OECD TaxBEN	Personal income tax Employee SIC standard rate		Universal credit (social assistance)[2] Child benefit	Support for mortgage interest	
United States	OECD TaxBEN	Personal income tax Local state income tax[3] Pension SIC Survivor SIC Disability SIC Medicare contribution Hospital insurance tax		Supplemental nutrition assistance programme (SNAP)[2],[3] Temporary assistance for needy families (TANF)[2],[3] Federal EITC State EITC[3] Child tax credit	General assistance programme Child care and development fund (modelled age limit is 6)[3] Housing benefits Other dependent tax credit	[3]varies on state level; OECD TaxBen mostly considers MI state programs by default (sometimes also CA, TX)

Note: [1]Certain tax allowances (e.g. donations, mortgage interest payments, private pension plans, special expenses) are not simulated. [2]Means-tested; relevant income / wealth may not be defined correctly due to lack of data. This table presents information on the micro simulation model coverage for different countries. We describe taxes and benefits that are covered by the micro-simulation model, as well as non-simulated taxes and transfers. In general, old-age pensions, widow(er), survivor or orphan's pensions and related benefits are not listed. Benefits for families with children under age 9 (e.g. birth grants, maternity leave pay, allowances for children before school, etc.), as well as benefits for large families (3 or more children) are not listed. Special rules that apply to civil servants, employees of the public sector, and self-employed are not listed. Sickness or disability benefits are not listed. Temporary unemployment benefits were not simulated and are not listed. Other income sources (capital income, rental income, sale of property, inheritance, etc.) are not considered, even though they can be modelled with EUROMOD in some countries. Taxes on land, real estate, wealth, gifts and other asset values, as well as VATs or excise duties are not listed. All taxes and benefits which are officially partly simulated are listed as "not simulated" if the data contains missing entries for the respective variable.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and EUROMOD (2016-19) country reports, and OECD TaxBEN country reports.

Table A3: Summary Statistics

Country	Data	Curr.	Child	N (N_T)	$\overline{y}$	y_{p50}	y_{p90}	$\frac{N_{\|y=0}}{N}$
Austria	SILC	EUR	No	1,107 (5,983)	32,827	30,943	65,339	15%
Austria	SILC	EUR	Yes	213 (5,983)	26,861	19,996	51,747	22%
Australia	HILDA	AUD	No	1,387 (9,842)	67,313	62,088	133,000	15%
Australia	HILDA	AUD	Yes	560 (9,842)	53,740	44,066	124,300	21%
Belgium	SILC	EUR	No	956 (6,787)	29,811	27,474	63,842	23%
Belgium	SILC	EUR	Yes	409 (6,787)	29,430	25,698	59,372	19%
Bulgaria	SILC	BGN	No	442 (7,340)	16,984	10,464	29,410	12%
Bulgaria	SILC	BGN	Yes	99 (7,340)	11,623	9,908	25,182	16%
Brazil	PNADc	BRL	No	63,158 (147,813)	16,324	11,976	36,000	34%
Brazil	PNADc	BRL	Yes	10,729 (147,813)	16,786	11,976	36,000	29%
Canada	CIS	CAD	No	6,130 (42,437)	42,840	36,000	90,000	17%
Canada	CIS	CAD	Yes	1,919 (42,437)	39,658	32,000	90,000	20%
Switzerland	SHP	CHF	No	884 (6,028)	73,892	72,000	125,000	7%
Switzerland	SHP	CHF	Yes	245 (6,028)	77,966	74,500	150,000	9%
Chile	PIAAC	1000 CLP	No	840 (5,212)	6,192	3,506	12,626	26%
Chile	PIAAC	1000 CLP	Yes	842 (5,212)	6,190	3,506	12,626	26%
Cyprus	SILC	EUR	No	365 (4,211)	21,234	17,668	42,239	8%
Cyprus	SILC	EUR	Yes	145 (4,211)	15,528	13,006	38,215	14%
Czech Republic	SILC	10 CZK	No	802 (8,707)	35,758	34,157	62,766	9%
Czech Republic	SILC	10 CZK	Yes	277 (8,707)	27,984	28,448	49,546	13%
Germany	SILC	EUR	No	2,233 (12,350)	32,148	31,321	62,067	18%
Germany	SILC	EUR	Yes	438 (12,350)	29,540	28,308	56,995	15%
Denmark	SILC	10 DKK	No	678 (5,817)	27,795	29,832	56,191	17%
Denmark	SILC	10 DKK	Yes	165 (5,817)	28,913	30,547	54,251	10%
Ecuador	ENEMDU	USD	No	6,758 (16,993)	3,824	2,640	9,120	30%
Ecuador	ENEMDU	USD	Yes	2,054 (16,993)	3,898	2,400	8,880	24%
Estonia	SILC	EUR	No	667 (6,265)	12,947	12,677	25,216	10%
Estonia	SILC	EUR	Yes	166 (6,265)	14,071	11,572	28,266	5%
Greece	SILC	EUR	No	1,362 (17,914)	13,682	13,398	25,366	25%
Greece	SILC	EUR	Yes	270 (17,914)	12,994	12,602	25,107	25%
Spain	SILC	EUR	No	1,405 (15,887)	18,874	16,087	37,422	13%
Spain	SILC	EUR	Yes	506 (15,887)	17,460	12,877	38,772	20%
Finland	SILC	EUR	No	1,054 (9,646)	25,524	25,302	51,250	19%
Finland	SILC	EUR	Yes	206 (9,646)	27,898	28,004	58,135	14%
France	SILC	EUR	No	1,407 (11,737)	26,549	25,238	50,390	12%
France	SILC	EUR	Yes	583 (11,737)	24,853	22,480	46,630	11%
Croatia	SILC	10 HRK	No	521 (7,880)	6,937	5,698	16,620	28%
Croatia	SILC	10 HRK	Yes	119 (7,880)	6,985	5,410	14,244	14%
Hungary	SILC	100 HUF	No	590 (6,911)	25,013	22,169	47,690	11%
Hungary	SILC	100 HUF	Yes	210 (6,911)	26,717	26,418	45,986	3%
Ireland	SILC	EUR	No	417 (4,382)	27,935	23,128	69,868	28%
Ireland	SILC	EUR	Yes	242 (4,382)	28,027	10,489	44,971	33%
Israel	PIAAC	ILS	No	544 (5,538)	199,998	61,436	179,812	28%
Israel	PIAAC	ILS	Yes	557 (5,538)	196,130	60,637	179,812	28%
Iceland	SILC	100 ISK	No	213 (2,969)	62,400	62,491	107,743	10%
Iceland	SILC	100 ISK	Yes	118 (2,969)	61,578	60,152	120,597	11%
Italy	SILC	EUR	No	3,332 (21,173)	26,292	22,977	47,024	10%
Italy	SILC	EUR	Yes	606 (21,173)	23,673	20,652	44,103	13%
Japan	JHPS	100 JPY	No	543 (6,170)	27,348	26,000	51,000	15%
Japan	JHPS	100 JPY	Yes	75 (6,170)	28,943	24,800	51,000	5%

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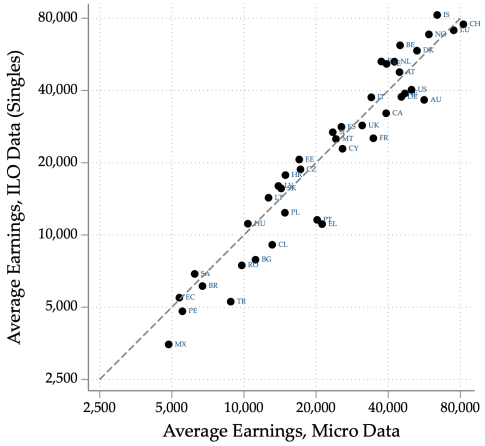
Table A3: Summary Statistics (cont.)

Country	Source	Curr.	Child	N (N_T)	$\overline{y}$	y_{p50}	y_{p90}	$\frac{N_{\mid y=0}}{N}$
South Korea	KLIPS	1000 KRW	No	1,385 (11,719)	26,690	25,000	48,000	13%
South Korea	KLIPS	1000 KRW	Yes	251 (11,719)	26,122	24,000	45,480	13%
Lithuania	SILC	EUR	No	588 (5,131)	9,376	6,896	20,405	16%
Lithuania	SILC	EUR	Yes	214 (5,131)	8,170	6,344	16,492	14%
Luxembourg	SILC	EUR	No	369 (3,842)	53,465	44,511	115,248	17%
Luxembourg	SILC	EUR	Yes	147 (3,842)	54,804	44,133	105,182	13%
Latvia	SILC	EUR	No	647 (5,279)	10,329	8,828	21,996	14%
Latvia	SILC	EUR	Yes	136 (5,279)	10,440	9,490	20,962	8%
Malta	SILC	EUR	No	212 (3,785)	19,392	16,573	36,439	12%
Malta	SILC	EUR	Yes	68 (3,785)	10,763	9,856	24,381	33%
Mexico	ENIGH	10 MXN	No	24,046 (74,607)	7,391	4,748	16,513	24%
Mexico	ENIGH	10 MXN	Yes	9,846 (74,607)	6,711	4,748	15,015	18%
Netherlands	SILC	EUR	No	1,856 (13,764)	29,222	26,370	58,910	20%
Netherlands	SILC	EUR	Yes	411 (13,764)	26,239	20,776	55,017	22%
Norway	SILC	10 NOK	No	777 (6,080)	40,682	42,347	79,284	16%
Norway	SILC	10 NOK	Yes	185 (6,080)	39,018	40,146	73,791	17%
New Zealand	PIAAC	NZD	No	818 (6,177)	40,778	37,477	80,386	29%
New Zealand	PIAAC	NZD	Yes	818 (6,177)	40,778	37,477	80,386	29%
Peru	ENAHO	PEN	No	14,306 (34,562)	14,471	11,333	33,866	23%
Peru	ENAHO	PEN	Yes	4,427 (34,562)	14,417	10,795	31,622	13%
Poland	SILC	PLN	No	1,209 (19,874)	45,431	39,651	92,637	18%
Poland	SILC	PLN	Yes	429 (19,874)	41,202	33,533	86,373	15%
Portugal	SILC	EUR	No	910 (13,570)	15,092	10,955	32,710	14%
Portugal	SILC	EUR	Yes	456 (13,570)	14,679	10,689	28,943	10%
Romania	SILC	RON	No	685 (7,282)	31,304	30,303	66,679	18%
Romania	SILC	RON	Yes	92 (7,282)	36,063	32,580	72,834	16%
Russia	RLMS	100 RUB	No	1,119 (4,820)	2,254	1,644	5,517	36%
Russia	RLMS	100 RUB	Yes	403 (4,820)	2,269	1,460	5,934	19%
South Africa	NIDS	10 ZAR	No	7,546 (10,623)	3,765	0	10,092	55%
South Africa	NIDS	10 ZAR	Yes	898 (10,623)	2,767	0	7,533	58%
Sweden	SILC	10 SEK	No	666 (5,621)	29,069	30,576	51,106	13%
Sweden	SILC	10 SEK	Yes	193 (5,621)	32,613	31,840	59,548	13%
Slovenia	SILC	EUR	No	366 (8,590)	15,984	15,190	32,490	17%
Slovenia	SILC	EUR	Yes	154 (8,590)	18,896	16,500	36,010	11%
Slovak Republic	SILC	EUR	No	352 (5,591)	10,464	10,200	19,200	15%
Slovak Republic	SILC	EUR	Yes	112 (5,591)	9,883	10,620	16,350	14%
Turkey	TSILC	TRY	No	6,366 (24,918)	28,427	18,491	70,832	35%
Turkey	TSILC	TRY	Yes	1,086 (24,918)	19,776	5,935	56,092	44%
United Kingdom	HLS	GBP	No	2,126 (10,866)	18,014	16,245	39,996	28%
United Kingdom	HLS	GBP	Yes	519 (10,866)	11,655	8,280	28,205	32%
United States	PSID	USD	No	2,161 (9,569)	45,366	34,000	96,500	17%
United States	PSID	USD	Yes	1,149 (9,569)	34,880	27,000	69,000	16%

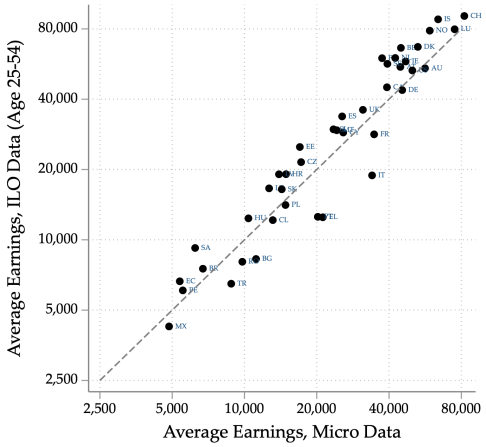
Notes: This table presents summary statistics for the micro data used to calibrate the income distributions. We focus on all single households consisting of unmarried individuals between ages 25 and 60. Samples are further distinguished between individuals with and without dependent children in the household. Column 2 displays the data source, and Column 3 displays the currency in which the income variable is measured. Column 4 distinguishes the sample of households with and without dependent children. Column 5 displays the number of households in the sub-samples, with the total number of households shown in brackets. For Chile, Israel, Japan, and New Zealand, the number of individuals is displayed, since the micro data in these countries are at the individual level. Columns 6–8 display summary statistics of the income distribution. Column 9 displays the share of individuals in the sample that have no income. All income values refer to the policy year used in the analysis. In cases where the reference year and policy year do not align (see Table A1), income values are uprated to the policy year using the Consumer Price Index (CPI) from the International Financial Statistics (IFS) of the International Monetary Fund (IMF).
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A1: Data Validation, Micro data vs. ILO statistics

(a) Validation I



(b) Validation II



Note: This figure presents a validation exercise of the earnings information in our micro data. Each of the two figures visualize average annual earnings in each country as of 2018 and measured in terms of US dollar. In case of unavailable data for 2018, we uprate earnings from the closest previous year available using CPI index from the International Monetary Fund. Figure A1a plots the average earnings based on own calculations from micro data in our sample of interest against the average earnings of single, widowed and divorced employees from the ILO Department of Statistics. Figure A1b plots the average earnings based on own calculations from micro data in our sample of interest against the average earnings of prime age employees (age 25-54) from the ILO Department of Statistics. All axes are in log-scales for improved visibility. The validation excludes Israel, Japan, New Zealand, Russia, and South Korea, since the respective earnings statistics are not available from ILO.
Source: Own calculation based on micro data described in Table A1, and summary statistics from the International Labour Organization (ILO).

Table A4: Hypothetical Household Characteristics

	EUROMOD	OECD TaxBEN
Household Type 1	Single, male, 40 years old, currently not in education, tertiary education, employed as employee, works 40 hours per week, main residence rented, housing cost of 20 percent of EU-SILC average wage.	Single, no children.
Household Type 2	Single, male, 40 years old, currently not in education, tertiary education, employed as employee, works 40 hours per week, main residence rented, housing cost of 20 percent of EU-SILC average wage. 2 children. Child 1 (2) is of age 13 (10) and did (not) complete primary school. Both children are pupils.	Single, two children.

Note: This table presents information on the hypothetical households that are used to calculate budget sets, marginal tax rates, and participation tax rates in EUROMOD and OECD TaxBEN.
Source: Own calculation based on EUROMOD and OECD TaxBEN.

Table A5: Downward Discontinuities, Singles without Children, Inc. Tax + Benefit + SIC

Country	Discontinuity	Benefit Phaseout	$\overline{D}$	$T'(\underline{D})$	$T'(\overline{D})$	$T'(\overline{D})-T'(\underline{D})$
Australia	Yes (1)	32,900	32,950	0.49	0.21	0.28
Austria	Yes (1)	16,080	16,110	0.69	0.33	0.36
Belgium	Yes (1)	10,740	11,070	0.96	0.14	0.82
Bulgaria	Yes (1)	2,160	780	0.70	0.22	0.48
Canada	Yes (4)	23,200	23,150	0.62	0.35	0.27
Croatia	Yes (1)	2,340	2,220	0.86	0.00	0.86
Cyprus	Yes (1)	7,800	7,830	1.08	0.08	1.00
Czech Republic	Yes (1)	80,496	81,270	0.66	0.11	0.55
Denmark	No	444,144	.	.	.	.
Estonia	Yes (1)	3,240	3,270	1.00	0.04	0.96
Finland	Yes (1)	18,120	18,150	0.81	0.35	0.46
France	Yes (3)	23,760	16,710	1.00	0.52	0.48
Germany	Yes (1)	19,440	19,470	0.73	0.45	0.28
Greece	Yes (1)	10,800	3,540	0.83	0.16	0.67
Ireland	Yes (1)	10,260	10,290	0.33	0.00	0.33
Italy	Yes (2)	11,160	11,130	0.75	0.36	0.39
Japan	Yes (1)	25,500	25,550	0.49	0.23	0.26
Latvia	Yes (1)	2,160	2,130	1.00	0.11	0.89
Lithuania	No	0	.	.	.	.
Luxembourg	Yes (3)	25,380	25,410	0.75	0.25	0.50
Netherlands	Yes (1)	13,260	13,290	0.93	0.08	0.85
Poland	No	11,616	.	.	.	.
Portugal	Yes (1)	3,180	3,210	0.42	0.11	0.31
Romania	Yes (1)	2,760	2,898	0.85	0.35	0.50
Slovak Republic	Yes (1)	2,100	2,130	0.47	0.09	0.38
Slovenia	Yes (1)	10,800	10,830	0.76	0.35	0.41
South Korea	Yes (3)	17,100	13,350	0.58	0.09	0.49
Spain	Yes (2)	5,460	5,490	0.90	0.28	0.62
Sweden	Yes (2)	86,736	87,048	0.88	0.47	0.41
Switzerland	Yes (1)	39,800	39,750	1.00	0.23	0.77
United Kingdom	Yes (1)	16,800	150	0.76	0.00	0.76
United States	Yes (1)	15,700	15,750	0.60	0.26	0.34

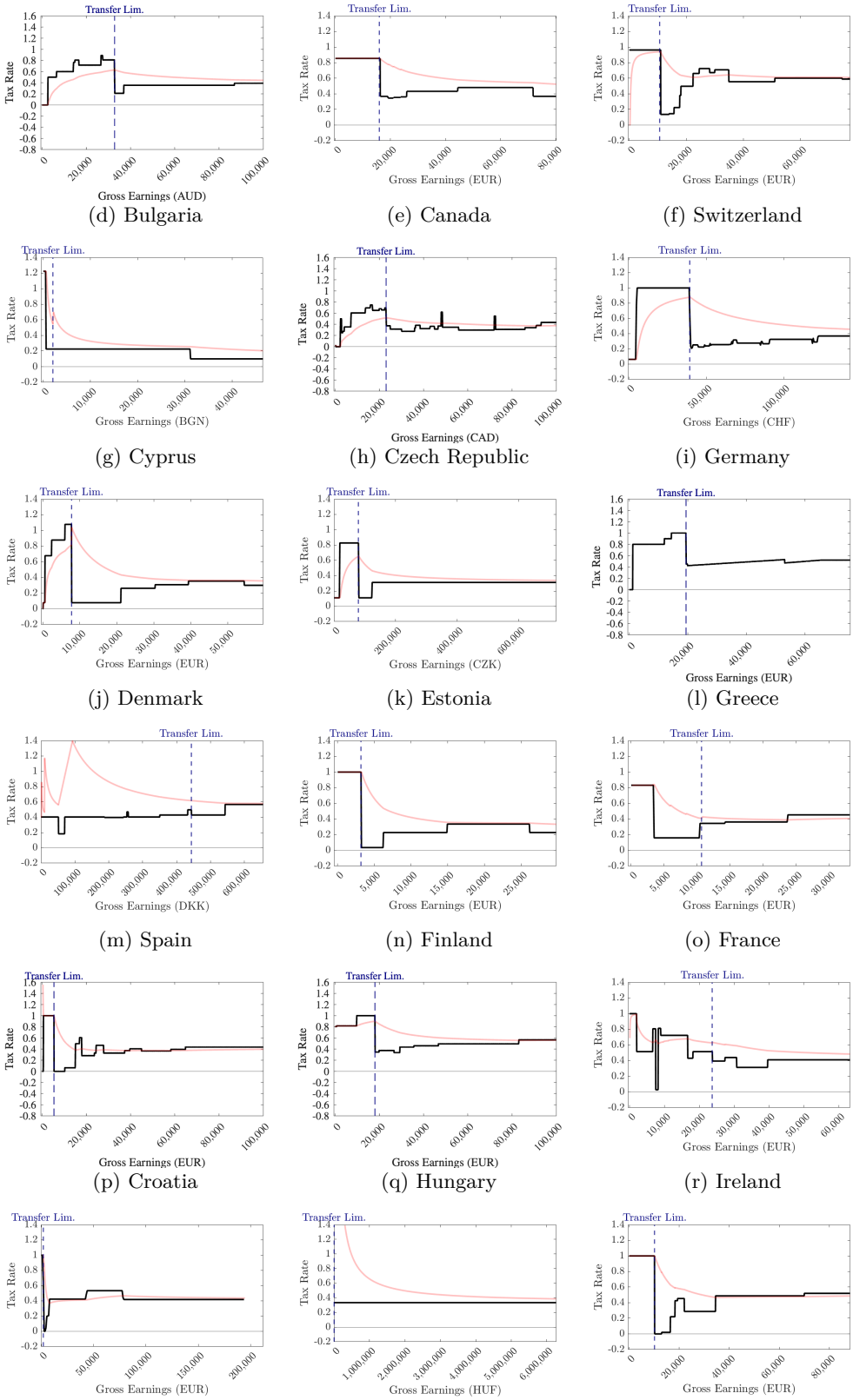
Note: This table shows whether countries' tax and benefit systems incorporate a downward discontinuity in the effective marginal tax rate schedule considering income tax, benefit payments and social insurance contributions. A downward discontinuity is defined as a discrete drop of the marginal tax rate of at least 25 percentage points. The table shows the existence and number of discontinuities in column 3. Column 4 displays the income level, at which major benefit programs are phased out. Column 5 displays the income level directly after the discontinuity $\overline{D}$. Column 6 (7) display the marginal tax rate at the income level left (right) to the discontinuity. Column 8 displays the size of the discontinuity. In case of multiple downward discontinuities, columns 5-8 refer to the discontinuity closest to the benefit phase out level.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Table A6: Downward Discontinuities, Singles with Children, Inc. Tax + Benefit + SIC

Country	Discontinuity	Benefit Phaseout	$\overline{D}$	$T'(\underline{D})$	$T'(\overline{D})$	$T'(\overline{D})-T'(\underline{D})$
Australia	Yes (1)	120,800	55,250	0.84	0.44	0.40
Austria	Yes (1)	26,880	26,910	0.74	0.36	0.38
Belgium	Yes (2)	14,340	14,370	0.45	–0.04	0.49
Bulgaria	Yes (1)	4,680	1,500	1.22	0.22	1.00
Canada	Yes (4)	30,000	48,650	0.60	0.35	0.25
Croatia	Yes (1)	3,720	3,840	0.99	0.00	0.99
Cyprus	Yes (1)	5,760	5,790	0.88	0.08	0.80
Czech Republic	Yes (1)	117,648	118,422	0.42	0.11	0.31
Denmark	No	449,616	.	.	.	.
Estonia	Yes (1)	6,420	6,450	0.81	0.04	0.77
Finland	Yes (1)	25,920	25,890	1.00	0.37	0.63
France	Yes (3)	38,940	38,970	0.90	0.52	0.38
Germany	Yes (2)	29,760	29,790	1.00	0.61	0.39
Greece	Yes (1)	17,640	3,660	0.83	0.16	0.67
Ireland	Yes (1)	0	35,130	0.72	0.29	0.43
Italy	Yes (2)	10,140	10,110	0.87	0.51	0.36
Japan	Yes (1)	45,000	44,950	1.00	0.28	0.72
Latvia	Yes (1)	4,380	4,410	0.37	0.11	0.26
Lithuania	Yes (1)	0	7,650	0.72	0.32	0.40
Luxembourg	Yes (2)	45,240	45,270	1.33	0.52	0.81
Netherlands	Yes (1)	11,940	11,970	0.42	0.00	0.42
Poland	Yes (1)	11,088	34,188	1.00	0.30	0.70
Portugal	Yes (1)	6,300	6,330	0.73	0.11	0.62
Romania	Yes (1)	6,624	6,762	1.01	0.35	0.66
Slovak Republic	Yes (1)	4,260	4,290	0.78	0.27	0.51
Slovenia	Yes (2)	31,860	31,830	1.00	0.43	0.57
South Korea	Yes (2)	29,700	22,750	0.61	0.11	0.50
Spain	Yes (2)	7,740	7,770	0.46	0.00	0.46
Sweden	Yes (1)	249,600	90,792	0.88	0.48	0.40
Switzerland	Yes (1)	47,400	47,350	1.00	0.18	0.82
United Kingdom	Yes (1)	32,000	32,050	0.76	0.32	0.44
United States	Yes (2)	26,600	26,650	0.73	0.37	0.36

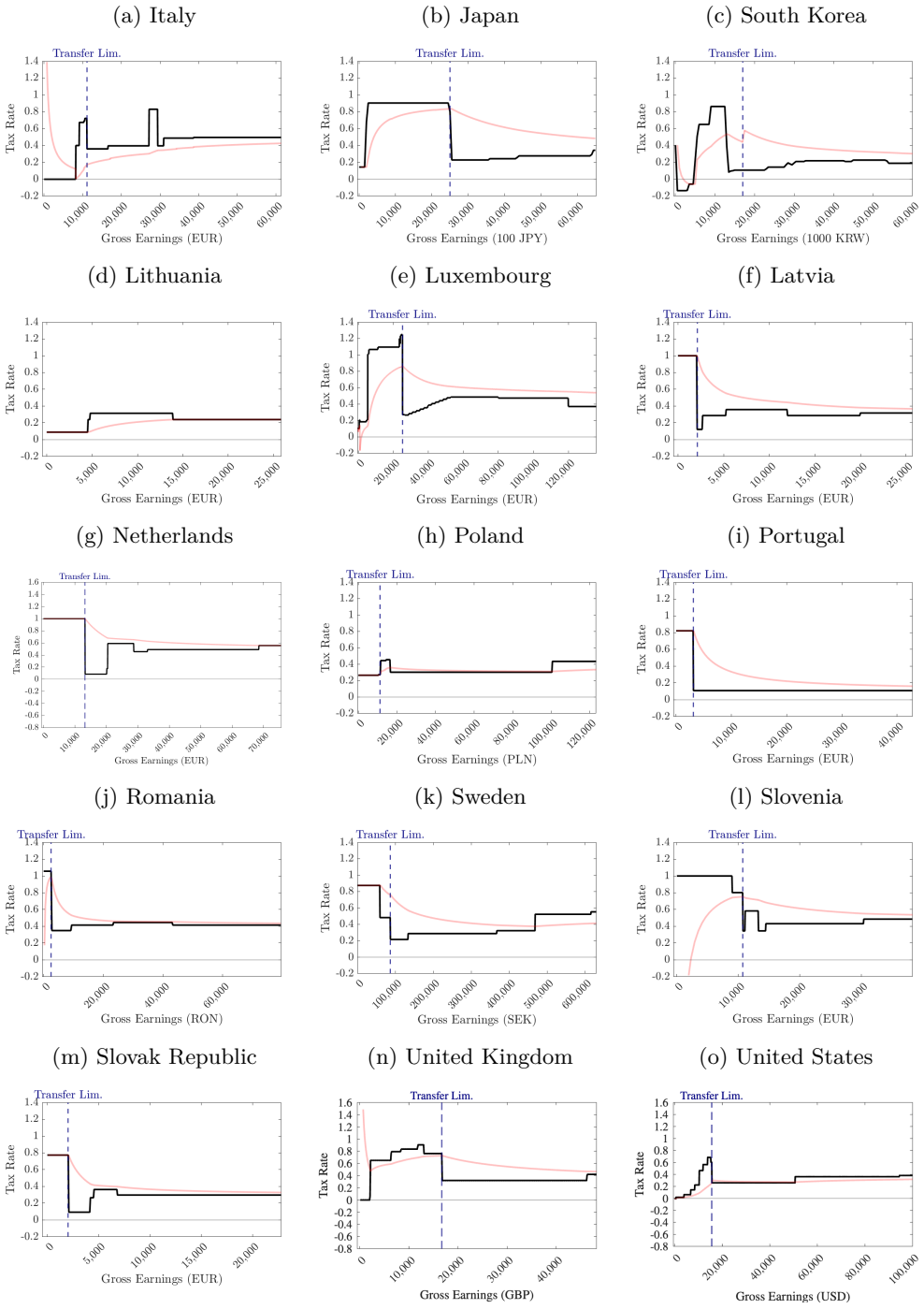
Note: This table shows whether countries' tax and benefit systems incorporate a downward discontinuity in the effective marginal tax rate schedule considering income tax, benefit payments and social insurance contributions. A downward discontinuity is defined as a discrete drop of the marginal tax rate of at least 25 percentage points. The table shows the existence and number of discontinuities in column 3. Column 4 displays the income level, at which major benefit programs are phased out. Column 5 displays the income level directly after the discontinuity $\overline{D}$. Column 6 (7) display the marginal tax rate at the income level left (right) to the discontinuity. Column 8 displays the size of the discontinuity. In case of multiple downward discontinuities, columns 5-8 refer to the discontinuity closest to the benefit phase out level.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A2: Tax Rates, 2018, Singles without Children



Note: Continues on next page.

Figure A2: Tax Rates, 2018, Singles without Children (cont.)



Note: This figure displays the marginal tax rates (black lines) and participation tax rates (red lines) for single individuals without children. Tax rates are calculated from budget sets using EUROMOD and the OECD calculator of taxes and benefits. The vertical dashed line indicates the income level at which the major transfer programs (social assistance, unemployment benefits, housing and in-work benefits) are completely phased out. *Source:* Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A3: Tax Rates, 2018, Singles with Children

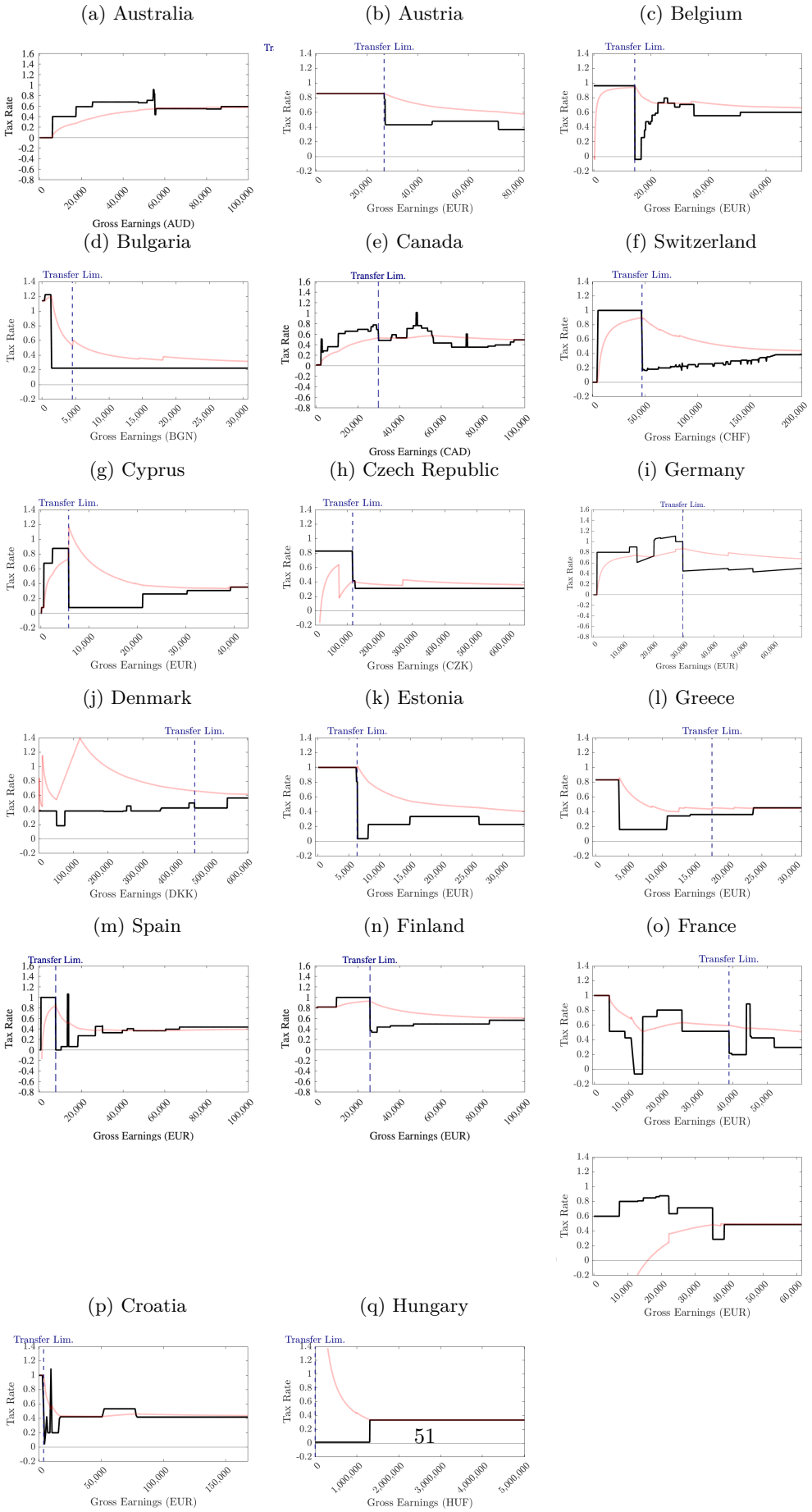
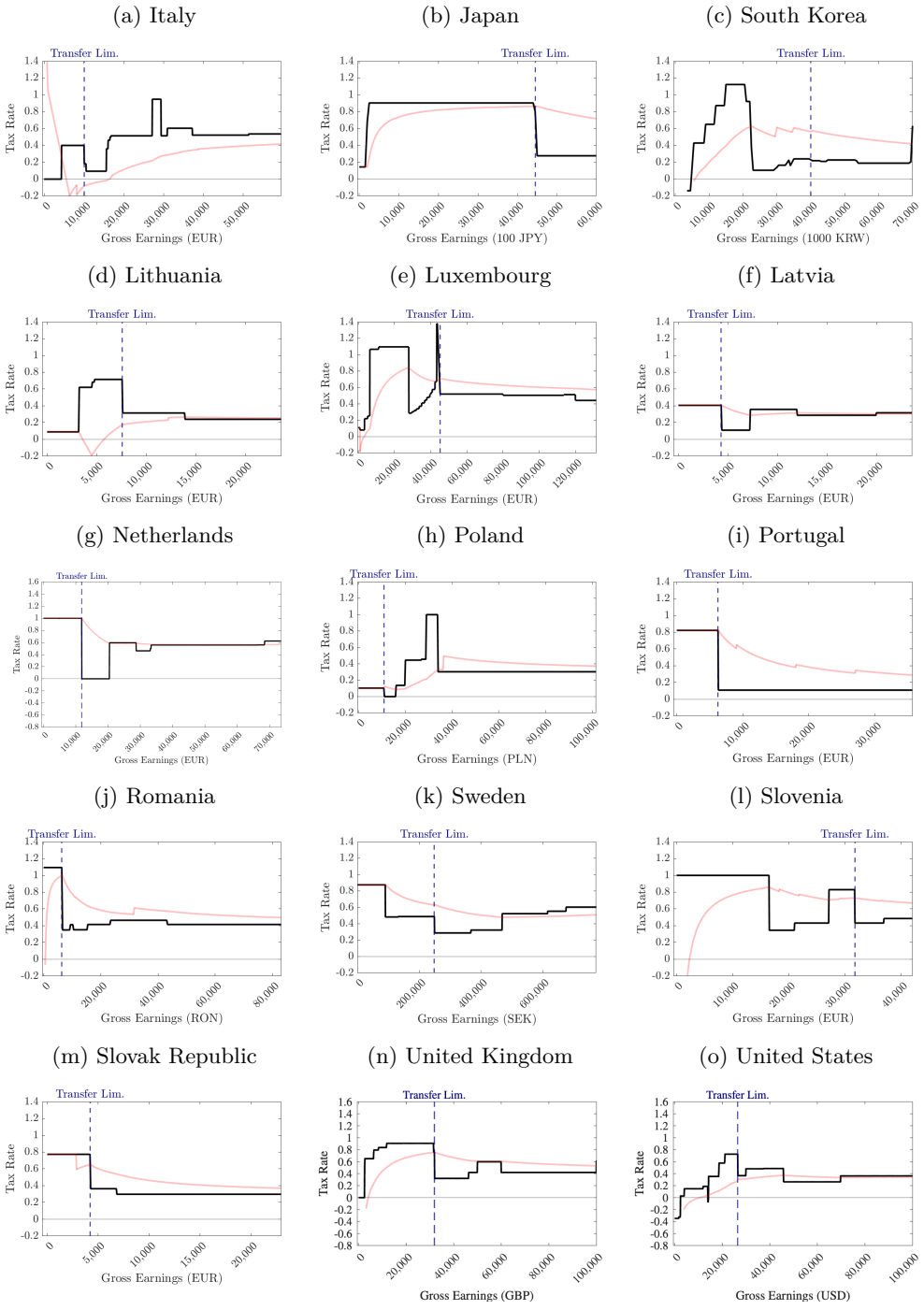
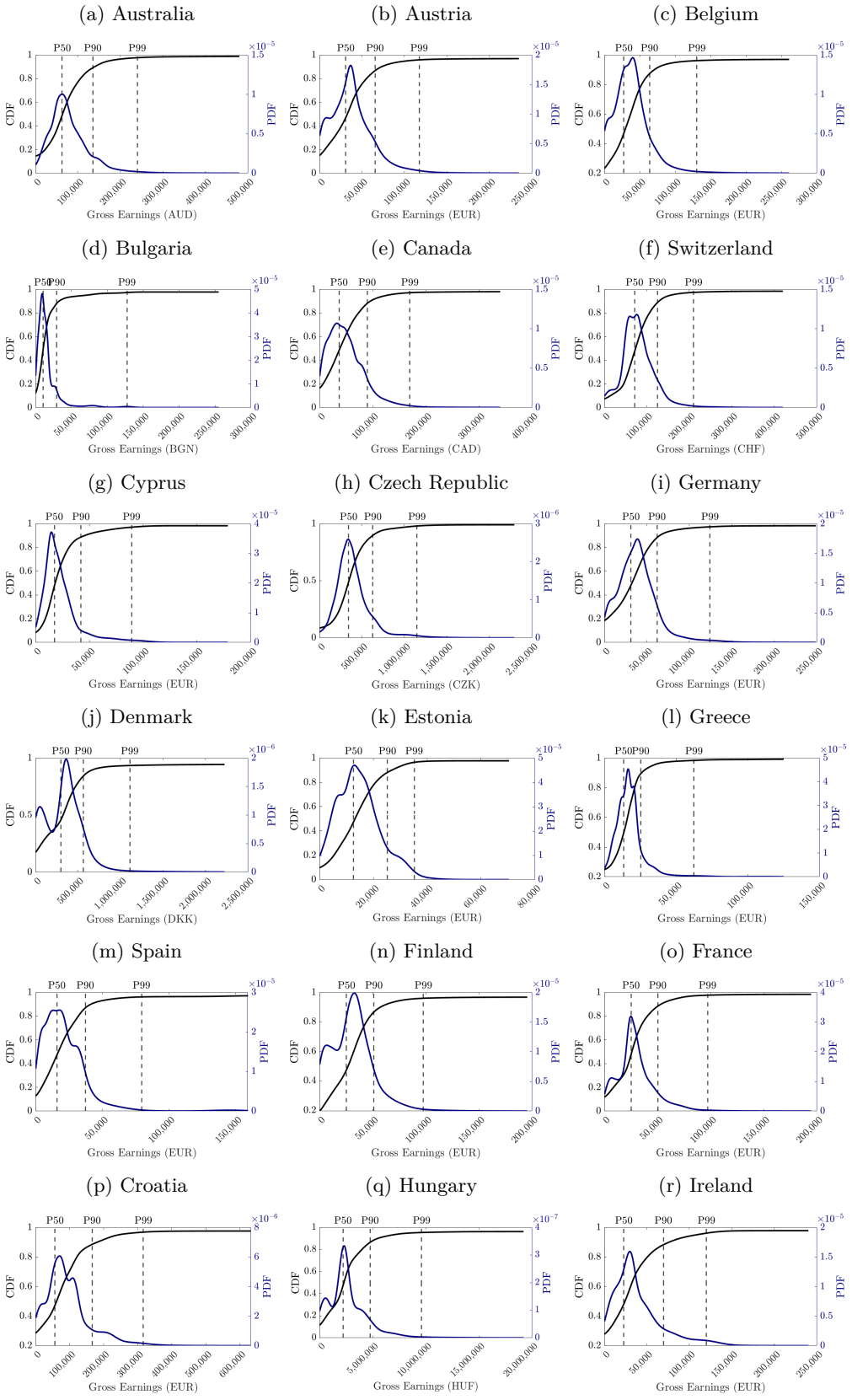


Figure A3: Tax Rates, 2018, Singles with Children (cont.)



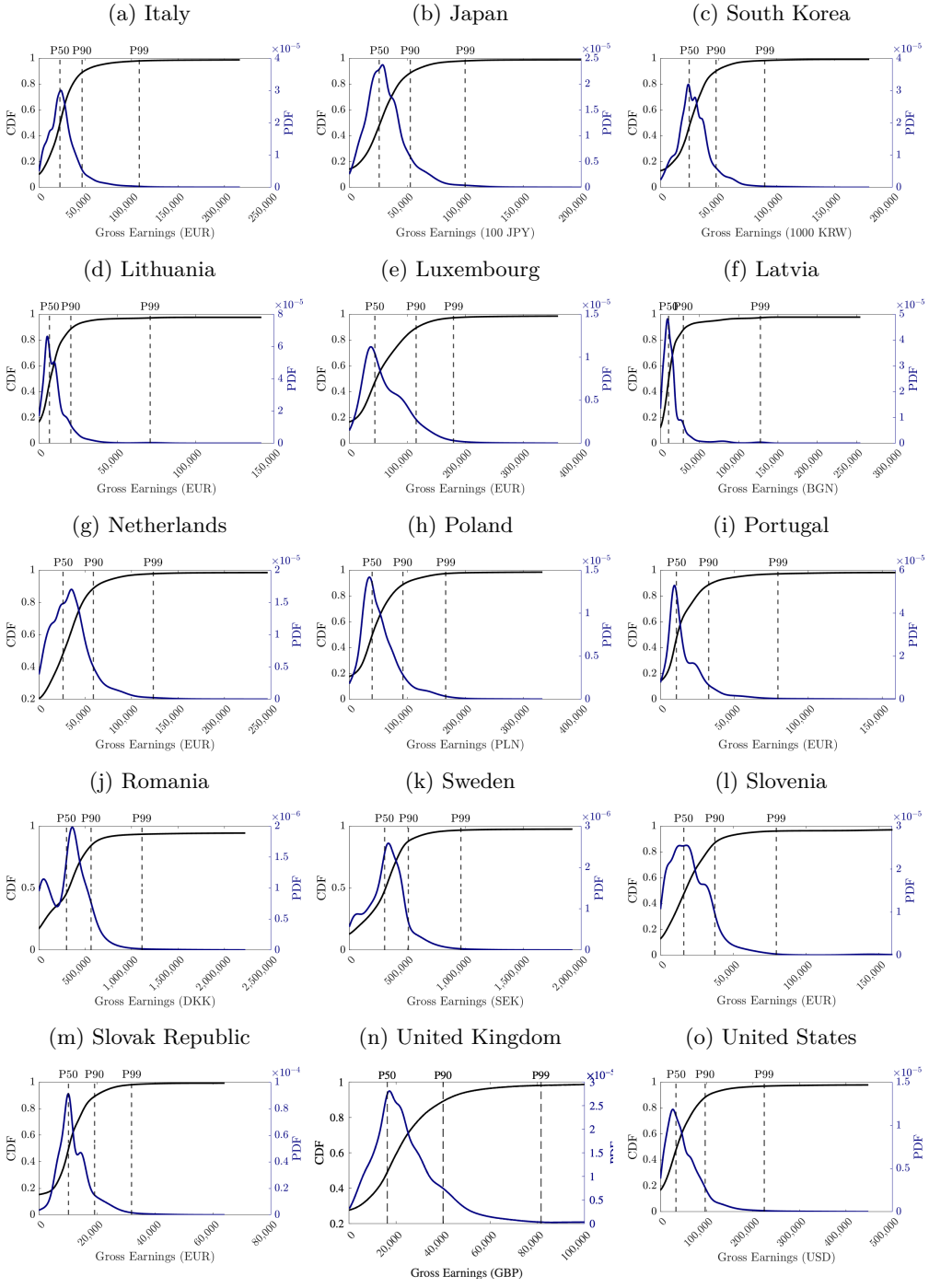
Note: This figure displays the marginal tax rates (black lines) and participation tax rates (red lines) for single individuals with two children. Tax rates are calculated from budget sets using EUROMOD and the OECD calculator of taxes and benefits. The vertical dashed line indicates the income level at which the major transfer programs (social assistance, unemployment benefits, housing and in-work benefits) are completely phased out. *Source:* Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A4: Distributions, Singles without Children



Note: Continues on next page.

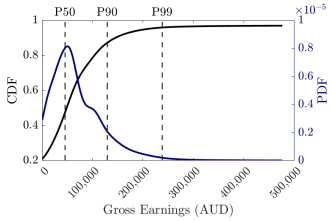
Figure A4: Distributions, 2018, Singles without Children (cont.)



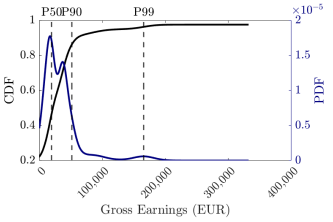
Note: This figure displays in the cumulative distribution function (cdf) and the probability density function (pdf) for singles without children as black and blue lines. All information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Vertical dashed lines indicate selected percentiles of the distribution. The distributions are estimated for gross earnings consisting of income from employment and self-employment. We estimate the distribution by means of an adjusted kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. All estimations are weighted using survey weights provided through EU-SILC. The sample consists of unmarried single households of age 25 to 60 without children. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A5: Distributions, Singles with Children

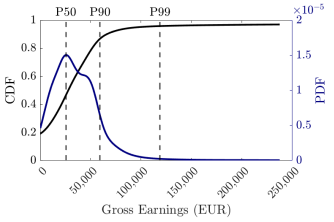
(a) Australia



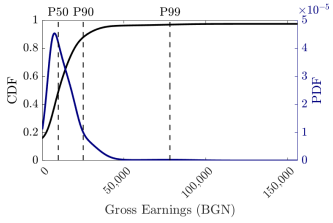
(b) Austria



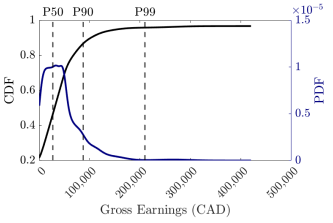
(c) Belgium



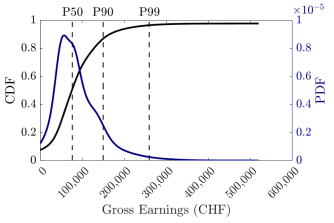
(d) Bulgaria



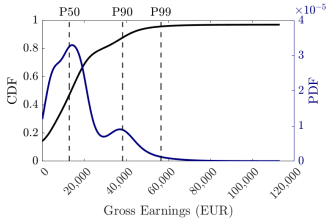
(e) Canada



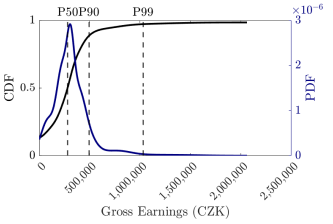
(f) Switzerland



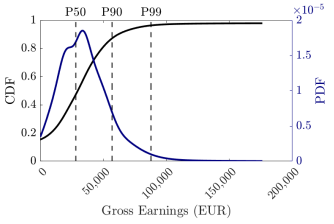
(g) Cyprus



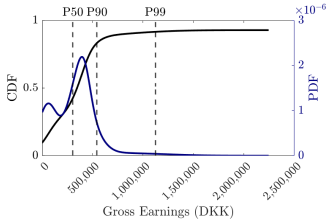
(h) Czech Republic



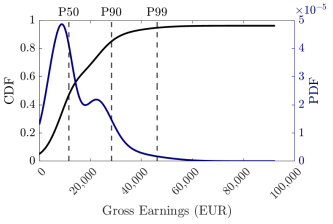
(i) Germany



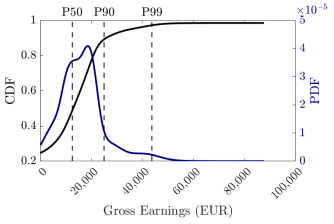
(j) Denmark



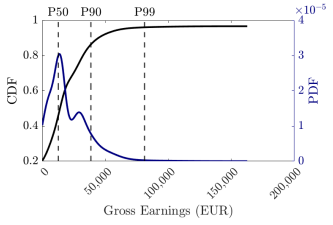
(k) Estonia



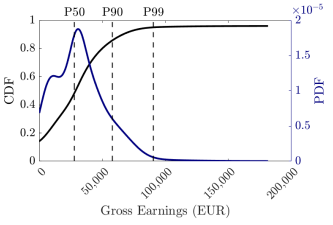
(l) Greece



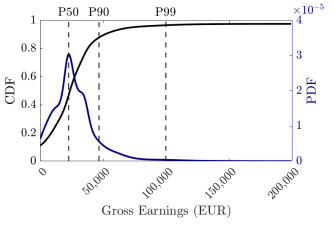
(m) Spain



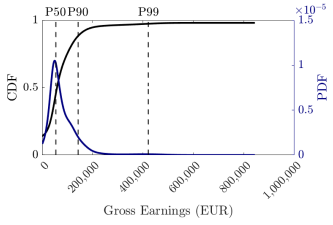
(n) Finland



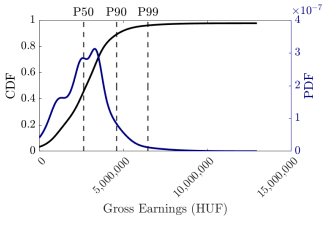
(o) France



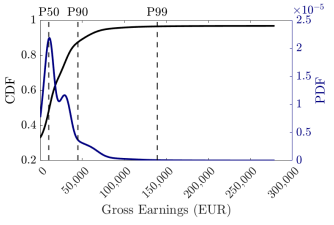
(p) Croatia



(q) Hungary

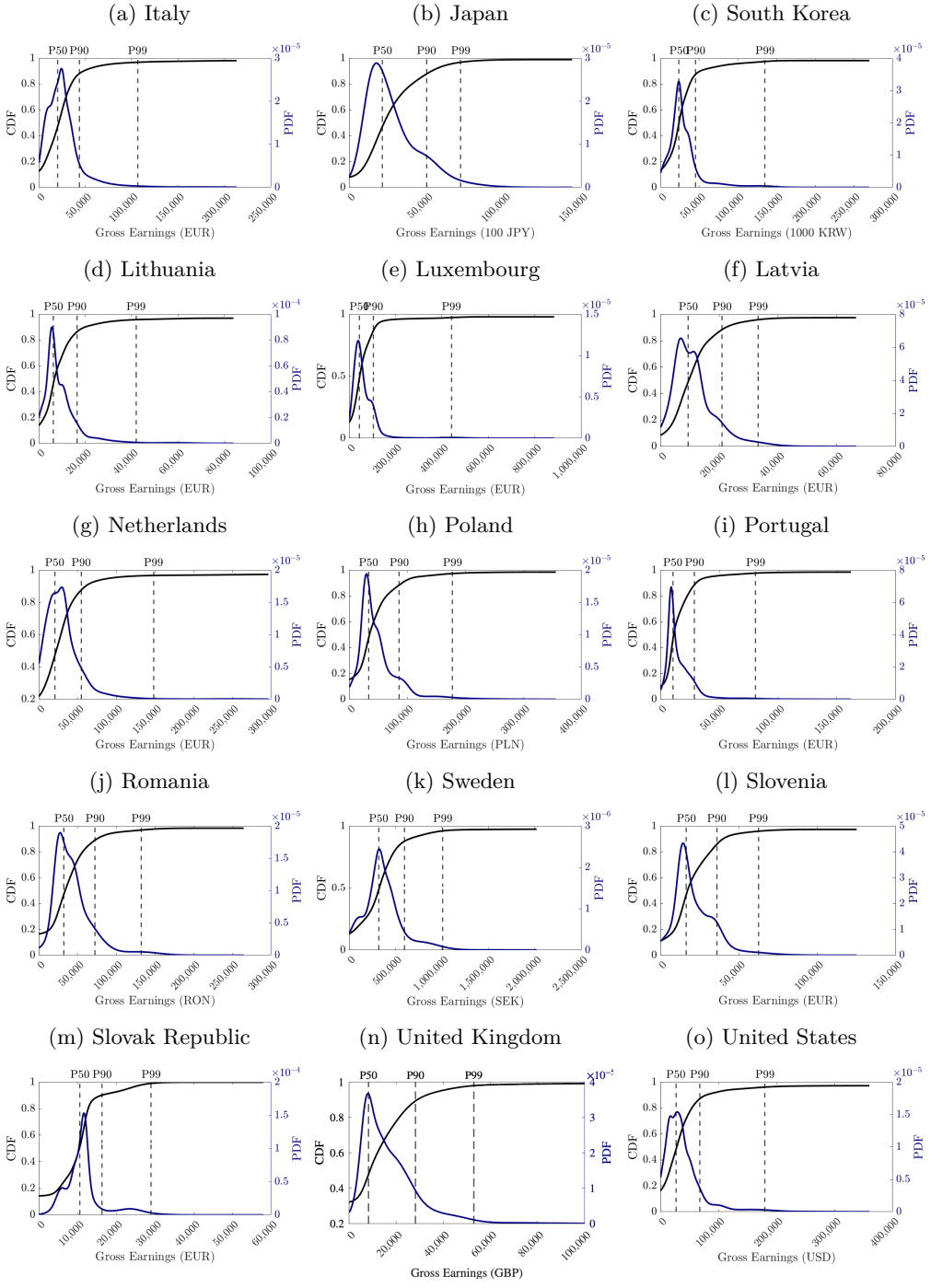


(r) Ireland



Note: Continues on next page.

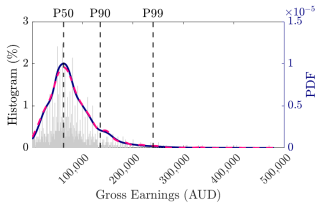
Figure A5: Distributions, 2018, Singles without Children (cont.)



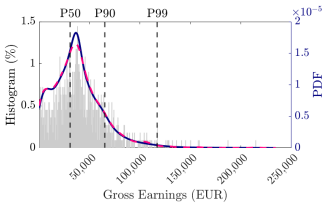
Note: This figure displays in the cumulative distribution function (cdf) and the probability density function (pdf) for singles with two children as black and blue lines. All information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Vertical dashed lines indicate selected percentiles of the distribution. The distributions are estimated for gross earnings consisting of income from employment and self-employment. We estimate the distribution by means of an adjusted kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. All estimations are weighted using survey weights provided through EU-SILC. The sample consists of unmarried single households of age 25 to 60 with children. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A6: Distribution (Robustness), Singles without Children

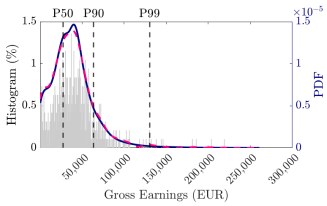
(a) Australia



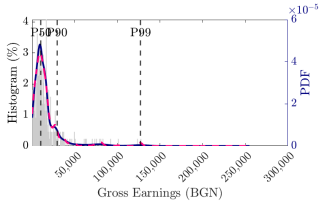
(b) Austria



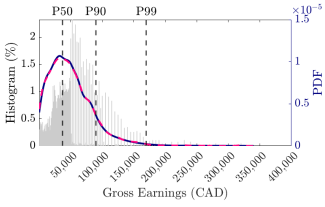
(c) Belgium



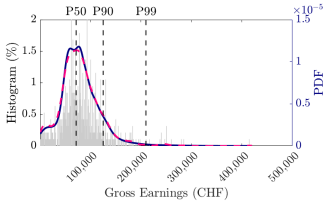
(d) Bulgaria



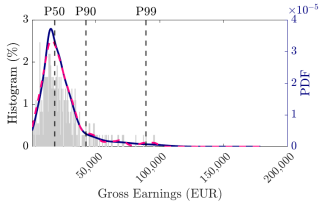
(e) Canada



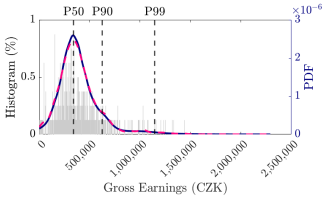
(f) Switzerland



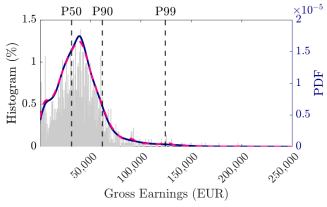
(g) Cyprus



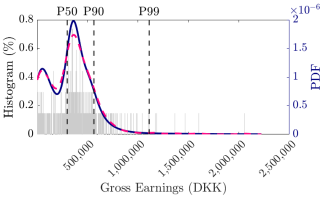
(h) Czech Republic



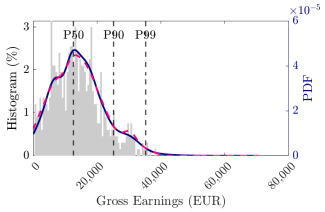
(i) Germany



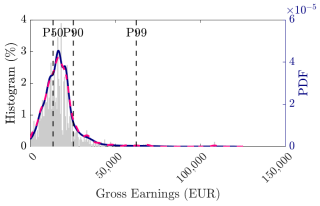
(j) Denmark



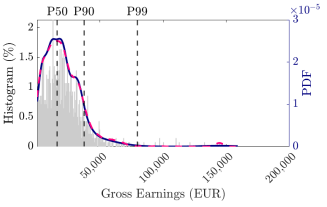
(k) Estonia



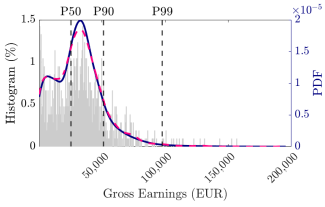
(l) Greece



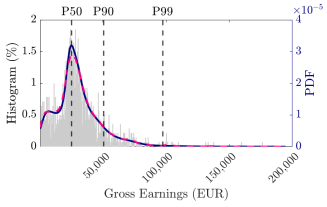
(m) Spain



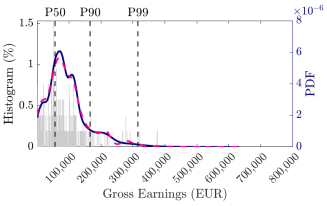
(n) Finland



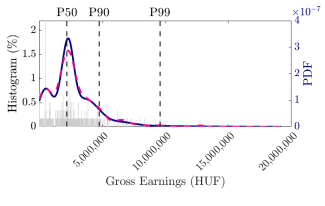
(o) France



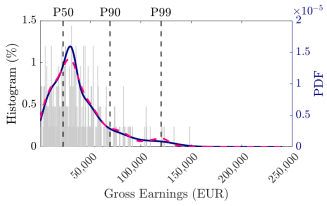
(p) Croatia



(q) Hungary

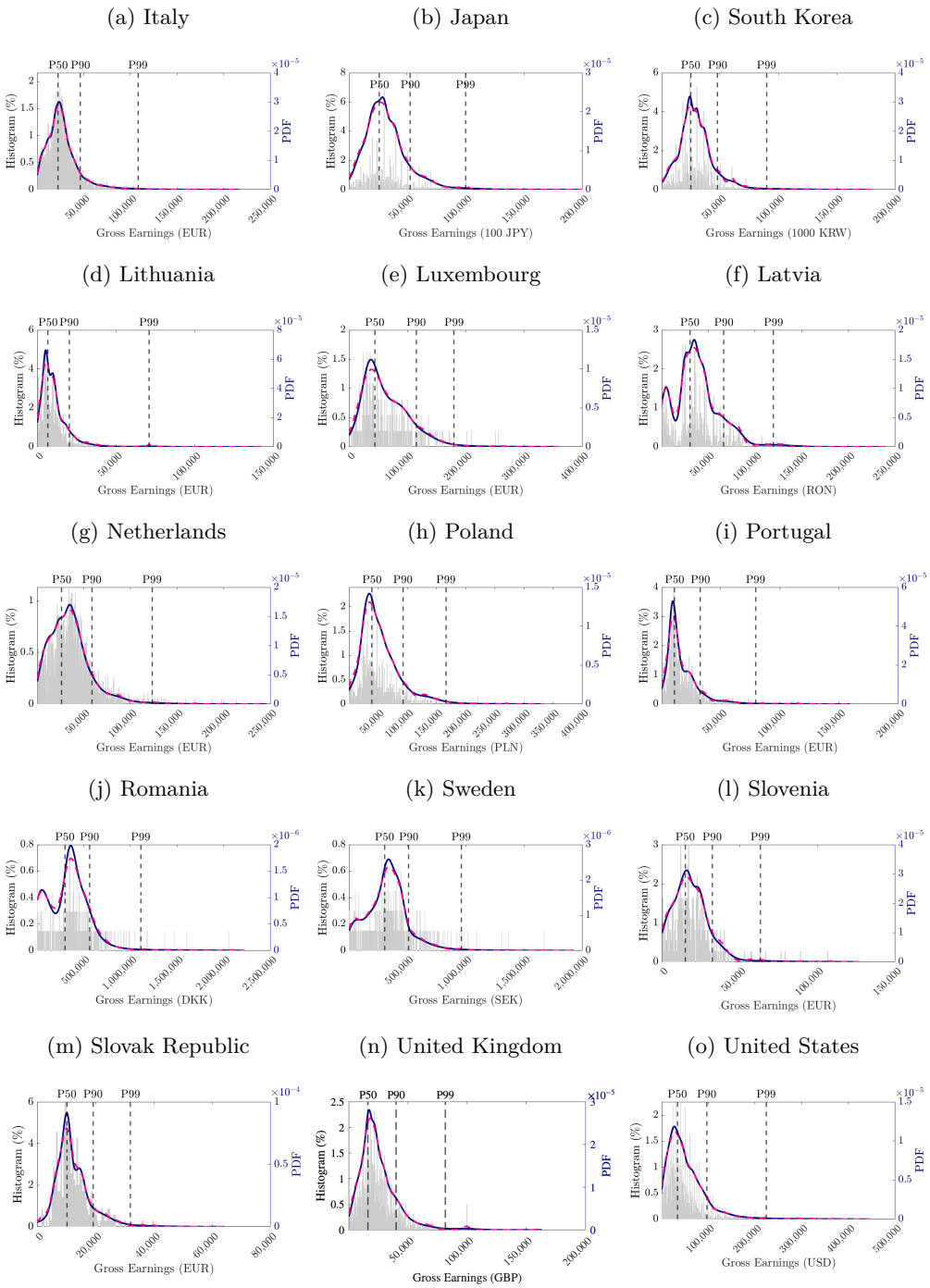


(r) Ireland



Note: Continues on next page.

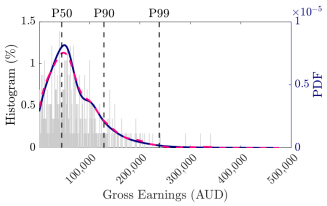
Figure A6: Distributions, 2018, Singles without Children (cont.)



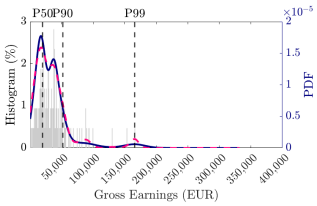
Note: This figure displays histograms and probability density functions (pdf) for singles without children. All information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Histograms of a fixed bandwidth of 500 are shown as gray bars. We estimate the distribution by means of a kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. The baseline estimation uses an adjusted kernel density estimator (blue line). An alternative kernel estimation with a fixed bandwidth according to Silverman's rule of thumb is also shown (pink line). Vertical dashed lines indicate selected percentiles of the distribution. The distributions are estimated for gross earnings consisting of income from employment and self-employment. Histograms are unweighted while the kernel density estimations are weighted using survey weights (if available). All estimates are shown for positive incomes up to twice the 99th percentile. The sample consists of unmarried single households of age 25 to 60 without children. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A7: Distribution (Robustness), Singles with Children

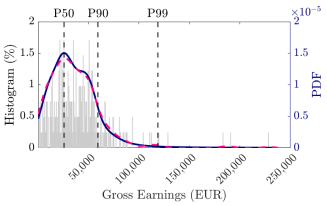
(a) Australia



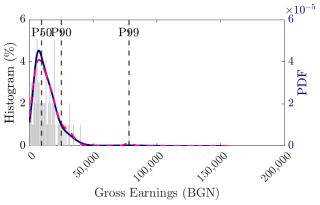
(b) Austria



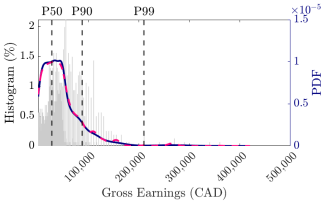
(c) Belgium



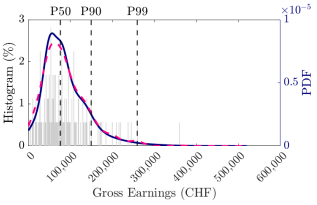
(d) Bulgaria



(e) Canada



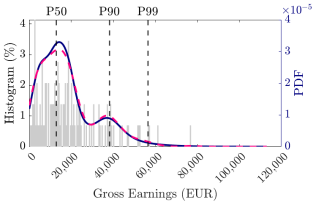
(f) Switzerland

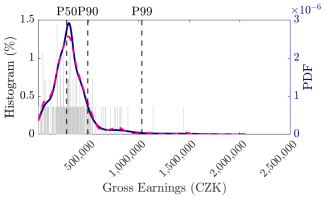


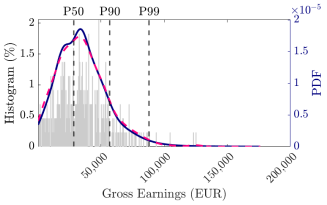
(g) Cyprus

(h) Czech Republic

(i) Germany



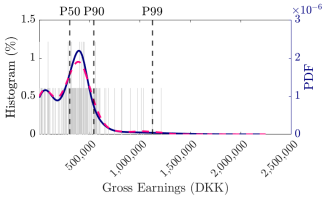


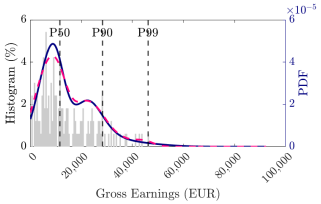


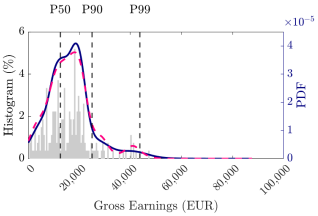
(j) Denmark

(k) Estonia

(l) Greece



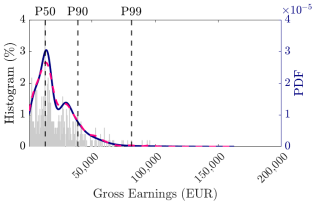


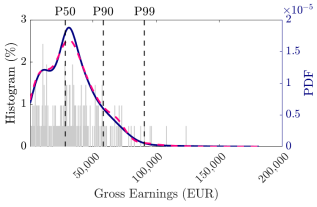


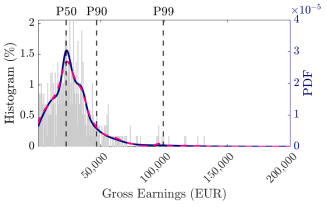
(m) Spain

(n) Finland

(o) France



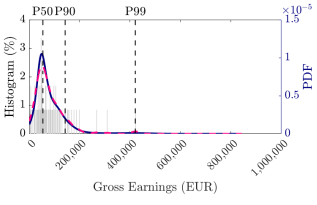


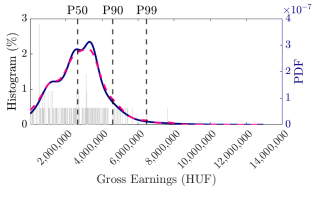


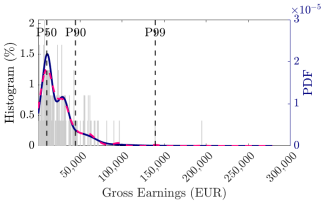
(p) Croatia

(q) Hungary

(r) Ireland

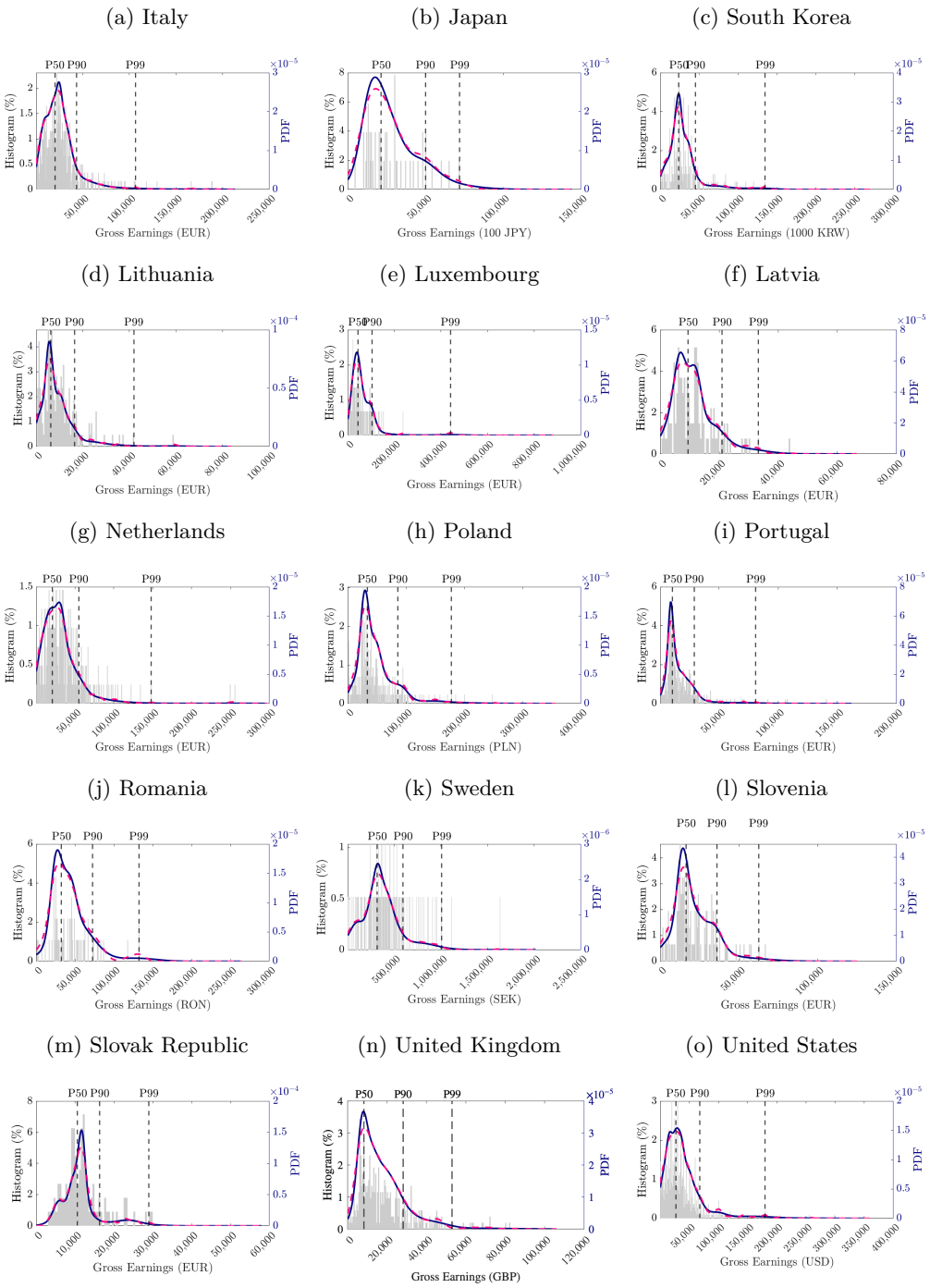






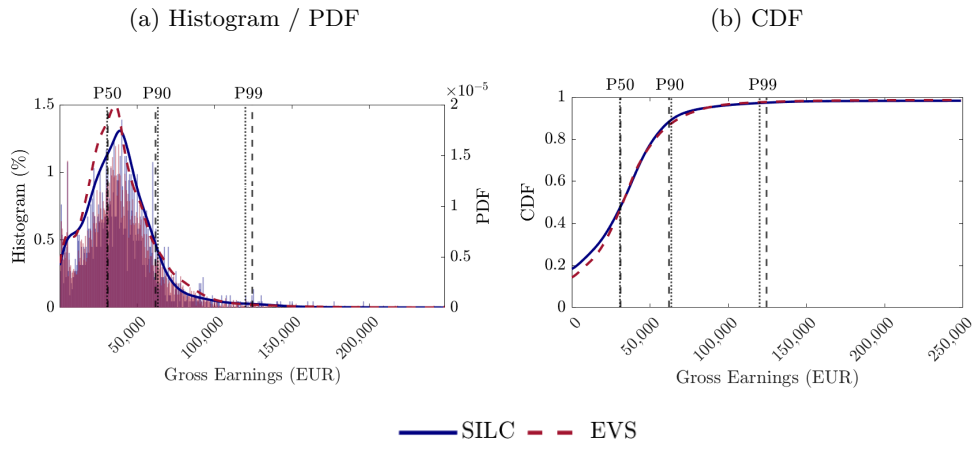
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Figure A7: Distributions, 2018, Singles with Children (cont.)



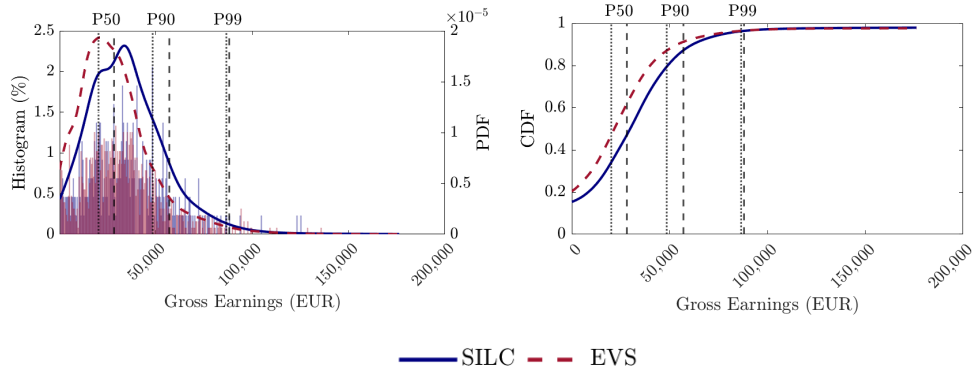
Note: This figure displays histograms and probability density functions (pdf) for singles with two children. All information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Histograms of a fixed bandwidth of 500 are shown as gray bars. We estimate the distribution by means of a kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. The baseline estimation uses an adjusted kernel density estimator (blue line). An alternative kernel estimation with a fixed bandwidth according to Silverman's rule of thumb is also shown (pink line). Vertical dashed lines indicate selected percentiles of the distribution. The distributions are estimated for gross earnings consisting of income from employment and self-employment. Histograms are unweighted while the kernel density estimations are weighted using survey weights (if available). All estimates are shown for positive incomes up to twice the 99th percentile. The sample consists of unmarried single households of age 25 to 60 with children. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A8: Distribution (Robustness) — Germany, Singles without Children



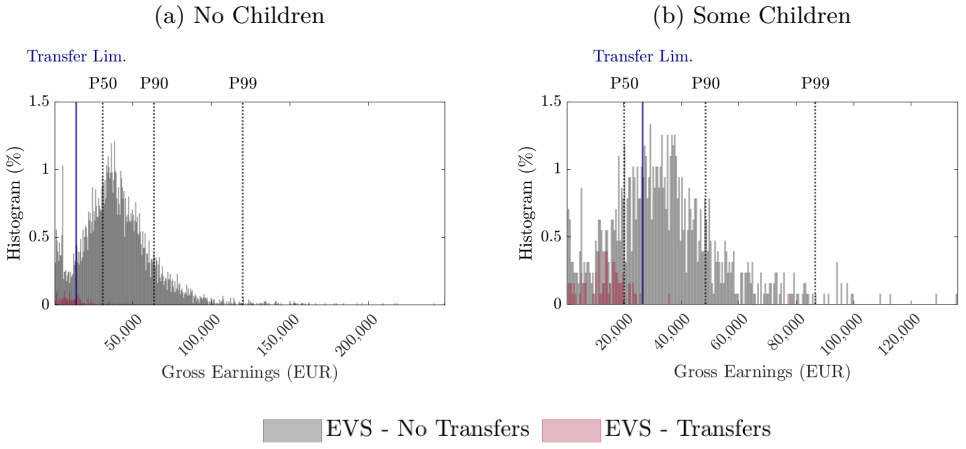
Note: This figure displays the (estimated) income distribution in Germany according to data from EU-SILC (blue) and the EVS (red) in the reference year 2018. The left panel of Figure A8a displays histograms based on the unweighted raw data at a fixed grid of 500 EUR, as well as estimated probability density functions (pdf). The right panel of Figure A8b displays the associated cumulative distribution functions (cdf). We estimate the distribution by means of a kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. Vertical dashed (dotted) lines indicate selected percentiles of the distribution based on EU-SILC and EVS respectively. The distributions are estimated for gross earnings consisting of employee income and income from self-employment. Both histogram values and estimated densities are only shown for the positive income range up to twice the 99th percentile of the income distribution. The sample consists of unmarried single households of age 25 to 60 without children.
Source: Own calculations based on EU-SILC, and EVS.

Figure A9: Distribution (Robustness) — Germany, Singles with Children



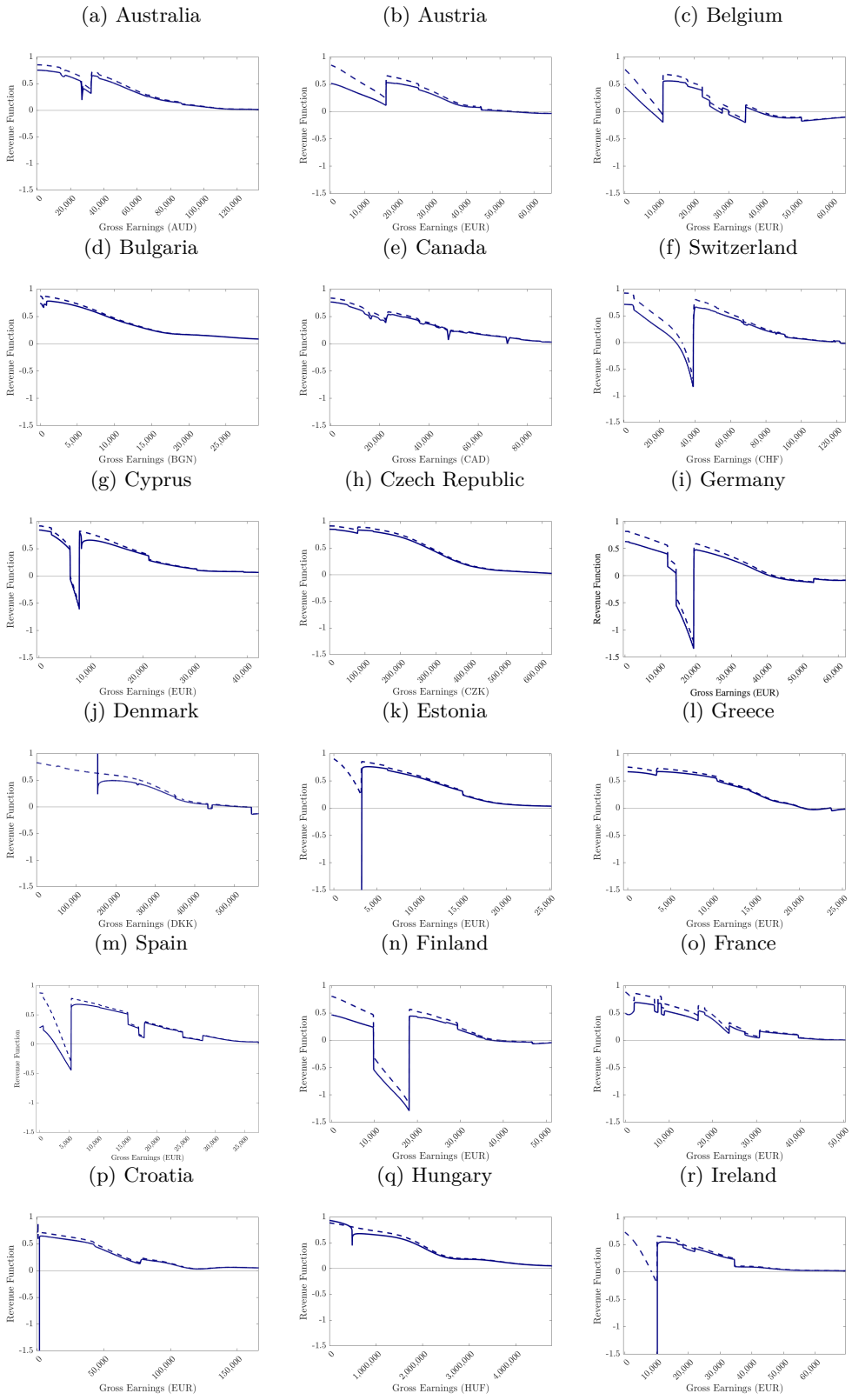
Note: This figure displays the (estimated) income distribution in Germany according to data from EU-SILC (blue) and the EVS (red) in the reference year 2018. The left panel of Figure A9a displays histograms based on the unweighted raw data at a fixed grid of 500 EUR, as well as estimated probability density functions (pdf). The right panel of Figure A9b displays the associated cumulative distribution functions (cdf). We estimate the distribution by means of a kernel density estimator with a gaussian kernel at a country specific grid of 1000 points between zero and twice the 99th percentile of the income distribution. Vertical dashed (dotted) lines indicate selected percentiles of the distribution based on EU-SILC and EVS respectively. The distributions are estimated for gross earnings consisting of employee income and income from self-employment. Both histogram values and estimated densities are only shown for the positive income range up to twice the 99th percentile of the income distribution. The sample consists of unmarried single households of age 25 to 60 with some children.
Source: Own calculations based on EU-SILC, and EVS.

Figure A10: Distribution by Transfer Receipt — Germany



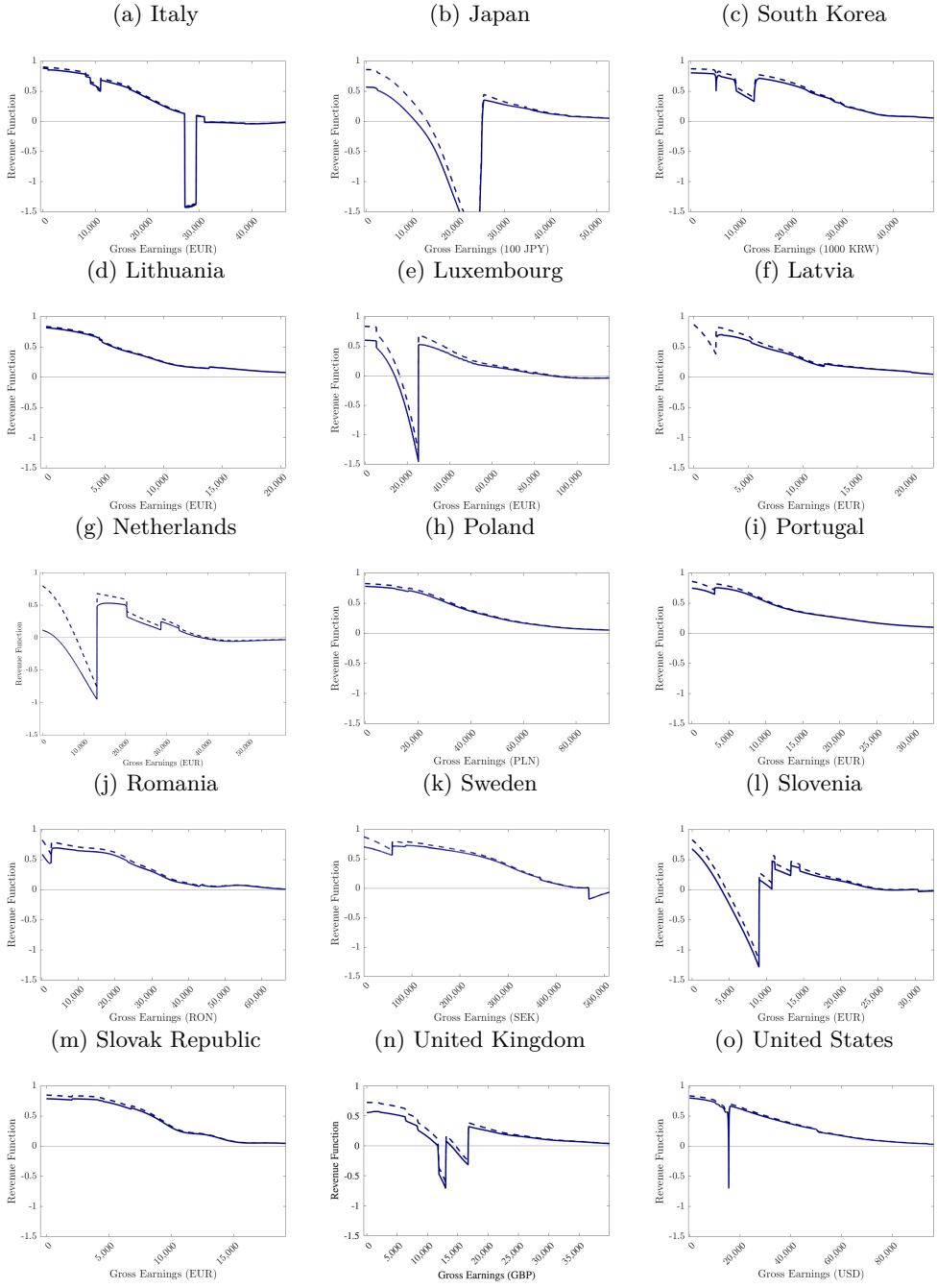
Note: This figure displays unweighted histograms at a fixed grid of 500 EUR in Germany according to data from EVS for individuals that do not receive transfers (gray bars) and for individuals with transfer receipt (red bars). All information is based on the reference year 2018. Figure A10a displays results for singles with children while Figure A10b displays the results for singles with at least one child. Vertical dashed lines indicate selected percentiles of the distribution. The vertical solid blue line indicates the income level, at which a single household without children (with two children) starts to have a net tax liability. The distributions are estimated for gross earnings consisting of employee income and income from self-employment. Transfers include *Arbeitslosengeld ii* as well as *Wohngeld*. Histogram values and estimated densities are only shown for the positive income range up to twice the 99th percentile of the income distribution. The sample consists of unmarried single households.
Source: Own calculations based on EVS.

Figure A11: Revenue Functions, Rational Behavior, Singles without Children



Note: Continues on next page.

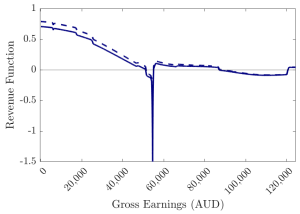
Figure A11: Revenue Functions, Rational Behavior, Singles without Children (Cont.)



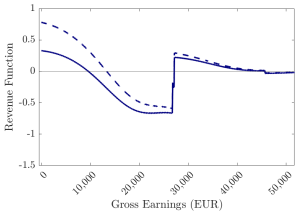
Note: This figure displays the revenue functions for singles without children excluding (including) extensive margin responses as dashed (solid) blue lines. Tax systems refer to the policy year 2018. Income information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A12: Revenue Functions, Rational Behavior, Singles with Children

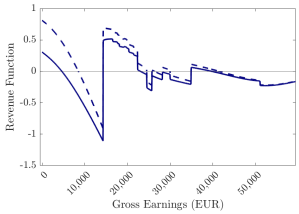
(a) Australia



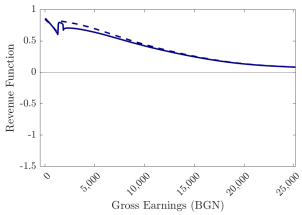
(b) Austria



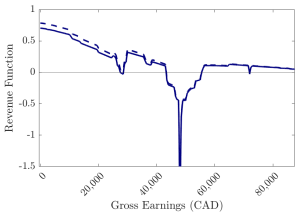
(c) Belgium



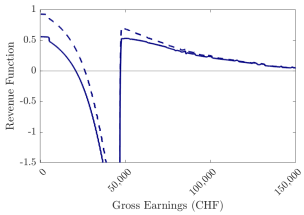
(d) Bulgaria



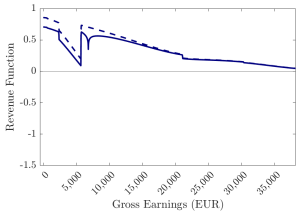
(e) Canada



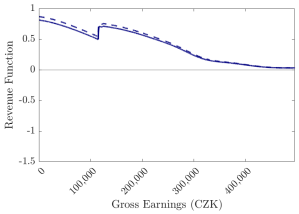
(f) Switzerland



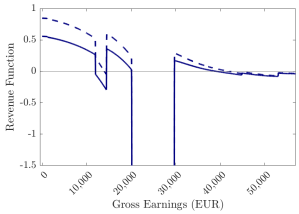
(g) Cyprus



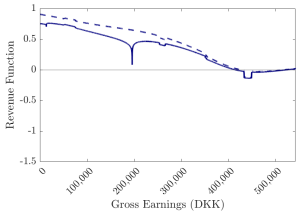
(h) Czech Republic



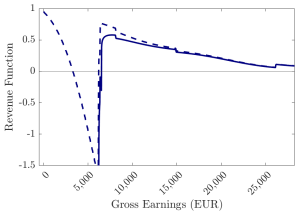
(i) Germany



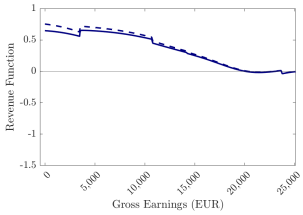
(j) Denmark



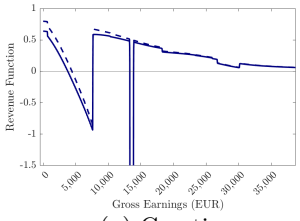
(k) Estonia



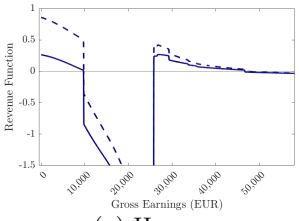
(l) Greece



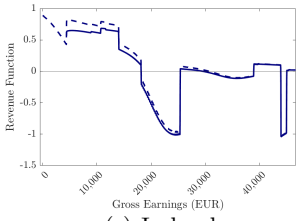
(m) Spain



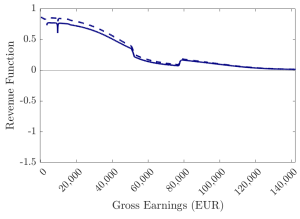
(n) Finland



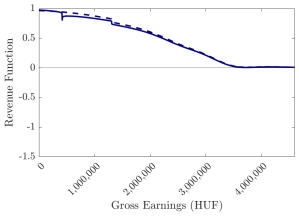
(o) France



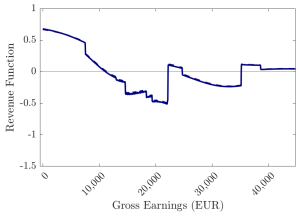
(p) Croatia



(q) Hungary



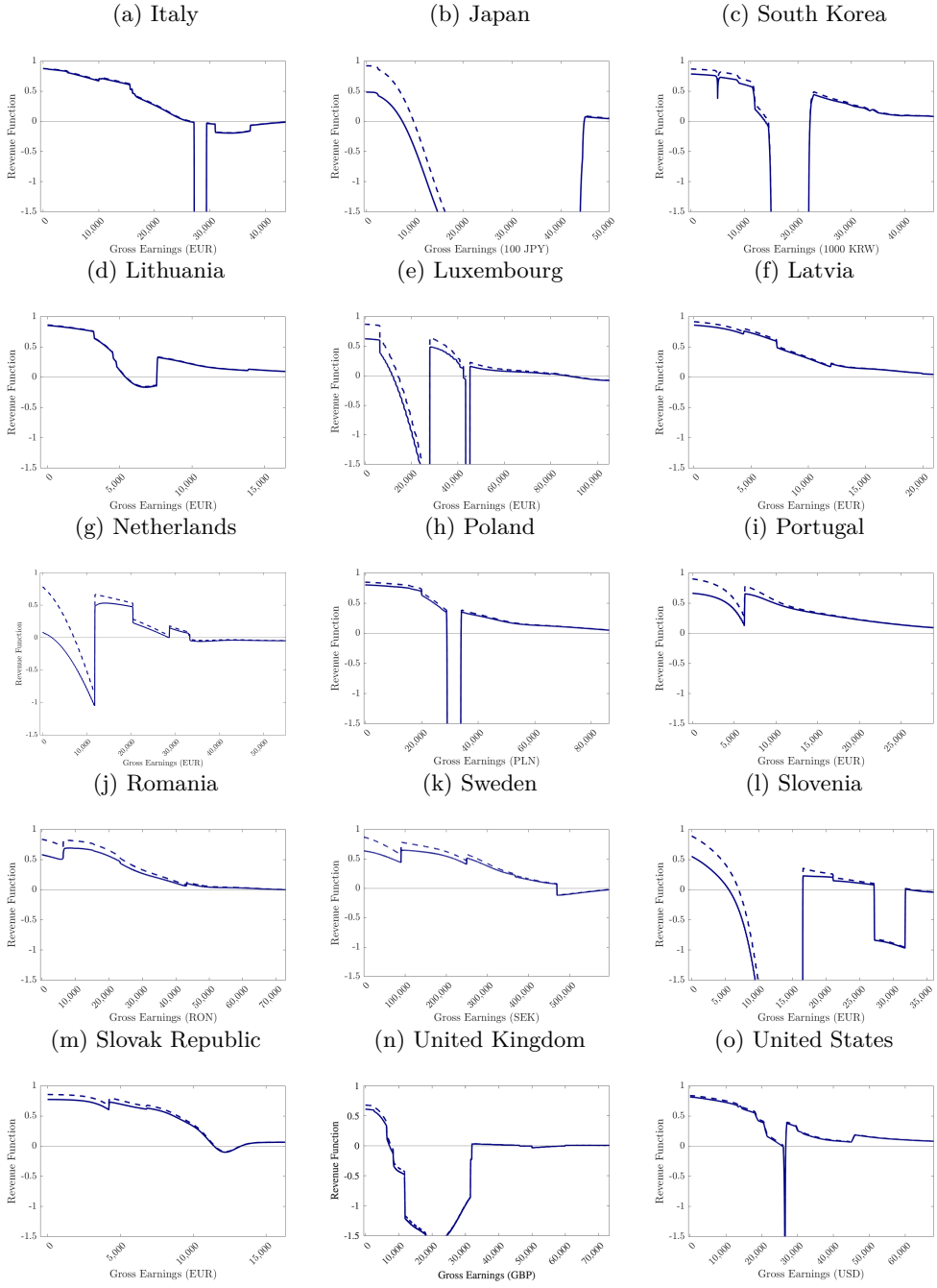
(r) Ireland





Note: Continues on next page.

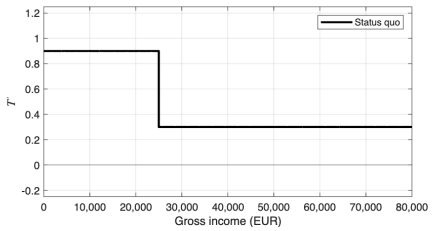
Figure A12: Revenue Functions, Singles with Children (cont.)



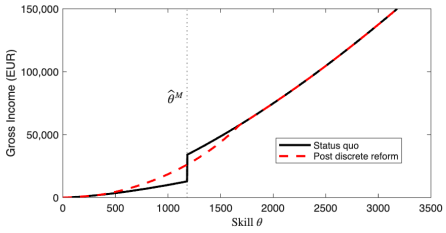
Note: This figure displays the revenue functions for singles without children excluding (including) extensive margin responses as dashed (solid) blue lines. Tax systems refer to the policy year 2018. Income information refers to the reference year 2017 for Ireland and Italy, and 2018 for all other countries. Descriptive statistics for the sample are shown in Table A3.
Source: Own calculations based on EUROMOD, OECD TaxBEN, and micro data described in Table A1.

Figure A13: Illustration, Rational Behavior, Downward MTR Jump

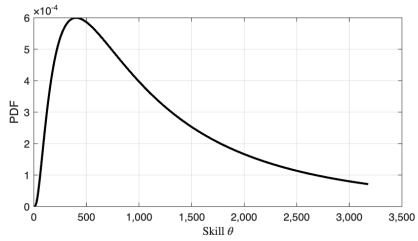
(a) Status Quo Tax Rate



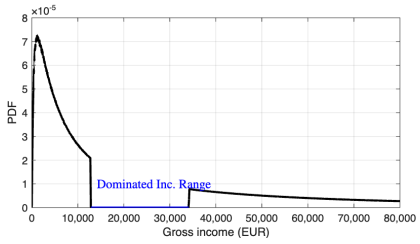
(b) Skill/Income Relation



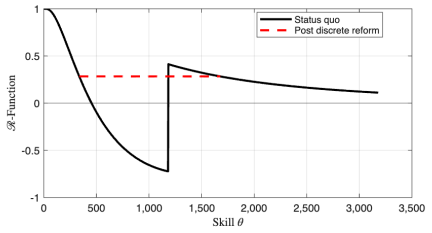
(c) Skill Distribution



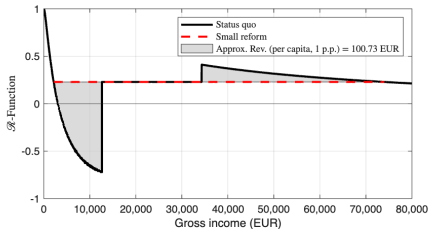
(d) Income Distribution



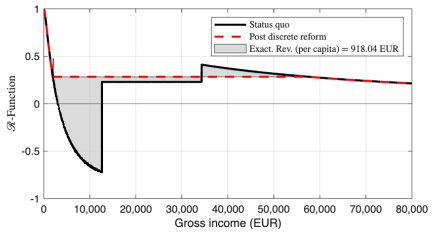
(e) Revenue Function (over skill)



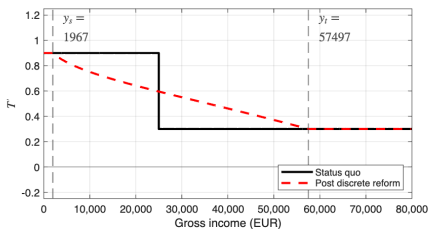
(f) Revenue Function (small reform)



(g) Revenue Function (discrete reform)

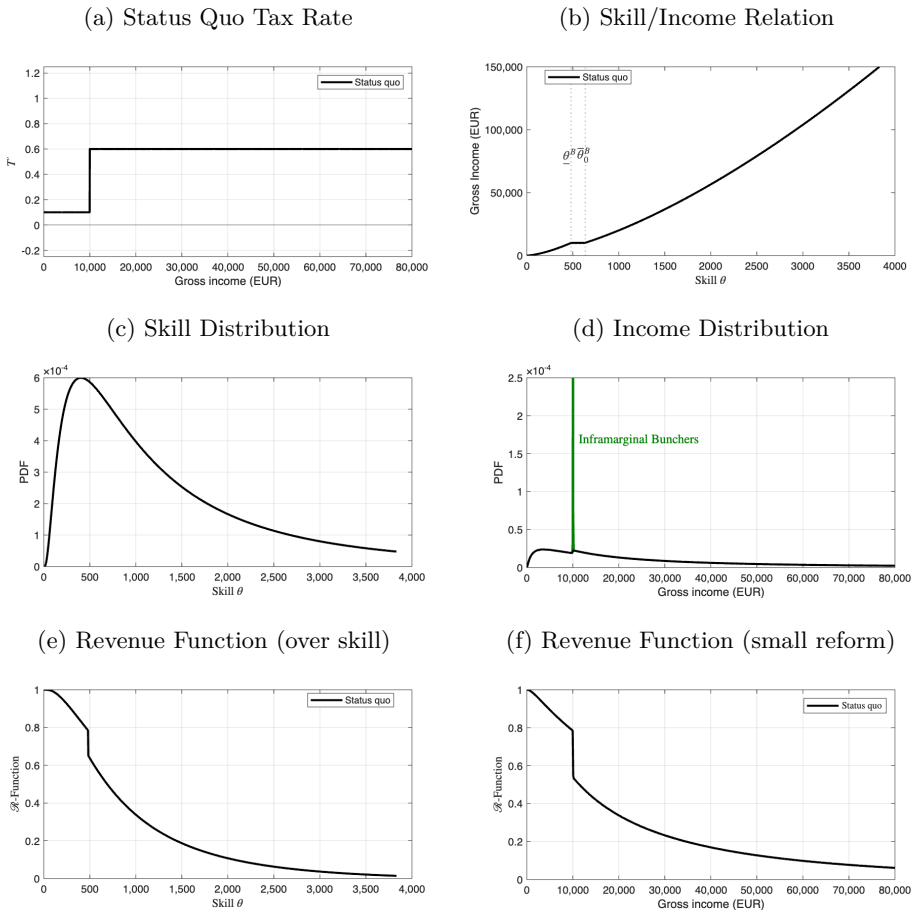


(h) MTR, Discrete Reform



Note: This figure illustrates the mechanics behind a discrete tax reform under a status quo tax system that features one downward jump. The simulation is based on a tax schedule with two brackets ($\tau_1 = 0.9, \tau_2 = 0.3$) and a corresponding bracket threshold of 25,000 EUR (Figure A13a). We assume that preferences are quasi-linear and iso-elastic with an intertemporal elasticity of substitution $\sigma = 0.5$. As shown by Figure A13b, the downward jump in the marginal tax rate yields a dominated income range, i.e., at the threshold skill level $\hat{\theta}^M$, the chosen income value jumps discretely. Under the assumption of a smooth log-normal skill distribution with $\mu = 7$ and $sd = 1$ (Figure A13c), this causes a missing mass in the income distribution (Figure A13d). Even with the missing mass in the income distribution, there is still an inefficiency as implied by the increasing revenue function over (Figure A13e). The hole in the income distribution implies that the revenue function in the income space features two steps with a constant part in the dominated income range (Figure A13f). The revenue-maximizing reform direction yields an approximate per capita tax revenue increase of around 100 EUR for each percentage point change in the marginal tax rate. The discrete reform yields a per capita increase in tax revenues of 918 EUR (Figure A13f). The discrete reform smooths out the discrete drop. (Figure A13h).
Source: Own calculations based on a hypothetical two-bracket tax schedule.

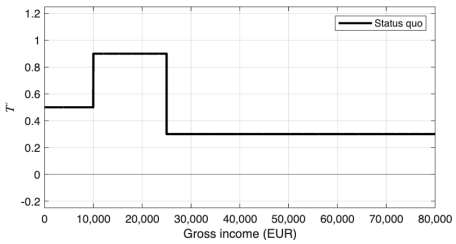
Figure A14: Illustration, Rational Behavior, Upward MTR Jump



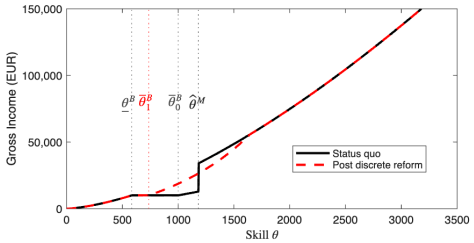
Note: This figure illustrates the mechanics behind a discrete tax reform under a status quo tax system that features an upward jump. The simulation is based on a tax schedule with two brackets ($\tau_1 = 0.1, \tau_2 = 0.5$) and a corresponding bracket threshold of 10,000 EUR (Figure A14a). We assume that preferences are quasi-linear and iso-elastic with an intertemporal elasticity of substitution $\sigma = 0.5$. As shown by Figure A14b, the upward jump in the marginal tax rate at 10,000 EUR implies that there is bunching between $\underline{\theta}^B$ and $\overline{\theta}_0^B$. Under the assumption of a smooth log-normal skill distribution with $\mu = 7$ and $sd = 1$ (Figure A14c), the revenue function in the skill (income) space features a discrete drop as shown in Figure A14e (A14f). Since the revenue function is monotonic, there exists no Pareto improving two-bracket tax reform.
Source: Own simulation based on a hypothetical two-bracket tax schedule.

Figure A15: Illustration, Rational Behavior, More than Two Brackets

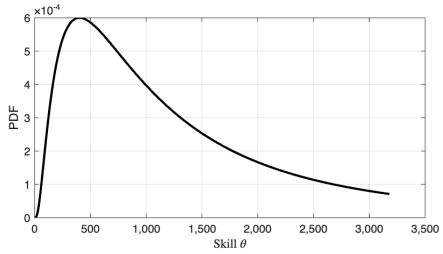
(a) Status Quo Tax Rate



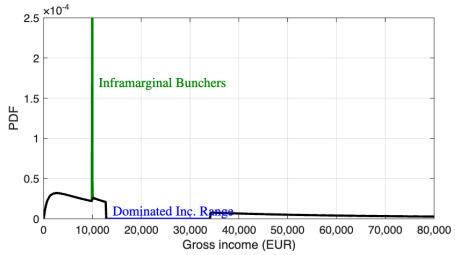
(b) Skill/Income Relation



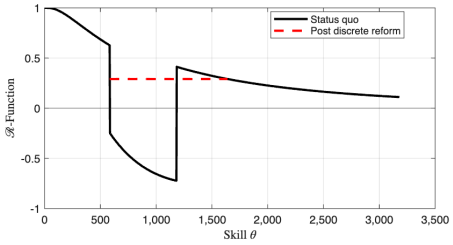
(c) Skill Distribution



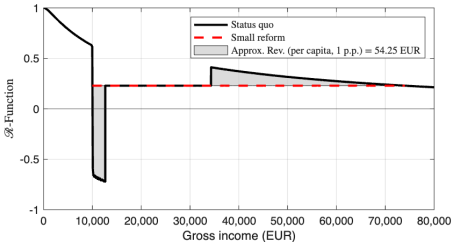
(d) Income Distribution



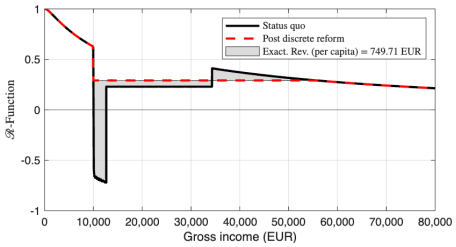
(e) Revenue Function (over skill)



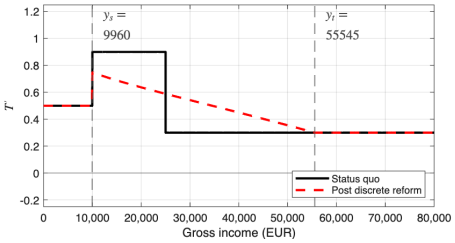
(f) Revenue Function (small reform)



(g) Revenue Function (discrete reform)



(h) MTR, Discrete Reform



Note: This figure illustrates the mechanics behind a discrete tax reform under a status quo tax system that features both upward and downward jumps. The simulation is based on a tax schedule with three brackets ($\tau_1 = 0.5, \tau_2 = 0.9, \tau_3 = 0.3$) and corresponding bracket thresholds of 10,000 EUR and 25,000 EUR (Figure A15a). We assume that preferences are quasi-linear and iso-elastic with an intertemporal elasticity of substitution $\sigma = 0.5$. As shown by Figure A15b, the upward jump in the marginal tax rate at 10,000 EUR implies that there is bunching between $\underline{\theta}^B$ and $\overline{\theta}_0^B$. The downward jump in the marginal tax rate yields a dominated income range, i.e., at the threshold skill level $\hat{\theta}^M$, the chosen income value jumps discretely. Under the assumption of a smooth log-normal skill distribution with $\mu = 7$ and $sd = 1$ (Figure A15c), this causes a missing mass in the income distribution (Figure A15d). Even with the missing mass in the income distribution, there is still an inefficiency as implied by the increasing revenue function over (Figure A15e). The hole in the income distribution implies that the revenue function in the income space features two steps with a constant part in the dominated income range (Figure A15f). The revenue-maximizing reform direction yields an approximate per capita tax revenue increase of around 54 EUR for each percentage point change in the marginal tax rate. The discrete reform yields a per capita increase in tax revenues of 750 EUR (Figure A15f). The discrete reform smooths out the discrete drop, but preserves the upward jump at a lower value. (Figure A15h). This implies that bunching is reduced, but not completely eliminated through the reform (see red line in Figure A15b).
Source: Own simulation based on a hypothetical three-bracket tax schedule.

B Supplementary Material — Theory

B.1 Income distribution with a concave kink

We start with a lemma that characterizes the income distribution F_y that results if the status-quo tax T_0 involves a concave kink.

Lemma 2 *Assume that Assumptions 1 and 2 hold. There are a unique skill level $\hat{\theta} \in (\underline{\theta}, \bar{\theta})$ and two income levels $y_a \in (y_L, \hat{y})$, $y_b \in (\hat{y}, y_R)$ such that*

- *for all $\theta_1 \in \left[\theta_0(y_L), \hat{\theta}\right)$, $y_0(\theta_1)$ is below y_a, continuously differentiable and strictly increasing in θ_1,*
- *for all $\theta_1 \in \left(\hat{\theta}, \theta_0(y_R)\right]$, $y_0(\theta_1)$ is above y_b, continuously differentiable and strictly increasing in θ_1.*

The density $f_y(y)$ of the income distribution is strictly positive and continuously differentiable on $[y_L, y_a)$ and on $(y_b, y_R]$. It is zero for all $y \in (y_a, y_b)$.

Proof. Denote by $\theta_L = y_0^{-1}(y_L)$ and by $\theta_R = y_0^{-1}(y_R)$ the skill types for whom y_L and y_R are the optimal earnings levels, respectively. Denote by $z_L(\theta_1)$ the earnings level that maximizes $u\left(C_0(y), y, \theta_1\right)$ over $y \in [y_L, \hat{y}]$, and by $z_R(\theta_1)$ the earnings level that maximizes $u\left(C_0(y), y, \theta_1\right)$ over $y \in [\hat{y}, y_R]$. By construction, $z_R(\theta_1) > z_L(\theta_L)$. By the single-crossing condition, there are (i) a threshold $\bar{\theta}_L \in (\theta_L, \theta_R)$ such that $z_L(\theta_1) = \hat{y}$ for all $\theta_1 \geq \bar{\theta}_L$ and (ii) a threshold $\underline{\theta}_R \in (\theta_L, \theta_R)$ such that $z_R(\theta_1) = \hat{y}$ for all $\theta_1 \leq \underline{\theta}_R$. Moreover, $\underline{\theta}_R < \bar{\theta}_L$ and both z_L and z_R are continuous and strictly increasing in θ_1 for any $\theta_1 \in \left(\underline{\theta}_R, \bar{\theta}_L\right)$.

Define the auxiliary function

$$\Phi(\theta_1) = u\left(C_0(z_L(\theta_1)), z_L(\theta_1), \theta_1\right) - u\left(C_0(z_R(\theta_1)), z_R(\theta_1), \theta_1\right) \ . \tag{35}$$

Invoking the envelope theorem, the derivative of Φ is given by

$$\begin{aligned} \Phi'(\theta_1) &= u_\theta\left(C_0(z_L(\theta_1)), z_L(\theta_1), \theta_1\right) - u_\theta\left(C_0(z_R(\theta_1)), z_R(\theta_1), \theta_1\right) \\ &= -\int_{z_L(\theta_1)}^{z_R(\theta_1)} C_0'(y) u_{c\theta}\left(C_0(y), y, \theta_1\right) + u_{y\theta}\left(C_0(y), y, \theta_1\right) dy \\ &< 0 \ , \end{aligned} \tag{36}$$

where the negative sign follows because $u_{y\theta} > 0$ and $u_{c\theta} \geq 0$ by the single-crossing condition. Note that, at $\hat{y}$, the concave kink in T_0 implies a convex kink in C_0. For $\underline{\theta}_R$, the indifference curve through $\hat{y}$ is smooth and tangent to the budget line to the right of $\hat{y}$, but below the budget line at point $(\hat{y} - \varepsilon, C_0(\hat{y} - \varepsilon))$ for small $\varepsilon > 0$. Hence, $\Phi(\underline{\theta}_R) > 0$: Type $\underline{\theta}_R$ strictly prefers $z_L(\underline{\theta}_R)$ to $z_R(\underline{\theta}_R)$. The opposite is true for type $\bar{\theta}_L$, i.e., $\Phi(\bar{\theta}_L) < 0$. Together with $\Phi'(\theta_1) < 0$, this implies that there is a unique type $\hat{\theta} \in \left(\underline{\theta}_R, \bar{\theta}_L\right)$ such that that $\Phi(\hat{\theta}) = 0$; this type is indifferent between $y_a = z_L(\hat{\theta}) < \hat{y}$ and $y_b = z_R(\hat{\theta}) > \hat{y}$. Agents with skill types in $[\theta_L, \hat{\theta})$ have optimal incomes between y_L and y_a, those with skill types in $(\hat{\theta}, \theta_R]$ have optimal incomes between y_b and y_R. The income range between y_a and y_b is dominated.

Note that type $\hat{\theta}$ is indifferent between the income levels y_a and y_b, and strictly worse off with all income levels in (y_a, y_b). Moreover, for this type, a first-order condition is satisfied both for y_a and y_b. Henceforth, we denote by $c_a = C_0(y_a)$ and $c_b = C_0(y_b)$ the consumption levels associated with the income levels y_a and y_b, respectively.

B.2 Proof of Proposition 1

Under Assumption 2, there are only labor supply effects at the intensive margin. As shown in Bierbrauer et al. (2023), the revenue function $\mathcal{R}_0$ is given by

$$\mathcal{R}_0(y) = (1-\mathcal{M}_0)^{-1}\left\{1-F_y(y)-f_y(y)\;\varepsilon(y)\;y\;\frac{T_0'(y)}{1-T_0'(y)}-\int_y^\infty f_y(y')\;\eta(y')\;T_0'(y')\;dy'\right\}\;, \tag{37}$$

at all income values where f_y is strictly positive and continuous, i.e., below y_a and above y_b. In this formula, ε captures substitution effects and η captures income effects in labor supply. In the dominated income range between y_a and y_b, the density $f_y(y)$ is zero but there is an additional (constant) term. To understand this term, note that a small reform at some income in the range leads some agents with initial incomes above y_b to switch to income y_a. The additional term captures the revenue effects of these discrete labor supply responses, $f_y(y_b)\frac{d^2y_b}{d\tau d\ell}\left[T(y_a)-T(y_b)\right]$.

Consider a non-dominated income $y'=y_a-z<y_a$, which is individually optimal for type $\theta'=\theta_0(y')$. At income level y',the revenue function satisfies

$$\mathcal{R}_0(y')(1-\mathcal{M}_0) \;\;=\;\; 1-F_y(y')-f_y(y')\;\varepsilon(y')\;y'\;\frac{T_0'(y')}{1-T_0'(y')}-\int_{y'}^\infty f_y(y)\;\eta(y)\;T_0'(y)\;dy\;.$$

The second term, capturing the effects of intensive-margin responses, can be rewritten as

$$\begin{aligned} f_y(y')\;\varepsilon(y')\;y'\;\frac{T_0'(y')}{1-T_0'(y')} &= f(\theta')\left(\frac{dy_0(\theta')}{d\theta}\right)^{-1}\frac{dy_0(\theta')}{d[1-T'(y')]}T_0'(y') \\ &= -f(\theta')\left(\frac{\partial MRS(C_0(y'),y',\theta')}{\partial\theta}\right)^{-1}T_0'(y') \end{aligned} \tag{38}$$

where we use $f(\theta)=f_y(y_0(\theta))\frac{dy_0(\theta)}{d\theta}$, the definition of the elasticity, $\varepsilon(y)=\frac{dy_0(\theta_0(y))}{d[1-T'(y)]}\frac{1-T'(y)}{y}$, and the marginal rate of substitution, $MRS(c,y,\theta)=-\frac{u_y(c,y,\theta)}{u_c(c,y,\theta)}$. Note also that the last line follows directly from implicit differentiation of the first-order condition in the form $1-T'(y_0(\theta))-MRS(C_0(y_0(\theta)),y_0(\theta),\theta)=0$.

As shown by Lemma 2, there is a dominated income range (y_a,y_b) around the kink at $\hat{y}$. To simplify notation, define the shorthands $\tau_a=T_0'(y_a)$, $\tau_b=T_0'(y_b)$, $c_a=C_0(y_a)$, and $c_b=C_0(y_b)$. To prove the Proposition, we focus on comparing the limits of $\mathcal{R}_0(y_a-\varepsilon)$ and $\mathcal{R}_0(y_b+\varepsilon)$ for $z>0$ converging to 0. The difference between these limits, multiplied by $(1-\mathcal{M}_0)$, is

$$\begin{aligned} \lim_{z\to0}\left[\mathcal{R}_0(y_a-z)-\mathcal{R}_0(y_b+z)\right] &= F_y(y_b)-F_y(y_a)-\int_{y_a}^{y_b}f_y(y)\;\eta(y)\;T_0'(y)\;dy \\ &\quad+\lim_{z\to0}f_y(y_b+z)\;\varepsilon(y_b+z)\;(y_b+z)\;\frac{\tau_b}{1-\tau_b} \\ &\quad-\lim_{z\to0}f_y(y_a-z)\;\varepsilon(y_a-z)\;(y_a-z)\;\frac{\tau_a}{1-\tau_a} \\ &= -f(\hat{\theta})\left(\frac{\partial MRS(c_b,y_b,\hat{\theta})}{\partial\theta}\right)^{-1}\tau_b \\ &\quad+f(\hat{\theta})\left(\frac{\partial MRS(c_a,y_a,\hat{\theta})}{\partial\theta}\right)^{-1}\tau_a\;. \end{aligned} \tag{39}$$

where the first line of the right-hand side equals zero because $f_y(y)=0$ for all incomes in (y_a,y_b).

Note that, by construction, a type $\hat{\theta}$ agent is indifferent between the bundles (c_a, y_a) and (c_b, y_b), and we have $c_b > c_a$, $y_b > y_a$. Under Assumption 2, hence, the right-hand side of the previous equation is strictly negative. Hence, $\mathcal{R}_0(y_a - z) < \mathcal{R}_0(y_b + z)$ for $z > 0$ small enough. As $y_b > y_a$, Theorem 1 in Bierbrauer et al. (2023) implies that (T_0, c_0) is not Pareto-efficient.

B.3 Proof of Proposition 2

Recall that the direction of a one-bracket reform $(\tau, \ell, \hat{y})$ is given by

$$h^s(y) \coloneqq \begin{cases} 0 & \text{for} \quad y \leq \hat{y}\,, \\ y - \hat{y} & \text{for} \quad y \in (\hat{y}, \hat{y} + \ell)\,, \\ \ell & \text{for} \quad y \geq \hat{y} + \ell\,. \end{cases} \tag{40}$$

After this reform, hence, the tax function reads

$$T_1(y) = T_0(y) + \tau h^s(y) = \begin{cases} T_0(y) & \text{for} \quad y \leq \hat{y}\,, \\ T_0(y) + \tau(y - \hat{y}) & \text{for} \quad y \in (\hat{y}, \hat{y} + \ell)\,, \\ T_0(y) + \tau\ell & \text{for} \quad y \geq \hat{y} + \ell\,. \end{cases} \tag{41}$$

The average tax rate follows as

$$t_1(y) = \frac{T_1(y)}{y} = \begin{cases} t_0(y) & \text{for} \quad y \leq \hat{y}\,, \\ t_0(y) + \tau\,\frac{y - \hat{y}}{y} & \text{for} \quad y \in (\hat{y}, \hat{y} + \ell)\,, \\ t_0(y) + \tau\frac{\ell}{y} & \text{for} \quad y \geq \hat{y} + \ell\,. \end{cases} \tag{42}$$

The marginal effect on the average tax rate (i.e., on $T^{p\prime}$) is hence given by

$$m_0(y, h^s) = \frac{dt_0(y)}{d\tau} = \begin{cases} 0 & \text{for} \quad y \leq \hat{y}\,, \\ \frac{y - \hat{y}}{y} & \text{for} \quad y \in (\hat{y}, \hat{y} + \ell)\,, \\ \frac{\ell}{y} & \text{for} \quad y \geq \hat{y} + \ell\,. \end{cases} \tag{43}$$

Hence, the perceived tax rate for ironers is affected for all agents with incomes above $\hat{y}$. In particular, this includes those with incomes above $\hat{y} + \ell$, for whom only the average tax changes while the marginal tax does not. For people with pre-reform income below $\hat{y}$, the reform does not affect the perceived tax rate.

Denoting $\theta_1 = \theta_0(\hat{y})$ and $\theta_2(\ell) = \theta_0(\hat{y} + \ell)$, the marginal effect of a one-bracket reform on tax revenue

is given by

$$\begin{aligned}
R^i_\tau(0,h^s) &= \int_{\theta_1}^{\theta_2(\ell)} f(\theta)\left[y_0(\theta)-\hat{y}\right]d\theta + \ell\int_{\theta_2(\ell)}^{\bar{\theta}} f(\theta)d\theta \\
&\quad + \int_{\theta_1}^{\bar{\theta}} f(\theta)\ \frac{dy^i_0(\theta)}{d\gamma} m_0(y,h^s)T_0'(y^i_0(\theta))d\theta \\
&= \int_{\theta_1}^{\theta_2(\ell)} f(\theta)\left[y_0(\theta)-\hat{y}\right]d\theta + \ell\int_{\theta_2(\ell)}^{\bar{\theta}} f(\theta)d\theta \\
&\quad - \int_{\theta_1}^{\bar{\theta}} f(\theta)\ \varepsilon^i_{y,1-t}(\theta)\frac{y^i_0(\theta)}{1-t_0\left(y^i_0(\theta)\right)} m_0(y,h^s)T_0'(y^i_0(\theta))d\theta\ . \\
&= \int_{\theta_1}^{\theta_2(\ell)} f(\theta)\left[y_0(\theta)-\hat{y}\right]d\theta + \ell\int_{\theta_2(\ell)}^{\bar{\theta}} f(\theta)d\theta \\
&\quad - \int_{\theta_1}^{\theta_2(\ell)} f(\theta)\ \varepsilon^i_{y,1-t}(\theta)\ \left[y^i_0(\theta)-\hat{y}\right]\ \frac{T_0'(y^i_0(\theta))}{1-t_0(y^i_0(\theta))}d\theta\ . \\
&\quad -\ell\int_{\theta_2(\ell)}^{\bar{\theta}} f(\theta)\ \varepsilon^i_{y,1-t}(\theta)\ \frac{T_0'(y^i_0(\theta))}{1-t_0(y^i_0(\theta))}d\theta\ .
\end{aligned}$$

The revenue function follows as the second-order derivative with respect to τ and ℓ,

$$\mathcal{R}^i_0(\hat{y}) = \left.\frac{R^i_\tau(0,h^s)}{d\ell}\right|_{\ell=0} = \int_{\theta_0(y)}^{\bar{\theta}} f(\theta)\left[1-\varepsilon^i_{y,1-t}(\theta)\ \frac{T_0'(y^i_0(\theta))}{1-t_0(y^i_0(\theta))}\right]d\theta\ . \tag{44}$$

We can rewrite this equation to get equation (44) in Proposition 2 by substituting the integration variable, using that $f_y(y) = f(\theta_0(y))\theta_0'(y)$.

B.4 Proof of Proposition 3

Consider a two bracket reform that reduces the marginal tax by τ in the interval $(\hat{y}_1, \hat{y}_1+\ell)$ and increases it by τ in the interval $(\hat{y}_2, \hat{y}_2+\ell)$, with $\hat{y}_2 > \hat{y}_1+\ell$, $\ell>0$. The effect of such a reform on individual utility of a type θ ironer is given by

$$V_\tau(0,h_2,\theta) = R_\tau(0,h_2) - h_2(y_0(\theta)) + \left[t_0(y_0(\theta)) - T_0'(y_0(\theta))\right] m_0(y^i_0(\theta),h_2)\frac{dy^i(\theta)}{d\gamma}\ , \tag{45}$$

where $dy^i(\theta)/d\gamma < 0$ and $m_0(y,h_2)<0$ and $h_2(y)<0$ for any $y\in(\hat{y}_1,\hat{y}_2+\ell)$, while $m_0(y,h_2)=h_2(y)=0$ for any $y\le\hat{y}_1$ and any $y\ge\hat{y}_2+\ell$.

One necessary condition for this reform to be Pareto-improving is that $R_\tau(h_2,y)$ needs to be positive. Otherwise, taxpayers with pre-reform income below $\hat{y}_1$ or above $\hat{y}_2+\ell$ would be worse off. A second necessary condition is that

$$R_\tau(0,h_2) > \max_{\theta\in(\theta_1,\theta_2)}\left[h_2(y^i_0(\theta)) - \left[t_0(y^i_0(\theta)) - T_0'(y^i_0(\theta))\right] m_0(y^i_0(\theta),h_2)\frac{dy^i(\theta)}{d\gamma}\right]\ . \tag{46}$$

In general, this second condition might be more or less restrictive than the first condition. If T_0 is weakly regressive with $t_0(y)\ge T_0'(y)$ for all incomes in $(\hat{y}_1,\hat{y}_2+\ell)$, however, the right-hand side of (46) is strictly negative. Hence, a small two-bracket tax cut is Pareto-improving whenever $R_\tau(0,h_2)>0$, i.e., whenever

it is self-financing.

Using Proposition 2 in Bierbrauer et al. (2023), the revenue effect of a small two-bracket tax cut is given by

$$\begin{aligned} R_\tau(0,h_2) &= \int_0^\infty h_2'(y)\ \mathcal{R}(y)\ dy \\ &= \int_{\hat{y}_2}^{\hat{y}_2+\ell} \mathcal{R}(y)\ dy - \int_{\hat{y}_1}^{\hat{y}_1+\ell} \mathcal{R}(y)\ dy\ . \end{aligned}$$

As can be seen from the previous equation, there is a self-financing two-bracket tax cut if and only if the revenue function is strictly increasing in some income range. Differentiating the revenue function given in Proposition 2, we get

$$\mathcal{R}'(y) = -f_y(y)\left(1-\varepsilon_{y,1-t}\frac{T_0'(y)}{1-t_0(y)}\right)\ .$$

Hence, we know that there is a Pareto-improving two-bracket tax cut if there is an income level y at which, first, the last expression is strictly positive and, second, $t_0(0) > T_0'(y)$ is satisfied.

B.5 Proof of Proposition 4

Under the assumption of iso-elastic preferences, the elasticity $\varepsilon^i_{y,1-t}$ equals

$$\begin{aligned} \varepsilon^i_{y,1-t}(\theta) &= \frac{1}{y}\ \frac{v_y(y,\theta)}{v_{yy}(y,\theta)+t_0'(y)} = \frac{\sigma y^{1/\sigma}\theta^{-(1+1/\sigma)}}{y^{1/\sigma}\theta^{-(1+1/\sigma)}+\sigma\ y\ t_0'(y)} \\ &= \frac{\sigma}{1+\sigma\ y\ \frac{t_0'(y)}{y^{1/\sigma}\theta^{-(1+1/\sigma)}}} \end{aligned}$$

for $y = y_0^i(\theta)$. Using $t_0'(y) = \left[T_0'(y) - t_0(y)\right]/y$, we get the expression

$$\varepsilon^i_{y,1-t}(\theta) = \frac{\sigma}{1+\sigma\frac{T_0'(y_0^i(\theta))-t_0(y_0^i(\theta))}{1-t_0(y_0^i(\theta))}}$$

Plugging this expression into the derivative of the revenue function, we get

$$\mathcal{R}'(y) = -f_y(y)\frac{1-(1+\sigma)t_0(y)}{1-(1+\sigma)t_0(y)+\sigma T_0'(y)}\ .$$

If $t_0(y)$ is larger than $\frac{1}{1+\sigma}$, the numerator of the fraction above is negative. If it is smaller than $\frac{1+\sigma T_0'(y)}{1+\sigma}$, moreover, the denominator is positive. In both conditions are satisfied, the derivative $\mathcal{R}'(y)$ is strictly positive at income y.

B.6 Proof of Proposition 5

Assume that $y_0(\theta)$ is strictly increasing and continuously differentiable on some subset $[\theta_1, \theta_2]$ of interest. With quasi-linear, isoelastic preferences and no fixed costs of working, the revenue function is

$$\begin{aligned}\mathcal{R}_0(y) &= 1 - F_y(y) - y\ f_y(y)\varepsilon_0(y)\frac{T_0'(y)}{1-T_0'(y)} \\ &= 1 - F(\theta_0(y)) - \theta_0(y)f(\theta_0(y))\frac{\varepsilon_0(y)}{\mu_0(y)}\frac{T_0'(y)}{1-T_0'(y)}\ ,\end{aligned}$$

where $\mu_0(y)$ is the elasticity of $y_0(\theta)$ with respect to θ. In the Diamond model, $varepsilon_0(y)/\mu_0(y)$ equals $\sigma/[1+\sigma]$, where σ is the preference parameter. Thus, we can also write the revenue function in the status quo as a function of skill type θ instead of income y,

$$\mathcal{R}_0^\theta(\theta) = 1 - F(\theta) - \theta f(\theta)\frac{\sigma}{1+\sigma}\frac{T_0'(y_0(\theta))}{1-T_0'(y_0(\theta))}\ . \tag{47}$$

Note that only for skill types such that $y_0'(\theta) > 0$, this expression equals the revenue function at income level $y_0(\theta)$.

For skill types such that $y_0'(\theta) = 0$, i.e., who bunch at some income $\hat{y}$, $y_0(\theta)$ cannot be inverted; hence, we cannot target those agents with a Saezian reform and the revenue function is not defined. We can determine a 'virtual marginal tax' $T_v'(\theta)$ and a 'virtual revenue function' $\mathcal{R}_v(\theta)$ for these skill types, though, given by

$$T\text{`}_v(\theta) = 1 - \frac{\hat{y}^{1/\sigma}}{\theta^{1+1/\sigma}}\ , \text{ and} \tag{48}$$

$$\mathcal{R}_v(\theta) = 1 - F(\theta) - \theta f(\theta)\frac{\sigma}{1+\sigma}T_v'(\theta)\ . \tag{49}$$

The intuition is as follows: If the marginal tax to the right of $\hat{y}$, $\lim_{y\to\hat{y}, y>\hat{y}} T_1'(y)$ is decreased to $T\text{`}_v(\theta)$, then type θ agents are the marginal bunchers, while all higher-skilled agents choose income above $\hat{y}$. The virtual revenue function $\mathcal{R}_v(\theta)$ gives the revenue effect of a small one-bracket tax reform at $\hat{y}$, starting from a hypothetical tax schedule with $T_1'(\hat{y}) = T\text{`}_v(\theta)$.

After a given reform that implements T_1, the revenue function equals

$$\mathcal{R}_1^\theta(\theta) = 1 - F(\theta) - \theta f(\theta)\frac{\sigma}{1+\sigma}\frac{T_1'(y_1(\theta))}{1-T_1'(y_1(\theta))}\ ; \tag{50}$$

i.e., only the last term changes because the type distribution and the elasticity parameter are exogenous objects.

Assume that the revenue-maximizing tax cut implements T_1 such that $y_1(\theta)$ is continuously differentiable and strictly increasing for all types between θ_1 and θ_2. To ensure that $\mathcal{R}_1^\theta(\theta) = z$ for all $\theta \in (\theta_1, \theta_2)$,[16] we simply have to ensure that

$$\begin{aligned}\frac{T_1'(y_1(\theta))}{1-T_1'(y_1(\theta))} = Z(\theta, z) &= \frac{1-F(\theta)-z}{\theta f(\theta)}\ \frac{1+\sigma}{\sigma} \\ \Leftrightarrow T_1'(y_1(\theta)) &= \frac{Z(\theta,z)}{1+Z(\theta,z)}\ .\end{aligned} \tag{51}$$

[16] It is possible that θ_1 is an inframarginal buncher under the pre-reform tax schedule. In that case, θ_1 additionally needs to satisfy $\mathcal{R}_v(\theta_1) = z$.

The individually optimal income of type θ agents in this range follows as

$$y_1(\theta) = \theta^{1+\sigma}\left[1 - T_1(y_1(\theta))\right]^{\sigma} = \theta^{1+\sigma}\left[1 + Z(\theta, z)\right]^{-\sigma} \ .$$

Note that y_1 and T_1' depend on the chosen level of the auxiliary variable z. The required level of z is defined by the condition

$$\int_{y_s}^{y_t} \left[T_1'(y) - T_0'(y)\right] dy = 0 \ . \tag{52}$$

This condition implies that we have a two-bracket tax cut between y_s and y_t, and that $T_1(y) = T_0(y)$ for all $y > y_t$.

Show that revenue-maximizing tax cut implements $\mathcal{R}_1(y) = z$ in such a way that $T_1(y) < T_0(y)$ for all $y \in (y_s, y_t)$ and $T_1(y) = T_0(y)$ for all $y \notin (y_s, y_t)$. We sketch a proof of Proposition 5 in three steps.

Step 1: Show that $\max_{y\in\mathcal{Y}} h_R(y) \leq 0$.

Assume that there is a number $\bar{h} > 0$ such that $\max_{y\in\mathcal{Y}} h_R(y) = \bar{h} > 0$, and let $y^* = \inf\left\{y \in \mathcal{Y} : h(y) = \bar{h}\right\}$. Then, there are two numbers $\varepsilon > 0$ and $\delta \in (0, y^*)$ such hat $h_R'(y) \geq \varepsilon$ for each $y \in (y^* - \delta, y^*)$. For any $\tilde{y} < y^*$, an increase in $h'(\tilde{y})$ leads to an increase in $h(y^*)$. Hence, the derivative of $\Pi(\tau, h)$ with respect to $h'(\tilde{y})$ at (τ_R, h_R) is given by

$$\begin{aligned}
\frac{d\Pi(\tau_R, h_R)}{dh'(\tilde{y})} &= \int_0^{\tau_R} \mathcal{R}_1(\tilde{y}, \tau', h_R) d\tau' + \tau_R \int_0^{\tau_R}\int_0^{\bar{y}} h_R'(y) \frac{d\mathcal{R}_1(y, \tau, h_R)}{dh'(\tilde{y})} dy d\tau - \tau_R \times \mathbb{1}\left[y < y^*\right] \\
&\leq \tau_R E\left[\mathcal{R}_1(\tilde{y}, \tau', h_R) \mid \tau' \in (0, \tau_R)\right] - \tau_R \times \mathbb{1}\left[y < y^*\right] \ ,
\end{aligned}$$

which is strictly negative for any $y < y^*$ because $\mathcal{R}_1(\tilde{y}, \tau', h_R) < 1$ for any τ'. This is inconsistent with (τ_R, h_R) being a maximizer of Π.

Step 2: Show that $\max_{y\in\mathcal{Y}} h_R(y) = 0$.

Let y_t be the largest income level such that $h_R'(y) \neq 0$. Assume that $h(y_t) < 0$. This implies that there is a range of incomes $\tilde{y}$ in (y^*, y_t) such that (i) $h'(\tilde{y}) < 0$ and (ii) a small increase in $h'(\tilde{y})$ does not affect $\max_y h(y)$. Note that $\mathcal{R}_1(y, \tau_R, h_R) = \mathcal{R}_0(y) > 0$ for all $y > \max\{y_t, y_b\}$. Then, for $\tilde{y} > \max\{y_t, y_b\}$, the derivative of $\Pi(\tau, h)$ with respect to $h'(\tilde{y})$ at (τ_R, h_R) is given by

$$\begin{aligned}
\frac{d\Pi(\tau_R, h_R)}{dh'(\tilde{y})} &= \int_0^{\tau_R} \mathcal{R}_1(\tilde{y}, \tau', h_R) d\tau' + \tau_R \int_0^{\tau_R}\int_0^{\bar{y}} h_R'(y) \frac{d\mathcal{R}_1(y, \tau, h_R)}{dh'(\tilde{y})} dy d\tau \\
&\quad \int_0^{\tau_R} \mathcal{R}_1(\tilde{y}, \tau', h_R) d\tau' + \tau_R \int_0^{\tau_R} \frac{d\mathcal{R}_1(y_t, \tau, h_R)}{dh'(\tilde{y})} \int_0^{y_t} h_R'(y) dy d\tau \\
&\quad \int_0^{\tau_R} \mathcal{R}_1(\tilde{y}, \tau', h_R) d\tau' + \tau_R \int_0^{\tau_R} \frac{d\mathcal{R}_1(y_t, \tau, h_R)}{dh'(\tilde{y})} h(y_t) d\tau \\
&> 0 \ ,
\end{aligned}$$

where the last inequality follows because $\mathcal{R}_1(\tilde{y}, \tau', h_R) > 0$ and $\frac{d\mathcal{R}_1(y_t, \tau, h_R)}{dh'(\tilde{y})} \leq 0$ for each $\tau' \in (0, \tau_R)$, and $h(y_t) < 0$ by assumption.

Hence, an increase in $h'(y)$ at each $y > \max\{y_t, y_b\}$ raises Pi as long as $h_R(y_t) < 0$. This is not compatible with h_R maximizing Π.

Step 3: Show that there is a $z \in (0, 1)$ such that $\mathcal{R}_1(y, \tau_R, h_R) = z$ for all $y \in \mathcal{Y}$ such that $h_R'(y) \neq 0$.

The first-order condition with respect to τ is given by

$$\frac{d\Pi(\tau_R, h_R)}{dtau} = \int_0^{\bar{y}} h_R'(y)\mathcal{R}_1(y, \tau_R, h_R)dy - \max_y h(y) \ .$$

By step 2, both $\max_y h_R(y)$ and $\int_0^{\bar{y}} h'(y)dy$ equal zero. Hence, the first-order condition is trivially satisfied if $\mathcal{R}_1(y, \tau_r, h_R)$ equals the same number for all y such that $h'(y) \neq 0$.

One alternative is that there are two income levels y_1, $y_2 > y_1$ with $h_R'(y_1), h_R'(y_2) \neq 0$ such that $\mathcal{R}(y_1, \tau_R, h_R) < \mathcal{R}(y_2, \tau_R, h_R)$. Then, we can increase Π by reducing $h'(y_1)$ by some small amount $\varepsilon > 0$ and increasing $h'(y_2)$ by the same amount without changing $\max_y h(y)$ or $h(y)$ for any $y > y_2$.

The other alternative is that there are two income levels y_1, $y_2 > y_1$ with $h_R'(y_1), h_R'(y_2) \neq 0$ such that $\mathcal{R}(y_1, \tau_R, h_R) > \mathcal{R}(y_2, \tau_R, h_R)$. Assume that $h(y) < 0$ for all $y \in [y_1, y_2]$. Then, we can increase Π by increasing $h'(y_1)$ by some small amount $\varepsilon > 0$ and decreasing $h'(y_2)$ by the same amount without violating $h(y) \leq 0$ for all $y \in \mathcal{Y}$, or changing $h(y)$ for any $y > y_2$. This implies that $\mathcal{R}_1$ can only be decreasing in y at income levels where both $h_R(y)$ and $h_R'(y)$ equal zero. Put differently, at any income level where $h_R(y) < 0$, we must have $d\mathcal{R}_1(y_1, \tau_R, h_R)/dy = 0$.

B.7 Additive separable preferences

Consider preferences captured by a utility function of the class

$$U(c, y, \theta) = u(c) - v(y, \theta) \ , \tag{53}$$

with $u' > 0$, $u'' \leq 0$, $v_y > 0$, $v_{yy} > 0$, $v_{y\theta} < 0$, and $v_{yy\theta} < 0$.

For these preferences, the first-order condition of a type θ individual is given by

$$\begin{aligned} & [1 - T'(y)]\, u'(C_0(y)) - v_y(y, \theta) = 0 \\ \Leftrightarrow \quad & MRS(C_0(y), y, \theta) = \tfrac{v_y(y,\theta)}{u'(C_0(y))} = 1 - T_0'(y) \ , \end{aligned}$$

defining the income level $y_0(\theta)$.

Assume first that there are no kinks in T, and that $y_0(\theta)$ is continuously differentiable and strictly positive. Then, the revenue function can be written in terms of the skill distribution as

$$\begin{aligned} M_0 \cdot \mathcal{R}(y) &= 1 - F(\theta_0(y)) - \theta f(\theta_0(y)) \frac{\varepsilon_0(y)}{\mu_0(y)} \frac{T_0'(y)}{1 - T_0'(y)} - \int_\theta^\infty f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta))d\theta \\ &= 1 - F(\theta_0(y)) + f(\theta_0(y)) \frac{u'\left(C_0(y)\right)}{v_{y\theta}\left(y, \theta_0(y)\right)} T_0'(y) - \int_\theta^{\bar{\theta}} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T_0'(y_0(\theta)d\theta \ , \end{aligned} \tag{54}$$

where the multiplier M_0 captures income effects,

$$M_0 = 1 - \int_{\underline{\theta}}^{\bar{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta \tag{55}$$

and we have

$$\frac{\partial y(\theta)}{\partial c_0} = \frac{[1 - T'(y)]\, u''(C_0(y))}{v_{yy}(y, \theta_0(y)) - [1 - T'(y)]^2 u''(C_0(y)) + T''(y) u'(C_0(y))} < 0 \ .$$

With a concave kink at $\hat{y}$ in T_0, there is a dominated income range (y_a, y_b) around $\hat{y}$ where a unique

skill type $\hat{\theta}$ is indifferent between y_a and y_b. Net tax revenue in the status quo is given by

$$R(0,h) \quad = \quad \int_{\underline{\theta}}^{\hat{\theta}} f(\theta) T_0(y_0(\theta)) d\theta + \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) T_0(y_0(\theta)) d\theta - c_0 \ .$$

Then, the revenue function equals

$$\begin{aligned} M_0 \cdot \mathcal{R}(y) \quad = \quad & 1 - F(\theta_0(y)) + \mathbb{1}_{y \notin (y_a, y_r)} f(\theta_0(y)) \frac{u'\left(C_0(y)\right)}{v_{y\theta}\left(y, \theta_0(y)\right)} T_0'(y) \\ & - \mathbb{1}_{y \leq y_a} \int_{\theta}^{\hat{\theta}} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta - \int_{\max\left\{\theta_0(y), \hat{\theta}\right\}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \\ & - \mathbb{1}_{y \leq y_a} f(\hat{\theta}) \frac{u'(c_b) - u'(c_a)}{v_\theta(y_b, \hat{\theta}) - v_\theta(y_a, \hat{\theta})} \left[T(y_a) - T(y_b)\right] \\ & - \mathbb{1}_{y \in (y_a, y_r)} f(\hat{\theta}) \frac{u'(C_0(y_b))}{v_\theta(y_b, \hat{\theta}) - v_\theta(y_a, \hat{\theta})} \left[T(y_a) - T(y_b)\right] \ , \end{aligned} \tag{56}$$

where $c_a = C_0(y_a)$ and $c_b = C_0(y_b)$. The term in the second-to-last line is a jump income effect in the revenue function because a tax increase below y_a lowers the skill threshold $\hat{\theta}$, inducing agents around this threshold to choose y_a instead of y_b and paying discretely lower taxes. Similarly, the term in the last line is a jump effect because an tax increase in the interval (y_a, y_b) raises the skill threshold $\hat{\theta}$, inducing agents around the cutoff to discretely increase their earnings level (and tax payment). The multiplier M_0 changes correspondingly to

$$\begin{aligned} M_0 \quad = \quad & 1 - \int_{\underline{\theta}}^{\hat{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta - \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta \\ & + f(\hat{\theta}) \frac{u'(c_b) - u'(c_a)}{v_\theta(y_b, \hat{\theta}) - v_\theta(y_a, \hat{\theta})} \left[T(y_a) - T(y_b)\right] \ . \end{aligned}$$

To investigate potential non-monotonicities in the revenue function, we note that

$$\begin{aligned} M_0 \cdot \lim_{y \to y_a^-} \mathcal{R}(y) \quad = \quad & 1 - F(\hat{\theta}) + f(\hat{\theta}) \frac{u'\left(c_a\right)}{v_{y\theta}\left(y_a, \hat{\theta}\right)} T_0'(y_a) \\ & - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \\ & - f(\hat{\theta}) \frac{u'(c_b) - u'(c_a)}{v_\theta(y_b, \hat{\theta}) - v_\theta(y_a, \hat{\theta})} \left[T(y_a) - T(y_b)\right] \ , \\ M_0 \cdot \mathcal{R}(y \mid y \in (y_a, y_b)) \quad = \quad & 1 - F(\hat{\theta}) - f(\hat{\theta}) \frac{u'(c_b)}{v_\theta(y_b, \hat{\theta}) - v_\theta(y_a, \hat{\theta})} \left[T(y_a) - T(y_b)\right] \\ & - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \ , \\ M_0 \cdot \lim_{y \to y_b^+} \mathcal{R}(y) \quad = \quad & 1 - F(\hat{\theta}) + f(\hat{\theta}) \frac{u'\left(c_b\right)}{v_{y\theta}\left(y_b, \hat{\theta}\right)} T_0'(y_b) \\ & - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \ . \end{aligned} \tag{57}$$

The difference between the value of the revenue function slightly above y_b and in the dominated area is

$$\begin{aligned} M_0\left[\lim_{y\to y_b^+}\mathcal{R}(y)-\mathcal{R}(y\mid y\in(y_a,y_b))\right] &= f(\hat{\theta})u'(c_b)\left[\frac{T_0'(y_b)}{v_{y\theta}\left(y_b,\hat{\theta}\right)}-\frac{T(y_b)-T(y_a)}{y_b-y_a}\frac{y_b-y_a}{v_\theta(y_b,\hat{\theta})-v_\theta(y_a,\hat{\theta})}\right] \\ &= f(\hat{\theta})u'(c_b)\left[\frac{T_0'(y_b)}{v_{y\theta}\left(y_b,\hat{\theta}\right)}-\frac{E\left[T'(y)\mid y\in(y_a,y_b)\right]}{E\left[v_{y\theta}(y,\hat{\theta})\mid y\in(y_a,y_b)\right]}\right]>0\,, \end{aligned}$$

where the term in brackets is strictly positive because $E\left[T'(y)\mid y\in(y_a,y_b)\right]>T'(y_b)>0$ by Assumption 1 and $v_{y\theta}(y_b,\hat{\theta})<E\left[v_{y\theta}(y,\hat{\theta})\mid y\in(y_a,y_b)\right]<0$ by the assumption that $v_{yy\theta}<0$.

The difference between the value of the revenue function in the dominated area and slightly below y_a is

$$\begin{aligned} M_0\left[\mathcal{R}(y\mid y\in(y_a,y_b))-\lim_{y\to y_a^-}\mathcal{R}(y)\right] &= f(\hat{\theta})u'(c_b)\frac{T(y_b)-T(y_a)}{v_\theta(y_b,\hat{\theta})-v_\theta(y_a,\hat{\theta})}-f(\hat{\theta})u'(c_a)\frac{T_0'(y_a)}{v_{y\theta}\left(y_a,\hat{\theta}\right)} \\ &\quad -f(\hat{\theta})\frac{u'(c_b)-u'(c_a)}{v_\theta(y_b,\hat{\theta})-v_\theta(y_a,\hat{\theta})}\left[T(y_b)-T(y_a)\right] \\ &= f(\hat{\theta})u'(c_a)\left[\frac{E\left[T'(y)\mid y\in(y_a,y_b)\right]}{E\left[v_{y\theta}(y,\hat{\theta})\mid y\in(y_a,y_b)\right]}-\frac{T_0'(y_a)}{v_{y\theta}\left(y_a,\hat{\theta}\right)}\right]>0\,, \end{aligned}$$

where the positive sign follows because $T'(y_a)>E\left[T'(y)\mid y\in(y_a,y_b)\right]>0$ and both $v_{y\theta}$ and $v_{yy\theta}$ are strictly negative.

Hence, the revenue function is discretely increasing both at y_a and at y_b.

B.8 Functional form example with income effects

Consider preferences with constant relative risk aversion and iso-elastic effort costs of the class

$$U(c,y,\theta)=\frac{1}{1-\eta}c^{1-\eta}-\frac{1}{1+\frac{1}{\sigma}}\left(\frac{y}{\theta}\right)^{1+\frac{1}{\sigma}}\,. \tag{58}$$

These preferences are additively separable. The revenue function follows as

$$\begin{aligned} M_0\cdot\mathcal{R}(y) &= 1-F(\theta_0(y))-\mathbb{1}_{y\notin(y_a,y_r)}f(\theta_0(y))\frac{C_0(y)^{-\eta}}{(1+1/\sigma)y^{1/\sigma}}\theta_0(y)^{2+1/\sigma}T_0'(y) \\ &\quad -\mathbb{1}_{y\le y_a}\int_{\theta_0(y)}^{\hat{\theta}}f(\theta)\frac{\partial y_0(\theta)}{\partial c_0}T'(y_0(\theta))d\theta-\int_{\max\left\{\theta_0(y),\hat{\theta}\right\}}^{\infty}f(\theta)\frac{\partial y_0(\theta)}{\partial c_0}T'(y_0(\theta))d\theta \\ &\quad +\mathbb{1}_{y\le y_a}f(\hat{\theta})\frac{c_b^{-\eta}-c_a^{-\eta}}{y_b^{1+1/\sigma}-y_a^{1+1/\sigma}}\hat{\theta}^{2+1/\sigma}\left[T(y_a)-T(y_b)\right] \\ &\quad +\mathbb{1}_{y\in(y_a,y_r)}f(\hat{\theta})\frac{c_b^{-\eta}}{y_b^{1+1/\sigma}-y_a^{1+1/\sigma}}\hat{\theta}^{2+1/\sigma}\left[T(y_a)-T(y_b)\right]\,, \end{aligned} \tag{59}$$

where the multiplier is given by

$$\begin{aligned} M_0 &= 1 - \int_{\underline{\theta}}^{\hat{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta - \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta \\ &\quad - f(\hat{\theta}) \frac{c_b^{-\eta} - c_a^{-\eta}}{y_b^{1+1/\sigma} - y_a^{1+1/\sigma}} \hat{\theta}^{2+1/\sigma} \left[T(y_a) - T(y_b)\right] \ . \end{aligned}$$

and the marginal income effects are given by

$$\frac{\partial y(\theta)}{\partial c_0} = - \frac{\eta \left[1 - T'(y)\right] C_0(y)^{-(1+\eta)}}{\frac{1}{\sigma} y^{1/\sigma - 1} \theta^{-(1+1/\sigma)} + \eta \left[1 - T'(y)\right]^2 C_0(y)^{-(1+\eta)} + T''(y) C_0(y)^{-\eta}} < 0 \ .$$

B.9 General preferences

Consider preferences captured by a utility function of the class

$$U(c, y, \theta) \ , \tag{60}$$

with $u_c > 0$, $u_y > 0$, $MRS = -\frac{u_y}{u_c} > 0$, $MRS_\theta < 0$, and $MRS_y + MRS \cdot MRS_c > 0$.

For these preferences, the first-order condition of a type θ individual is given by

$$\begin{aligned} & \left[1 - T'(y)\right] u_c(C_0(y), y, \theta) + u_y(C_0(y), y, \theta) = 0 \\ \Leftrightarrow \quad & MRS(C_0(y), y, \theta) = -\tfrac{u_y(C_0(y), y, \theta)}{u_c(C_0(y), y, \theta)} = 1 - T_0'(y) \ , \end{aligned}$$

defining the income level $y_0(\theta)$.

Assume first that there are no kinks in T, and that $y_0(\theta)$ is continuously differentiable and strictly positive. Then, the revenue function can be written in terms of the skill distribution as

$$\begin{aligned} M_0 \cdot \mathcal{R}(y) &= 1 - F(\theta_0(y)) - \theta f(\theta_0(y)) \frac{\varepsilon_0(y)}{\mu_0(y)} \frac{T_0'(y)}{1 - T_0'(y)} - \int_\theta^\infty f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \\ &= 1 - F(\theta_0(y)) + f(\theta_0(y)) \left[MRS_\theta(C_0(y), y, \theta)\right]^{-1} T_0'(y) - \int_\theta^{\bar{\theta}} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T_0'(y_0(\theta) d\theta \\ &= 1 - F(\theta_0(y)) - f(\theta_0(y)) \frac{u_c(C_0(y), y, \theta)}{u_{y\theta} + MRS \cdot u_{c\theta}} T_0'(y) - \int_\theta^{\bar{\theta}} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T_0'(y_0(\theta) d\theta \ , \end{aligned} \tag{61}$$

where the multiplier M_0 captures income effects,

$$M_0 = 1 - \int_{\underline{\theta}}^{\bar{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T'\left(y_0(\theta)\right) d\theta \ . \tag{62}$$

With a concave kink at $\hat{y}$ in T_0, there is a dominated income range (y_a, y_b) around $\hat{y}$ where a unique skill type $\hat{\theta}$ is indifferent between y_a and y_b. Net tax revenue in the status quo is given by

$$R(0, h) = \int_{\underline{\theta}}^{\hat{\theta}} f(\theta) T_0(y_0(\theta)) d\theta + \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) T_0(y_0(\theta)) d\theta - c_0 \ .$$

Then, the revenue function equals

$$\begin{aligned} M_0 \cdot \mathcal{R}(y) &= 1 - F(\theta_0(y)) - \mathbb{1}_{y \notin (y_a, y_r)} f(\theta_0(y)) \frac{u_c(C_0(y), y, \theta)}{u_{y\theta} + MRS \cdot u_{c\theta}} T_0'(y) \\ &\quad - \mathbb{1}_{y \leq y_a} \int_{\theta}^{\hat{\theta}} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta - \int_{\max\{\theta_0(y), \hat{\theta}\}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \\ &\quad + \mathbb{1}_{y \leq y_a} f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta}) - u_c(c_a, y_a, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \left[T(y_a) - T(y_b) \right] \\ &\quad + \mathbb{1}_{y \in (y_a, y_r)} f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \left[T(y_a) - T(y_b) \right] , \end{aligned} \tag{63}$$

where $c_a = C_0(y_a)$ and $c_b = C_0(y_b)$. The term in the second-to-last line is a jump income effect in the revenue function because a tax increase below y_a lowers the skill threshold $\hat{\theta}$, inducing agents around this threshold to choose y_a instead of y_b and paying discretely lower taxes. Similarly, the term in the last line is a jump effect because an tax increase in the interval (y_a, y_b) raises the skill threshold $\hat{\theta}$, inducing agents around the cutoff to discretely increase their earnings level (and tax payment). The multiplier M_0 changes correspondingly to

$$\begin{aligned} M_0 &= 1 - \int_{\underline{\theta}}^{\hat{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T' \left(y_0(\theta) \right) d\theta - \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) \frac{\partial y(\theta)}{\partial c_0} T' \left(y_0(\theta) \right) d\theta \\ &\quad - f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta}) - u_c(c_a, y_a, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \left[T(y_a) - T(y_b) \right] . \end{aligned}$$

To investigate potential non-monotonicities in the revenue function, we note that

$$\begin{aligned} M_0 \cdot \lim_{y \to y_a^-} \mathcal{R}(y) &= 1 - F(\hat{\theta}) - f(\hat{\theta}) \frac{u_c(c_a, y_a, \hat{\theta})}{u_{y\theta}(c_a, y_a, \hat{\theta}) + MRS(c_a, y_a, \hat{\theta}) \cdot u_{c\theta}(c_a, y_a, \hat{\theta})} T_0'(y_a) \\ &\quad - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta \\ &\quad + f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta}) - u_c(c_a, y_a, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \left[T(y_a) - T(y_b) \right] , \\ M_0 \cdot \mathcal{R}(y \mid y \in (y_a, y_b)) &= 1 - F(\hat{\theta}) + f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \left[T(y_a) - T(y_b) \right] \\ &\quad - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta , \\ M_0 \cdot \lim_{y \to y_b^+} \mathcal{R}(y) &= 1 - F(\hat{\theta}) + f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta})}{u_{y\theta}(c_b, y_b, \hat{\theta}) + MRS(c_b, y_b, \hat{\theta}) \cdot u_{c\theta}(c_b, y_b, \hat{\theta})} T_0'(y_b) \\ &\quad - \int_{\hat{\theta}}^{\infty} f(\theta) \frac{\partial y_0(\theta)}{\partial c_0} T'(y_0(\theta)) d\theta . \end{aligned} \tag{64}$$

The difference between the value of the revenue function slightly above y_b and in the dominated area is

$$\begin{aligned} M_0 \left[\lim_{y \to y_b^+} \mathcal{R}(y) - \mathcal{R}(y \mid y \in (y_a, y_b)) \right] &= -f(\hat{\theta}) u_c \left(c_b, y_b, \hat{\theta} \right) \left[\frac{T_0'(y_b)}{\chi(y_b)} - \frac{T(y_b) - T(y_a)}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} \right] \\ &= -f(\hat{\theta}) u' \left(c_b \right) \left[\frac{T_0'(y_b)}{\chi(y_b)} - \frac{E\left[T'(y) \mid y \in (y_a, y_b) \right]}{E\left[\chi(y) \mid y \in (y_a, y_b) \right]} \right] > 0 , \end{aligned}$$

where $\chi(y) = u_{c\theta}(\tilde{c}(y), y, \hat{\theta}) \cdot MRS(\tilde{c}(y), y, \hat{\theta}) + u_{y\theta}(\tilde{c}(y), y, \hat{\theta})$ and $\tilde{c}(y)$ is implicitly defined by $u(\tilde{c}(y), y, \hat{\theta}) = u(c_b, y_b, \hat{\theta})$. The term in brackets is strictly positive because $E[T'(y) \mid y \in (y_a, y_b)] > T'(y_b) > 0$ by Assumption 1, and $\chi(y) > 0$ by the single-crossing property. We assume that $\chi'(y) \geq 0$ as well.

The difference between the value of the revenue function in the dominated area and slightly below y_a is

$$\begin{aligned} M_0 \left[\mathcal{R}(y \mid y \in (y_a, y_b)) - \lim_{y \to y_a^-} \mathcal{R}(y) \right] &= -f(\hat{\theta}) u_c \left(c_b, y_b, \hat{\theta} \right) \frac{T(y_b) - T(y_a)}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} + f(\hat{\theta}) u_c \left(c_a, y_a, \hat{\theta} \right) \frac{T_0'(y_a)}{\chi(y_a)} \\ &\quad + f(\hat{\theta}) \frac{u_c(c_b, y_b, \hat{\theta}) - u_c(c_a, y_a, \hat{\theta})}{u_\theta(c_b, y_b, \hat{\theta}) - u_\theta(c_a, y_a, \hat{\theta})} [T(y_b) - T(y_a)] \\ &= -f(\hat{\theta}) u_c \left(c_a, y_a, \hat{\theta} \right) \left[\frac{E[T'(y) \mid y \in (y_a, y_b)]}{E[\chi(y) \mid y \in (y_a, y_b)]} - \frac{T_0'(y_a)}{\chi(y_a)} \right] > 0 , \end{aligned}$$

where the positive sign follows because $T'(y_a) > E[T'(y) \mid y \in (y_a, y_b)] > 0$, $\chi(y) > 0$ and $\chi'(y) \geq 0$.

Hence, the revenue function is discretely increasing both at y_a and at y_b.

B.10 Notches and self-financing tax cuts

Consider a (pure or proportional notch) in the tax-transfer schedule at $\hat{y}$. Hence, $C_0(y)$ is discontinuously falling at $\hat{y}$. Then, there are two skill types θ_a and $\hat{\theta}$ such that all types $\theta \in (\theta_a, \hat{\theta})$ bunch at $\hat{y}$. Type θ_a is the only skill type such that a first-order condition is satisfied at $\hat{y}$, while $\hat{\theta}$ is indifferent between $\hat{y}$ and an income $y_b > \hat{y}$. The income range $(\hat{y}, y_b)$ is dominated and not chosen by any agent.

The tuple $(\hat{\theta}, y_b)$ is jointly defined by the first-order condition

$$u_c(C_0(y_b), y_b, \hat{\theta}) [1 - T_0'(y_b)] + u_y(C_0(y_b), y_b, \hat{\theta}) = 0$$

and the indifference condition

$$u(C_0(y_b) - b, y_b, \hat{\theta}) - u(C_0(\hat{y}), \hat{y}, \theta) = 0 .$$

In the following, we use the shorthands $c_b = C_0(y_b)$ and $\hat{c} = C_0(\hat{y})$.

Consider a small one-bracket tax increase at some income in $(\hat{y}, y_b)$. This mechanically increases tax liability for all agents with $\theta > \hat{\theta}$ and increases $\hat{\theta}$ by

$$\frac{d\hat{\theta}}{d\delta} = \frac{u_c(C_0(y_b), y_b, \hat{\theta})}{u_\theta(C_0(y_b), y_b, \hat{\theta}) - u_\theta(C_0(\hat{y}), \hat{y}, \theta)} = \frac{u_c(C_0(y_b), y_b, \hat{\theta})}{\int_{\hat{y}}^{y_b} \left[u_{c\theta}(\tilde{c}(y) y, \hat{\theta}) MRS(\tilde{c}(y), y, \hat{\theta}) - u_{y\theta}(\tilde{c}(y), y, \theta) \right] dy} > 0 .$$

B.11 Spotlighting

Consider quasi-linear preferences and assume that some agents around a convex kink at $\hat{y}$ use the spotlighting heuristic, implying that they choose incomes in the dominated income range. A sufficient condition for the existence of a small self-financing reform is that

$$\lim_{\varepsilon \to 0^+} \frac{f_y(y - \varepsilon)}{f_y(y + \varepsilon)} > \lim_{\varepsilon \to 0^+} \frac{T_0'(y + \varepsilon)[1 - T_0'(y - \varepsilon)]}{T_0'(y - \varepsilon)[1 - T_0'(y + \varepsilon)]}. \tag{65}$$

Note that the critical value at the right-hand side is bounded away from 1 from below. If this condition is satisfied, then the revenue function increases discretely at income level $\hat{y}$.

Intuitively, with spotlighting, the revenue-maximizing tax cut will in many cases be the same as with rational taxpayers. The reason is that spotlighting disappears if each skill type has a unique locally optimal income level. We can verify whether the discrete reform for rational taxpayers is self-financing by comparing the gross tax revenue after and before the reform, using the observed income distributions f_y in the dominated income range. The revenue gain with spotlighting may be smaller or larger than with rational behavior. The additional utility gains for agents locating in the dominated income range are strictly larger than those for rational taxpayers not making any mistakes.