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Bo Hyun Chang, Yongsung Chang and Sun-Bin Kim

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Pareto Weights in Practice: A Quantitative Analysis Across 32 OECD Countries*

Bo Hyun Chang
Ministry of Strategy and Finance of Korea

Yongsung Chang
University of Rochester
Yonsei University

Sun-Bin Kim
Yonsei University

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Abstract

We develop a quantitative heterogeneous-agents general equilibrium model that reproduces the income inequalities of 32 countries in the Organization for Economic Co-operation and Development. Using this model, we compute the optimal income tax progressivity and redistribution for each country under the equal-weight utilitarian social welfare function. A policy reform to adopt the optimal progressivity is supported by the majority of the population. Finally, we uncover the Pareto weights in the social welfare functions of each country that justify the current redistribution policy.

Keywords: Income Inequality, Optimal Tax, Pareto Weights, Political Economy, Redistribution

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1. Introduction

The unequal distribution of economic resources and opportunities has been a primary concern for social scientists and policy makers. Income and wealth inequality is widespread across the world, and all societies adopt various redistribution policies to alleviate this problem.[1] Figure 1 plots the Gini coefficients of incomes (for both before and after taxes/transfers) for 32 countries in the Organization for Economic Co-operation and Development (OECD) based on the OECD database.[2] The Gini coefficient of income before tax and transfers ranges from 0.34 (South Korea) to 0.58 (Ireland). The "improvement rate" in income inequality (measured by the percentage decrease in the income Gini coefficients between before and after taxes/transfer) ranges from 5% in Chile to 49% in Ireland.[3]

Understanding and comparing redistribution policies across countries in a unified framework is not an easy task. Economists' ability to quantitatively evaluate the political outcome of redistribution policies is limited because it requires modeling a complex political process and aggregating individual preferences. However, recent developments in quantitative general equilibrium heterogeneous-agents models enable us to take first steps in addressing these issues. We can compute the optimal income tax policy under various welfare criteria and simulate voting outcomes of alternative policies. We can even uncover the welfare weights (so-called Pareto weights) that would justify each country's current redistribution policy. To our knowledge, this is the first study that compares how

[1] Alesina and Glaeser (2004) provide a detailed survey of a broad range of sources, their interactions, and the socio-economic consequences of income and wealth inequality.

[2] Out of the 34 OECD countries, we exclude Mexico and Hungary from our analysis because of data availability.

[3] The specific measures and degree of income redistribution caused by individual policies differ considerably across countries. Progressive income taxation and a variety of income transfer programs are typical redistribution policies intended to reduce the inequality of disposable income. There are also indirect transfer programs, which redistribute wealth through providing goods and services that individuals would have otherwise purchased at their own expense. Examples include free education, health care and child care. Different countries have a variety of policy tools. For example, according to the OECD (2015), the top statutory personal income-tax rate ranges from 15% (Czech Republic) to 57% (Sweden) and the property tax share of total tax revenue varies from a mere 1.1% (Estonia) to 13% (U.S.).

societies (or governments) aggregate individual preferences over the redistribution policies, and does so across a large set of countries. We relate our estimated Pareto weights to each country's Democracy Index, electoral turnout rates, and the social perception about income redistribution in the World Values Survey, all of which are often used in political science and sociology.

More specifically, we ask three questions: (i) What is the optimal progressivity of income tax for each country under the equal-weight utilitarian social welfare function? (ii) What would be the outcome of the voting simulation on the fiscal reform to adopt the optimal tax? (iii) What are the Pareto weights in the social welfare function that justify the progressivity of current income tax (which is suboptimal according to the equal-weight criteria) in each country? We examine these questions through the lens of the model seen in Aiyagari (1994), where households face uncertainty about future earnings. As a result of the precautionary savings and labor supply motive to insure against this future uncertainty, the cross-sectional wealth distribution emerges as an equilibrium.

We calibrate the model to reproduce the income distribution for each of the 32 OECD countries. The stochastic process of individual productivity shocks (which is the source of cross-sectional income inequality) is chosen to match the *before*-tax income Gini in the data. Summarizing the progressivity of the income tax/transfer system (especially for cross-country comparison) is not a simple task because of the complexity of the tax and transfer schedule. One practical way is to assume a specific parametric form of tax function with a few parameters. We assume that the individual income tax schedule follows the log-linear tax function, which is widely used in various literatures (e.g., Benabou (2002), Heathcote et al. (2016)). We choose the progressivity of income tax to match the *change* in the income Gini after taxes and transfers. Thus, for each country, the model closely matches the before- and after-tax income Gini coefficients. The progressivity of tax in our model turns out to be remarkably close to that in the data, indicating that our model captures important characteristics of income inequality and redistribution in these countries.

According to our benchmark model, the optimal tax progressivity—measured by the exponent of the log-linear tax function—under the equal-weight utilitarian social welfare function ranges from 0.13 (South Korea) to 0.39 (Ireland). The optimal progressivity in the income tax schedule is higher than the current level in 4 out of the 32 OECD countries we consider (Chile, S. Korea, Turkey, and the U.S.).[4] According to the model-based voting simulation, the tax reform needed to adopt the optimal progressivity is supported by the majority of the population in all 32 OECD countries.

If the optimal tax reform is supported by the majority of citizens in these countries, why haven't they adopted it yet? The "optimality" depends on the specification of the social welfare function. Despite its popular use in quantitative analyses, it is not obvious whether each government's goal is to maximize the equal-weight utilitarian welfare function. There could be many other alternative criteria. One may argue that it is desirable for a society to maximize the welfare of the poorest members instead of the average (i.e., Rawlsian). The society's choice for redistribution is also affected by various factors such as the externality of public expenditure (Heathcote et al., 2016) or profession (Lockwood, Nathanson and Weyl, 2016), the preference heterogeneity (Lockwood and Weinzierl, 2015), the reference point (Charité et al., 2015), benefit-based taxation (Weinzierl, 2016), or the "equal sacrifice" rule (Weinzierl, 2014). Moreover, the process under which policies are actually determined is much more complicated than the simple majority rule. For example, the political equilibrium under a multi-party system can be different from that under the median voter theorem. These questions are immensely important, but beyond the scope of this paper.

In this paper we instead ask a rather simple positive question within the utilitarian framework. For each country, we ask: what are the weights in the social welfare function that justify the current tax progressivity as optimal? We interpret these relative weights in the social welfare function as broadly representing each society's preferences for redistribution and political arrangement—i.e., a reduced-form representation of various factors. Thus, we interpret the persistence of the current suboptimal tax schedule (despite overwhelming support for optimal tax reform) as evidence of deviation from the equal-weight utilitarian social welfare function. According to our calculations, in the U.S., the Pareto weights on the richest 20% (1.14) is 34% larger than that of the poorest 20%

[4] The current income tax schedule is close to the utilitarian optimal in Switzerland.

households (0.85). In Sweden (one of the countries with a highly progressive tax system), the Pareto weight on the poorest 20% of the population (2.7) is about 12 times as large as that on the richest 20% (0.23). By contrast, in Chile, the Pareto weight on the richest 20% (2.37) is almost 12 times as large as that on the poorest 20% (0.2). We provide indirect evidence that may serve as potential interpretations for the estimated shape of Pareto weights across countries: (i) the Democracy Index from the Economist Intelligence Unit, (ii) electoral voting turnout rates by income from Mahler (2008), and (iii) the society's preference for income redistribution from the World Values Survey.

Our results are closely related to those in the existing literature. Romer (1975) and Roberts (1977) present models of a median-voter-led income redistribution. Our model enables us to compute individual welfare under a specific policy and simulate a voting result. Acemoglu et al. (2014) find that among 184 countries, democracy has a significant and robust effect on tax revenues as a fraction of GDP. Since they only measure whether a country's political system is democracy—i.e., a discrete variable that takes a value of either 0 or 1, their results are better interpreted as the effect of democratization. Our analysis—which is based on the weighted average of various measures of democracy—suggests that the degree to which democracy is embraced in each OECD country affects the adoption of redistribution policies. Heathcote and Tsujiyama (2016) compare alternative tax systems in the U.S. based on the social weights that justify current tax rates. We examine the redistribution policies of 32 OECD countries and uncover the implied Pareto weights of the social welfare function of each country. A large literature, including Saez and Stantcheva (2016), and Lockwood and Weinzierl (2016), extends Mirrlees's (1971) framework to uncover social weights. While most of the Mirrleesian approaches are static,[5] our model allows precautionary savings at the cost of assuming a simple parametric form for taxes.[6] We also compare the estimated marginal social welfare weights from

[5]Recently, Chang and Park (2017) extended Saez's (2001) optimal tax formula in a dynamic environment where households have access to a private savings market.

[6]Conesa and Krueger (2006) computed the optimal progressivity of the income tax schedule in an overlapping generations model. They argue that the optimal U.S. income tax is a flat tax rate (17.2%) with a fixed deduction. While we also use the U.S. as our benchmark case, we extend the analysis to include a wider set of economies (e.g., 32 OECD countries) at the cost of not considering more detailed households' heterogeneity and a functional form of tax.

our model to those from Lockwood and Weinzierl (2016). Holter et al. (2015) measure the progressivity of the labor income tax for 20 OECD countries and compute the additional tax revenues generated by increasing labor income taxes. Our measure of progressivity includes other income and public transfers as well as labor income, and we focus on the discrepancy between the current and the optimal progressivity.

The remainder of the paper is organized as follows. Section 2 documents key statistics about equality and welfare across 32 OECD countries and investigates their relationships. Section 3 lays out the benchmark model economy, which is calibrated to match the before- and after-tax income Ginis for each country. In Section 4, we calibrate our model economy and show that our model generates a reasonable income distribution. In Section 5, we compute the optimal progressivity of income tax under the equal-weight utilitarian social welfare function and examine whether the optimal tax reform is supported by the majority of the population. We then uncover the Pareto weights that justify the current progressivity, relate our estimated Pareto weights to each country's Democracy Index, electoral voting turnout rates by income, and the perception of income redistribution in the World Values Survey, and compare our results to the Mirrleesian approach. Section 6 concludes.

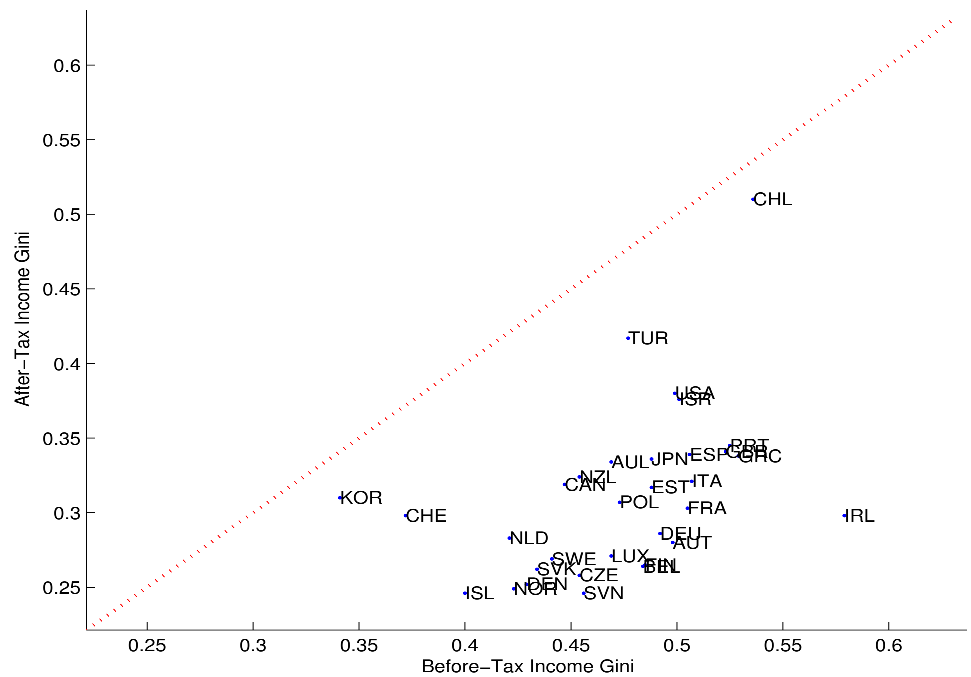
2. Income Inequalities in the OECD Countries

In this section, we document stylized facts about the income inequality and redistribution policies of the OECD countries. These facts are summarized in Tables 1 and 2. The first and second columns of Table 1 report the available before- and after-tax/transfer income Ginis for the OECD countries, which are taken from the OECD database.[7] The before-tax income Gini ranges from 0.34 (South Korea) to 0.58 (Ireland), with an average of 0.47 and a standard deviation of 0.05. The after-tax income Gini varies from 0.25 (Iceland) to 0.51 (Chile), with an average of 0.31 and a standard deviation of 0.06.

Figure 1 plots the before- and after-tax income Ginis for the 32 OECD countries. All 32 countries are located below the 45-degree line, indicating that, in all countries,

[7]The OECD database provides the income Gini coefficients, which are standardized across countries. http://stats.oecd.org.

Figure 1: Before-Tax and After-Tax Income Inequality



incomes are redistributed from the rich to the poor. The two income Ginis are, however, modestly correlated with the correlation coefficient of 0.44, indicating varying degrees of redistribution policies across countries.

Based on before- and after-tax income Gini coefficients, we calculate the improvement rate in income inequality—i.e., the percentage decrease in the Gini coefficient after taxes and transfers—for each country, which serves as a measure of the strength of the redistribution policies. The improvement rate, shown in the third column of Table 1, varies widely, from 5% (Chile) to 49% (Ireland), with an average of 33.9% and a standard deviation of 10.7%. The improvement rates are only weakly correlated with the before-tax income Gini (the correlation coefficient of 0.21), suggesting that a country with high income inequality does not necessarily adopt a stronger redistribution policy.

Progressive income tax is commonly used in OECD countries. However, comparing the progressivity across countries is not a simple task because of the complexity of tax schedules and deductions that are specific to each country. The marginal income tax rate for the highest income group is often used as a proxy for tax progressivity. However, the

Table 1: Key Statistics for the 32 OECD Countries in 2010

	Income Gini Before Tax	Income Gini After Tax	$-\Delta$(%)	Tax/Y (%)	Democracy Index	Wealth Gini	G/Y (%)
Australia	0.469	0.334	28.8	25.6	9.22	0.636	17.9
Austria	0.498	0.280	43.8	42.2	8.49	0.693	20.4
Belgium	0.484	0.264	45.5	43.5	8.05	0.655	23.6
Canada	0.447	0.319	28.6	30.6	9.08	0.728	22.0
Chile	0.536	0.510	4.9	19.5	7.67	0.774	12.3
Czech Republic	0.454	0.258	43.2	33.9	8.19	0.743	20.5
Denmark	0.429	0.252	41.3	47.4	9.52	0.701	27.6
Estonia	0.488	0.317	35.0	34.0	7.68	0.660	20.1
Finland	0.485	0.265	45.4	42.5	9.19	0.662	23.9
France	0.505	0.303	40.0	42.9	7.77	0.755	23.8
Germany	0.492	0.286	41.9	36.2	8.38	0.777	19.1
Greece	0.529	0.338	36.1	31.6	7.92	0.714	21.6
Iceland	0.400	0.246	38.5	35.2	9.65	0.663	24.7
Ireland	0.579	0.298	48.5	27.4	8.79	0.727	18.9
Israel	0.501	0.376	25.0	32.4	7.48	0.783	22.5
Italy	0.507	0.321	36.7	43.0	7.83	0.646	20.4
Japan	0.488	0.336	31.1	27.6	8.08	0.596	19.7
Korea	0.341	0.310	9.1	25.1	8.11	0.726	14.5
Luxembourg	0.469	0.271	42.2	37.3	8.88	0.623	16.5
Netherlands	0.421	0.283	32.8	38.9	8.99	0.812	26.5
New Zealand	0.454	0.324	28.6	31.1	9.26	0.725	19.8
Norway	0.423	0.249	41.1	42.6	9.80	0.779	21.4
Poland	0.473	0.307	35.1	31.7	7.05	0.753	19.3
Portugal	0.525	0.345	34.3	31.2	8.02	0.725	20.7
Slovak Republic	0.434	0.262	39.6	28.3	7.35	0.621	19.2
Slovenia	0.456	0.246	46.1	38.1	7.69	0.639	20.3
Spain	0.506	0.339	33.0	32.5	8.16	0.662	20.5
Sweden	0.441	0.269	39.0	45.4	9.50	0.806	25.2
Switzerland	0.372	0.298	19.9	28.1	9.09	0.806	10.7
Turkey	0.477	0.417	12.6	26.2	5.73	0.842	14.3
United Kingdom	0.523	0.341	34.8	34.9	8.16	0.675	21.6
United States	0.499	0.380	23.8	23.8	8.18	0.852	16.9
Average	0.472	0.311	33.9	34.1	8.34	0.717	20.2
Standard Dev.	0.049	0.056	10.7	7.1	0.87	0.069	3.8

Note: See Appendix A for a detailed description of the data. The percentage decrease in the income Gini coefficient after taxes and transfers is denoted by "$-\Delta$."

Table 2: Correlations for the 32 OECD Countries

	Before Gini	After Gini	Change (%)	Tax/Y (%)	Democracy Index	Wealth Gini	G/Y (%)
Before-Tax Income Gini	1.00	0.44	0.21	-0.09	-0.34	-0.09	0.04
After-Tax Income Gini	0.44	1.00	-0.78	-0.67	-0.50	0.33	-0.52
Change in Gini (%)	0.21	-0.78	1.00	0.70	0.32	-0.42	0.63
Tax/Y (%)	-0.09	-0.67	0.70	1.00	0.36	-0.16	0.74
Democracy Index	-0.34	-0.50	0.32	0.36	1.00	-0.08	0.36
Wealth Gini	-0.09	0.33	-0.42	-0.16	-0.08	1.00	-0.17
G/Y (%)	0.04	-0.52	0.63	0.74	0.36	-0.17	1.00

Source: Authors' calculation with data from OECD (2015, 2016), Economist Intelligence Unit (2011), and Credit Suisse (2012)

top statutory tax rate is not at all systematically correlated with the improvement rate of income Gini coefficients across 32 OECD countries (correlation coefficient of 0.12).

One practical way to compare the progressivity is to assume a specific parametric form of tax function. We adopt a log-linear tax function widely used in the literature (e.g., Benabou (2002), Heathcote et al. (2016)) as follows. When y_i denotes the market income,

$$\begin{aligned} \text{Tax:} \quad T(y_i) &= y_i - \lambda y_i^{1-\tau} \\ \text{Disposable income:} \quad D(y_i) &= \lambda y_i^{1-\tau} \\ \log D(y_i) &= \log \lambda + (1-\tau) \log y_i \end{aligned}$$

where τ reflects a progressivity of income taxes and transfers and λ controls the average level of taxation. Using the Luxembourg Income Study (LIS) database, we estimate the tax progressivity (τ) for 25 OECD countries.[8] The LIS collects and harmonizes household data across countries. Market income is defined as factor income plus private transfers. Disposable income is defined as market income plus public transfers minus income taxes

[8]Data for 19 countries (Australia, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Netherlands, Poland, Slovak Republic, Spain, the U.K. and the U.S.) are based on 2010 data. Data for the Czech Republic (2007), Japan (2008), Korea (2006), Norway (2004), Sweden (2005), and Switzerland (2004) are based on earlier years. Households with income lower than the 20th percentile in each country are excluded in the estimation.

and contributions. We estimate tax progressivity ($\hat{\tau}$) by regressing the log of disposable income on the log of market income. Incomes are rescaled according to household size.

Table 3 reports our estimates ($\hat{\tau}$) for each country. Nordic countries (Denmark 0.485, Norway 0.477, Sweden 0.489) and Germany (0.509) operate more progressive tax systems, while Asian countries (Korea 0.07, Japan 0.155) and the U.S. (0.248) have less progressive systems. Our estimate of the progressivity of income tax for the U.S. is 0.248, which is slightly larger than the estimates by Heathcote et al. (2016): 0.181 (from the PSID) and 0.200 (CBO tables).[9]. Holter et al. (2015) also estimate the progressivity of labor income tax using labor income and the progressivity tax wedge from the OECD data.[10] Their estimates, ranging from 0.101 (Japan) to 0.258 (Denmark), are smaller than our estimates, but the relative progressivity across countries is similar to ours: income taxes are more progressive in Nordic countries and less progressive in the U.S. (0.137) and Japan (0.101). Since they estimate the progressivity of only labor income tax, and do not include capital income tax or public transfers, their estimates are smaller than ours.

Our estimates for tax progressivity $\hat{\tau}$ are closely related to the improvement rates of income Ginis across countries (Figure 2), whose correlation coefficient is 0.79. The estimates are also highly correlated with the tax-to-GDP ratios (correlation coefficient of 0.73). This implies that this simple log-linear tax function summarizes the strength of income redistribution across countries fairly well.

We have also collected the wealth Gini coefficients for OECD countries from the 2012 edition of the Global Wealth Databook issued by Credit Suisse. The wealth distributions are more dispersed: the average wealth Gini coefficient among OECD countries is 0.72. Unfortunately, however, unlike the data on incomes, wealth data are known to be both less reliable and not standardized across countries. Thus, our analysis will mainly focus

[9]The CBO measure of transfers includes the value of food stamps, school lunches, and housing and energy assistance, but excludes state-level taxes and transfers.

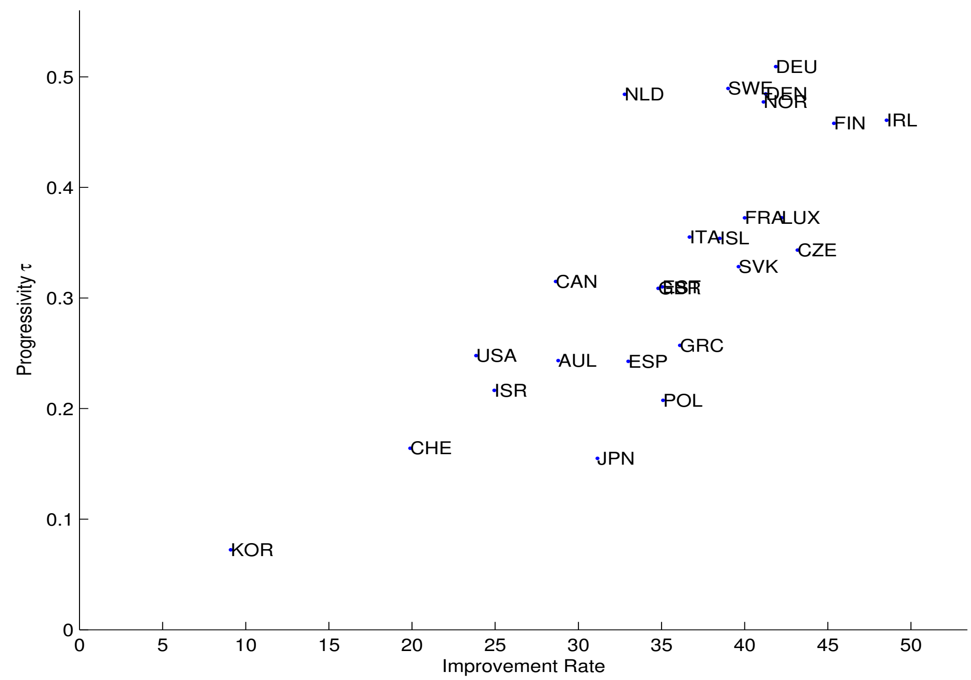
[10]Holter et al. (2015) also assume a log-linear form of the tax function on labor income, and estimate the parameter $\hat{\tau}$ using the progressivity tax wedge from the OECD data.

Table 3: Estimated Progressivity of Income Tax Schedule

	$\hat{\tau}$	S.E.	Obs.	R^2
Australia	0.243	(0.004)	9,647	0.892
Austria	...	...	...	...
Belgium	...	...	...	...
Canada	0.315	(0.004)	16,124	0.781
Chile	...	...	...	...
Czech Republic	0.343	(0.006)	6,317	0.774
Denmark	0.485	(0.003)	55,367	0.691
Estonia	0.310	(0.008)	3,098	0.765
Finland	0.458	(0.008)	6,920	0.693
France	0.373	(0.007)	10,476	0.652
Germany	0.509	(0.007)	8,432	0.570
Greece	0.257	(0.009)	2,837	0.723
Iceland	0.354	(0.011)	2,350	0.773
Ireland	0.461	(0.009)	2,096	0.723
Israel	0.216	(0.005)	3,909	0.873
Italy	0.355	(0.013)	4,907	0.564
Japan	0.155	(0.009)	2,245	0.776
Korea	0.072	(0.003)	10,541	0.900
Luxembourg	0.373	(0.009)	3,665	0.673
Netherlands	0.484	(0.009)	7,708	0.592
New Zealand	...	...	...	...
Norway	0.477	(0.009)	10,046	0.643
Poland	0.207	(0.003)	22,065	0.791
Portugal	...	...	...	...
Slovak Republic	0.328	(0.010)	3,239	0.651
Slovenia	...	...	...	...
Spain	0.243	(0.006)	7,049	0.722
Sweden	0.489	(0.010)	10,828	0.625
Switzerland	0.164	(0.012)	2,390	0.762
Turkey	...	...	...	...
United Kingdom	0.309	(0.005)	13,951	0.722
United States	0.248	(0.001)	51,102	0.878

Note: We estimate $1-\hat{\tau}$ from LIS (2016) and the reported standard errors (S.E.) are for $1-\hat{\tau}$.

Figure 2: Tax Progressivity and Gini Improvement Rates



on the income Ginis.[11]

3. Model

The model economy (which will serve as a laboratory for various quantitative analyses) extends Aiyagari's (1994) model to the endogenous labor supply.

Households: There is a continuum (measure one) of worker-households that have identical preferences and face an idiosyncratic productivity shock x, which evolves over time according to a Markov process with a transition probability distribution function $\pi_x(x'|x) =$

[11] The wealth Gini coefficients based on the data from Credit Suisse show a weak correlation (-0.09) with the before-tax income Gini from the OECD database, while it is positively correlated (0.33) with the after-tax income Gini. Interestingly, unlike income Ginis, the wealth Ginis are not highly correlated with any of the redistribution policy measures we consider, such as the tax-to-GDP ratio, the top statutory income tax rate, the property tax revenue share, or the Democracy Index. The correlation coefficients (with the wealth Gini) for those measures are -0.16, 0.05, 0.03, and -0.08, respectively. These patterns may arise because of the difficulty in collecting precise and standardized wealth data across countries.

$\Pr(x_{t+1} \leq x'|x_t = x)$. When a household with labor productivity x_t chooses to work for h_t hours, its labor income is $w_t x_t h_t$, where w_t is the wage rate for the efficiency unit of labor. Households hold assets, a_t, that yield the real rate of return, r_t. The total (labor and capital) income is subject to a log-linear net tax function. A household maximizes its lifetime utility:

$$\max_{\{c_t,h_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{{c_t}^{1-\sigma}-1}{1-\sigma} - B\frac{{h_t}^{1+1/\gamma}}{1+1/\gamma} \right\}$$

subject to

$$c_t + a_{t+1} = \lambda(w_t x_t h_t + r_t a_t)^{1-\tau} + a_t,$$

$$a_{t+1} \geq \underline{a},$$

where c_t is consumption. Parameters σ and γ represent the relative risk aversion and labor-supply elasticity, respectively. Capital markets are incomplete in two senses: (i) physical capital is the only available asset for households to insure against idiosyncratic shocks to their productivity and (ii) households face an exogenous borrowing constraint $\underline{a}$: $a_{t+1} \geq \underline{a}$ for all t. Households differ *ex post* with respect to their productivity x_t and asset holdings a_t, whose cross-sectional joint distribution is characterized by the probability measure $\mu_t(a_t, x_t)$.

Firms: The representative firm produces output according to a constant-returns-to-scale Cobb-Douglas production function in capital, K_t, and effective units of labor, $L_t = \int h_t x_t d\mu$. Capital depreciates at the rate δ each period and the total factor productivity of the country is A:

$$Y_t = F(L_t, K_t) = A{L_t}^{\alpha}{K_t}^{1-\alpha}.$$

Government: The government operates a progressive tax/transfer system and spends on government purchases, G_t, which do not directly enter into the household's utility function.[12] The government runs a balanced budget each period:

$$G_t = \int \left\{ \big(w_t x_t h(a_t, x_t) + r_t a_t\big) - \lambda\big(w_t x_t h(a_t, x_t) + r_t a_t\big)^{1-\tau} \right\} d\mu(a_t, x_t).$$

[12]When we consider tax reform below, we will assume that the government purchase is fixed at the current steady-state level ($\bar{G}$).

Recursive Representation: It is useful to consider a recursive equilibrium. Let $V(a,x)$ denote the value function of a household with asset holdings a and productivity x. Then, V can be expressed as follows:

$$V(a,x) = \max_{c,h} \left\{ \frac{c^{1-\sigma}-1}{1-\sigma} - B\frac{h^{1+1/\gamma}}{1+1/\gamma} + \beta\mathbb{E}\big[V(a',x')|x\big] \right\}$$

subject to

$$c + a' = \lambda(wxh + ra)^{1-\tau} + a,$$

$$a' \geq \underline{a}.$$

The intertemporal first-order condition for optimal consumption is:

$$c(a,x)^{-\sigma} = \beta\mathbb{E}\big[\big\{1 + \lambda(1-\tau)(w'x'h' + r'a')^{-\tau}r'\big\}c(a',x')^{-\sigma}\big].$$

The intra-temporal first-order condition for optimal hours worked is:

$$Bh(a,x)^{1/\gamma}c(a,x)^{\sigma} = \lambda(1-\tau)(wxh + ra)^{-\tau}wx.$$

Equilibrium: A stationary equilibrium consists of a value function, $V(a,x)$; a set of decision rules for consumption, asset holdings, and labor supply, respectively, $c(a,x)$, $a'(a,x)$, and $h(a,x)$; aggregate input, K and L; and the invariant distribution of households, μ(a,x), such that:

1. Individual households optimize: Given w and r, the individual decision rules $c(a,x)$, $a'(a,x)$, $h(a,x)$, and $V(a,x)$ solve the Bellman equation.

2. The representative firm maximizes profits:

$$w = \alpha A(K/L)^{1-\alpha}$$

$$r + \delta = (1-\alpha)A(K/L)^{-\alpha}.$$

3. The goods market clears:

$$\int \big\{a'(a,x) + c(a,x)\big\}d\mu = F(L,K) + (1-\delta)K.$$

4. The factor markets clear:

$$L = \int xh(a,x)d\mu$$
$$K = \int ad\mu.$$

5. The government balances the budget:

$$G = \int \{wxh(a,x) + ra - \lambda(wxh(a,x)+ra)^{1-\tau}\}d\mu.$$

6. Individual and aggregate behaviors are consistent: For all $A^0 \subset \mathcal{A}$ and $X^0 \subset \mathcal{X}$,

$$\mu(A^0, X^0) = \int_{A^0,X^0} \left\{ \int_{\mathcal{A},\mathcal{X}} \mathbf{1}_{a'=a'(a,x)} d\pi_x(x'|x)d\mu \right\} da'dx'.$$

4. Quantitative Analysis

4.1. Calibration

Our calibration strategy is as follows. First, we calibrate our model economy to reproduce the salient features of the U.S. economy. Second, we assume that underlying preferences (i.e., discount factor β, risk aversion σ, and Frisch elasticity of labor supply γ) and production technology (such as the labor income share α) are identical across countries. Finally, we choose 4 country-specific parameters (the disutility from working B, the magnitude of individual productivity shocks σ_x, and two parameters in the tax/transfer function (λ and τ)) to match 4 data moments (average hours of work H, the government purchase to GDP ratio G/Y, and the before- and after-tax income Ginis) for each country.

Common Parameters: The time unit is one year. The labor-income share, α, is 0.64, and the annual depreciation rate of capital, δ, is 10%. Workers are not allowed to borrow, so $\underline{a} = 0$. Since many households are actually in debt, we also report the results when borrowing is allowed in Section 5.7. The relative risk aversion (σ) and the labor supply elasticity (γ) and time discount factor (β) may be important determinants of the optimal tax policy. We will assume that preferences are identical across countries to highlight the role of differences in taxes.

As is common in the macroeconomic literature, the relative risk aversion, σ, is assumed to be one (i.e., the log utility in consumption) to be consistent with the balanced growth path.[13] The Frisch elasticity of labor supply, γ, is set to 0.5, close to the estimates in the literature (e.g., Keane (2011), Chetty et al. (2011)). The time discount factor, β, is set so that the real interest rate is 4%, which is the average real rate of returns to capital in the U.S. for the post-World War II period. Given the log preference in consumption ($\sigma = 1$), the labor supply decisions along the balanced growth path does not depend on the level of TFP. Thus, we abstract from the differences in the level of TFP across countries.

Country-Specific Parameters: Individual productivity x is assumed to follow an AR(1) process: $\ln x' = \rho_x \ln x + \varepsilon_x$, where $\varepsilon_x \sim N(0, \sigma_x^2)$. A sizable literature has estimated this process using wages from panel data, including Floden and Linde (2001), Chang and Kim (2006), and Heathcote et al. (2008). While there are differences in the estimates of the magnitude of the shocks, the consensus is that these shocks are large and persistent. Our benchmark model adopts a persistence value of $\rho_x = 0.92$, also used in Floden and Linde (2001) and Pijoan-Mas (2006). We assume that this value is common across countries, consistent with many empirical studies that find highly persistent wage processes in various countries. The magnitude of the shocks, σ_x, is set to match the before-tax income Gini coefficient in each country. The chosen value of σ_x for the U.S. is 0.36, somewhat larger than the estimate (0.21) by Floden and Linde (2001) based on the Panel Study of Income Dynamics. We interpret x as a broad measure of households' ability to generate labor income (broader than the pure stochastic components of individual wages). Thus, the model requires a larger value of σ_x to match the overall cross-sectional distribution of household incomes. The required value of σ_x across countries ranges from 0.22 (South Korea) to 0.48 (Ireland).

[13] Chetty (2006) argues that a mean estimate of the risk aversion is close to one. Gandelman and Hernández-Murillo (2015) estimate the coefficient of risk aversion for 75 countries and argue that the coefficient varies closely around one. Among the OECD countries, the null hypothesis of the coefficient log utility is rejected in only one country (S. Korea).

As described in the previous section, we assume that the individual income tax schedule follows the log-linear tax function. In the log-linear tax function, two parameters, λ (which affects the average level of tax) and τ (tax progressivity), characterize disposable income (market income, y_i, minus taxes plus public transfer), $D(y_i)$, as a function of the household's market income y_i: $D(y_i) = \lambda y_i^{1-\tau}$. We choose λ to achieve the balanced budget of the government. The G/Y ratio of each country is set to the average government-consumption-to-GDP ratio in the data. The current progressivity of income tax, τ_0, in our model is calibrated to match the Gini coefficients after taxes and transfers. Note that since the income distribution is endogenous, we need to iterate the values of σ_x and τ_0 until the model exactly matches the before- and after-tax income Gini coefficients in the data. The model-implied τ_0 for the U.S. is 0.264, slightly larger than the estimate of 0.20 by Heathcote et al. (2016) and our own estimate of 0.248 based on the LIS data in Section 2. Across 32 countries, the model-implied τ ranges between 0.051 (Chile) and 0.511 (Ireland). Finally, the disutility from working, B, is chosen so that average hours worked in the steady state become the average work hours for each country, which is the average share of discretionary time devoted to working.[14]

Table 4 summarizes the parameter values of the benchmark model economy. Table C.1 in the Appendix lists the values of B, σ_x, and τ_0 for all 32 countries.

4.2. Steady State

Table 5 compares the calibrated tax progressivity for 3 countries: the U.S., Sweden, and Chile. (We report these statistics for all 32 OECD countries in Appendix Table C.1.) We chose Sweden as an example of countries that adopt an aggressive redistribution policy: the Gini coefficient decreases by 39% as a result of taxes and transfers. We chose Chile as an opposite case, the country that exhibits the smallest decrease in the Gini coefficient–a 4.3% decrease after taxes and transfers. As we calibrate the magnitude of the productivity shock and the tax progressiviity to match the before and after tax/transfer income Gini

Table 4: Parameters of the Benchmark Economy

Common for All Countries		
β	0.958	Time discount factor
σ	1.00	Relative risk aversion
γ	0.50	Labor supply elasticity
ρ	0.92	Persistence of idiosyncratic productivity
α	0.64	Labor share in production function
δ	0.10	Depreciation rate of captial
Country-Specific Parameters		
B	9.02 - 31.08	Disutility from working
σ_x	0.22 - 0.48	Std. deviation of idiosyncratic shocks
τ_0	0.05 - 0.51	Income tax rate

Note: See Table C.1 in the Appendix for the values of B, σ_x, and τ_0 for each country.

coefficients, two Gini coefficients in the model are identical to those in the data (Table 1).

The model-implied progressivity (τ_0) is also close to the estimated progressivity from the LIS ($\hat{\tau}$). Figure 3 compares the estimated tax progressivity in the LIS and those implied by our model. Two values are closely related (correlation coefficient of 0.77).[15]

According to our calibration strategy, by construction, the model closely matches the before- and after-tax Gini coefficients in the data. To check whether our model captures other moments of the income distributions in the data, we also compare the income ratios across deciles between the model and the data in Table 6. For example, the "P90/P10" ratio denotes the income ratio between the 90th and 10th percentile of the income distri-

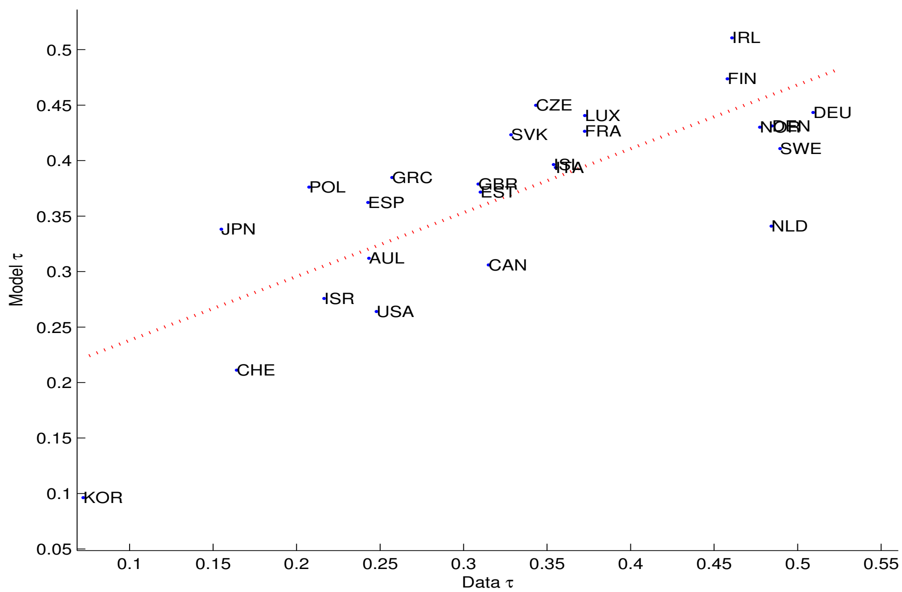
[14]We normalize the average annual working hours in 2010 (OECD, 2015) by the total discretionary hours of 5,500.

[15]Given the benchmark (based on the U.S. economy) β, we choose the magnitude of the individual productivity shock (σ_x) and the income tax progressivity (τ_0) to replicate the before- and after-tax income inequality. Thus, the equilibrium interest rate (r) will be different across countries. A larger σ_x implies a larger uncertainty for individual households. This strengthens precautionary savings motives, which in turn lowers the real interest rate. A strong redistribution policy in the form of a high tax progressivity (τ) reduces the incentive to work and provides insurance (thus raising the real interest rate). Table C.1 in the Appendix reports the equilibrium real interest rate and average hours of work for all 32 countries.

Table 5: Results for 3 Countries

	U.S.	Sweden	Chile
Decrease in Gini after tax/transfer	23.8%	39%	4.3%
Progressivity from LIS ($\hat{\tau}$)	0.248	0.489	...
Magnitude of shocks (σ_x)	0.358	0.329	0.365
Model-implied progressivity (τ_0)	0.264	0.411	0.051
– Marginal tax rate for median	29%	49%	18%
Optimal Progressivity (τ^*)	0.292	0.210	0.327
– Marginal tax rate for median	31%	32%	31%
– Approval Rate for τ^*	55%	81%	79%
Progressivity chosen by majority voting (τ^M)	0.294	0.221	0.321
Weighting parameter (η)	0.182	-2.187	1.141
Pareto Weights			
1^{st} quintile	0.853	2.698	0.204
2^{nd}	0.950	1.014	0.473
3^{rd}	1.003	0.644	0.765
4^{th}	1.055	0.419	1.188
5^{th}	1.138	0.225	2.370

Figure 3: Tax Progressivity (τ): Model vs. Data



Note: The values for the data are estimated using LIS (2016).

bution. For the U.S. both the P90/P10 (5.7) and the P50/P10 (2.3) ratios in our models are slightly smaller than those (6.1 and 2.7) in the data. However, the overall income ratios across deciles in our model are quite similar to those in the data. The correlation coefficients of those ratios between our models and the data are 0.96 (P90/P10), 0.95 (P90/P50) and 0.83 (P50/P10) across countries.

5. Optimal Tax Reform and Pareto Weights

We developed a quantitative model that matches the before- and after-tax income Gini coefficients in the data and illustrated that it approximates the progressivity of the income tax schedules of 32 OECD countries fairly well. We now ask the following questions using this model economy: (i) What is the optimal progressivity of the income tax schedule (τ) for each country under the equal-weight utilitarian social welfare function? (ii) Would a majority of the population vote for the policy reform that proposes to adopt the utilitarian optimal progressivity? (iii) What are the Pareto weights in the social welfare function that justify the current progressivity τ_0, which is suboptimal under the equal weights?

Table 6: Disposable Income Ratios across Percentiles

	Model			Data		
	P90/P10	P90/P50	P50/P10	P90/P10	P90/P50	P50/P10
Australia	4.7	2.2	2.2	4.5	2.0	2.2
Austria	3.3	1.8	1.8	3.5	1.8	1.9
Belgium	3.2	1.8	1.7	3.3	1.7	2.0
Canada	4.4	2.1	2.1	4.1	2.0	2.1
Chile	11.1	3.4	3.3	...	...	...
Czech Republic	3.1	1.8	1.8	3.1	1.7	1.8
Denmark	3.1	1.8	1.7	2.9	1.6	1.8
Estonia	4.3	2.1	2.1	4.4	2.1	2.1
Finland	3.2	1.8	1.7	3.2	1.7	1.9
France	3.9	2.0	1.9	3.6	1.9	1.9
Germany	3.6	1.9	1.9	3.6	1.9	1.9
Greece	4.6	2.2	2.1	4.6	2.0	2.3
Iceland	3.0	1.7	1.7	2.8	1.6	1.7
Ireland	3.6	2.0	1.8	3.8	2.0	1.9
Israel	5.6	2.4	2.4	6.4	2.2	2.9
Italy	4.2	2.1	2.1	4.3	2.0	2.2
Japan	4.7	2.2	2.2	...	...	...
Korea	4.2	2.1	2.0	4.8	1.9	2.5
Luxembourg	3.3	1.8	1.8	3.4	1.9	1.8
Netherlands	3.8	1.9	2.0	3.3	1.8	1.8
New Zealand	4.5	2.1	2.1	...	...	...
Norway	3.1	1.8	1.7	2.9	1.6	1.8
Poland	4.1	2.0	2.0	4.0	1.9	2.1
Portugal	4.8	2.2	2.2	4.6	2.2	2.1
Slovak Republic	3.2	1.8	1.8	3.2	1.8	1.8
Slovenia	3.0	1.7	1.7	3.2	1.7	1.9
Spain	4.7	2.2	2.2	4.8	2.1	2.3
Sweden	3.4	1.8	1.8	3.3	1.7	2.0
Switzerland	3.9	2.0	1.9	...	...	...
Turkey	6.7	2.6	2.5	6.5	2.5	2.6
United Kingdom	4.7	2.2	2.2	4.1	2.1	2.0
United States	5.7	2.4	2.3	6.1	2.3	2.7

5.1. Optimal Tax and Social Welfare

One of the important topics in public economics is how to design an optimal tax schedule. This task often requires aggregating individual preferences, which is challenging and controversial. A common practice is to use a social welfare function that averages the utility of the population with equal weights. For example, in the context of our model, when the society adopts a new tax progressivity τ (once-and-for-all change from τ_0), the social welfare is:[16]

$$\mathcal{W} \equiv \int V(a, x; \tau)\, d\mu_0(a, x),$$

where $V(a, x; \tau)$ is the discounted sum of the lifetime utility of a household with asset holdings a and productivity x and $\mu_0(a, x)$ is the steady-state distribution of households under τ_0. In other words,

$$V(a, x; \tau) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t(a, x; \tau)^{1-\sigma} - 1}{1-\sigma} - B \frac{h_t(a, x; \tau)^{1+1/\gamma}}{1+1/\gamma} \right\}.$$

We would like to find the optimal progressivity τ^* that maximizes the above equal-weight utilitarian social welfare function for each of the 32 OECD countries. We assume that each country is at the steady state under its current tax progressivity τ_0 as reported in Table C.1. We look for the tax progressivity τ^* that maximizes the social welfare $\mathcal{W}$, *including* the welfare of households during the transition periods to the new steady state. A detailed computational algorithm is provided in Appendix B.2.

Table 5 reports the optimal progressivity of income tax for 3 countries: the U.S., Sweden, and Chile. In the U.S., the optimal tax progressivity is 0.29, higher than the current progressivity of 0.26. Under the optimal τ^*, the marginal tax rate of the median household would increase from 29% to 31.1%. For Chile, the optimal progressivity (0.33) is more than 5 times larger than the current level (0.06). The marginal tax rate of the median household would increase from 17.5% to 30.8% under the optimal τ^*.

In Sweden, however, the current τ (0.41) is larger than the optimal level (0.21) according to the equal-weight utilitarian social welfare. Table 7 reports the optimal progressivity

[16]This utilitarian social welfare function has been commonly used in the literature (e.g., Aiyagari and McGrattan (1998)).

of the income tax schedules for all 32 countries. The optimal progressivity is larger than the (model-implied) current progressivity ($\tau^* > \tau_0$) in 4 countries (Chile, S. Korea, Turkey and the U.S.). If we compare the optimal progressivity to those estimated from the LIS ($\tau^* > \hat{\tau}$), Australia, Greece, Israel, Poland, Spain, and the U.K. are also included in this list.

5.2. Approval Rate for Optimal Tax Reform

According to our model, the current tax progressivity is different from the optimal progressivity for almost all OECD countries—in Switzerland, the current progressivity (0.215) is close to optimal (0.211). A fiscal reform is hardly Pareto improving—there will be winners and losers. We now ask whether the majority of the population would support the optimal progressivity. We simulate a binary voting between the current (τ_0) and the optimal (τ^*) tax progressivity. Given the once-and-for-all reform (permanent and irreversible), a household would vote for the optimal tax reform if $V(a, x; \tau^*) > V(a, x; \tau_0)$. We take into account welfare during the transition period to the new steady state.

Table 5 shows that the optimal tax reform is supported by the majority of the population in all three countries. In the U.S., 55% of the population support a policy proposal to increase the tax progressivity to the optimal level. In Chile, 79% of the population support the optimal tax reform. In Sweden, the majority of the population would vote to decrease the progressivity of the income tax schedule. Table 7 reports the approval rates for the optimal tax reform for all 32 OECD countries. Essentially, for all countries, the fiscal reform to adopt the optimal tax progressivity is supported by the majority of the population.

5.3. Close-to-Optimal Tax Chosen by the Majority

As an alternative to the majority rule, one may argue that the political outcome should be the tax rate that maximizes the welfare of the median households instead of the average—the so-called median voter theorem. However, the median voter theorem may not be easily applicable in our model where households differ in multiple dimensions and the characteristics of households (assets and productivity) change over time. We

Table 7: Tax Reform and Marginal Tax Rate

	Data	Current		Utilitarian Optimal			Majority Chosen	
	$\hat{\tau}$	τ_0	T'_m	τ^*	T'_m	Approve	τ^M	T'_m
Australia	0.243	0.312	34.6%	0.266	30.8%	57.4%	0.272	31.3%
Austria	...	0.464	45.9	0.289	29.0	76.6	0.304	30.1
Belgium	...	0.472	49.3	0.272	30.2	81.5	0.282	30.9
Canada	0.315	0.306	40.0	0.212	32.8	63.2	0.216	33.1
Chile	...	0.051	17.5	0.327	30.8	78.6	0.321	30.3
Czech Republic	0.343	0.450	47.2	0.259	29.5	78.3	0.270	30.3
Denmark	0.485	0.431	53.2	0.188	32.7	86.5	0.201	33.5
Estonia	0.310	0.372	39.1	0.277	31.0	63.6	0.282	31.3
Finland	0.458	0.474	50.3	0.268	30.7	82.8	0.284	31.9
France	0.373	0.426	44.7	0.281	31.2	73.4	0.286	31.7
Germany	0.509	0.443	42.3	0.304	28.8	71.3	0.313	29.6
Greece	0.257	0.385	38.7	0.300	31.0	62.9	0.305	31.4
Iceland	0.354	0.396	50.5	0.161	31.2	83.7	0.176	32.2
Ireland	0.461	0.511	37.5	0.386	22.1	70.5	0.401	23.7
Israel	0.216	0.276	36.0	0.251	34.2	53.3	0.256	34.5
Italy	0.355	0.394	39.5	0.294	30.5	64.9	0.304	31.3
Japan	0.155	0.338	36.7	0.274	31.5	59.4	0.278	31.7
Korea	0.072	0.096	24.2	0.131	26.6	55.5	0.136	27.0
Luxembourg	0.373	0.441	41.9	0.295	28.0	71.0	0.301	28.4
Netherlands	0.484	0.341	47.5	0.164	33.8	76.2	0.171	34.2
New Zealand	...	0.309	37.4	0.237	31.7	60.0	0.239	31.9
Norway	0.477	0.430	48.3	0.223	30.0	80.2	0.230	30.5
Poland	0.207	0.376	39.5	0.272	30.5	64.9	0.276	30.8
Portugal	...	0.372	37.0	0.303	30.9	60.3	0.312	31.6
Slovak Republic	0.328	0.423	45.0	0.250	29.4	74.8	0.263	30.4
Slovenia	...	0.475	48.4	0.270	28.8	80.7	0.285	30.0
Spain	0.243	0.362	37.5	0.290	31.2	60.7	0.292	31.4
Sweden	0.489	0.411	49.3	0.210	32.3	80.9	0.221	33.0
Switzerland	0.164	0.211	25.5	0.215	25.8	52.1	0.221	26.3
Turkey	...	0.141	22.8	0.276	31.1	67.1	0.271	30.8
United Kingdom	0.309	0.379	34.2	0.325	29.2	58.3	0.329	29.5
United States	0.248	0.264	29.0	0.292	31.1	54.8	0.294	31.3

Note: Data $\hat{\tau}$ are the tax progressivity estimated from the LIS database. T'_m denotes the marginal tax rate (%) for the median income worker. "Approve" is the approval rate (%) for the optimal tax reform. "Majority Chosen" (τ^M) refers to the progressivity chosen by the successive majority voting.

address this issue by finding the close-to-optimal progressivity that would be approved by the majority under the successive binary voting. More specifically, we simulate the binary voting between the current (e.g., $\tau_0 = 0.26$ for the U.S.) and a candidate (e.g., $\tau = 0.27$) that is 0.01 closer to the optimal. If the proposed progressivity is approved by the majority, we immediately propose the next candidate (e.g., $\tau = 0.28$) that is closer to the optimal and simulate the binary voting between the previous winner ($\tau = 0.27$) and the new contender ($\tau = 0.28$) and so forth. The final winner of the binary voting can be interpreted as a politically feasible reform that is closest to the optimal tax progressivity. The results based on this successive voting simulation for 32 countries are summarized in the last column in Table 7. The progressivity chosen by this successive voting is actually very close to the optimal progressivity in most countries. For example, in the U.S. the successive binary voting will eventually achieve the utilitarian optimum.

5.4. Pareto Weights in Practice

We have shown that the current income tax schedule is far from optimal and that the majority of the population would support the optimal tax reform in almost all 32 OECD countries. Then, why haven't these countries adopted the optimal progressivity? The optimality depends on the specification of the social welfare function. For example, it is not obvious whether the equal-weight utilitarian welfare function (often used in the literature) is the actual objective of these societies (or governments). It is well known that equity is highly valued in many societies. Moreover, the decision-making process in selecting policies is much more complex than a simple majority rule. For instance, the rich often have more resources to influence the outcome of policy debates (e.g., lobbies). Heathcote et al. (2016) and Weinzierl (2016) emphasize the role of government expenditure in determining the optimal tax policy. Weinzierl (2014) presents the survey report that many respondents prefer the principle of "equal sacrifice" over conventional utilitarian objectives. Charité et al. (2015) argue that the reference point affects individual preferences for redistribution. These questions are immensely important but beyond the scope of this paper.

In this subsection, we ask a rather simple question within the utilitarian framework:

for each country, what are the weights in the social welfare function that would justify the current tax progressivity? We interpret these weights—the so-called Pareto weights—as a reduced-form representation of a society's preferences and political decision-making process. For example, if a society is plutocratic, the government would assign larger weights to rich households, whereas an egalitarian society is likely to assign larger weights to poor households.

We assume that the Pareto weight θ exhibits the following parametric form in consumption where η reflects the slope of Pareto weights in the cross-sectional distribution of consumption:

$$\mathcal{W} \equiv \int \theta(\tau_0) V(a,x;\tau) d\mu_0(a,x),$$
$$\text{where} \quad \theta(\tau_0) = \frac{c_0(a,x)^\eta}{\int c_0(a,x)^\eta d\mu_0(a,x)}.$$

The case with $\eta = 0$ corresponds to the equal-weight utilitarian social welfare function. The case with $\eta > 0$ can be interpreted as a plutocracy or the political system where larger weights are assigned to the rich. The case with $\eta < 0$ can be interpreted as a strong preference for an egalitarian society. As η goes to negative infinity, the social welfare function approaches the Rawlsian.[17]

The value of η that justifies the current tax progressivity (τ_0) as the social optimum is the solution to the following problem:

$$\tau_0 = \underset{\tau}{\text{argmax}}\ \mathcal{W} = \underset{\tau}{\text{argmax}} \int \theta(\tau_0) V(a,x;\tau) d\mu_0(a,x). \tag{1}$$

Using the value of η that solves the above problem, we can uncover the Pareto weights that justify the current redistribution policy τ_0.[18]

[17]The slope parameter for Pareto weights η can be related to the "inequality aversion" in Benabou (2002) as follows. Benabou (2002) defines the social welfare function as: $\mathcal{U}_\psi \equiv \ln\left(\int_0^1 (U^i)^{\frac{\psi-1}{\psi}} di\right)^{\frac{\psi}{\psi-1}}$, where U^i is the utility of agent i, and ψ is an interpersonal elasticity of substitution. According to this criterion, $1/\psi$ measures society's degree of inequality aversion. To a first-order approximation (in logs) his index is related to our social welfare function as: $\mathcal{U}_\psi \approx \int_0^1 \frac{(U^i)^{-\frac{1}{\psi}}}{\int_0^1 (U^i)^{\frac{\psi-1}{\psi}} di} (U^i - U^i_{ss}) di$, where U^i_{ss} is the utility of agent i in the steady state. Thus, the slope of Pareto weights (η) in our social welfare function is proportional to the inequality aversion (-$\frac{1}{\psi}$).

[18]We numerically show that a progressive tax schedule indeed results in a smaller value of

We would like to mention a caveat regarding our choice of Pareto weights θ. The Pareto weights are often assumed to depend on a household's inherent characteristics (or permanent type) such as ability and preferences. In a static environment, a household's productivity is a natural choice (e.g., Heathcote and Tsujiyama (2016) and Saez and Stantcheva (2016)). Unfortunately, our model does not have any ex ante heterogeneity. In a dynamic environment such as our model where households can save and their productivities change over time, the state of the household depends on two variables: asset holdings (a) and productivity (x). (For technical reasons, we would like to have Pareto weights as one dimensional. When Pareto weights depend on multiple variables, we cannot guarantee the unique representation of Pareto weights for a given distribution of assets and productivity.) According to the permanent income hypothesis, consumption is a better proxy for the well-being of the household than the current level of productivity is. One drawback of using consumption is that it is an endogenous variable, which makes it difficult to use the weights, as they are, for welfare analysis of an alternative (counter-factual) policy.[19] Despite the endogeneity issue, we believe that our attempt is still a valid exercise to infer information from a *steady-state* distribution and we can interpret the uncovered weights as reflecting the underlying social preferences (or political equilibrium) of the status quo.[20]

According to our model, $\eta = 0.18$ is required to justify the current U.S. tax progressivity $\tau_0 = 0.26$ (given the steady-state distribution $\mu_0(a, x)$) as socially optimal. Since $\eta > 0$ the Pareto weight increases with the level of consumption; the social welfare function assigns larger weights to the rich. Table 5 reports the Pareto weights (implied by this

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η, according to the above problem in Equation (1). Based on our calibrated U.S. economy, we compute the steady-state equilibrium under various τ's. Then, we solve for η that justifies the given τ as a social optimum. Figure C in the Appendix shows that there is a monotonically decreasing relationship between η and the given τ.

[19] See Chang (2016) for various counter-factual welfare analyses of changes in the productivity trend when Pareto weights are assumed to depend on the permanent component of productivity only.

[20] From a practical point of view, it is not uncommon to tie the shape of Pareto weights to endogenous variables such as the observed income distribution (e.g., Lockwood and Weinzierl (2016) and many other empirical works), which may be contaminated by endogenous labor-supply responses (to productivity as well as non-labor income).

value of $\eta = 0.18$ and the steady-state distribution $\mu_0(a, x)$) for 5 consumption quintile groups. The average Pareto weights are 0.85, 0.95, 1.00, 1.06, and 1.14, respectively, from the 1st (poorest 20%) to the 5th (richest 20%) quintiles. In Sweden, $\eta = -2.19$ justifies the current tax progressivity. As $\eta < 0$, the social welfare function assigns smaller weights to the rich. The average Pareto weight on the poorest 20% of households is 2.70, about 12 times as large as that of the richest 20% (0.23). By contrast, in Chile $\eta = 1.14$ justifies the current tax progressivity and steady-state distribution. The average Pareto weight of the richest 20% of households (2.37) is almost 12 times as large as that of the poorest 20% (0.2).

Table 8 reports the values of η and the Pareto weights that justify the current tax progressivity for each of 32 OECD countries. We sort them in a descending order of η. Four countries—Chile (1.14), Turkey (0.72), S. Korea (0.24), and the U.S. (0.13)—exhibit a positive slope: i.e., larger weights on the rich. Switzerland (0.031) shows pretty much equal weights across households. The next group of countries puts slightly larger weights on the poor (a ratio of less than 3 between the poorest 20% and the richest 20%). The final group of countries puts significantly larger weights on the poor. For example, the social welfare function of Denmark puts almost 30 times larger weights on the poorest 20% than the richest 20%.

5.5. Potential Sources for Unequal Pareto Weights

We found that the shape of Pareto weights in the social welfare function varies vastly across 32 OECD countries. A Pareto weight is a reduced-form representation of complex aspects of the society (such as preferences for equity, the electoral system, and the distribution of political power, etc.). Understanding how each of these components affects the Pareto weights is beyond the scope of this paper. Here, we propose three measures that are potentially important for the shape of the Pareto weights: democracy of the political system, electoral voting turnout rates by income, and the society's perception of equity.

One may expect that a democratic society is less subject to plutocracy and tends to advocate an equal distribution of resources and opportunities. Thus, such a society is more likely to adopt a stronger redistribution policy. To examine this premise, we obtain

Table 8: Pareto Weights across OECD Countries

	Parameter	Consumption Quintile				
	η	1st	2nd	3rd	4th	5th
Chile	1.141	0.20	0.47	0.76	1.19	2.37
Turkey	0.726	0.47	0.74	0.95	1.18	1.66
Korea	0.243	0.85	0.95	1.00	1.06	1.14
United States	0.182	0.85	0.95	1.00	1.06	1.14
Switzerland	0.031	0.98	0.99	1.00	1.01	1.02
Israel	-0.160	1.14	1.04	0.99	0.95	0.89
Australia	-0.336	1.27	1.06	0.97	0.90	0.80
United Kingdom	-0.427	1.35	1.08	0.96	0.87	0.74
Japan	-0.497	1.41	1.09	0.95	0.84	0.70
Portugal	-0.550	1.47	1.09	0.94	0.82	0.67
New Zealand	-0.549	1.44	1.09	0.95	0.83	0.69
Spain	-0.583	1.50	1.10	0.94	0.81	0.66
Greece	-0.720	1.62	1.11	0.92	0.77	0.59
Canada	-0.736	1.61	1.10	0.92	0.77	0.60
Estonia	-0.792	1.65	1.11	0.91	0.76	0.58
Italy	-0.885	1.74	1.11	0.89	0.73	0.53
Poland	-0.906	1.72	1.11	0.89	0.73	0.54
Germany	-1.501	2.16	1.11	0.79	0.58	0.36
France	-1.511	2.26	1.09	0.77	0.55	0.33
Luxembourg	-1.558	2.14	1.11	0.80	0.58	0.37
Netherlands	-1.642	2.35	1.06	0.74	0.53	0.32
Slovak Republic	-1.877	2.37	1.08	0.74	0.51	0.30
Ireland	-1.913	2.50	1.11	0.70	0.45	0.23
Sweden	-2.187	2.70	1.01	0.64	0.42	0.23
Austria	-2.198	2.64	1.05	0.66	0.43	0.22
Czech Republic	-2.303	2.67	1.03	0.65	0.42	0.22
Norway	-2.444	2.74	1.01	0.63	0.40	0.21
Iceland	-2.711	2.94	0.95	0.57	0.36	0.18
Belgium	-2.824	3.09	0.94	0.53	0.30	0.14
Slovenia	-2.919	3.03	0.96	0.54	0.32	0.15
Finland	-3.041	3.28	0.89	0.47	0.26	0.11
Denmark	-3.066	3.26	0.87	0.48	0.27	0.12

the Democracy Index from the Economist Intelligent Unit (EIU). The EIU evaluates the development of democracy in a society based on 60 questions in 5 categories: (i) electoral process and pluralism, (ii) functioning of government, (iii) political participation, (iv) political culture, and (v) civil liberties. A country is scored from 0 to 10 in each of the 5 categories. A country's Democracy Index is its average score across these 5 categories.[21] According to the EIU, among the OECD countries, Norway (9.8) is the most democratic, Turkey (5.73) is the least, and the U.S. (8.18) is around the median. The Democracy Index is modestly positively correlated (0.36) with the tax-to-GDP ratio. It is modestly correlated (0.32) with the improvement rate of the income Gini. Figure 4 compares the slope of the Pareto weight η implied by our model to the Democracy Index ($y-$axis) across the 32 OECD countries. They are modestly negatively correlated (-0.46): a democratic society tends to put more weights on the poor. If we exclude formerly Communist societies, where equity is highly valued, the two variables are more strongly negatively correlated (-0.60).

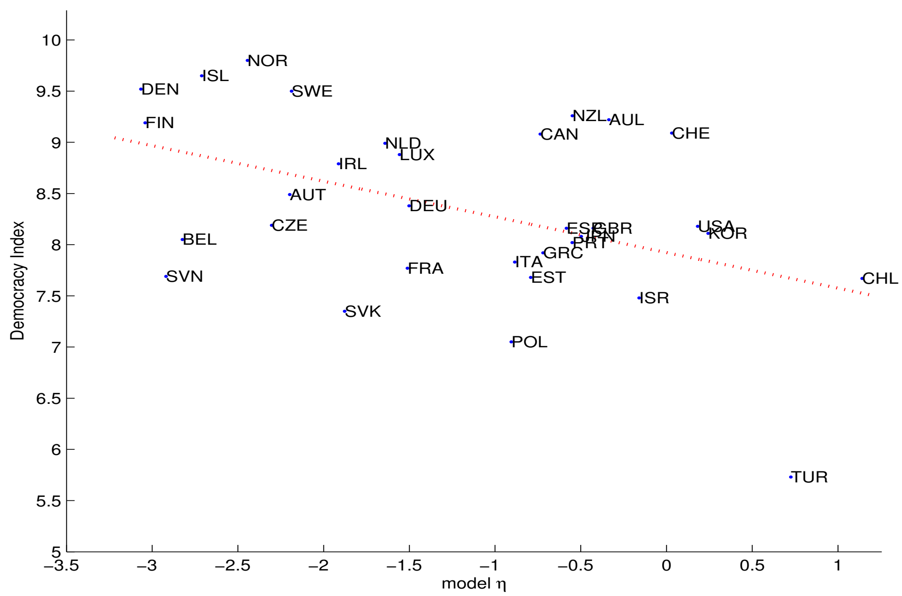
Another possible interpretation of Pareto weights in the social welfare function is turnout rates in voting. It is well known that low-income earners are less likely to vote than are high-income earners. We use Mahler's (2008) estimates on the electoral turnout rates by income quintiles across 15 countries from the Comparative Study of Electoral Systems.[22] Figure 5 plots the Gini coefficient of turnout rates in each country against our estimate of η across these 15 countries. The two variables are modestly positively correlated (0.43). In a country where the rich participate in voting more actively than the poor, they receive larger weights in the social welfare function.

The society's taste for equity can be different across countries, too. The World Values

[21] Two alternative—and perhaps more commonly used—measures of democracy are those from the Freedom House and Polity IV. However, these measures are not suitable for our analysis, since they do not show much variation across the 32 OECD countries. For instance, according to the Freedom House Democracy Index, 31 OECD countries are classified as "Free" and only Turkey is ranked "Partially Free." According to the Polity IV Index, most of the OECD countries score 10, with the exceptions of Estonia (9), France (9), Belgium (8), the Czech Republic (8), South Korea (8), and Turkey (8).

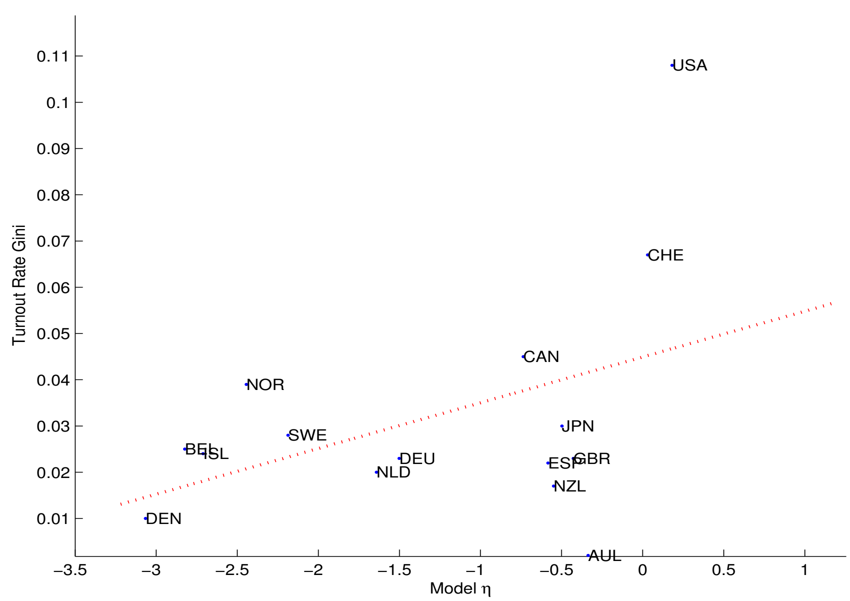
[22] They include Australia, Belgium, Canada, Denmark, Germany, Iceland, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the U.K., and the U.S.

Figure 4: Democracy Index and Slope of Pareto Weights (η)



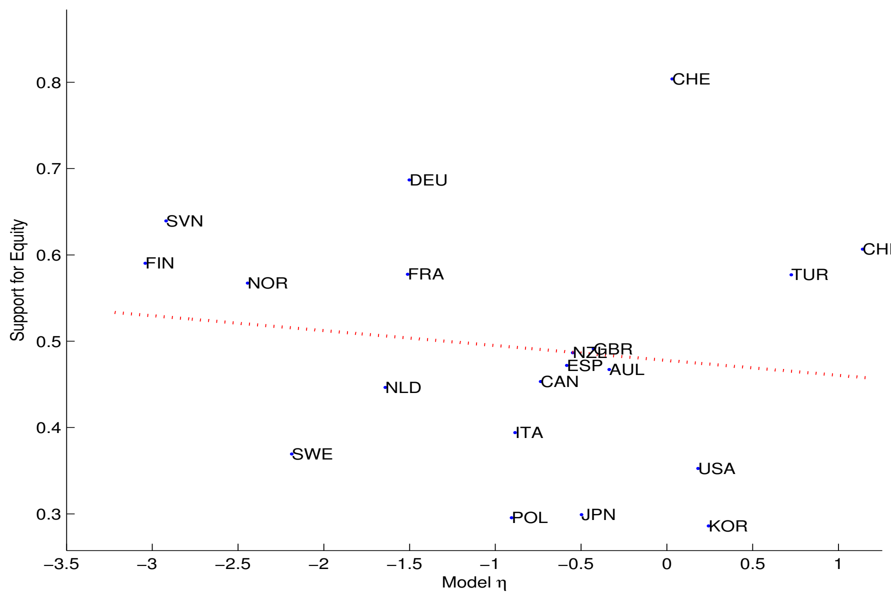
Note: Democracy Index (y-axis) is from the Economist Intelligence Unit (EIU).

Figure 5: Voter Turnout Rates by Income and Slope of Pareto Weights (η)



Note: The Gini coefficients in turnout rates (y-axis) are from Mahler (2008).

Figure 6: Fraction of Population in Favor of More Redistribution and η



Note: The fraction of the population in favor of more redistribution (y-axis) is taken from the WVS.

Survey (WVS) examines the perception of various social issues in almost 100 countries. One of the survey questions asks about the trade-off between equity and efficiency in income redistribution. The participants choose their views on a scale of 0-10 between "Incomes should be made more equal (0)" and "We need larger income difference as incentives for individual effort" (10). We calculate the fraction of the population with a scale between 0 and 5 (who are favorable to more income redistribution). Figure 6 compares the slope of Pareto weights η implied by our model for this measure (the fraction of people who favor redistribution). The two measures are mildly negatively correlated (-0.14). However, we would like to add one caveat in interpreting this correlation. It is not clear whether respondents' answers in the WVS represent the underlying social preferences for equity or their discontent with the current income distribution. Respondents may have expressed their opinions (perhaps their frustration with) about the *current* redistribution policy. This endogenous nature of the survey answers may explain the low correlation between the two measures.

5.6. Comparison to the Mirrleesian (1971) Approach

A highly popular approach to estimating the Pareto weights is to use the Mirrlees (1971) model. While most Mirrleesian models are static, which prevents a direct comparison to our model (which allows for savings), it might still be of interest to compare the marginal weights in the social welfare function in two different approaches. Lockwood and Weinzierl (2016) estimate the marginal social weights (marginal utility multiplied by Pareto weight) of the U.S. based on the CBO's income data and the marginal tax schedule from the NBER's TAXSIM. According to the optimal tax rate formula derived in Saez (2001), they derive the marginal social welfare weights as:

$$g(y) = -\left(\frac{1}{f(y)}\right)\frac{d}{dy}\left[1 - F(y) - \frac{T'(y)}{1-T'(y)}(\epsilon y f(y))\right] \tag{2}$$

where $g(y)$, y, $F(y)$, $f(y)$, $T(y)$, and ϵ are marginal social welfare weights, earnings, the cumulative distribution of earnings, the marginal density of earnings distribution, the income tax code, and the elasticity of taxable income (ETI), respectively. Figure 7, taken from Lockwood and Weinzierl (2016), exhibits the estimated marginal social welfare weights across the 0-20th, 20-40th, 40-60th, 60-80th, 80-90th, 90-95th, 95-99th, and 99-100th percentiles of income based on the CBO under ETI=0.3 in 1980 (denoted by circles) and 2010 (diamonds).[23] The marginal welfare weights are more or less flat from the 20th to the 80th percentiles and then fall sharply afterward.

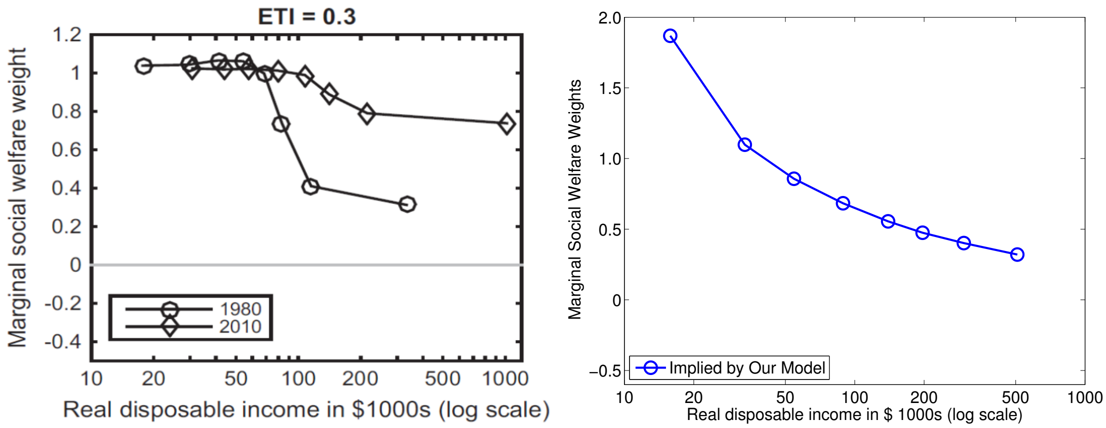
In our model, the marginal social welfare weights are (after normalization):

$$g(a,x) = u'(c(a,x)) \cdot \theta_0) = \frac{c(a,x)^{\eta-\sigma}}{\int c(a,x)^{\eta-\sigma} d\mu}.$$

The right panel of Figure 7 shows the marginal social welfare weights of the U.S. economy uncovered by our model, respectively, across income groups. For a comparison to Lockwood and Weinzierl (2016), we rescale the incomes in our models so that the average income in our model matches that in the data (\$79,300). While the Pareto weights

[23]They consider four values of ETI (which is close to the Hicksian labor supply elasticity in our model): 0.1, 0.3, 0.4 and 0.6. Since the Hicksian income elasticity approximates to $(1/\sigma \cdot \gamma)/(1/\sigma + \gamma)$, which is 1/3 in our model, we compare their results under ETI=0.3 to ours.

Figure 7: Marginal Social Welfare Weights of U.S.



Note: The left panel (Figure 4 in Lockwood and Weinzierl (2016)) shows the average marginal welfare weights across the 0-20th, 20-40th, 40-60th, 60-80th, 80-90th, 90-95th, 95-99th, and 99-100th percentiles of income distribution under ETI=0.3. The right panel shows the marginal welfare weights from our benchmark model economy. Incomes in the model economy are rescaled so that the average income is the same as that in the data ($79,300).

increase with consumption in our model (η=0.18), the marginal social weights monotonically decrease with income, as the effect of marginal utility (of consumption) outweighs that of the Pareto weights. There are several differences between our model and theirs. First, they assume a more fat-tailed distribution of income (Pareto log-normal) than ours (closer to log-normal as the productivity shocks are drawn from the log-normal distribution). Second, their marginal tax rates, obtained from the NBER's TAXSIM, increases rapidly from the bottom to middle income groups and then becomes almost flat afterward. In our model, the marginal tax rates increase monotonically. Third, income is equal to consumption in a static environment, whereas in our model economy (where households can save) consumption is not necessarily equal to income. Finally, Lockwood and Weinzierl (2016) use a quasilinear utility where there is no income effect in labor supply.

Table 9 summarizes the marginal social welfare weights of all 32 OECD countries. In all 32 OECD countries except for Chile, the marginal social welfare weights monotonically decrease with consumption.

Table 9: Marginal Social Welfare Weights across OECD countries

	Parameter	Consumption Quintile				
	η	1st	2nd	3rd	4th	5th
Chile	1.141	0.843	0.945	1.004	1.060	1.149
Turkey	0.726	1.285	1.064	1.064	0.892	0.790
S. Korea	0.243	1.603	1.093	0.913	0.777	0.615
United States	0.182	1.869	1.098	0.857	0.684	0.493
Switzerland	0.031	1.772	1.096	0.878	0.718	0.536
Israel	-0.160	2.289	1.063	0.752	0.548	0.348
Australia	-0.336	2.304	1.062	0.749	0.543	0.342
United Kingdom	-0.427	2.427	1.054	0.718	0.502	0.299
Japan	-0.497	2.497	1.035	0.697	0.484	0.287
Portugal	-0.550	2.589	1.024	0.673	0.455	0.259
New Zealand	-0.549	2.492	1.032	0.698	0.487	0.291
Spain	-0.583	2.599	1.020	0.670	0.453	0.258
Greece	-0.720	2.737	0.996	0.631	0.412	0.223
Canada	-0.736	2.677	0.995	0.646	0.435	0.247
Estonia	-0.792	2.712	0.998	0.638	0.421	0.231
Italy	-0.885	2.800	0.983	0.613	0.395	0.209
Poland	-0.906	2.751	0.989	0.627	0.410	0.223
Germany	-1.501	3.105	0.920	0.524	0.308	0.143
France	-1.511	3.270	0.863	0.475	0.271	0.121
Luxembourg	-1.558	3.032	0.937	0.546	0.328	0.157
Netherlands	-1.642	3.346	0.815	0.453	0.264	0.122
Slovak Republic	-1.877	3.239	0.868	0.485	0.280	0.128
Ireland	-1.913	3.337	0.899	0.449	0.229	0.087
Sweden	-2.187	3.579	0.746	0.384	0.206	0.085
Austria	-2.198	3.474	0.808	0.412	0.218	0.088
Czech Republic	-2.303	3.483	0.796	0.411	0.220	0.090
Norway	-2.444	3.546	0.765	0.393	0.210	0.086
Iceland	-2.711	3.717	0.688	0.344	0.180	0.072
Belgium	-2.824	3.834	0.670	0.304	0.143	0.049
Slovenia	-2.919	3.743	0.708	0.331	0.160	0.058
Finland	-3.041	3.981	0.606	0.260	0.116	0.037
Denmark	-3.066	3.984	0.584	0.264	0.125	0.044

5.7. Borrowing

The demand for social insurance may vary to the extent that the financial market can provide private insurance against future uncertainty. While our benchmark model does not allow households to borrow at all ($\underline{a} = 0$), most households do have access to financial markets or family/friends to borrow from. To see whether our results are sensitive to the borrowing limit, we relax the borrowing limit in our benchmark calibration (i.e., the U.S.). The exogenous borrowing constraint is now set to half of the average annual earnings in the model ($\underline{a}$ = -0.2) following Chang and Kim (2007), which is based on the maximum credit card(s) limit (non-collateral debt) for the average household in the survey data. While households are liable to tax on interest income, most interest payments are not deductible. Thus, we modify the disposable income of households as:

$$D(y) = \begin{cases} \lambda(wxh + ra)^{1-\tau}, & if\ a \geq 0 \\ \lambda(wxh)^{1-\tau} + ra, & if\ a < 0. \end{cases}$$

Table 10 compares results with and without borrowing for the U.S.[24] According to our model, 20% of households are now in debt when borrowing is allowed. The wealth Gini increases to 0.633 from 0.591 in the benchmark model without borrowing.[25] Due to non-deductible interest payments, households in debt face a higher tax rate than those without debt, even though their incomes (after interest payments) are the same. Hence, the tax progressivity (0.266) generating the same after-tax income Gini is slightly higher in the model with borrowing.

Since the demand for social insurance diminishes when borrowing is allowed, the optimal progressivity ($\tau^* = 0.284$) under the equal-weight utilitarian social welfare function

[24]As in the benchmark case, the time discount factor (β), disutility from labor (B), the standard deviation of innovation (σ_x), tax progressivity (τ_0), and average level of taxation (λ) are all re-calibrated to match interest rates, working hours, Gini coefficients, and the G/Y ratio in the data.

[25]The magnitude of the productivity shock (σ_x) required to match the before-tax income Gini is somewhat smaller. Since household debt lowers aggregate savings, a higher time discount factor (β) is required to maintain the steady-state rate of return to capital.

Table 10: Borrowing Allowed

	Benchmark	Borrowing Allowed
Time Discount Factor (β)	0.958	0.959
Disutility from Working (B)	16.703	16.746
Magnitude of Shocks (σ_x)	0.358	0.355
Model-implied Progressivity (τ_0)	0.264	0.266
– Marginal Tax Rate for Median	29.0%	29.3%
– Gini Improvement Rate	23.8%	23.8%
– Wealth Gini	0.591	0.633
Optimal Progressivity (τ^*)	0.292	0.284
– Marginal Tax Rate for Median	31.1%	30.8%
– Gini Improvement Rate	26.6%	25.6%
Weighting Function Parameter (η)	0.182	0.115
Pareto Weights		
1st Quintile	0.853	0.907
2nd	0.950	0.970
3rd	1.003	1.004
4th	1.055	1.035
5th	1.138	1.085

is slightly smaller than that (0.292) in the benchmark model without borrowing. The slope of Pareto weights (η) also decreases from 0.182 to 0.115, raising the Pareto weights on the poor (relative to the rich). Overall, the impact on the uncovered Pareto weights is small—a change of less than 10%. For example, the weights on the bottom quintile increase from 0.853 to 0.907.

6. Conclusion

Economic inequality is at the heart of policy debates. We develop a general equilibrium model for a quantitative analysis of income inequality and redistribution policy. With the model calibrated to reproduce the cross-sectional income inequality and the progressivity of the income tax/transfer schedule of each of the 32 OECD countries, we ask the following: (i) What is the optimal progressivity of government tax and transfer under the equal-weight utilitarian social welfare function? (ii) Will the optimal tax reform be supported by the majority of the population? (iii) What are the Pareto weights in the social welfare function that justify the current redistribution policy?

According to our model, the optimal progressivity of income tax/transfer under the equal-weight utilitarian social welfare function varies vastly across countries. For 4 countries, the optimal tax/transfer system is much more progressive than the current schedule. According to the simulated voting, a policy reform to adopt the optimal progressivity is supported by the majority of the population in almost all countries. For example, in Chile the policy to increase to the socially optimal level is supported by 79% of the population.

We interpret the persistence of the current suboptimal progressivity (despite the population's overwhelming support for optimal tax reform) as evidence of unequal Pareto weights in the social welfare function. For the U.S., the average Pareto weight on the richest 20% of the population is 33% larger than that of the poorest 20%. In Chile, the average Pareto weight on the richest 20% is almost 12 times as large as that of the poorest 20%. We provide some evidence, although indirect, that a country's Democracy Index, higher voter turnout rates among the rich, and society's preferences for equity may account for the Pareto weights uncovered by our model.

References

Acemoglu, D., S. Naidu, P. Restrepo, Robinson, J.A., 2014. Democracy, redistribution, and inequality, in: A. Atkinson and F. Bourguignon (Eds.), Handbook of Income Distribution Vol. 2, 1885-1966.

Aiyagari, S. R., 1994. Uninsured idiosyncratic risk and aggregate savings. Quarterly Journal of Economics 109(3), 659-684.

Aiyagari, S. R., McGrattan, E.R., 1998. The optimum quantity of debt. Journal of Monetary Economics 42(3), 447-469.

Alesina, A., Glaeser, E.L., 2004. Fighting Poverty in the U.S. and Europe. Oxford University Press.

Benabou, R., 2002. Tax and education policy in a heterogeneous agent economy: what levels of redistribution maximize growth and efficiency? Econometrica 70, 481-517.

Chang, B.H., 2016. Can productivity slowdown explain demand for redistribution? Working Paper, University of Rochester.

Chang, Y., Kim, S.B., 2006. From individual to aggregate labor supply: a quantitative analysis based on a heterogeneous agent macroeconomy. International Economic Review 47(1), 1-27.

Chang, Y., Kim, S.B., 2007. Heterogeneity and aggregation: implications for labor-market fluctuations. American Economic Review 97 (5), 1939-1956.

Chang, Y., Park, Y., 2017. Optimal taxation with private insurance. Rochester Center for Economic Research Working Paper No. 599.

Charité, J., Fisman, R., Kuziemko, I., 2015. Reference points and redistributive preferences: experimental evidence. National Bureau of Economic Research Working Paper No. 21009.

Chetty, R., 2006. A new method of estimating risk aversion. American Economic Review 96(5), 1821-1834.

Chetty, R., Guren, A., Manoli, D., Weber, A., 2011. Are micro and macro labor supply elasticities consistent? a review of evidence on the intensive and extensive margins. American Economic Review 101(3), 471-475.

Conesa, J.C., Krueger, D., 2006. On the optimal progressivity of the income tax code. Journal of Monetary Economics 53(7), 1425-1450.

[Global Wealth Databook] Credit Suisse, 2012.

[EIU] Economist Intelligence Unit, 2011. Democracy index 2011: democracy under stress.

Floden, M., Linde, J., 2001. Idiosyncratic risk in the United States and Sweden: is there a role for government insurance? Review of Economic Dynamics 4(2), 406-437.

Gandelman, N., Hernández-Murillo, R., 2015. Risk aversion at the country level. Federal Reserve Bank of St. Louis Review 97(1), 53-66.

Heathcote, J., Storesletten, K., Violante, G.L., 2008. Insurance and opportunities: a welfare analysis of labor market risk. Journal of Monetary Economics 55(3), 501-525.

Heathcote, J., Storesletten, K., Violante, G.L., 2016. Optimal tax progressivity: an analytical framework. Quarterly Journal of Economics, forthcoming.

Heathcote, J., Tsujiyama, H., 2016. Optimal income taxation: Mirrlees meets Ramsey. Working paper.

Holter, H., Krueger, D., Stepanchuk, S., 2015. How does tax progressivity and household heterogeneity affect Laffer curves? Working Paper.

Keane, M., 2011, Labor supply and taxes: a survey. Journal of Economic Literature 49(4), 961-1075.

[LIS] Luxembourg Income Study, 2016. http://www.lisdatacenter.org (multiple countries; January 2016).

Lockwood, B., Weinzierl, M., 2015. De gustibus non est taxandum: heterogeneity in preferences and optimal redistribution. Journal of Public Economics 124, 74-80.

Lockwood, B., Weinzierl, M., 2016. Positive and normative judgments implicit in U.S. tax policy, and the costs of unequal growth and recessions. Journal of Monetary Economics 77, 30-47.

Lockwood, B., Nathanson, C.G., Weyl, E.G., 2016. Taxation and the allocation of talent. Journal of Political Economy, Forthcoming.

Mahler, V.A., 2008. Electoral turnout and income redistribution by the state: a cross-national analysis of the developed democracies. European Journal of Political Research 47, 161-183.

Mirrlees, J.A., 1971. An exploration in the theory of optimum income taxation. Review of Economic Studies 38(2), 175-208.

[OECD] Organization for Economic Cooperation and Development database in 2014 and 2015. http://stat.oecd.org. (Extracted on 2015-01-30: Tax, National Accounts), 2015-04-16 (Working hours), 2015-10-05 (Government Consumption), 2015-12-17 (Gini coefficients), and 2016-04-04 (Decile Ratio)).

Pijoan-Mas, J., 2006. Precautionary savings or working longer hours. Review of Economic Dynamics 9(2), 326-352.

Ríos-Rull, J.V., 1999. Computation of equilibria in heterogeneous-agents models: in Marimon R. and A. Scott (Eds.) Computational Methods for the Study of Dynamic Economies. New York: Oxford University Press.

Roberts, K.W.S., 1977. Voting over income tax schedules. Journal of Public Economics 8, 329-340.

Romer, T., 1975. Individual welfare, majority voting, and the properties of a linear income tax. Journal of Public Economics 7, 163-88.

Saez, E., 2001. Using elasticities to derive optimal income tax rates. Review of Economic Studies 68(1), 205-229.

Saez, E., Stantcheva, S., 2016. Generalized social marginal welfare weights for optimal tax theory. American Economic Review 106(1), 24-45.

Tauchen, G., 1986. Finite state Markov-chain approximations to univariate and vector autoregressions. Economics Letters 20, 177-181.

Weinzierl, M., 2014. The promise of positive optimal taxation: normative diversity and a role for equal sacrifice. Journal of Public Economics 118, 128-142.

Weinzierl, M., 2016. Revisiting the classical view of Benefit-Based Taxation." *National Bureau of Economic Research Working Paper.*

[WVS] World Values Survey database 2005-2009. World Values Survey Association.

Appendix

A. Data

A.1. Income and Wealth Distribution

The income Gini coefficients and income ratios across deciles are obtained from the Organization for Economic Cooperation and Development (OECD) database (http://stats.oecd.org, extracted on 2015-12-17 (Gini) and 2016-04-04 (income ratios)). The base year is 2010 except for the coefficients of Chile, Hungary, Ireland, Japan, New Zealand, Switzerland, and the UK, where the base year is 2009. The OECD database provides two Gini coefficients (before and after taxes and transfers) based on household income per equivalent-household member. The social security contributions and transfers are also included. The income ratios across deciles are based on disposable income. The wealth Gini coefficients for OECD countries are obtained from the 2012 version of the Global Wealth Databook by Credit Suisse. Wealth is defined as the marketable value of financial assets plus non-financial assets less debt.

A.2. Taxes, Expenditures, and Working Hours

Data on tax revenues, tax rates, and tax wedges are from the OECD tax database (http://stats.oecd.org, extracted on 2015-01-30). The base year is 2010. The tax wedge is the difference between labor costs to the employer and the corresponding net take-home value of the employee, which is calculated by the sum of personal income tax and employee plus employer social security contributions together with any payroll tax, minus benefits as a percentage of labor costs. The OECD provides the tax wedges for various types of households by the number of members in the household, number of earners, and income level. The composition of general government expenditure is also from the OECD database ("National Accounts at a Glance", http://stats.oecd.org, extracted on 2015-01-30). The gap between the tax revenue and government expenditure reflects the government budget deficit and non-tax revenue. Working hours are calculated using the information on average annual working hours from the OECD database (http://stats.oecd.org, extracted on 2015-04-16). We divide the OECD's numbers by 5,500 hours, the total amount of annual discretionary time. Government consumption, GDP (extracted on 2015-10-05) and per capita GDP (extracted on 2014-06-22) are also obtained from the OECD database (http://stats.oecd.org).

A.3. Democracy Index

The Democracy Index is obtained from the Economist Intelligent Unit (EIU). The EIU evaluates the development of democracy in a society based on 60 questions in 5 categories: (i) electoral process and pluralism, (ii) functioning of government, (iii) political participation, (iv) political culture, and (v) civil liberties. A country is scored from 0 to 10 in each of the 5 categories. The Democracy Index is the average of these 5 scores.

A.4. World Values Survey

The World Values Survey (www.worldvaluessurvey.org) is a global network of social scientists studying changing values and their impact on social and political life. The WVS consists of nationally representative surveys conducted in almost 100 countries, which contain almost 90% of the world's population, using a common questionnaire. We use the WVS 2005-2009 data. Twenty countries out of 32 OECD countries are included: Australia, Canada, Chile, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Poland, Slovenia, Spain, Sweden, Switzerland, Turkey, the U.K. and the U.S. One of the questions is related to the equity-efficiency trade off. The participants choose their views between "Incomes should be made more equal (0)" and "We need larger income difference as incentives for individual effort" (10). We calculated the fraction of the population with a scale between 0-5, who are favorable to income redistribution.

A.5. Luxembourg Income Study

The Luxembourg Income Study (LIS, http://www.lisdatacenter.org) collects and harmonizes micro datasets around the world (46 countries as of 2016). The LIS datasets contain variables on market income, public transfers and taxes, household- and person-level characteristics, labor market outcomes, and, in some datasets, expenditures. Twenty-five countries out of 32 OECD countries report detailed information on market and disposable income. We define market income as factor income (variable name "factor") plus private transfer ("hitp"), and disposable income as market income plus public transfer ("hits") minus taxes and contributions ("hxit"). The base year for 19 countries (Australia, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Poland, Slovak Republic, Spain, the U.K. and the U.S.) is 2010. The Czech Republic (2007), Japan (2008), Korea (2006), Norway (2004), Sweden (2005), and Switzerland (2004) are based on earlier years. All incomes are re-scaled by household size. The micro data were completed in January 2016. In estimating the progressivity of tax/transfer, we drop 20% of low-income households, since their income and tax data contain numerous measurement errors.

B. Computational Procedures

B.1. Steady-State Equilibrium

The distribution of households, $\mu(a, x)$, is time-invariant in the steady state, as are factor prices. We modify the algorithm suggested by José-Víctor Ríos-Rull (1999) in finding a time-invariant distribution μ. Computing the steady-state equilibrium amounts to finding the value functions, the associated decision rules, and the time-invariant measure of households. For the U.S., we search for (i) the discount factor β that clears the capital market at the given annual rate of return of 4%; (ii) the disutility parameter B to match the average hours worked, 0.323; (iii) the standard deviation of idiosyncratic productivity, σ_x and the current tax progressivity (τ_0) that matches the before- and after-tax Gini coefficient (0.499, 0.380); and (iv) the average level of taxation (λ) to match the government-consumption-to-output ratio (16.9%). The details are as follows:

1. Choose the grid points for asset holdings (a) and idiosyncratic productivity (x). The number of grids is denoted by N_a and N_x, respectively. We use $N_a = 309$ and $N_x = 21$. The asset holding a_t is in the range of [0, 39.8]. The grid points of assets are not equally spaced. We assign more points to the lower asset range to better approximate the savings decisions of households near the borrowing constraint.

2. Pick initial values of β, B, σ_x, τ_0 and λ. For idiosyncratic productivity, we construct a grid vector of length N_x, whose elements (each denoted by $\ln x_j$) are equally spaced on the interval $[-3\sigma_x/\sqrt{1-\rho_x^2}]$. Then, we approximate the transition matrix of the idiosyncratic productivity using the algorithm from Tauchen (1986).

3. Given β, B, σ_x, τ_0, and λ, we solve the individual value functions V at each grid point for individual states. In this step, we also obtain the optimal decision rules for asset holdings $a'(a_i, x_j)$ and labor supply $h(a_i, x_j)$. This step involves the following procedure:

   (a) Initialize value functions $V_0(a_i, x_j; \tau_0)$ for all $i = 1, 2, \cdots, N_a$, and $j = 1, 2, \cdots, N_x$.

(b) Update value functions by evaluating the discretized versions:

$$V_1(a_i, x_j; \tau_0) = \max \Big\{ u\Big(\big(\lambda(wh(a_i, x_j; \tau_0)x_j + ra_i)\big)^{1-\tau_0} + a_i - a', h(a_i, x_j; \tau_0)\Big) + \beta \sum_{j'=1}^{N_x} V_0(a', x'_j; \tau_0))\pi_x(x_{j'}|x_j) \Big\},$$

where $\pi_x(x_{j'}|x_j)$ is the transition probability of x, which is approximated using Tauchen's algorithm.

(c) If V_1 and V_0 are close enough for all grid points, then we have found the value functions. Otherwise, set $V_0 = V_1$, and go back to step 3(b).

4. Using $a'(a_i, x_j)$ and $\pi_x(x_{j'}, x_j)$ obtained from step 3, we obtain the time-invariant measures $\mu^*(a_i, x_j)$ as follows

(a) Initialize the measure $\mu_0(a_i, x_j)$.

(b) Update the measure by evaluating the discretized version of a law of motion:

$$\mu_1(a_{i'}, x_{j'}) = \sum_{i=1}^{N_a} \sum_{j=1}^{N_x} \mathbf{1}_{a_{i'}=a'(a_i,x_j)} \mu_0(a_i, x_j)\pi_x(x_{j'}|x_j).$$

(c) If μ_1 and μ_0 are close enough in all grid points, then we have found the time-invariant measure. Otherwise, replace μ_0 with μ_1 and go back to step 4(b).

5. We calculate the real interest rate, Gini coefficients, individual's working hours, net tax revenues, and other aggregate variables of interest using μ^* and decision rules. Net tax revenues are:

$$TR = \int_{a,x} \{wxh + ra - \lambda(wxh + ra)^{1-\tau_0}\} d\mu^*(a, x).$$

If the calculated real interest rate, average hours worked, and before- and after-tax Gini coefficient and government consumption are close to the assumed ones, we have found the steady state. Otherwise, we choose a new β, B, σ_x, τ_0 and λ and go back to step 2.

The computational procedure for other countries is similar except that we fix β from the U.S. case.

B.2. Optimal Tax Reform

We include the transition path from the initial to the new steady states. The details are as follows:

1. Compute the initial steady state under the current progressivity (τ_0). Use the algorithm for the steady-state equilibrium above.

2. Choose a new tax progressivity (τ).

   (a) Compute the new steady state under a new τ.

   (b) Assume that the transition is completed after $T-1$ periods, so that the economy has arrived at the new steady state at time T. Choose a T big enough so that the transition path is unaltered by increasing T.

   (c) Guess the capital-labor ratios $\{K_t/E_t\}_{t=2}^{T-1}$ and compute the associated $\{r_t, w_t\}_{t=2}^{T-1}$.

   (d) Guess the path of the average level of taxation $\{\lambda_t\}_{t=2}^{T-1}$. Note that the average levels of taxation are all different in each period, since the decision rules and distribution measures are time varying. Going backward, compute the value functions and policy functions for all transition periods by using $V_T(\cdot)$ from the final steady state. Using the initial steady-state distribution μ_1 and the decision rules, find the distribution measures for all periods $\{\mu_t\}_{t=2}^{T-1}$.

   (e) Based on the decision rules and measures, compute the aggregate variables and net tax revenues. If the net tax revenue is close to the assumed government consumption, we obtain the average level of taxation. Otherwise, choose a new path of the average level of taxation and go back to 2(d).

   (f) Compute the paths of aggregated capital and effective labor and compare them with the assumed paths. If they are close enough in each period, we find the transition paths. Otherwise, update $\{K_t/E_t\}_{t=2}^{T-1}$ and go back to 2(c).

3. Choose the tax progressivity that yields the highest social welfare. This is the optimal τ under the utilitarian criteria. We also compute the voting outcome for this optimal tax reform. Voting takes place at the beginning of period 2, after

the idiosyncratic productivity shock has been realized. The voting decision of an individual with state (a, x) is determined as follows: if $V(a, x; \tau) > V(a, x; \tau_0)$, then this household is in favor of new τ.

B.3. Uncovering Pareto Weights

We search for the value of η so that the current progressivity τ_0 yields the highest social welfare. Details are as follows:

1. Define a set of tax progressivity around the current one.

2. Given a tax progressivity τ, compute $c(a, x)$, $V(a, x; \tau)$, $\mu(a, x)$, and other related variables using the algorithm for the steady-state equilibrium.

3. Assume η and compute the social welfare under each tax progressivity using the algorithm for the optimal tax reform:

$$\mathcal{W} = \int \theta(\tau_0) V(a, x; \tau) d\mu_0(a, x),$$

   where

$$V(a, x; \tau) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t; \tau) \quad \text{and } \theta(\tau_0) = \frac{c_0(a, x)^\eta}{\int c_0(a, x)^\eta d\mu_0(a, x)}$$

4. Compare the social welfares and choose the highest social welfare and the corresponding tax progressivity (τ^*). If the tax progressivity (τ^*) is close enough to τ_0, then we obtain η and Pareto weights for individuals. Otherwise, we choose a new η and go back to step 3.

C. Additional Figure and Tables

Figure C shows the values of tax progressivity τ and its corresponding Pareto weight parameter η that justifies τ as a social optimal, uncovered by our procedure using the benchmark model calibrated to the U.S. data. There is a monotonic relationship between τ and η: the more progressive the tax schedule is, the larger is η that justifies the tax schedule as a social optimal.

Figure C: Tax Progressivity (τ) and Pareto Weight Parameter (η)

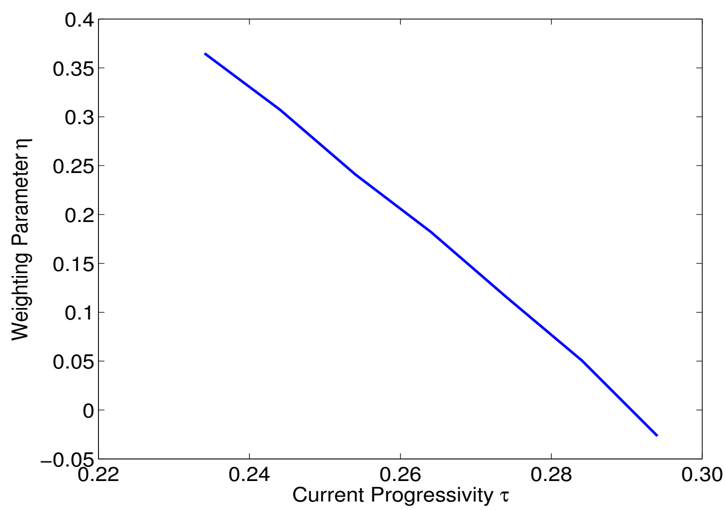


Table C.1: Steady State for OECD

	Disutility from Labor (B)	SD of Innovation (σ_x)	Implied Tax Porgressivity (τ)	Interest Rates (r)	Hours Worked (H)
Australia	18.223	0.337	0.312	0.049	0.307
Austria	13.477	0.370	0.464	0.064	0.304
Belgium	16.394	0.372	0.472	0.069	0.282
Canada	17.832	0.319	0.306	0.055	0.309
Chile	13.823	0.365	0.051	0.019	0.376
Czech Republic	11.165	0.340	0.450	0.067	0.329
Denmark	18.410	0.323	0.431	0.078	0.281
Estonia	11.675	0.361	0.372	0.054	0.342
Finland	12.765	0.380	0.474	0.070	0.305
France	20.775	0.388	0.426	0.061	0.269
Germany	23.878	0.377	0.443	0.059	0.256
Greece	9.018	0.396	0.385	0.052	0.367
Iceland	15.557	0.286	0.396	0.075	0.307
Ireland	14.216	0.476	0.511	0.052	0.280
Israel	12.804	0.362	0.276	0.046	0.349
Italy	13.209	0.379	0.394	0.054	0.322
Japan	15.862	0.357	0.338	0.050	0.315
Korea	11.725	0.217	0.096	0.043	0.398
Luxembourg	15.610	0.350	0.441	0.060	0.297
Netherlands	31.076	0.305	0.341	0.068	0.251
New Zealand	16.154	0.324	0.309	0.052	0.320
Norway	24.645	0.315	0.430	0.070	0.257
Poland	10.600	0.349	0.376	0.055	0.353
Portugal	14.459	0.393	0.372	0.049	0.316
Slovak Republic	12.052	0.325	0.423	0.065	0.329
Slovenia	13.247	0.348	0.475	0.070	0.305
Spain	16.656	0.378	0.362	0.051	0.304
Sweden	16.341	0.329	0.411	0.070	0.297
Switzerland	24.418	0.247	0.211	0.045	0.297
Turkey	17.014	0.327	0.141	0.032	0.341
United Kingdom	16.841	0.394	0.379	0.047	0.300
United States	16.703	0.358	0.264	0.040	0.323

Table C.2: Gini Coefficients under the Optimal Tax Reform

	Current			Optimal Tax (τ^*)			Majority Chosen (τ^M)		
	Before Tax	After Tax	$-\Delta(\%)$	Before Tax-	After Tax	$\%\Delta$	Before Tax	After Tax	$\%\Delta$
Australia	0.469	0.334	28.8	0.475	0.360	24.3	0.474	0.356	24.9
Austria	0.498	0.280	43.8	0.510	0.376	26.2	0.508	0.368	27.6
Belgium	0.484	0.264	45.5	0.514	0.389	24.4	0.513	0.382	25.4
Canada	0.447	0.319	28.6	0.459	0.370	19.3	0.458	0.368	19.7
Chile	0.536	0.510	4.9	0.500	0.350	30.0	0.501	0.354	29.3
Czech Republic	0.454	0.258	43.2	0.480	0.367	23.6	0.478	0.361	24.6
Denmark	0.429	0.252	41.3	0.466	0.386	17.1	0.464	0.379	18.3
Estonia	0.488	0.317	35.0	0.501	0.375	25.1	0.501	0.373	25.5
Finland	0.485	0.265	45.4	0.523	0.397	24.0	0.521	0.388	25.5
France	0.505	0.303	40.0	0.530	0.397	25.1	0.530	0.394	25.6
Germany	0.492	0.286	41.9	0.516	0.374	27.5	0.515	0.369	28.4
Greece	0.529	0.338	36.1	0.536	0.392	26.8	0.535	0.389	27.3
Iceland	0.400	0.246	38.5	0.423	0.361	14.8	0.422	0.353	16.2
Ireland	0.579	0.298	48.5	0.608	0.400	34.2	0.605	0.388	35.8
Israel	0.501	0.376	25.0	0.504	0.390	22.6	0.504	0.388	23.0
Italy	0.507	0.321	36.7	0.519	0.382	26.5	0.518	0.376	27.4
Japan	0.488	0.336	31.1	0.497	0.373	24.9	0.497	0.371	25.2
Korea	0.341	0.310	9.1	0.339	0.297	12.4	0.338	0.294	12.9
Luxembourg	0.469	0.271	42.2	0.488	0.356	26.9	0.487	0.353	27.5
Netherlands	0.421	0.283	32.8	0.447	0.380	14.9	0.446	0.376	15.6
New Zealand	0.454	0.324	28.6	0.463	0.363	21.6	0.463	0.362	21.8
Norway	0.423	0.249	41.1	0.453	0.361	20.4	0.452	0.357	21.1
Poland	0.473	0.307	35.1	0.488	0.367	24.8	0.488	0.365	25.1
Portugal	0.525	0.345	34.3	0.533	0.388	27.2	0.532	0.383	28.0
Slovak Republic	0.434	0.262	39.6	0.463	0.357	22.9	0.461	0.350	24.2
Slovenia	0.456	0.246	46.1	0.488	0.368	24.5	0.486	0.360	26.0
Spain	0.506	0.339	33.0	0.518	0.383	26.1	0.518	0.382	26.3
Sweden	0.441	0.269	39.0	0.471	0.381	19.1	0.469	0.375	20.0
Switzerland	0.372	0.298	19.9	0.372	0.296	20.2	0.371	0.294	20.9
Turkey	0.477	0.417	12.6	0.463	0.346	25.3	0.463	0.348	24.9
United Kingdom	0.523	0.341	34.8	0.532	0.376	29.3	0.531	0.373	29.7
United States	0.499	0.380	23.8	0.495	0.364	26.6	0.495	0.363	26.8

Note: All numbers are income Gini coefficients under the steady state. "Current" denotes the current steady state from the model. The percentage decrease in the income Gini coefficient before and after tax/transfer is denoted by "$-\Delta$."