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

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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 rate for each country under the equal-weight utilitarian social welfare function. We simulate the voting outcome for the utilitarian optimal tax reform for each country. 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. According to the 2007 Survey of Consumer Finances, the top 1% of the population in the United States owns 34% of the country's total wealth, whereas the bottom 20% of the population owns almost nothing—in fact, they are in debt. Income and wealth inequality is widespread across the world, and many countries adopt redistribution policies to alleviate this issue.[1] Figure 1 plots the Gini coefficients of incomes (for both before- and after-tax/transfers) for 32 countries in the Organization for Economic Co-operation and Development (OECD) based on the 2010 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 Gini coefficients between before- and after-tax/transfer incomes) ranges from 4% 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 general equilibrium heterogeneous-agents models enable us to take first steps in addressing these issues. We can compute the optimal income tax rate under various welfare criteria and simulate voting outcomes of alternative policy reforms. We can even uncover the welfare weights (so-called Pareto weights) that justify each country's current redistri-

[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.

[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, the top statutory personal income-tax rate ranges from 15% (Czech Republic) to 57% (Sweden). The property tax share of total tax revenue varies from a mere 1.1% (Estonia) to 13% (U.S.).

bution policy. To our knowledge, this is the first study that compares how 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 proportional income tax rate (and lump-sum transfer) for each country under the equal-weight utilitarian social welfare function? (ii) What would be the outcome of voting on the fiscal reform to adopt the utilitarian optimal tax rate? (iii) What are the Pareto weights in the social welfare function that justify the current redistribution policy (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 economy for each of the 32 OECD countries. The stochastic process of individual productivity shocks (which is the source of the cross-sectional income inequality) is chosen to match the *before*-tax income Gini coefficient in the data. In our benchmark model, the government adopts a simple income redistribution policy through a proportional income tax and lump-sum transfer.[4] We choose the income tax rate to match the after-tax Gini coefficient in the data. As a result, for each country, the model exactly matches the before- and after-tax income Gini coefficients. The tax rates in our model turn out to be remarkably close to those in the data (measured by the tax-to-GDP ratio or the so-called "income tax wedge"), indicating that our model captures important characteristics of income inequality and redistribution in these countries quite well. For example, in the U.S., the implied tax rate in the model is 23.8%, identical to the tax-GDP ratio in 2010. This value is close to, but slightly lower than the average tax wedge, 25.4%,

[4]In our benchmark model, the average tax rate after the transfer is still progressive because of the lump-sum transfer, even though the marginal tax rate is constant.

for a household with two earners and two children in 2010. We also extend our benchmark model to introduce the progressive income tax in the form of log-linear function, which is widely used in the literature (such as Heathcote et al. (2014)).

According to our benchmark model, the optimal tax rate under the equal-weight utilitarian social welfare function ranges between 23.5% (South Korea) and 40.8% (Chile). For 14 of the 32 OECD countries we consider, the optimal tax rate is higher than the current average tax rate (measured by the tax-to-GDP ratio). In the other 18 countries, mostly Scandinavian or former Communist countries, the optimal tax rate is lower than the current rate.[5]

We then simulate the voting outcome for the reform policy needed to adopt the utilitarian optimal tax rate—i.e., the policy that changes the current tax rate to the optimal level that maximizes the equal-weight utilitarian social welfare function.[6] Optimal tax reform is favored by the majority of the population in all OECD countries we consider. For example, in Chile, which has a very low average tax rate (4.3% according to our model-implied measure), 83% of the population supports the policy to increase the income tax rate to the socially optimal rate of 40.8%.

If 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. However, it is not obvious whether each government's goal is to maximize the equal-weight utilitarian welfare function, which is widely used in quantitative macroeconomic analysis. There might be alternative criteria. For example, 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). Moreover, the process under which policies are actually determined is much more complicated than the simple majority rule. For instance, the rich often have more resources to influence the outcome of politics (e.g., lobbies). The

[5] These countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Slovak Republic, Slovenia, and Sweden.

[6] For this, we compute the changes in the value functions of individual households not only in the new steady state with the optimal tax rate but also in route to the new steady state. If the majority of people benefit from the change in the tax rate, this policy reform can be supported as a political equilibrium.

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 rate as an optimum? We interpret these relative weights in the social welfare function as broadly representing each society's preference for redistribution and political arrangement. One can view this as a reduced-form representation of the policy determination process. For example, if a society is plutocratic, the social welfare function assigns relatively larger weights to rich households.

We interpret the persistence of the current suboptimal tax rate (despite overwhelming support for optimal tax reform) as evidence for deviation from equal weighting in the social welfare function. The welfare weights that justify the current tax rate reveal interesting social preferences for each country.[7] According to our calculations, in Sweden, the Pareto weight on the richest 20% of the population is only 7.5%, whereas that on the poorest 20% is 39%. By contrast, in Chile, the Pareto weight on the richest 20% is 67%, whereas that on the poorest 20% is a mere 1%. We also provide three potential interpretations of estimated Pareto weights across countries by relating our estimates to (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 2010 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 the individual welfare under a specific policy and simulate a voting result. Acemoglu et al. (2013) find that among 184 countries, democracy has a significant and robust effect on tax revenues as a fraction of GDP. Since their measure of democracy

[7]Since democratic societies tend to promote an equal distribution of resources and opportunities, they are more likely to adopt aggressive redistribution policies and, as a result, exhibit larger Pareto weights on poor households in the social welfare function. In fact, the correlation between the tax-to-GDP ratio and the Democracy Index (from The Economist Intelligence Unit, 2010) is 0.39 among the 34 OECD countries.

is dichotomous, their results are better interpreted as the effect of democratization. Our findings suggest that the degree to which democracy is embraced in each OECD country affects the adoption of redistribution policies. Heathcote and Tsujiyama (2015) 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 Lockwood and Weinzierl (2014) extends the Mirrlees's (1971) framework to uncover social weights. While most of the Mirrleesian approaches are static, our model allows precautionary savings at the cost of assuming a simple parametric form for taxes. We compare the estimated marginal social welfare weights from our model to those from Lockwood and Weinzierl (2014).

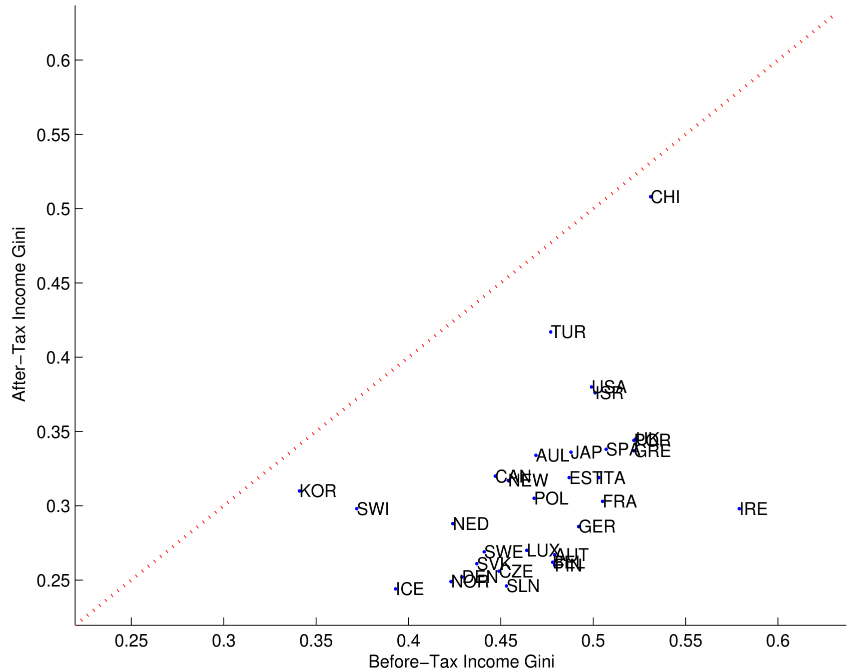
The remainder of the paper is organized as follows. Section 2 documents key statistics about equality and welfare across 32 OECD countries and investigates their relationships. Section 3 lays out the benchmark model economy, which is calibrated to match the before- and after-tax income Ginis for each country. In Section 4, we calibrate our model economy and show that our model generates a reasonable distribution of income and wealth. In Section 5, we compute the optimal tax rate 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 tax rate. Section 6 relates 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. In Section 7, we extend the model to incorporate a progressive taxation and compare our results to the Mirrleesian approach. Section 8 concludes.

2. Income Inequalities in the OECD Countries

In this section, we document stylized facts about the income inequality and redistribution policies of 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 income Ginis for OECD countries, which are taken from the OECD database.[8] The before-tax income Gini

[8]The OECD database provides the income Gini coefficients, which are standardized across

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



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 0.24 (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 32 OECD countries. Hungary and Mexico are not included because their before-tax income Ginis are not available. All 32 countries are located below the 45-degree line, indicating that in all countries incomes are redistributed from the rich to the poor. The two income Ginis are, however, modestly correlated with the correlation coefficient of 0.45, 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 tax 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

sources and measures: http://stats.oecd.org.

Table 1: Key Statistics for the 34 OECD Countries in 2010

	Before-Gini	After-Gini	Improvement (%)	Tax/Y (%)	Democracy Index	Wealth Gini	G/Y (%)
Australia	0.469	0.334	28.8	25.6	9.22	0.636	17.9
Austria	0.479	0.267	44.3	42.2	8.49	0.693	20.4
Belgium	0.478	0.262	45.2	43.5	8.05	0.655	23.6
Canada	0.447	0.320	28.4	30.6	9.08	0.728	22.0
Chile	0.531	0.508	4.3	19.5	7.67	0.774	12.3
Czech Republic	0.449	0.256	43.0	33.9	8.19	0.743	20.5
Denmark	0.429	0.252	41.3	47.4	9.52	0.701	27.6
Estonia	0.487	0.319	34.5	34.0	7.68	0.660	20.1
Finland	0.479	0.260	45.7	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	0.522	0.337	35.4	31.6	7.92	0.714	21.6
Hungary	...	0.272	...	38.0	7.21	0.641	21.6
Iceland	0.393	0.244	37.9	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	0.503	0.319	36.6	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	0.464	0.270	41.8	37.3	8.88	0.623	16.5
Mexico	...	0.466	...	18.9	6.93	0.78	11.7
Netherlands	0.424	0.288	32.1	38.9	8.99	0.812	26.5
New Zealand	0.454	0.317	30.2	31.1	9.26	0.725	19.8
Norway	0.423	0.249	41.1	42.6	9.80	0.779	21.4
Poland	0.468	0.305	34.8	31.7	7.05	0.753	19.3
Portugal	0.522	0.344	34.1	31.2	8.02	0.725	20.7
Slovak Republic	0.437	0.261	40.3	28.3	7.35	0.621	19.2
Slovenia	0.453	0.246	45.7	38.1	7.69	0.639	20.3
Spain	0.507	0.338	33.3	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	0.345	34.0	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	0.470	0.313	33.9	33.8	8.27	0.717	20.0
Std. Dev.	0.048	0.061	10.7	7.4	0.90	0.069	4.0

Note: See Appendix A for a detailed description of the data.
Source: OECD (2014, 2015), Economist Intelligence Unit (2011), and Credit Suisse (2012)

Table 2: Correlations for the 34 OECD Countries

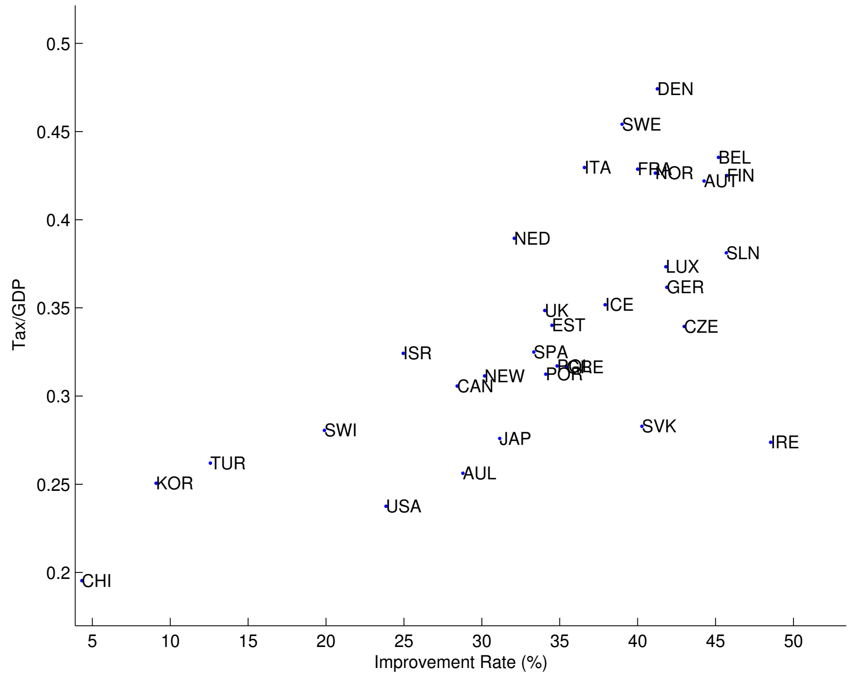
	Before Gini	After Gini	Improvement(%)	Tax / Y (%)	Democracy Index	Wealth Gini	G/Y (%)
Before Gini	1.00	0.45	0.18	-0.11	-0.35	-0.07	0.04
After Gini	0.45	1.00	-0.78	-0.72	-0.51	0.38	-0.60
Improvement (%)	0.18	-0.78	1.00	0.70	0.33	-0.42	0.63
Tax / Y (%)	-0.11	-0.72	0.70	1.00	0.39	-0.22	0.77
Democracy Index	-0.35	-0.51	0.33	0.39	1.00	-0.07	0.40
Wealth Gini	-0.07	0.38	-0.42	-0.22	-0.07	1.00	-0.23
G/Y (%)	0.04	-0.60	0.63	0.77	0.40	-0.23	1.00

Source: Authors' calculation with data from OECD (2014, 2015), Economist Intelligence Unit (2011), and Credit Suisse (2012)

4% (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 0.18), suggesting that a country with high income inequality does not necessarily adopt a stronger redistribution policy.

While redistribution policies take various forms across countries, we will use the average tax rate—measured by the tax revenue to GDP ratio—as a summary statistic of redistribution policies. As Figure 2 illustrates, the improvement rate is fairly strongly correlated with the tax-to-GDP ratios (correlation coefficient of 0.70). This is confirmed by Figure 3, which shows a strong negative correlation, -0.72, between the tax-to-GDP ratio and the after-tax income Gini. The OECD also reports the average tax wedge (an employer's labor cost minus an employee's take-home value) for various household types. We find that the tax-to-GDP ratio is actually quite close to the average tax wedge in the data, confirming that the tax-to-GDP ratio is a good approximation of the average income tax rate for households. The correlation of the average tax wedges with the after-tax income Gini is -0.51 and its correlation with the improvement rate is 0.56. Broadly speaking, high taxes are likely to be used for income redistribution purposes and thus make the society more equalized. Latin American countries such as Chile (19.5%) tend to show low values of their tax-to-GDP ratios. Nordic countries such as Denmark (47.4%)

Figure 2: Tax/GDP and Improvement Rate



and Sweden (45.4%) exhibit, on average, high tax-to-GDP ratios. The tax-to-GDP ratio, however, does not show a strong correlation (-0.11) with the before-tax income Gini.

Not all government spending is used for the redistribution of income. Table 3 reports the composition of government spending for the 32 OECD countries with information available from the OECD (all except for New Zealand and Chile). The general government-spending-to-GDP ratio varies from 30% (Korea) to 65% (Ireland), with an average of 46%. Expenditure on social benefits accounts for the largest share of general government spending in most OECD countries, with the social benefits-to-GDP ratio varying from 6% (Israel) in Mexico to 26% in France. The social benefits expenditure is widely considered to be an income redistribution policy. In fact, Figure 4 shows that the improvement rate is positively correlated with the social benefits-to-GDP ratio, with a correlation coefficient of 0.44, and the tax-to-GDP ratio also shows a correlation, 0.40, with the social benefits-to-GDP ratio. We argue that the tax-to-GDP ratio serves as a good proxy for the strength of redistribution policies. It is also consistent with the policy

Figure 3: Tax/GDP and After-Tax Income Inequality

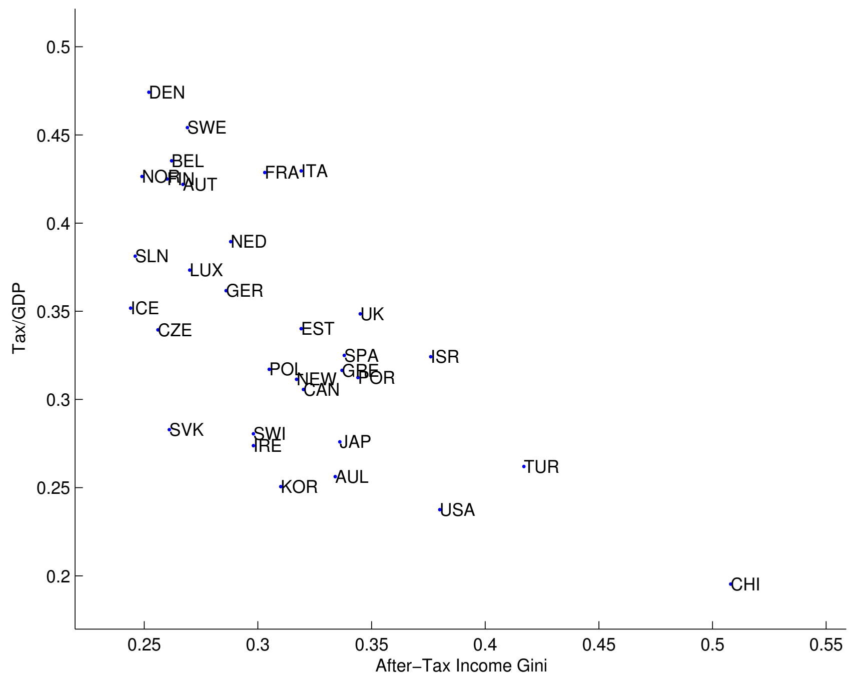


Figure 4: Social Benefits to GDP Ratio and Improvement Rate

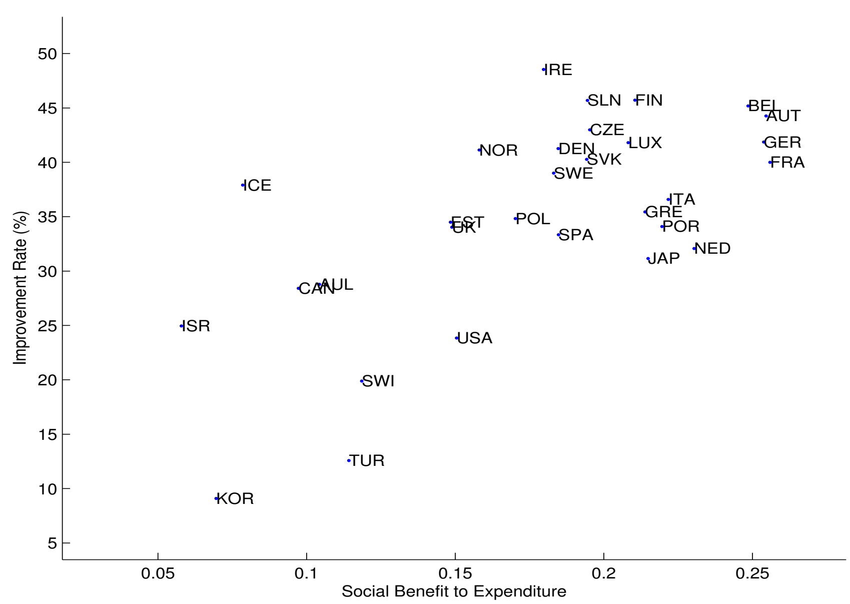


Table 3: Composition of General Government Expenditure (% of GDP) in 2010

	Total	Employee Compensation	Social Benefits	Consumption	Fixed Capital Formation	Other
Australia	36.4	...	10.4	...	3.8	...
Austria	52.8	9.8	25.5	4.5	1.1	12.0
Belgium	52.6	12.6	24.9	3.7	1.6	9.8
Canada	42.3	12.4	9.7	9.9	4.7	5.6
Chile	..	8.2	..	..	2.2	..
Czech Republic	43.7	7.5	19.5	6.2	4.2	6.3
Denmark	57.7	19.0	18.5	9.9	2.2	8.2
Estonia	40.5	11.9	14.8	7.5	3.9	2.4
Finland	55.8	14.5	21.0	11.5	2.5	6.3
France	56.6	13.4	25.6	5.8	3.1	8.7
Germany	47.9	7.8	25.4	4.9	1.7	8.1
Greece	51.4	12.5	21.4	6.0	2.3	9.3
Iceland	51.6	14.8	7.9	12.2	2.9	13.8
Ireland	65.5	12.2	18.0	5.9	3.4	26.1
Israel	42.3	11.1	5.8	12.2	1.5	11.8
Italy	50.4	11.1	22.2	5.8	2.1	9.2
Japan	40.7	6.1	21.5	4.1	3.3	5.7
Korea	30.1	6.9	7.0	4.0	5.1	7.2
Luxembourg	43.5	8.2	20.8	3.7	4.1	6.7
Netherlands	51.3	10.1	23.0	8.0	3.6	6.6
New Zealand	...	...	...	...	...	...
Norway	45.2	13.6	15.8	6.7	3.2	5.8
Poland	45.4	10.2	17.0	6.2	5.6	6.4
Portugal	51.5	12.2	22.0	5.2	3.8	8.4
Slovak Republic	40.0	7.7	19.4	4.9	2.6	5.4
Slovenia	49.4	12.7	19.4	6.8	4.5	6.0
Spain	46.3	12.0	18.5	5.9	4.0	5.9
Sweden	52.3	14.5	18.3	9.2	3.5	6.8
Switzerland	33.9	7.8	11.9	4.7	2.3	7.2
Turkey	40.2	8.7	11.4	5.5	2.7	11.9
United Kingdom	49.9	11.4	14.9	13.0	2.5	8.2
United States	42.6	11.0	15.0	7.6	4.1	5.0

Source: National Accounts at a Glance (2014), OECD database.

measure (proportional income tax rate) in our model economy.

Progressive income tax is regarded as a powerful redistribution policy tool. 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 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 0.08). One practical way to compare the progressivity is to assume a specific parametric form of tax function. When we extend the benchmark model to incorporate progressivity, we adopt a log-linear tax function widely used in the literature (e.g., Heathcote et al. (2014)).

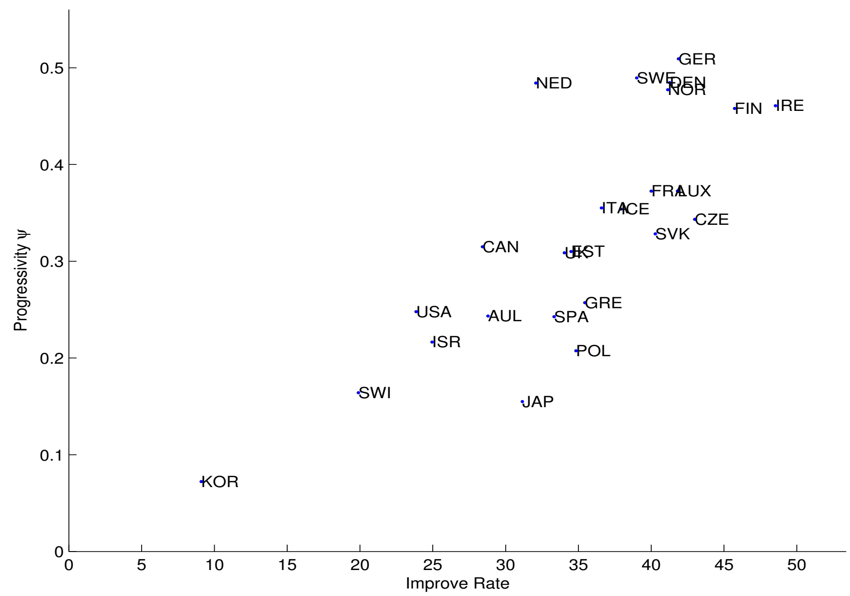
$$\begin{aligned} \text{Tax} \quad & T(y_i) && = y_i - \lambda y_i^{1-\psi} \\ \text{Disposable income} \quad & D(y_i) && = \lambda y_i^{1-\psi} \\ & \log D(y_i) && = \log \lambda + (1-\psi) \log y_i \end{aligned}$$

where λ is the average level of taxation and ψ is a progressivity of taxes and transfer. Using the Luxembourg Income Study (LIS) database, we estimate tax progressivity from 25 OECD countries.[9] Figure 5 plots the estimated progressivity ψ and the improvement rate of income Ginis across countries, whose correlation coefficient is 0.79. The progressivity is also highly correlated with the tax-to-GDP ratio (correlation coefficient of 0.73). The estimated values of ψ for each country are provided in Appendix Table C.1.

We have also collected the wealth Gini coefficients for OECD countries from the 2012 edition of the Global Wealth Databook issued by Credit Suisse. Wealth is distributed more

[9]LIS collects and harmonizes micro data from a variety of countries. We define market income as factor income plus private transfers, and disposable income as market income plus public transfers minus income taxes and contributions. Then, we can estimate tax progressivity by regressing the log of disposable income on the log of market income. All incomes are equivalized by household size. Those of 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. The Czech Republic (2007), Japan (2008), Korea (2006), Norway (2004), Sweden (2005), and Switzerland are based on earlier years. We drop 20% of low-income households, since those data are very noisy.

Figure 5: Tax Progressivity and Gini Improvement Rates



unevenly than incomes are: the average wealth Gini coefficient among OECD countries is 0.72. Unfortunately, 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 on income Gini coefficients.[10]

3. Model

The model economy will serve as a laboratory for various quantitative analyses. The benchmark economy extends Aiyagari's (1994) model to 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

[10] The wealth Gini coefficient based on data from Credit Suisse shows a weak correlation with the before-tax income Gini from the OECD database, while it is positively correlated (0.37) with the after-tax income Gini. Interestingly, unlike income Ginis, the wealth Gini is not highly correlated with any of the redistribution policy measures we consider above, 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 -0.22, 0.02, 0.04, and -0.07, respectively. These patterns may arise due to the difficulty in collecting precise wealth data across countries. The wealth measures in the Credit Suisse data are not as standardized across countries as those for income data in the OECD database.

according to a Markov process with a transition probability distribution function $\pi_x(x'|x) = \Pr(x_{t+1} \leq x'|x_t = x)$. 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, r_t. Both labor and capital incomes are subject to income taxes at the rate τ. Households receive a lump-sump transfer T_t from the government. A household maximizes its lifetime utility, shown as:

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

subject to

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

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

where c_t is consumption. Parameters σ and γ represent relative risk aversion and labor-supply elasticity, respectively. Capital markets are incomplete in the sense that physical capital is the only available asset for households to insure against idiosyncratic shocks to their productivity, and households face a borrowing constraint: $a_t \geq \underline{a}$ 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 through constant-returns-to-scale Cobb-Douglas technology using 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:

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

Government: The government operates a simple fiscal policy characterized by a flat tax rate (τ) on workers' total income and a lump-sum transfer (T) to all households. We further assume that the government runs a balanced budget, in which all tax revenues are transferred to households:

$$T_t = \int \tau \big\{ w_t x_t h(a_t, x_t) + r_t a_t \big\} d\mu(a_t, x_t).$$

We will introduce a progressive income tax in Section 7.

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

$$c + a' = (1-\tau)(wxh + ra) + a + T,$$

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

The intertemporal first-order condition for optimal consumption is:

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

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

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

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:

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

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

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:

$$T = \int \tau\{wxh(a,x) + ra\}d\mu.$$

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 benchmark our model to reproduce the salient features of the income and wealth distributions of the U.S. economy. Second, we assume that preferences and production technology are identical across countries. Third, the two country-specific parameters (the magnitude of individual productivity shocks and the income tax rate) are chosen to match the before-tax and after-tax income Gini for each country.

Common Parameters: The time unit is one year. Workers are not allowed to borrow, so $\underline{a} = 0$. The labor-income share, α, is 0.64, and the annual depreciation rate of capital, δ, is 10%. As is common in the macroeconomic literature, the relative risk aversion, σ, is set to 1 (log utility) to be consistent with the balanced growth path. The labor supply elasticity, γ, is set to 1. This value is larger than the typical micro estimate. However, considering that typical micro estimates do not reflect the extensive margin of labor (i.e., the labor-market participation decision), a larger value is desirable following Chang and Kim (2006). 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. The disutility from working, B, is chosen so that average hours worked in the steady state is 0.323, which is the average share of discretionary time devoted to working.[11]

Country-Specific Parameters: Two parameters are country specific: σ_x and τ. 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 0.29, 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 value of σ_x to match each country's before-tax income Gini ranges from 0.19 (South Korea) to 0.34 (Chile).

Finally, we choose the income tax rate (τ), the redistribution measure, to match the after-tax income Gini of the country. It turns out that with the proportional income tax rate and lump-sum transfers, the implied tax rate is the same as the improvement rate of income Ginis (before- and after-tax).[12]

For the U.S., the model-implied income tax rate, τ, is 23.8%, exactly the same as

[11] We normalize the average annual working hours in the OECD data by the total discretionary hours of 5,500.

[12] Let x be a population share from the bottom and $y(x)$ be the income of the marginal agent at x. The Lorenz curve ($L(x)$) is the cumulative income share up to x: i.e., $L(x) = \int_0^x y(x)dx/Y$, where Y is the aggregate output. The Gini coefficient (G) is defined by $1 - 2\int_0^x L(x)dx$. Let G_B and G_A denote the before- and after-tax/transfers Gini coefficients, respectively. The balanced

Table 4: Parameters of the Benchmark Economy

Common for All Countries		
β	0.9510	Time discount factor
B	4.6645	Disutility from working
σ	1.0	Relative risk aversion
γ	1.0	Labor supply elasticity
ρ	0.92	Persistence of idiosyncratic productivity
α	0.64	Labor share in production function
δ	0.1	Depreciation rate of captial
Country-Specific Parameters		
σ_x	0.19–0.34	Std. deviation of idiosyncratic shocks
τ	0.04–0.49	Income tax rate

Note: See Table C.3 in the Appendix for the values of σ_x and τ for each country .

the tax-to-GDP ratio in 2010. Across 32 countries, the model-implied τ ranges between 4% (Chile) and 49% (Ireland), as does the improvement rate in income Ginis. Table 4 summarizes the parameter values of the benchmark model economy. Table C.3 in the Appendix lists the values of σ_x and τ for all 32 countries.

4.2. Steady State

According to our calibration strategy, the model exactly matches the before- and after-

budget implies $T = \tau Y$.

$$L_A(x) = \int_0^x \{(1-\tau)y(x) + T\}dx/Y\,dx = (1-\tau)L_B(x) + \tau x$$

$$\text{Then, } G_A = 1 - 2\int_0^1 L_A(x)dx = 1 - 2\int_0^1 ((1-\tau)L_B(x) + \tau x)dx$$

$$= 1 - 2(1-\tau)\int_0^1 L_B(x)dx - 2\tau\left[1/2x^2\right]_0^1$$

$$= (1-\tau)(1 - 2\int_0^1 L_B(x)dx) = (1-\tau)G_B$$

tax Gini coefficients in the data. The wealth Gini coefficient for the U.S. is 0.79 or 0.82 according to the PSID and SCF, respectively, whereas it is 0.73 in our model. Table 5 compares the quintile groups of the wealth distribution between the model and the data. It shows the wealth share, the ratio of group average to economy-wide average, and the earnings share across quintiles. The top 20% (the 5th quintile) of households own 83.4% or 76.2% of total wealth in the SCF and PSID, respectively; the corresponding share in our model is 75.1%. The PSID found that households in the 1st, 2nd, 3rd, and 4th quintiles own -0.52% (in debt), 0.50%, 5.06%, and 18.74%, respectively. These shares are also similar in the SCF. The corresponding shares in our model economy are 0%, 0.59%, 5.26%, and 19.09%. Broadly speaking, the wealth distribution from our benchmark model economy resembles that from the U.S. data quite well, although the model cannot generate an extremely high concentration of wealth at the top 5% or 1%. For example, according to the SCF, the top 1% of the population owns 34% of the total wealth in the U.S., whereas the top 1% of households own 10% of the total wealth in our model.

The model-implied tax rate in the U.S. is 23.8%, exactly the same as the tax-to-GDP ratio in 2010, but somewhat lower than the average tax wedge of 25.4% for households with two earners and two children.[13] Table 6 also compares the tax rates implied by the model to those in the data for 3 countries: the U.S., Sweden, and Chile. (We report these statistics for all 32 OECD countries in Appendix Table C.2.) We chose Sweden as an example of countries that adopt an aggressive redistribution policy: the Gini coefficient decreases by 39% as a result of tax and transfer. We chose Chile as an opposite case, the country that exhibits the lowest improvement rate in the Gini coefficient–a 4% decrease after tax and transfers. The implied tax rates square well with the tax-to-GDP ratio in the data. For Sweden, the model-implied tax rate is 39.0%, somewhat lower than but still close to the tax-to-GDP ratio, 45.4%, and the average tax wedge, 38.6%. For Chile, the implied tax rate is 4.3%, much lower than the tax-to-GDP ratio of 19.5%, but close to

Table 5: Earnings-Wealth Distributions in the U.S.

	Quintile					
	1st	2nd	3rd	4th	5th	Total
SCF						
Share of wealth	-0.2	1.1	4.5	11.2	83.4	100
Group avg/pop avg	-0.0	0.1	0.2	0.6	4.2	1
Share of earnings	6.9	10.8	14.9	19.4	48.0	100
PSID						
Share of wealth	-0.5	0.5	5.1	18.7	76.2	100
Group avg/pop avg	-0.0	0.0	0.3	0.9	3.8	1
Share of earnings	7.5	11.3	18.7	24.2	38.2	100
Model						
Share of wealth	0.0	0.6	5.3	19.1	75.1	100
Group avg/pop avg	0.0	0.0	0.3	1.0	3.7	1
Share of earnings	3.2	7.4	12.4	21.1	55.8	100

Source: The SCF statistics are based on Díaz-Giménez, Glover, and Ríos-Rull (2011). The PSID statistics are based on Chang and Kim (2011).

Table 6: Results for 3 Countries

	U.S.	Sweden	Chile
Magnitude of Shock (σ_x)	0.288	0.230	0.337
Implied Tax Rate (τ)	0.238	0.390	0.043
Tax/Y in 2010	0.238	0.454	0.195
Tax Wedge in 2010	0.254	0.386	0.066
Optimal Tax Rate (τ^*)	0.358	0.284	0.408
Approval Rate for τ^*	0.603	0.661	0.834
Tax Rate by Majority Voting	0.348	0.270	0.403
Weighting Function Parameter (η)	0.860	-1.564	1.914
Pareto Weight on 1st Quintile	0.093	0.394	0.011
2nd Quintile	0.139	0.239	0.041
3rd Quintile	0.182	0.169	0.091
4th Quintile	0.235	0.122	0.191
5th Quintile	0.351	0.075	0.667

the average tax wedge of 6.6%.

Figure 6 plots the implied tax rates and the tax-to-GDP ratios for 32 countries. Countries cluster around the 45-degree line, indicating that the model-implied tax rate approximates the average tax rate in the data fairly well, with the exceptions of Chile and Ireland, which exhibit the lowest and the highest Gini improvement rates after tax and transfer. Figure 7 plots the model-implied tax rates and the average tax wedges (for a household with two earners and two children) in the data. The model fits the data even better. In summary, our model provides a successful approximation to the actual redistribution policies. This pattern is consistent with previous research such as Romer (1975) and Meltzer and Richard (1981), in which a proportional income tax and a lump-sum transfer

Figure 6: Implied Tax Rate and Tax/GDP

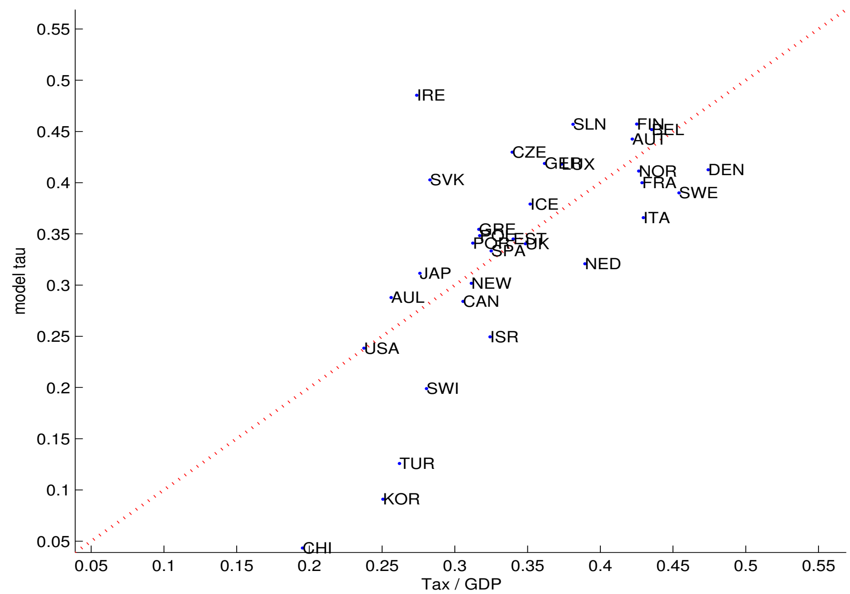
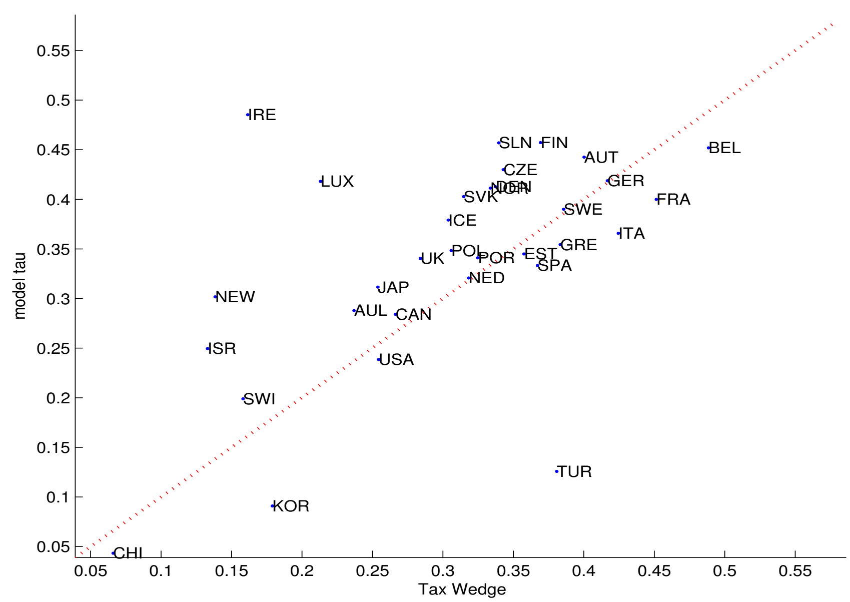


Figure 7: Implied Tax Rate and Tax Wedge



are commonly used as a simple approximation of redistribution policies.

Since we choose the magnitude of the individual productivity shock (σ_x) and the income tax rate (τ) to exactly replicate the before- and after-tax income inequality, these parameters affect the equilibrium real interest rate (r) and hours worked (h).[14] A larger σ_x implies a larger uncertainty for individual households. This strengthens precautionary savings motives, which in turn lowers the real interest rate and increases average hours worked (Pijoan-Mas, 2006). A strong redistribution policy in the form of a high tax rate (τ) reduces the incentive to work and provides insurance (thus raising the real interest rate). Table C.2 in the Appendix reports the equilibrium real interest rate and hours worked for all 32 countries.

5. Optimal Tax Reform and Pareto Weights

In the previous section, we developed a quantitative model that exactly matches the before- and after-tax income Gini coefficients in the data and illustrated that it approximates the redistribution policy of 32 OECD countries fairly well. We now address the following questions with this model economy: (i) What is the optimal income tax rate 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 tax rate? (iii) What are the Pareto weights in the social welfare function that justify the current tax rate, which is suboptimal under the equal weights?

5.1. Optimal Tax and Social Welfare

One of the most important goals in public finance is to characterize the optimal tax policy. This task often requires appropriately aggregating individual preferences, which is

[13] The tax wedge is the difference between gross income and after-tax income. According to the OECD's definition, it is the sum of personal income tax and employee plus employer social security contributions together with any payroll tax less cash transfers, expressed as a percentage of labor costs.

[14] In the calibration of the benchmark (the U.S. economy), we set the common preference parameters B and β so that the real interest rate is 4% and the average hours worked is 0.323 in the steady state.

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, the social welfare function can be written as:[15]

$$\mathcal{W}(\tau) = \int V(a_0, x_0; \tau)\, d\mu(a_0, x_0; \tau),$$

where $V(a_0, x_0; \tau)$ is the discounted sum of the lifetime utility of a household with asset holdings a_0 and productivity x_0, and $\mu(a_0, x_0; \tau)$ is the distribution of households in the steady state given the tax rate τ. In other words,

$$V(a_0, x_0; \tau) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c(a_t, x_t; \tau)^{1-\sigma} - 1}{1-\sigma} - B \frac{h(a_t, x_t; \tau)^{1+1/\gamma}}{1+1/\gamma} \right\}.$$

First, we look for the tax rate 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 income tax rate τ as reported in Table C.2. We then look for the new tax rate, τ^*, that maximizes $\mathcal{W}(\tau)$, *including* the welfare of households during the transition periods to the new steady state. A detailed computational algorithm is provided in Appendix B.2.[16]

Table 6 reports the optimal tax rates of 3 countries: the U.S., Sweden, and Chile. In the U.S., the optimal income tax rate is 35.8%, much higher than the current tax rate of 23.8%. For Chile, the optimal rate is 40.8%, almost 10 times larger than the current tax rate of 4%. This is not surprising because under the equal-weight utilitarian criteria, reallocating the resources from the rich (whose marginal utility is low) to the poor (whose marginal utility is high) would increase the average welfare. For Sweden, however, the current redistribution policy is somewhat excessive from the perspective of

[15] This utilitarian social welfare function has been commonly used in the literature, for example, in Aiyagari and McGrattan (1998).

[16] We include the welfare of households during the transition from the current steady state to a new steady state. When a new tax rate is in place at the current steady state, households start re-optimizing their consumption and hours worked. As a result, the corresponding paths of the value functions, $V_t(a_t, x_t; \tilde{\tau}^*)$, and the distribution, $\mu_t(a_t, x_t; \tilde{\tau}^*)$, will be different from those in the old steady state. Hence, the computation of the optimal tax needs to take into account changes in value functions and the distribution during transition periods until the economy reaches a new steady state.

the equal-weight utilitarian social welfare, as the optimal rate (28.4%) is much *lower* than the current rate (39%).

Table C.3 reports the optimal tax rates for all countries. The optimal tax rates are higher than the current tax rates in 14 countries, whereas the opposite is true in 17 countries. The latter group includes northern and central European welfare states (Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherland, Norway, and Sweden) and formerly communist societies (Estonia, Poland, the Czech Republic, the Slovak Republic, and Slovenia).

5.2. Majority Voting on Optimal Tax Reform

According to our model, the current tax rates are different from the optimal rates for almost all OECD countries.[17] However, any fiscal reform to adopt the optimal tax rate will hardly be Pareto improving—there will be winners and losers as a result of the reform. Thus, there is no guarantee that the optimal tax will be chosen as a political outcome. While the examination of a complicated political process to select a policy in each country is beyond our ability and knowledge, we can still ask a simple question: would the majority of the population be better off from a fiscal reform that adopts the utilitarian optimal tax rate? To answer this question, we simulate a binary voting between the current (τ) and the optimal (τ^*) tax rates. We assume that this is a once-and-for-all change (permanent and irreversible change) in the tax rate. A household would vote for the optimal tax reform if $V(a, x; \tau^*) > V(a, x; \tau)$. In computing the welfare under the optimal fiscal reform, we include welfare during the transition to the new steady state.

Table 6 reports this binary voting outcome for the U.S, Sweden, and Chile, according to our model simulation. The optimal tax reform is supported by the majority of the population in all three countries. In the U.S., the policy proposal to increase the tax rate to the optimal rate ($\tau^* = 0.36$) is supported by 60% of the population. In Chile, 83% of the population is better off under the optimal tax ($\tau^* = 0.41$). In Sweden, the approval rate to decrease the tax rate to the optimal rate ($\tau^* = 0.28$) is 66%. The approval rates

[17]The only exceptions are Greece (49%) and New Zealand, (49%) whose current tax rates are very close to the utilitarian optimal rates.

for optimal tax reform for all 32 OECD countries are reported in the Appendix Table C.3. Essentially, for all countries whose current tax rates deviate from the optimal rates, the fiscal reform to adopt the optimal tax rate is supported by the majority of the population.

5.3. Close-to-Optimal Tax Chosen by the Median Voter

A popular concept of political equilibrium is to find the tax rate that maximizes the welfare of the median household—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 (such as asset holding and productivity) and the state of households changes over time. The median household also differs under an alternative tax rate. We address this issue by finding the close-to-optimal tax rate that would be approved by the majority by simulating successive voting between the current tax rate and the optimal tax rate.[18] This way, we find a politically feasible tax rate that is closest to the optimal tax rate. The results based on this successive voting simulation for 32 countries are summarized in the last column in Table C.3. The tax rates chosen by the successive voting are actually very close to, but slightly lower than, the optimal tax rates in most countries. For example, in the U.S. the tax rate chosen by the majority voting is 34.8%, just 1 percentage point lower than the optimal tax rate of 35.8%.

5.4. Pareto Weights in Practice

We have shown that the current tax rate is far from optimal in almost all 32 OECD countries. We have also shown that for of these countries where the optimal rate deviates from the current rate, the majority of the population would be better off if the optimal rate is adopted. Then, why haven't these countries adopted the optimal tax rates? The optimality depends on the specification of the social welfare function. For example, it is not obvious whether the equal-weight utilitarian welfare (often used in the literature) is

[18] Starting with a tax rate that is 1 percentage point higher (or lower) than the current rate, we simulate the binary voting between the current tax (status quo) and the proposed tax rate (that is 1 percentage point higher, for example). If the proposed tax rate is approved by the majority, we propose the tax rate that is 2 percentage points higher (or lower) than the current one, etc.

the objective that these societies (or governments) maximize. One may argue that it is desirable to maximize the welfare of the poorest members of a society not the average of all (e.g., Rawlsian criteria). Moreover, the decision-making process 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). 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 marginal weights in the social welfare function that would justify the current tax rate? We interpret these weights—the so-called Pareto weights—as a reduced-form representation of a society's preferences and political decision-making process. If a society is plutocratic, the government assigns relatively larger weights to rich households, whereas an egalitarian society is likely to assign larger weights to poor households.

To answer this question we assume that the weights in the social welfare function depends on the state variable of the household. In our model, an individual household's state depends on two state variables: asset holdings (a) and productivity (x). For computational simplicity, we specify the Pareto weights in one dimension, the level of consumption. According to the permanent income hypothesis, consumption should reflect the overall welfare of the household. More specifically, we assume that the Pareto weight on a household with asset holdings a_0 and productivity x_0, $\theta(a_0, x_0)$ exhibits the following parametric form in consumption where η reflects the slope of Pareto weights in the cross-sectional distribution of consumption:

$$\mathcal{W} = \int \theta(a_0, x_0) V(a_0, x_0) d\mu(a_0, x_0),$$

where

$$V(a_0, x_0) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \quad \text{and } \theta(a_0, x_0) = \frac{c(a_0, x_o)^\eta}{\displaystyle\int c(a_0, x_o)^\eta d\mu(a_0, x_0)}$$

The case with $\eta = 0$ corresponds to the equal-weight utilitarian social welfare function: a flat slope for Pareto weights. The case with $\eta > 0$ can be interpreted as a plutocracy or the political system in which the rich have more influence in the determination of policies:

a positive slope for Pareto weights. The case with $\eta < 0$ can be interpreted as sympathy for the poor, or a strong preference for an egalitarian society: a negative slope. The value of η that justifies the current income tax rate (τ) as the social optimum is the solution to the following problem:

$$\tau = \text{argmax } \mathcal{W}(\hat{\tau}) = \int \theta(a_0, x_0) V(a_0, x_0; \hat{\tau}) d\mu(a_0, x_0; \hat{\tau}).$$

With the value of η that solves the above problem, we can uncover the Pareto weights on households based on the distribution of households $\mu(a, x)$.

For the U.S., $\eta = 0.86$ is required to justify the current tax rate as socially optimal. The Pareto weight increases with the level of consumption, as the social welfare function assigns larger weights to the rich. Table 6 reports the Pareto weights (implied by this value of η) for 5 consumption-quintile groups. The average Pareto weights are 9%, 14%, 18%, 24%, and 35%, respectively, from the 1st (poorest 20%) to the 5th (richest 20%) quintiles. In Sweden, $\eta = -1.56$ justifies the current tax rate. The social welfare function assigns larger weights on the poor. The average weight on the poorest 20% of households is 39%, whereas that on the richest 20% is only 7.5%. By contrast, in Chile $\eta = 1.91$ justifies the very low current tax rate (4.3%). The average Pareto weight on the poorest 20% of households is a mere 1%, whereas that on the richest 20% is almost 67%.

We report the values of η and the Pareto weights that justify the current tax rates for each country in Appendix Table C.4. Out of 32, 18 countries exhibit a negative slope of Pareto weights across consumption ($\eta < 0$): i.e., larger weights on the poor. In particular, northern and central European countries show strongly negatively sloped Pareto weights: Slovenia (-4.6), Finland (-3.4) and Belgium (-3.1) are the lowest η. On the opposite side, South Korea (1.38), Turkey (1.49), and Chile (1.91) exhibit strong positively sloped Pareto weights: i.e., larger weights on the rich.[19]

[19]The finding of a negative value of η, that is, larger weights on the poor, in most of the European countries is not surprising. Alesina and Glaeser (2004) explain this as differences in political structure. Almost all European countries have proportional representation systems, whereas the U.S. does not. Also, socialism does not succeed in the U.S., unlike in Europe.

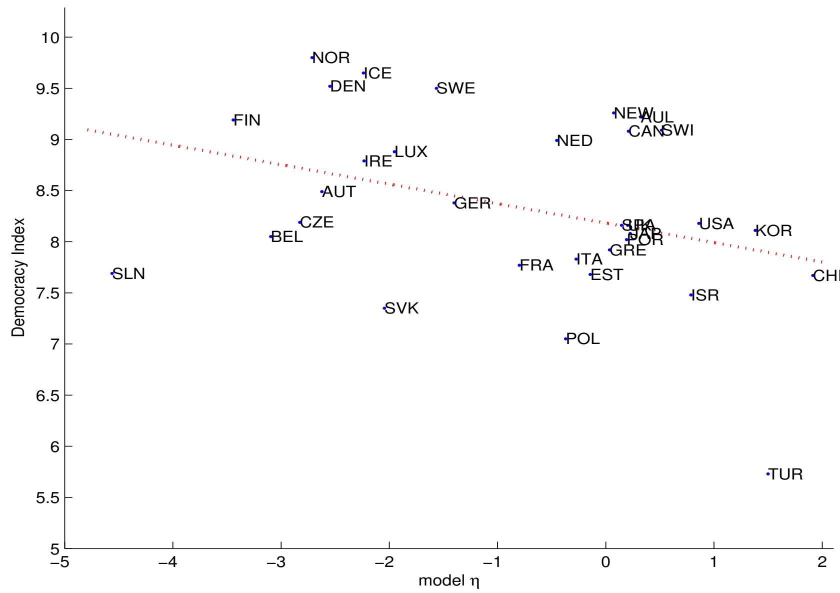
6. Potential Sources for Pareto Weights

We found that the shape of Pareto weights in the social welfare function varies vastly across 32 OECD countries. Pareto weight is a reduced form representation of complex aspects of the society (such as preferences for equity, electoral system, and distribution of political power, etc.). While understanding what the Pareto weights represents is beyond the scope of this paper, we propose three measures that are potentially important for the shape of Pareto weights: democracy of political system, electoral voting turnout rates by income, and the society's perception on 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 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, though not all questions are directly related to redistribution policy, including tax and transfers.[20] According to the EIU, among 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 (0.39) with the tax-to-GDP ratio. It is modestly correlated (0.33) with the improvement rate of the income Gini. Figure 8 compares the slope of Pareto weight η implied by our model to the Democracy Index ($y-$axis) across 32 OECD countries. They are modestly negatively correlated (-0.35): a democratic society tends to put more weights on the poor. If we exclude formerly Com-

[20]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 34 OECD countries. For instance, according to the Freedom House democracy index, 32 OECD countries are classified as "Free" and only Mexico and Turkey are 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), Mexico (8), and Turkey (8).

Figure 8: Democracy Index and Slope of Pareto Weights



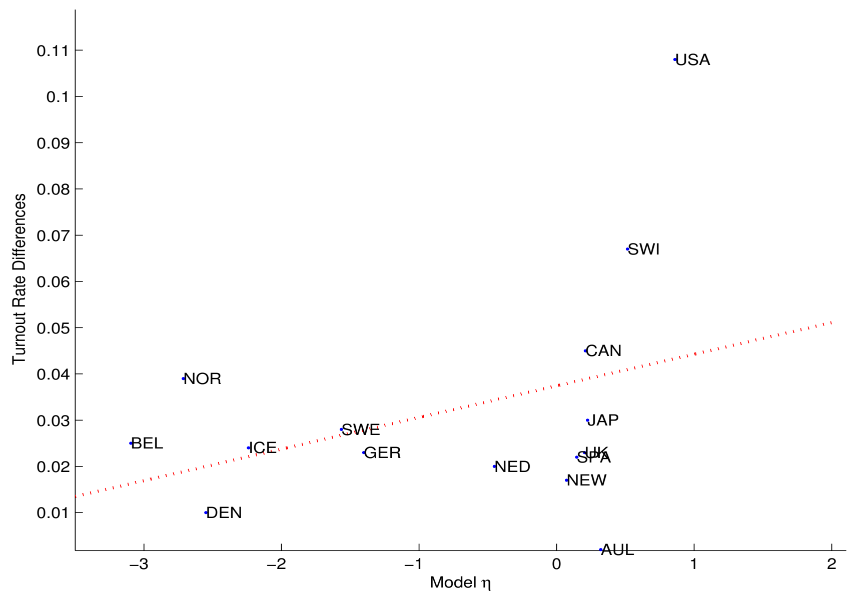
munist societies, where equity is highly valued, two variables are more strongly negatively correlated (-0.56).

Another interpretation of Pareto weights in the social welfare function is turn-out rates in voting. It is well known that low-income earners tend to participate less in voting than high-income earners in the U.S. We use the estimates in Mahler (2008) on the electoral turnout rates across 15 countries from the Comparative Study of Electoral Systems.[21] Figure 9 plots the difference in the average turnout rates of the top 40% in the income distribution and that of the bottom 40% (y-axis) against our estimate of η across 15 countries. Two variables are modestly positively correlated (0.35). In a country where the rich exhibit a higher voting turnout rate, they receive larger Pareto weights than the poor.

The society's preference for equity is probably different across countries, too. The *World Value Survey* examines the perception of various social issues in almost 100 countries. One question asks about the trade-off between equity and efficiency in income

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

Figure 9: Voter Turnout Rates by Income and Slope of Pareto Weights

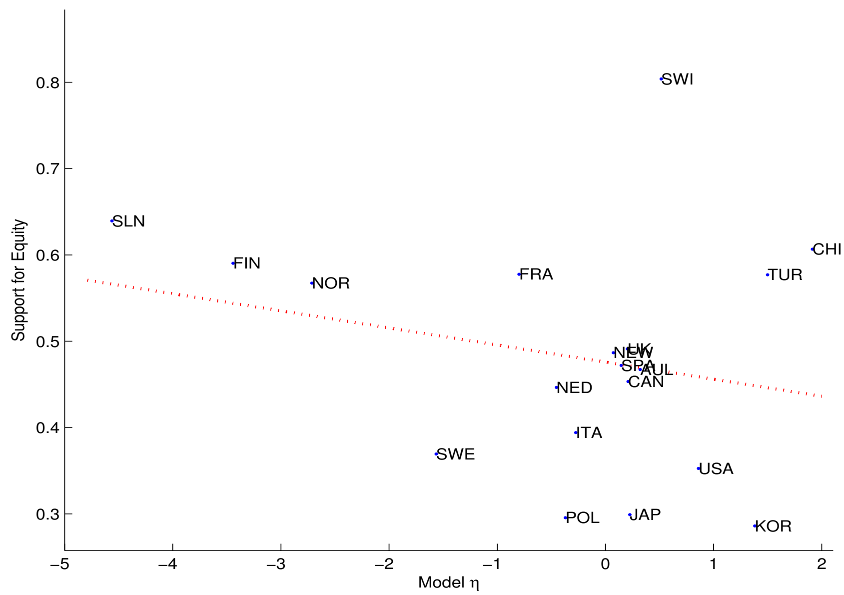


redistribution. The participants choose their views on a scale of 0-10 between "Incomes should be made more equal (0)" and "We need larger income difference as incentives for individual effort" (10). We calculate the fraction of the population with a scale between 0 and 5 (who are favorable to more income redistribution). Figure 10 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 (-0.25), implying that countries where more people support equity tend to put larger weights on the poor.

7. Robustness

While our benchmark model assumes a linear income tax and lump-sum transfer, which provides a certain degree of progressive taxation, progressive marginal income tax schedule is adopted in all OECD countries. Consumption or sales taxes are also common. In this section, we examine whether the implied tax rates in the model are robust to the introduction of progressive taxation and a consumption tax. We also provide a comparison between the marginal social welfare weights of the U.S. estimated by Lockwood and

Figure 10: Fraction of Population Favors Redistribution and Slope of Pareto Weights



Weinzierl (2014) and those implied by our model.

7.1. Progressive Taxation

Summarizing the progressivity of taxes (especially for cross-country comparison) is not a simple task because of the complexity of the income tax schedule and various deductions. 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., Heathcote et al. (2014)). In the log-linear tax function, two parameters, λ (average level of taxation) and ψ (tax progressivity), characterize disposal income, $D(y_i)$, as a function of the household's market income y_i.[22] Then, the household budget becomes as follows:

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

We also assume that the government incurs some expenditures, G, which do not directly enter into the household's utility function. The government expenditures-to-

[22] Disposable income is defined as the market income (y_i) minus taxes plus public transfer.

output ratio of each country in the steady state is chosen to match the government consumption-to-GDP ratio in the data. We assume this ratio is fixed under any tax reforms. The average level of taxation, λ, is determined by the government's budget balancing. Then, the government budget becomes as follows:

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

The progressivity of taxes, ψ, in our model is calibrated to match the Gini coefficients after taxes and transfers. The model-implied ψ in the U.S. is 0.261, which is close to but slightly higher than the estimate of 0.232 by Heathcote et al. (2014) and our estimate of 0.248 based on the LIS in Section 2.[23] Figure 11 compares the tax progressivity in the LIS and those implied by our model. Two values are fairly highly related (correlation coefficient of 0.77). The tax progressivity implied by our model is also highly correlated with the Gini improvement rates in the data (Figure 12).

Table 7 summarizes results for 3 countries (the U.S., Sweden, and Chile) under a progressive taxation. The model-implied tax progressivity, ψ, is 0.41 in Sweden and 0.05 in Chile. In steady states, the marginal tax rates for the median income worker are 0.29 (U.S.), 0.49 (Sweden), and 0.18 (Chile), respectively.

We now calculate the utilitarian optimal tax progressivity and voting outcome. The optimal tax progressivity is 0.34 in both the U.S. and Chile, much higher than the current values of 0.26 (U.S.) and 0.05 (Chile).[24] Under this optimal progressivity, the marginal tax rates for the median-income worker is 0.34 for the U.S. and 0.29 for Chile, again, much higher than the current values.[25] The optimal progressivity for Sweden is 0.31, much lower than the current value of 0.41. Under the optimal progressivity, the marginal

[23]Heathcote et al. (2014) estimated tax progressivity in the U.S. using the PSID and the CBO tables. Their estimates of progressivity are 0.151 (PSID) and 0.155 (CBO tables) without Social Security and Medicare transfers, and 0.232 (CBO tables) with Social Security and Medicare. Our model-implied ψ is close to the latter, since the Gini coefficients after taxes and transfers include Social Security transfers.

[24]The model-implied magnitude of the shocks is almost the same (0.336) in the U.S. and Chile, leading to a similar degree of optimal progressivity.

[25]Different marginal tax rates in the U.S. and Chile result from different government expenditure-to-GDP ratios.

Figure 11: Implied Tax Progressivity and Tax Progressivity in the Data

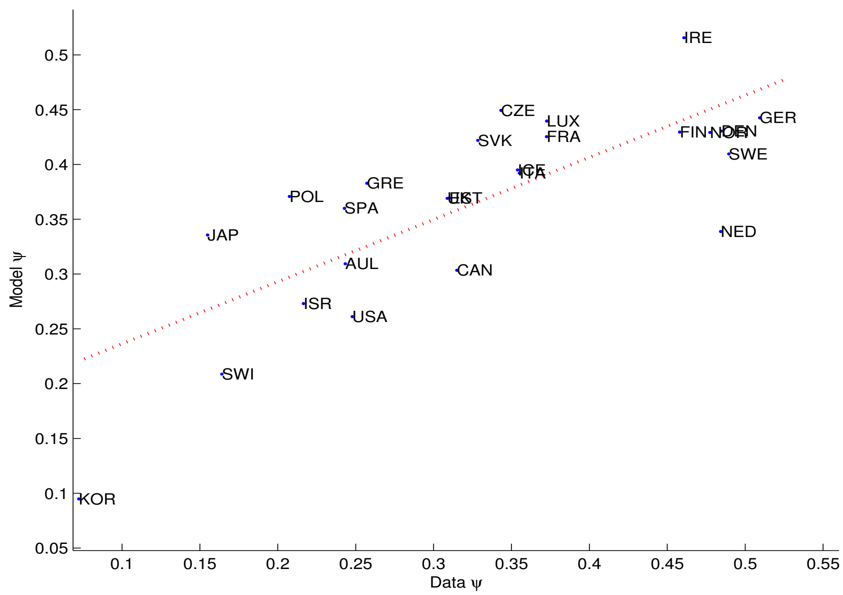


Figure 12: Implied Tax Progressivity and Gini Improvement Rates

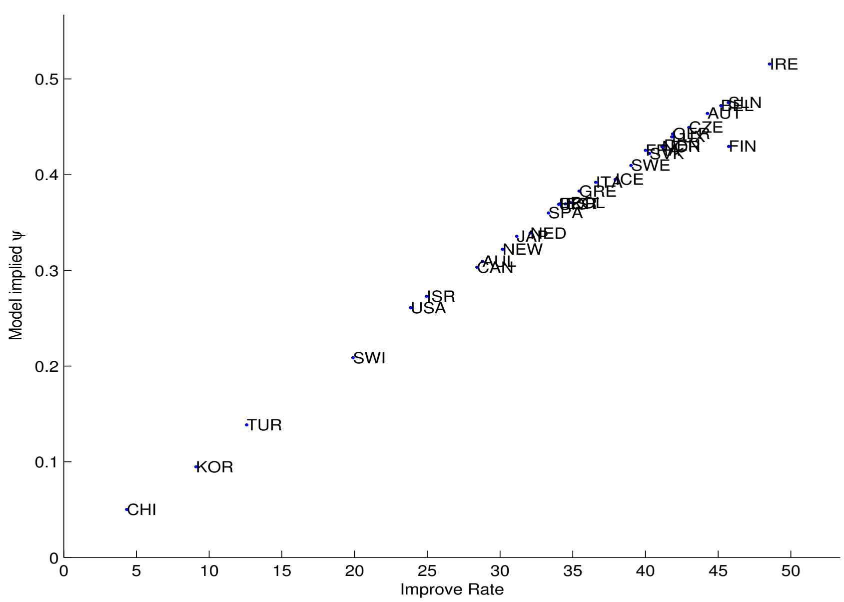
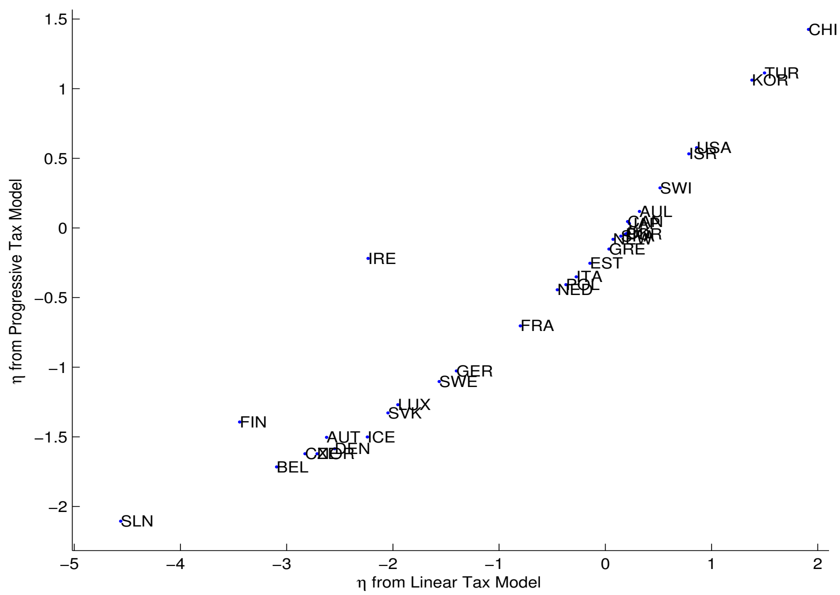


Figure 13: Pareto-Weight Function Parameter η in Two Models



tax rate for the median income worker in Sweden is 0.43. The tax progressivity supported by the majority of the population is close to the utilitarian optimum in all three countries. The optimal tax progressivity and the corresponding marginal tax rate for the median income workers for each of 32 OECD countries are summarized in Appendix Table C.5.

The estimated Pareto weights under a progressive taxation are not very different from those under a linear income tax and lump-sum transfer. For example, the Pareto weight parameters η under a progressive taxation are 0.58, 1.42, and -1.10, respectively, in the U.S., Chile, and Sweden, whereas those under a linear income tax model are 0.86, 1.91, and -1,56, respectively. Under the progressive income tax, the average Pareto weights in the U.S. are 12%, 17%, 20%, 23%, and 29%, respectively, from the 1st (poorest 20%) to the 5th quintiles (richest 20%), whereas those under the linear tax and lump-sum transfer model are 9%, 14%, 18%, 24%, and 35%. Figure 13 plots the values of η's under the benchmark linear tax and progressive log-linear income tax models. They exhibit a close-to-linear relationship. The cross-sectional dispersion of η across countries is somewhat smaller under a progressive taxation model. We report the values of η and the Pareto weights under a progressive taxation for all countries in Appendix Table C.6.

Table 7: Results under Progressive Tax

	U.S.	Sweden	Chile
Magnitude of Shock (σ_x)	0.336	0.312	0.336
Implied Tax Progressivity (ψ)	0.261	0.410	0.050
- Marginal Tax Rate for Median	0.291	0.490	0.175
Gini Improvement Rates	0.238	0.390	0.043
T/Y in 2010	0.238	0.454	0.195
Tax Wedge in 2010	0.254	0.386	0.066
G/Y in 2010	0.169	0.252	0.123
Optimal Tax Progressivity (ψ^*)	0.340	0.314	0.336
- Marginal Tax Rate for Median	0.337	0.428	0.284
Tax Progressivity by Majority Voting	0.341	0.320	0.340
- Marginal Tax Rate for Median	0.338	0.431	0.286
Estimated Value for η	0.576	-1.104	1.426
Pareto Weight on 1st Quintile	0.121	0.348	0.029
2nd Quintile	0.166	0.223	0.076
3rd Quintile	0.196	0.179	0.135
4th Quintile	0.229	0.145	0.229
5th Quintile	0.289	0.106	0.531

7.2. Consumption Tax

With the existence of a consumption tax, a more appropriate tax rate for households' consumption-leisure choice is $1-\tilde{\tau} = (1-\tau_l)/(1+\tau_c)$, where τ_l is the labor-income tax rate and τ_c is the consumption tax rate. We compute $\tilde{\tau}$ for each of the 32 OECD countries. We use the ratio of the labor-income tax revenue to total labor income for τ_l and the ratio of the consumption-tax revenue to total consumption for τ_c. The adjusted income tax rate ($\tilde{\tau}$) is highly correlated with the total tax revenue to GDP ratio (T/Y), which is our benchmark measure for the income tax rate, as well as with the model-implied tax rate. The correlation of $\tilde{\tau}$ with T/Y is 0.89 and that with the model-implied τ is 0.73. Alternatively, we also compute the adjusted tax rate ($\tilde{\tau}$) based on the average tax wedge (two-earner households) and consumption tax rate. This is also highly correlated with the model-implied tax rate (correlation coefficient of 0.72).

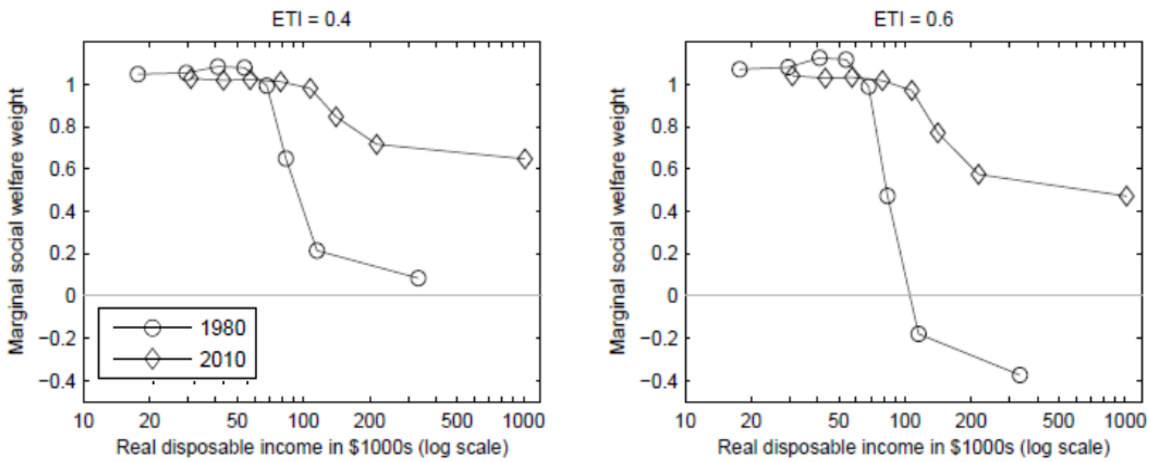
7.3. Comparison to the Mirrleesian (1971) Approach

A highly popular approach to estimating the Pareto weights is to use the Mirrlees (1971) model. While most of 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 (2014) estimate the marginal social weights of the U.S. based on the CBO's income data and marginal tax schedule from the NBER's TAXSIM. According to the optimal tax rate formula derived in Saez (2001), they derive the marginal social weights as:

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

where $g(y)$, y, $F(y)$, $f(y)$, $T(y)$, and ϵ are marginal social welfare weights: observable earnings, the cumulative distribution of earnings, the marginal density of earnings distribution, the income tax code, and the elasticity of labor supply with respect to taxable income, respectively. Figure 14, which is borrowed from Lockwood and Weinzierl (2014), exhibits the estimated marginal social welfare weights across the 0-20th, 20-40th, 40-60th, 60-80th, 80-90th, 90-95th, and 95-99th percentiles of income based on the CBO for two

Figure 14: Marginal Social Welfare Weights of U.S. from Lockwood and Weinzierl (2014)



Note: The average marginal weights across the 0-20th, 20-40th, 40-60th, 60-80th, 80-90th, 90-95th, and 95-99th percentiles of income distribution based on the CBO (Figure 4 in Lockwood and Weinzierl (2014)). The left (right) panel assumes the elasticity of labor-supply with respect to taxable income of 0.4 and (0.6).

values of the elasticity of labor supply: 0.4 (left panel) and 0.6 (right panel) for 1980 (denoted by lines with circles) and 2010 (lines with diamonds).[26] The marginal weights are more or less flat from the 20th to the 80th percentiles and then fall sharply after.

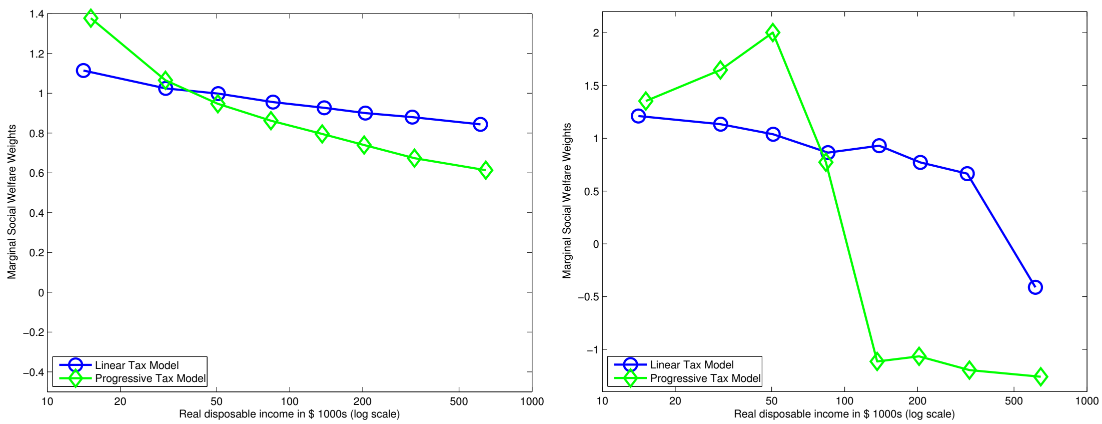
In our model, the marginal social welfare weights (after normalizing them summing to 1) can be written as:

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

The left panel in Figure 15 shows the marginal social welfare weights of the U.S. economy uncovered by our model under the linear (denoted by lines with circles) and log-linear (lines with diamonds) income tax, respectively, across income groups. For comparison, we rescale the incomes in our models so that the average income in our model matches that in the data ($79,300). While the Pareto weights increase with consumption in our models ($\eta = 0.86$ under the linear tax and $\eta = 0.58$ under the log-linear tax function,

[26]They consider four values of the elasticity of labor supply: 0.1, 0.3, 0.4 and 0.6. Since the Hicksian-income elasticity approximates to $(1/\sigma \cdot \gamma)/(1/\sigma + \gamma)$ (Keane and Rogerson (2012)), which is 0.5 in our model, we compare their results under the elasticity 0.4 and 0.6 to ours.

Figure 15: Marginal Social Welfare Weights of U.S. According to Our Model



Note: The average marginal weights across the 0-20th, 20-40th, 40-60th, 60-80th, 80-90th, 90-95th, and 95-99th percentiles of income distribution in our models. The left panel exhibits the marginal social welfare weights uncovered by our model. The right panel shows the marginal weights when the formula in Lockwood and Weinzierl (2014)–Equation (1)–was applied to our-model-generated data. Incomes in our models are rescaled so that the average income in the model matches that in the data ($79,300).

respectively), the marginal social weights decrease with consumption, as the effect of marginal utility outweighs that of the Pareto weights. The marginal social weights under the log-linear tax declines faster as income increases because the slope of the Pareto weight function is flatter (i.e., η is smaller).

The right panel in Figure 15 shows the marginal social welfare weights when the above formula in Lockwood and Weinzierl (2014)–Equation (1)–is applied to our model-generated income data and taxes.[27] The elasticity of labor supply with respect to taxable income is assumed to be 0.5. The marginal weights from our model-generated data, according to their formula, exhibit patterns similar to their estimates from the CBO data. From the bottom to middle income groups, the marginal weights are relatively flat (under the linear tax) or slightly increase (under the log-linear tax). As income approaches to

[27]Lockwood and Weinzierl (2014) assumes a Pareto distribution for income, whereas we use the model-generated equilibrium income distribution. In a linear tax model we use the average income in eight partitions of the income distribution. In a progressive tax model we calculate marginal social weights in percentiles, smooth them by weighting function, and average them in eight partitions.

80th percentile, the welfare weight decreases sharply (even to negative values, as their estimates do for the 1980 data). Compared to their estimates, the weights on the rich are smaller in our model-generated data. One reason is that they assume a more fat-tailed distribution of income (Pareto log-normal) than ours (approximately log-normal). Also, 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 progressive tax model, the marginal tax rates increase monotonically. Moreover, income is equal to consumption in a static environment: the marginal utility of consumption falls rapidly as income increases. However, under the Aiyagari economy as in our model economy), a household with high productivity saves a large portion of its income for precautionary motives—the marginal utility of consumption falls at a lower rate.[28]

8. Conclusion

Economic inequality is at the heart of policy debates in almost every society. We develop a quantitative general equilibrium model that can be used for the quantitative analysis of the political economy of redistribution policies. With this model, calibrated to exactly match the before- and after-tax income inequality in the data drawn from the OECD database, we ask the following questions for 32 OECD countries: (i) What is the optimal income tax and transfer policy under the equal-weight utilitarian social welfare function? (ii) Is the optimal tax reform supported by the majority of the population? (iii) What is the Pareto weight in the social welfare function that justifies the current redistribution policy?

According to our model, the optimal tax rate under the equal-weight utilitarian social welfare is quite high, between 23.5% (South Korea) and 40.8% (Chile). For 14 countries, the optimal tax rate is higher than the current average tax rate—measured by the tax-to-GDP ratio. For 18 European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherland,

[28] Also, Lockwood and Weinzierl (2014) use a quasilinear utility where there is no income effect on labor supply.

Norway, Poland, Slovak Republic, Slovenia, and Sweden), the optimal tax rate is lower than the current average tax rate. In Greece and New Zealand, the current tax rate is close to the social optimum.

In our model, a policy reform to adopt the optimal tax rate is supported by the majority of the population in all countries except for Greece and New Zealand. For example, in Chile the policy to increase the income tax rate to the socially optimal rate (40.8%) is supported by 83% of the population. We interpret the persistence of the current suboptimal tax rate (despite the population's overwhelming support for optimal tax reform) as evidence that Pareto weights in the social welfare function are far from equal. For example, in Chile, the Pareto weight—which would justify the currently low tax rates—on the richest 20% of households is 67%, whereas that on the poorest 20% is a mere 1%. Designing an appropriate redistribution policy requires aggregating preferences across different households. We provide some evidence, although it is indirect, that our Pareto weights are correlated with a country's democracy index, voting turnout rates by income, and preference for redistribution of incomes. We argue that the Pareto weights (which map individual welfare into social welfare) uncovered in this analysis will be a useful step for further quantitative analysis of income inequality and redistribution.

References

Acemoglu, Daron, Suresh Naidu, Pascual Restrepo, and James A. Robinson 2013. "Democracy, Redistribution, and Inequality." *National Bureau of Economic Research Working Paper.*

Aiyagari, S. Rao 1994. "Uninsured Idiosyncratic Risk and Aggregate Savings." *Quarterly Journal of Economics*, 109(3), 659-684.

Aiyagari, S. Rao, and Ellen R. McGrattan 1998. "The Optimum Quantity of Debt." *Journal of Monetary Economics*, 42(3), 447-469.

Alesina, Aleberto, and Edward L. Glaeser 2004. "Fighting Poverty in the U.S. and Europe." *Oxford University Press.*

Chang, Yongsung, and Sun-Bin Kim 2006 "From Individual to Aggregate Labor Supply: A Quantitative Analysis Based on a Heterogeneous Agent Macroeconomy." *International Economic Review*, 47(1), 1-27.

Chang, Yongsung, and Sun-Bin Kim 2011. "The Price of Egalitarianism." *The B.E. Journal of Macroeconomics*, Vol. 11 (Issue 1), Article 42.

Credit Suisse 2012 "Global Wealth Databook 2012," Credit Suisse.

Díaz-Giménez, Javier, Andy Glover, and José-Víctor Ríos-Rull 2011. "Facts on the Distributions of Earnings, Income, and Wealth in the United States: 2007 Update." *Federal Reserve Bank of Minneapolis Quarterly Review Vol.34, No 1, February 2011, pp-2-31*

EIU 2011 "Democracy index 2011. Democracy under stress," Economist Intelligence Unit (EIU).

Floden, Martin, and Jesper Linde 2001. "Idiosyncratic Risk in the United States and Sweden: Is There a Role for Government Insurance?" *Review of Economic Dynamics*, 4(2), 406-437.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante 2008. "Insurance and Opportunities: A Welfare Analysis of Labor Market Risk." *Journal of Monetary Economics*, 55(3), 501–525.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante 2014 "Optimal Tax Progressivity: An Analytical Framework." Working paper

Heathcote, Jonathan and Hitoshi Tsujiyama 2015. "Optimal Income Taxation: Mirrlees Meets Ramsey," Working paper.

Keane, Michael and Richard Rogerson 2012, "Micro and Macro Labor Supply Elasticities: A Reassessment of Conventional Wisdom," *Journal of Economic Literature*, 50:2, 464-476

LIS 2016. "Luxembourg Income Study (LIS) database, Waves for 4, 5, and 6," LIS

Lockwood, Benjamin B., and Matthew Weinzierl, 2014. "Positive and normative judgements implicit in U.S. tax policy, and the costs of unequal growth and recessions." Working paper

Mahler, Vincent 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.

Meltzer, Allan H., and Scott F. Richard 1981. "A Rational Theory of the Size of Government." *Journal of Political Economy*, 89(5), 914-27.

Mirrlees, James A. 1971. "An exploration in the theory of optimum income taxation," *Review of Economic Studies*, pp. 175-208.

OECD 2015. "Organization for Economic Cooperation and Development (OECD) database in 2014 and 2015," OECD.

Pijoan-Mas, Josep 2006. "Precautionary Savings or Working Longer Hours." *Review of Economic Dynamics*, 9(2), 326-352.

Ríos-Rull, José-Víctor 1999. "Computation of Equilibria in Heterogeneous-Agents Models," *Computational Methods for the Study of Dynamic Economies*, ed. Ramon Marimon and Andrew Scott, New York: Oxford University Press.

Roberts, Kevin W.S. 1977. "Voting Over Income Tax Schedules." *Journal of Public Economics*, 8, 329-340.

Romer, Thomas 1975. "Individual Welfare, Majority Voting, and the Properties of a Linear Income Tax." *Journal of Public Economics*, 7, 163-88.

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

Tauchen, George 1986. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions." *Economics Letters* 20, 177-181.

WVS 2015. "World Values Survey (WVS) database 2005-2009." World Values Survey Association.

Appendix A: Data Appendix

A.1. Income and Wealth Distribution

The income Gini coefficients used in this paper are obtained from the Organization for Economic Cooperation and Development (OECD) database. 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. Data in Ireland and Turkey are extracted in 2015, and other data are extracted in 2014. 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 statistics about the U.S. earnings and wealth distribution based on the Survey of Consumer Finances (SCF) are from Díaz-Giménez, Glover, and Ríos-Rull (2011), and those based on the Panel Study of Income Dynamics (PSID) are from Chang and Kim (2011). 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. The base year is 2010. The tax wedge is the difference between labor costs to the employer and the corresponding net take-home pay of the employee, which is calculated by expressing 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 (definition by the OECD). The OECD provides the tax wedges for several types of households categorized 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"). The gap between tax revenues and expenditures 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. We divide the OECD's numbers by 5500 hours, the total amount of annual discretionary time.

Per capita GDP is also from the OECD database.

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 percent of the worlds population, using a common questionnaire. We use the WVS 2005-2009 data. 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, as an indicator of support for the equity.

A.5. Luxembourg Income Study

The Luxembourg Income Study (LIS) 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 34 OECD countries report detailed information on market and disposable income in the LIS database; we define market income as factor income (factor) plus private transfer (hitp), and disposable income as market income plus public transfer (hits) minus taxes and contributions (hxit). The base year in 19 countries (Australia, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Netherland, 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 are based on earlier years. All incomes are equivalized by household size. In estimating tax progressivity, we drop 20% of low-income households, since those data are very noisy.

Appendix 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. The proportional income tax rate τ is read from the improvement rate in income Gini in the data. We search for (i) the discount factor β that clears the capital market at the given quarterly rate of return of 1%; (ii) the standard deviation of idiosyncratic productivity, σ_x, that matches the before-tax Gini coefficient; and (iii) the disutility parameter B to match the average hours worked, 0.323. 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 $N_a = 292$ and $N_x = 31$. The asset holding a_t is in the range of [0, 29.6]. The grid points of assets are not equally spaced. We assign more points on the lower asset range to better approximate the savings decisions of households near the borrowing constraint.

2. Pick initial values of β, B, and σ_x. 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. Start with an initial amount of government transfers T. Given β, B, σ_x, τ, and T, 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 $V_0(a_i, x_j)$ for all $i = 1, 2, \cdots, N_a$, and $j = 1, 2, \cdots, N_x$.

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

$$V_1(a_i, x_j) = \max\Big\{u\big((1-\tau)(wh(a_i, x_j)x_j + ra_i) + a_i + T - a', h(a_i, x_j)\big)$$

$$+\beta \sum_{j'=1}^{N_x} V_0(a', x'_j))\pi_x(x_{j'}|x_j)\Big\},$$

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. Using decision rules and invariant measures, check the balance of the government budget. Total tax revenues are:

$$TR = \int_{a,x} \tau(wxh + ra)d\mu(a, x).$$

   If TR is close enough to T, then we have obtained the amount of government transfers. Otherwise, choose a new T and go back to step 3.

6. We calculate the real interest rate, Gini coefficient, individual hours worked, and other aggregate variables of interest using μ^* and decision rules. If the calculated real interest rate, average hours worked, and before-tax Gini coefficient are close to the assumed ones, we have found the steady state. Otherwise, we choose a new β, B, and σ_x, and go back to step 2.

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

B.2. Optimal Tax Reform

Individual utilities include those in the transition periods from the initial to the new steady state. We compute the value functions and decision rules backwards and the measure of households forward. Computing the transition equilibrium amounts to finding the value functions, the associated decision rules, and measure of households in each period. The details are as follows:

1. Compute the initial steady state under the current tax rate. Use the algorithm for the steady-state equilibrium.

2. Choose a new tax rate and compute all transition paths as follows:

   (a) Compute the final steady state under a new tax rate. Use the algorithm for steady-state equilibrium.

   (b) Assume that the transition is completed after $T-1$ periods, and that the economy is in the initial steady state at time 1 and in the final steady state at 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 government transfers $\{T\}_{t=2}^{T-1}$. Note that the amounts of government transfers are all different in each period, since decision rules and measures are different. 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 measures of all periods $\{\mu_t\}_{t=2}^{T-1}$.

   (e) Based on the decision rules and measures, compute the aggregate variables and total tax revenues. If the total tax revenue is close to the assumed transfers, we obtain the amount of transfers. Otherwise, choose a new path of government transfers 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 rate that yields the highest social welfare. This is the optimal tax rate under the utilitarian criteria. We also compute the voting outcome for this tax reform policy. 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 $V(a, x, \tau^{new}, \tilde{r}, \tilde{w}) > V(a, x, \tau^{current}, r^*, w^*)$, then this individual votes in favor of the new tax rate.

B.3. Pareto Weights

We search for the value of η so that the current tax rate provides the highest social welfare in the steady state. Note that we compare the steady-state social welfares. Details are as follows:

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

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

3. Assume η and compute the social welfare under each tax rate:

$$\mathcal{W} = \int \theta(a_0, x_0) V(a_0, x_0) d\mu(a_0, x_0),$$

where

$$V(a_0, x_0) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \quad \text{and } \theta(a_0, x_0) = \frac{c(a_0, x_o)^\eta}{\displaystyle\int c(a_0, x_o)^\eta d\mu(a_0, x_0)}$$

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

Appendix C: Additional Tables

Table C.1: Estimation for the Tax Progressivity

	$1-\hat{\psi}$	SE	$\hat{\psi}$	N	R^2
Australia	0.757	(0.004)	0.243	9,647	0.892
Austria	...	...	...	...	...
Belgium	...	...	...	...	...
Canada	0.685	(0.004)	0.315	16,124	0.781
Chile	...	...	...	...	...
Czech Republic	0.657	(0.006)	0.343	6,317	0.774
Denmark	0.515	(0.003)	0.485	55,367	0.691
Estonia	0.690	(0.008)	0.310	3,098	0.765
Finland	0.542	(0.008)	0.458	6,920	0.693
France	0.627	(0.007)	0.373	10,476	0.652
Germany	0.491	(0.007)	0.509	8,432	0.570
Greece	0.743	(0.009)	0.257	2,837	0.723
Iceland	0.646	(0.011)	0.354	2,350	0.773
Ireland	0.539	(0.009)	0.461	2,096	0.723
Israel	0.784	(0.005)	0.216	3,909	0.873
Italy	0.645	(0.013)	0.355	4,907	0.564
Japan	0.845	(0.009)	0.155	2,245	0.776
Korea	0.928	(0.003)	0.072	10,541	0.900
Luxembourg	0.627	(0.009)	0.373	3,665	0.673
Netherlands	0.516	(0.009)	0.484	7,708	0.592
New Zealand	...	...	...	...	...
Norway	0.523	(0.009)	0.477	10,046	0.643
Poland	0.793	(0.003)	0.207	22,065	0.791
Portugal	...	...	...	...	...
Slovak Republic	0.672	(0.010)	0.328	3,239	0.651
Slovenia	...	...	...	...	...
Spain	0.757	(0.006)	0.243	7,049	0.722
Sweden	0.511	(0.010)	0.489	10,828	0.625
Switzerland	0.836	(0.012)	0.164	2,390	0.762
Turkey	...	...	...	...	...
United Kingdom	0.691	(0.005)	0.309	13,951	0.722
United States	0.752	(0.001)	0.248	51,102	0.878

Source: Authors' calculation from the LIS database (2016).

Table C.2: Steady State for OECD

	Implied Tax Rates (τ)	Tax/Y in 2010	Tax Wedge in 2010	Interest Rates (r)	Hours Worked (H)
Australia	0.288	0.256	0.237	0.048	0.323
Austria	0.443	0.422	0.400	0.070	0.275
Belgium	0.452	0.435	0.488	0.072	0.273
Canada	0.284	0.306	0.266	0.050	0.328
Chile	0.043	0.195	0.066	0.019	0.395
Czech Republic	0.430	0.339	0.343	0.071	0.284
Denmark	0.413	0.474	0.337	0.069	0.292
Estonia	0.345	0.340	0.358	0.054	0.303
Finland	0.457	0.425	0.369	0.073	0.271
France	0.400	0.429	0.451	0.061	0.283
Germany	0.419	0.362	0.417	0.065	0.280
Greece	0.354	0.316	0.383	0.052	0.294
Iceland	0.379	0.352	0.304	0.067	0.307
Ireland	0.485	0.274	0.162	0.069	0.243
Israel	0.250	0.324	0.133	0.041	0.330
Italy	0.366	0.430	0.424	0.056	0.294
Japan	0.311	0.276	0.254	0.050	0.313
Korea	0.091	0.251	0.179	0.041	0.397
Luxembourg	0.418	0.373	0.213	0.067	0.285
Netherlands	0.321	0.389	0.318	0.057	0.320
New Zealand	0.302	0.311	0.138	0.052	0.321
Norway	0.411	0.426	0.334	0.070	0.293
Poland	0.348	0.317	0.306	0.056	0.305
Portugal	0.341	0.312	0.325	0.050	0.298
Slovak Republic	0.403	0.283	0.315	0.067	0.294
Slovenia	0.457	0.381	0.340	0.075	0.275
Spain	0.333	0.325	0.367	0.051	0.303
Sweden	0.390	0.454	0.386	0.065	0.297
Switzerland	0.199	0.281	0.158	0.048	0.363
Turkey	0.126	0.262	0.381	0.031	0.373
United Kingdom	0.340	0.349	0.284	0.050	0.298
United States	0.238	0.238	0.254	0.040	0.333

Source: OECD database (2014, 2015) and authors' calculation.

Table C.3: Optimal Tax Reform and Approval Rate

	Magnitude Shock (σ_x)	Implied Tax Rate (τ)	Optimal Tax Rate (τ^*)	Approval Rate	Tax Rate (50% approval)
Australia	0.261	0.288	0.325	0.512	0.318
Austria	0.250	0.443	0.307	0.720	0.293
Belgium	0.248	0.452	0.305	0.725	0.292
Canada	0.246	0.284	0.306	0.502	0.294
Chile	0.337	0.043	0.408	0.834	0.403
Czech Republic	0.231	0.430	0.283	0.724	0.270
Denmark	0.220	0.413	0.268	0.722	0.253
Estonia	0.267	0.345	0.332	0.565	0.325
Finland	0.248	0.457	0.304	0.727	0.287
France	0.273	0.400	0.337	0.597	0.330
Germany	0.262	0.419	0.323	0.655	0.309
Greece	0.291	0.354	0.358	0.493	0.354
Iceland	0.200	0.379	0.241	0.719	0.229
Ireland	0.317	0.485	0.380	0.659	0.375
Israel	0.288	0.250	0.357	0.599	0.350
Italy	0.276	0.366	0.340	0.569	0.336
Japan	0.271	0.311	0.337	0.507	0.331
Korea	0.193	0.091	0.235	0.608	0.221
Luxembourg	0.242	0.418	0.299	0.671	0.288
Netherlands	0.226	0.321	0.280	0.580	0.271
New Zealand	0.249	0.302	0.309	0.486	0.302
Norway	0.216	0.411	0.263	0.724	0.251
Poland	0.253	0.348	0.314	0.574	0.308
Portugal	0.292	0.341	0.360	0.505	0.351
Slovak Republic	0.226	0.403	0.278	0.681	0.263
Slovenia	0.231	0.457	0.283	0.745	0.267
Spain	0.282	0.333	0.349	0.502	0.343
Sweden	0.230	0.390	0.284	0.661	0.270
Switzerland	0.204	0.199	0.250	0.517	0.239
Turkey	0.285	0.126	0.354	0.690	0.346
United Kingdom	0.293	0.340	0.361	0.506	0.350
United States	0.288	0.238	0.358	0.603	0.348

Note: The number in the last column is the tax rate that is supported by exactly 50% of the population from the current steady-state distribution.

Table C.4: Pareto Weights across Consumption Quintiles

	Parameter	Pareto Weights				
				Quintile		
	η	1st	2nd	3rd	4th	5th
Australia	0.322	0.159	0.181	0.198	0.215	0.245
Austria	-2.623	0.510	0.244	0.135	0.077	0.034
Belgium	-3.095	0.556	0.237	0.119	0.063	0.024
Canada	0.210	0.174	0.189	0.200	0.210	0.227
Chile	1.914	0.011	0.041	0.091	0.191	0.667
Czech Republic	-2.827	0.533	0.234	0.128	0.073	0.032
Denmark	-2.549	0.504	0.234	0.138	0.084	0.041
Estonia	-0.144	0.219	0.207	0.200	0.192	0.182
Finland	-3.442	0.588	0.231	0.108	0.053	0.019
France	-0.799	0.301	0.234	0.191	0.157	0.117
Germany	-1.401	0.374	0.246	0.175	0.127	0.078
Greece	0.034	0.196	0.198	0.200	0.202	0.205
Iceland	-2.240	0.466	0.231	0.149	0.099	0.054
Ireland	-2.233	0.448	0.273	0.154	0.087	0.037
Israel	0.787	0.102	0.144	0.185	0.233	0.336
Italy	-0.273	0.235	0.214	0.199	0.186	0.167
Japan	0.225	0.171	0.187	0.199	0.211	0.232
Korea	1.381	0.072	0.128	0.178	0.240	0.383
Luxembourg	-1.953	0.439	0.244	0.157	0.104	0.056
Netherlands	-0.452	0.256	0.218	0.196	0.178	0.153
New Zealand	0.073	0.191	0.196	0.200	0.204	0.209
Norway	-2.713	0.522	0.230	0.132	0.079	0.037
Poland	-0.370	0.247	0.217	0.197	0.181	0.158
Portugal	0.192	0.175	0.188	0.199	0.210	0.228
Slovak Republic	-2.046	0.450	0.239	0.154	0.102	0.055
Slovenia	-4.562	0.686	0.196	0.077	0.032	0.009
Spain	0.146	0.181	0.191	0.199	0.207	0.221
Sweden	-1.564	0.394	0.239	0.169	0.122	0.075
Switzerland	0.516	0.143	0.176	0.198	0.221	0.262
Turkey	1.498	0.039	0.087	0.145	0.232	0.497
United Kingdom	0.203	0.174	0.187	0.199	0.210	0.230
United States	0.860	0.093	0.139	0.182	0.235	0.351

Table C.5: Optimal Tax Reform under a Progressive Taxation

	Data	Steady State		Optimal Tax		50% Approval	
	ψ	ψ	$\frac{\partial t(y_m)}{\partial y_m}$	ψ^*	$\frac{\partial t(y_m)}{\partial y_m}$	ψ^M	$\frac{\partial t(y_m)}{\partial y_m}$
Australia	0.243	0.309	0.343	0.323	0.352	0.329	0.355
Austria	...	0.464	0.457	0.343	0.364	0.354	0.371
Belgium	...	0.472	0.491	0.344	0.398	0.352	0.403
Canada	0.315	0.303	0.396	0.309	0.399	0.313	0.402
Chile	...	0.050	0.175	0.342	0.287	0.330	0.279
Czech Republic	0.343	0.449	0.469	0.321	0.375	0.329	0.379
Denmark	0.485	0.430	0.529	0.307	0.452	0.320	0.459
Estonia	0.310	0.369	0.386	0.341	0.368	0.349	0.374
Finland	0.458	0.430	0.502	0.316	0.427	0.320	0.429
France	0.373	0.425	0.444	0.359	0.397	0.365	0.401
Germany	0.509	0.443	0.420	0.350	0.349	0.363	0.357
Greece	0.257	0.383	0.383	0.365	0.371	0.373	0.376
Iceland	0.354	0.395	0.501	0.277	0.426	0.285	0.430
Ireland	0.461	0.516	0.387	0.499	0.372	0.496	0.368
Israel	0.216	0.273	0.359	0.399	0.433	0.343	0.396
Italy	0.355	0.392	0.391	0.354	0.365	0.362	0.370
Japan	0.155	0.336	0.364	0.339	0.366	0.346	0.370
Korea	0.072	0.095	0.241	0.209	0.308	0.205	0.306
Luxembourg	0.373	0.440	0.416	0.329	0.329	0.340	0.336
Netherlands	0.484	0.339	0.470	0.296	0.445	0.299	0.447
New Zealand	...	0.322	0.378	0.313	0.373	0.322	0.378
Norway	0.477	0.429	0.480	0.300	0.389	0.309	0.394
Poland	0.207	0.371	0.392	0.328	0.363	0.331	0.365
Portugal	...	0.370	0.366	0.365	0.364	0.370	0.366
Slovak Republic	0.328	0.422	0.446	0.310	0.364	0.312	0.366
Slovenia	...	0.475	0.483	0.326	0.369	0.335	0.375
Spain	0.243	0.360	0.371	0.354	0.368	0.360	0.371
Sweden	0.489	0.410	0.490	0.314	0.428	0.320	0.431
Switzerland	0.164	0.209	0.253	0.239	0.274	0.239	0.273
Turkey	...	0.139	0.228	0.315	0.318	0.309	0.314
United Kingdom	0.309	0.369	0.334	0.365	0.332	0.369	0.334
United States	0.248	0.261	0.291	0.340	0.337	0.341	0.338

Note: ψ is tax progressivity, $\frac{\partial t(y_m)}{\partial y_m}$ is the marginal tax rate for the median income worker.
Source: Data for ψ are calculated by authors from the LIS database.

Table C.6: Pareto Weights across Consumption Quintiles under a Progressive Taxation

	Parameter	Pareto Weights				
		Quintile				
	η	1st	2nd	3rd	4th	5th
Australia	0.118	0.184	0.195	0.201	0.206	0.215
Austria	-1.504	0.408	0.224	0.165	0.123	0.080
Belgium	-1.716	0.435	0.223	0.158	0.114	0.070
Canada	0.046	0.194	0.198	0.200	0.202	0.205
Chile	1.426	0.029	0.076	0.135	0.229	0.531
Czech Republic	-1.621	0.417	0.222	0.163	0.121	0.078
Denmark	-1.586	0.406	0.223	0.165	0.124	0.082
Estonia	-0.254	0.236	0.210	0.197	0.186	0.171
Finland	-1.393	0.385	0.223	0.170	0.132	0.090
France	-0.703	0.302	0.221	0.188	0.161	0.128
Germany	-1.027	0.347	0.224	0.179	0.145	0.105
Greece	-0.151	0.222	0.206	0.199	0.191	0.181
Iceland	-1.502	0.387	0.222	0.169	0.131	0.090
Ireland	-0.219	0.227	0.208	0.198	0.189	0.177
Israel	0.532	0.127	0.169	0.197	0.226	0.281
Italy	-0.352	0.251	0.213	0.196	0.181	0.160
Japan	0.032	0.195	0.199	0.200	0.202	0.204
Korea	1.061	0.095	0.150	0.190	0.236	0.329
Luxembourg	-1.270	0.376	0.223	0.172	0.135	0.094
Netherlands	-0.444	0.258	0.213	0.194	0.178	0.156
New Zealand	-0.082	0.211	0.203	0.199	0.196	0.191
Norway	-1.621	0.410	0.222	0.164	0.123	0.081
Poland	-0.408	0.257	0.214	0.195	0.178	0.156
Portugal	-0.043	0.206	0.202	0.200	0.198	0.194
Slovak Republic	-1.328	0.378	0.223	0.172	0.134	0.093
Slovenia	-2.106	0.478	0.218	0.147	0.100	0.058
Spain	-0.059	0.206	0.202	0.200	0.198	0.195
Sweden	-1.104	0.348	0.223	0.179	0.145	0.106
Switzerland	0.287	0.166	0.189	0.201	0.213	0.232
Turkey	1.113	0.064	0.122	0.174	0.241	0.400
United Kingdom	-0.039	0.206	0.202	0.200	0.198	0.195
United States	0.576	0.121	0.166	0.196	0.229	0.289