Income Tax Progressivity: A Cross-Country Comparison*

Xincheng Qiu[†] Nicolo Russo[‡]

June 22, 2022

Preliminary and Incomplete

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Abstract

This paper studies income taxes across the world using detailed micro-data from the Luxembourg Income Study. We first show that income tax systems worldwide are approximated remarkably well by a two-parameter effective tax function. Then, we estimate country-and-year specific tax functions to compare the level of average taxation and income tax progressivity across countries and over time and examine the effects of government transfers and family structure. We find that a higher level of taxation is associated with a higher degree of progressivity. In particular, countries with a high degree of social insurance display the highest progressivity and average taxation levels. We also find that, for all countries we consider, government transfers play a crucial role for redistribution. On average, government transfers increase the progressivity of the income tax system twelve-fold. Finally, we find that the effect of family structure on income tax progressivity varies extensively by country. The presence of children in the family has the largest effect on progressivity in countries like the United Kingdom and Finland. In turn, marriage has the biggest impact on progressivity in countries like the United States and France.

Keywords:

JEL Codes:

*We would like to thank Margherita Borella, Mariacristina De Nardi, Johannes Fleck, Jeremy Lise, Jo Mullins, Kjetil Storesletten, and all the participants of the Macro-Micro Workshop at the University of Minnesota.

†Department of Economics, University of Pennsylvania, Ronald O. Perelman Center for Political Science and Economics, 133 S. 36th Street, Philadelphia, PA, United States, 19104. Email: qiux@sas.upenn.edu.

‡Department of Economics, University of Minnesota, 1925 Fourth Street South, Minneapolis, MN 55455. Email: russo087@umn.edu.

1 Introduction

Income tax systems are complicated by nature. In a single country, numerous factors must be accounted for: deductions, credits, and tax rates that depend on how taxpayers file their returns. Across countries, more complications arise. Comparing tax systems in different countries requires comparing fundamentally different institutions and policies. For these reasons, the literature on income taxes has mainly focused on one country in isolation or compared countries in pairs. In this paper, we build on this literature and compare the income tax systems of thirty-seven countries across the world. We characterize the average level of effective taxation and income tax progressivity and study the determinants of income tax progressivity across countries and time.

Income taxes are fundamental objects of interest both for macroeconomists and policymakers. Macroeconomists need effective income tax functions to compute after-tax income in their models. We provide estimates for numerous countries and years, which can be readily inserted into any structural model of the economy. Policymakers need an accurate assessment of the progressivity of the tax system to guide redistribution and social insurance policies. We analyze the effects of government transfers and family structure and provide evidence that they significantly affect income tax progressivity.

We use household microdata from the Luxembourg Income Study (LIS) Database to estimate effective income tax functions for over thirty countries over the last forty years. LIS has many advantages which make it the ideal dataset for our analysis. First, it covers a large number of countries, and it spans a long time. Second, it harmonizes data across countries, which allows us to compare variables across countries and survey waves. Third, it has a very large sample size: our final sample consists of almost eight million household-wave observations. Finally, it contains much information: we have data on labor and capital income, public social benefits, taxes, contributions, demography, employment, and consumption.

Using a detailed and large sample of working-age households from LIS, we estimate log-linear effective tax functions. This functional form has been used extensively in the literature on earnings dynamics. Our tax function is easy to estimate and allows us to characterize income tax systems parsimoniously. In particular, we compare inherently complicated tax systems by comparing two parameters: the average level of taxation and tax progressivity.

Our paper has several contributions. First, we demonstrate that our log-linear tax function is a remarkably accurate approximation of income tax systems worldwide. We show that our tax function can almost entirely explain the variation of post-tax income in all countries and waves in our sample. Due to the high approximation quality, our estimates can be used for many projects and datasets beyond our own. Any structural model of the economy which require the computation of post-tax income can incorporate our tax functions. Then, our estimates can supplement datasets lacking specific measures of income. For example, the public data from the Survey on Household Income and Wealth (SHIW), conducted by the Bank of Italy, only contains information on post-tax income for Italian households. Researchers can use our estimated tax functions for Italy to construct an accurate measure of pre-tax income using public SHIW data.

Second, we show that government transfers significantly affect income tax progressivity. Transfers are essential tools governments can use for redistribution, and we show that the progressivity net of government transfers is, on average, twelve times higher than its gross counterpart. Our estimates for the net average level of taxation and progressivity can be used in models that do not explicitly model government transfers. Thus, we offer a parsimonious way of modeling a wide range of government policies using a single function.

Third, we show considerable differences in progressivity across family structures. We study the effects of marriage and children and find that they significantly affect progressivity. For example, in the United States, marriage results in higher gross progressivity. In the United Kingdom and Finland, on the other hand, having children leads to higher income tax progressivity. Once transfers are taken into account, unmarried parents worldwide enjoy the highest degree of progressivity.

The rest of the paper is organized as follows. Section 2 highlights our contributions in the context of the related literature. Section 3 defines our tax function and estimation strategy. Section 4 describes the LIS Database, our sample selection, and the income definitions for our tax functions. Section 5 presents evidence on the fit of our tax function and discusses the evolution of the average level of taxation and progressivity across countries and time. Section 6 analyzes the effects of government transfers on progressivity. Section 7 presents effective tax functions by family type. Section 8 concludes.

2 Related Literature

First, our paper connects to the rich literature on **approximating the income tax and transfer system with a log-linear function** of post-tax income on pre-tax income.

The "log-linear approach" was pioneered by Feldstein (1969) and Benabou (2000) and made popular by Heathcote, Storesletten, and Violante (2017). While there are various approaches to modeling the income tax and transfer system, these papers argue in favor of the log-linear specification due to both its simplicity, as it requires only two parameters which can be estimated by ordinary least squares, and its excellent fit to the data.[1]

Numerous papers have used the log-linear tax function to study the income tax and transfer system in the United States. Guner, Kaygusuz, and Ventura (2014) use IRS data for the year 2000 and investigate how effective taxes change with family status and composition. They estimate several effective tax functions, including a log-linear one, and conclude that the log-linear tax function fits the data well. Heathcote, Storesletten, and Violante (2020) use data from the Congressional Budget Office to study tax progressivity between the end of the 1970s and 2016. They find that the level of progressivity is the same in 2012-2016 as in 1979-1983. Wu (2021) uses CPS data to study the evolution of tax progressivity between 1978 and 2016. He finds that the income tax in the US has become less progressive since the late 1970s. Fleck, Heathcote, Storesletten, and Violante (2021) use CPS data to study the progressivity of the tax and transfer system at the US state level. They estimate effective tax functions for each of the 50 states and find substantial heterogeneity in progressivity across states. Finally, Borella, De Nardi, Pak, Russo, and Yang (2020) use PSID data to study the evolution of effective tax rates between the end of the 1960s and 2016. They compile a history of income tax reforms over that period and compare the evolution of progressivity and average tax rates with the desired outcomes of the reforms.

A few recent papers have used the log-linear tax function for countries other than the US. García-Miralles, Guner, and Ramos (2019) use administrative tax data for Spain to study the distributions of pre and post-tax income and tax liabilities between 2002 and 2015. They find that the log-linear tax function approximates the Spanish personal income tax system quite well. Kaas, Kocharkov, Preugschat, and Siassi (2020) study homeownership in Germany and use the log-linear tax function in the context of a rich structural model. They show that it approximates the income tax and transfer system quite well. Finally, De Magalhaes, Martorell, and Santaeulalia-Llopis (2019) plan to use microdata to estimate and compare tax progressivity across over 20 countries. To our knowledge, they have not yet provided estimated tax functions.

Second, our paper connects to the literature on **cross-country comparisons of tax progres-**

[1]There are numerous ways of modeling the tax function. These range from a simple proportional tax on income to the arctangent tax function in Kurnaz and Yip (2020), passing from the popular three-parameter tax function of Gouveia and Strauss (1994).

sivity.

Holter, Krueger, and Stepanchuk (2019) study the role of tax progressivity to assess how much additional tax revenue governments can generate by increasing labor income taxes. They use a log-linear tax function and compare progressivity measured by the progressivity wedge across OECD countries between 2000 and 2007.[2] They find substantial heterogeneity in tax progressivity, with the most progressive taxes being in Denmark and the least progressive ones in Japan. Ayaz, Fricke, Fuest, and Sachs (2021) study how optimal income taxes should respond to an increase in public debt in five European countries. They find that, for all countries, income taxes should be less progressive as a response to an increase in fiscal pressure.

3 The Tax Function

We use a two-parameter log-linear effective tax function, which can be estimated by ordinary least squares (OLS).

3.1 Log-Linear Tax Function

Following Feldstein (1969), Benabou (2000), Heathcote, Storesletten, and Violante (2017), and Borella, De Nardi, Pak, Russo, and Yang (2020), we model taxes T on total income Y as:

$$T(Y) = Y - (1-\lambda)Y^{1-\tau}, \tag{1}$$

The associated average and marginal tax rates are given by:

$$\frac{T(Y)}{Y} = 1 - (1-\lambda)Y^{-\tau}, \tag{2}$$

$$T'(Y) = \frac{\partial T(Y)}{Y} = 1 - (1-\lambda)(1-\tau)Y^{-\tau}, \tag{3}$$

Equation 2 shows that the parameter λ corresponds to the average tax rate when income is equal to 1 unit of income and thus captures the notion of the level of taxation in the economy. Instead, the parameter τ captures the degree of progressivity of the income tax system. In particular, the

[2] The progressivity tax wedge between two arbitrary incomes $y_2 > y_1$ is given by:

$$PW(y_1, y_2) = 1 - \frac{1 - T'(y_2)}{1 - T'(y_1)},$$

It measures how marginal tax rates increase between the two income levels.

tax system is progressive when $\tau > 0$, regressive when $\tau < 0$, and flat with marginal and average tax rates set at λ when $\tau = 0$.[3]

3.2 Estimation Strategy

We take logs of Equation 1 to obtain:

$$\log(Y - T(Y)) = \log(1 - \lambda) + (1 - \tau) \log(Y). \tag{4}$$

We estimate Equation 4 by regressing the logarithm of post-tax income on a constant and on the logarithm of pre-tax income in each country and in each year. We run weighted regressions using the LIS-provided household-level cross-sectional weight to obtain results representative of the whole population of each country in each year. We compute the parameter λ from the estimated constant and the parameter τ from the estimated coefficient on the log of pre-tax income. Section 5.1 shows that this tax function fits our data remarkably well.

König (2021) argues that estimating log-linear tax functions by OLS results in biased estimates of the progressivity parameter τ and proposes an estimation strategy based on Pseudo-Poisson Maximum Likelihood (PPML). We will check the robustness of our results to this estimation strategy in a forthcoming Appendix.

4 Data

This section describes our data, sample selection, and income definitions.

4.1 Luxembourg Income Study (LIS)

We use microdata from the Luxembourg Income Study (LIS) Database. LIS has harmonized microdata from about 50 countries for over 50 years. LIS combines well-known datasets, such as the Current Population Survey for the United States and the German Socio-Economic Panel for Germany, and provides an aggregated micro-dataset that includes labor and capital income, public social benefits, private transfers, taxes and contributions, demography, employment, and consumption.

[3] The parameter τ is a measure of progressivity because the the elasticity of post-tax income with respect to pre-tax income, $\partial \log(Y - T(Y))/\partial \log(Y)$, is equal to $1 - \tau$.

4.2 Sample Selection

We conduct household-level analysis and focus on working-age households whose head is between 25 and 60 years old. We restrict our analysis to working-age households to facilitate the comparison across countries.

There are 11 available LIS waves spanning from the early 1970s to 2020. We use all waves and countries for which we have data on gross household income, income taxes, and government transfers. We operate at the wave level to ensure a consistent and comparable time unit across countries. Thus, when we observe a country for more than one year in a wave, we pool these years into the same wave to estimate the tax function for that wave. Table 1 in Appendix A.1 shows the countries in our sample, the waves we observe them in, and the number of observations in each country and wave. Our final sample is very large and consists of 7,625,531 household-wave observations for 37 countries, observed over different waves. The large sample size is an advantage of the LIS dataset and allows us to estimate our tax function parameters tightly.

In a first step, we restrict our attention to "standard" households, defined as the following four types of households: (1) one-person household; (2) couple without children; (3) couple with children; or (4) one parent with children. Therefore, we exclude households in which other relatives or non-relatives cohabit with the four groups described above. We select only standard households to have comparable households across countries. Our household selection is similar to the one of Heathcote, Storesletten, and Violante (2020), who, given their focus on the working age, only select households with children and non-elderly childless households. Figure 1 shows that most households with heads aged between 25 and 60 qualify as "standard." When we pool all countries and waves together, the mean share of standard households is 89 percent, and the median is 91.4 percent. Sections 5 and 6 presents results for standard households.

After estimating tax functions for standard households, to study the role of family composition for progressivity, we estimate effective tax functions separately for each of the four household types that make up our notion of a standard household. We present descriptive statistics on household composition and the estimated tax functions in Section 7.2.

4.3 Income Definitions and Adjustments

Our results on effective taxes depend crucially on the definitions of pre-and-post-tax income. We start by defining a *tax function*, in which household pre-tax income is given by the sum (for the

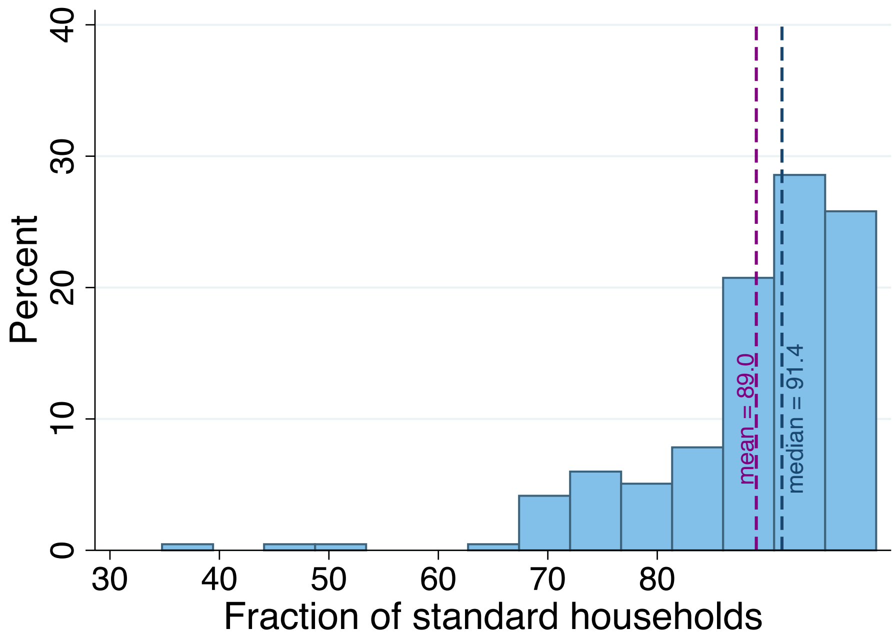

Figure 1: Share of households with heads between 25 and 60 that qualify as "Standard" Households. Results for all countries and all waves in our sample.

head and the spouse, if present) of labor income, capital income, pensions, public social benefits, and private transfers, while post-tax income is defined as pre-tax income minus income taxes and social security contributions. Public social benefits capture transfers from government insurance and assistance programs. Appendix A.2 describes the income components in detail. Using the tax function allows us to interpret the parameter λ from Equation (1) as the average tax rate and τ as a measure of progressivity of the income tax system. A tax function defined this way can be used in structural models which model government transfers explicitly, as it only captures income taxes. Section 5 reports the results for our tax function.

Then, to study the role of transfers and the government for progressivity, we define a *tax and transfer function,* in which we modify the income definitions so that public social benefits are included in post-tax income rather than in the pre-tax one. With this function, τ now captures a wider notion of redistribution in the economy. The tax and transfer function can be used in structural models which do not model government transfers explicitly, as it captures both income taxes and government transfers. Section 6 compares the results of the tax and the tax and transfer function.

The monetary quantities that make up our income definitions need to be adjusted to be comparable across country and time. First, we need Consumer Price Indices (CPIs) to compare real amounts over time within a country. Second, we need Purchasing Power Parity indicators (PPPs) to compare real amounts across countries. LIS directly provides adjustment factors that allow us to convert nominal monetary amounts into 2017 USD PPP. Using 2017 as the base year, the adjustment factor for country i in wave t is computed by LIS as:

$$LISPPP_{i,t} = \left(\frac{CPI_{i,t}}{100}\right) PPP_{i,2017},$$

To convert monetary quantities into 2017 USD PPP, we divide nominal amounts in each country and wave by the corresponding LIS PPP. All financial quantities reported in the paper are measured in 2017 USD PPP, which we refer to, for convenience, as 2017 dollars.

5 Effective Income Taxes

In this section, we first show that our tax function is a good approximation of the income tax systems of all countries in our sample. Then, we describe the average level of taxation and progressivity in the cross-section and over time.

5.1 Fit of the Tax Function

As Heathcote, Storesletten, and Violante (2017) show, the log-linear tax function in Equation 1 is a good approximation of the US federal income tax system. In this section, we show that the log-linear tax function is a good approximation of the income tax systems in all the countries in our sample.

First, in Figure 2 we show that our log-linear tax function is a remarkably accurate approximation of the income tax system in all the countries in our sample. We plot the logarithm of post-tax income as a function of the logarithm of pre-tax income for six countries in wave 10, corresponding to 2015-2017. To draw these graphs, we first select our sample of standard households with heads aged between 25 and 60, and then we construct weighed percentiles by country and wave. These graphs show that the relationship between post-tax income and pre-tax income is approximately log-linear in each country we consider and at all points of the log pre-tax income distribution, except for the first percentile.

Second, in Figure 3 we show that the R^2 from the regressions we use to estimate our tax func-

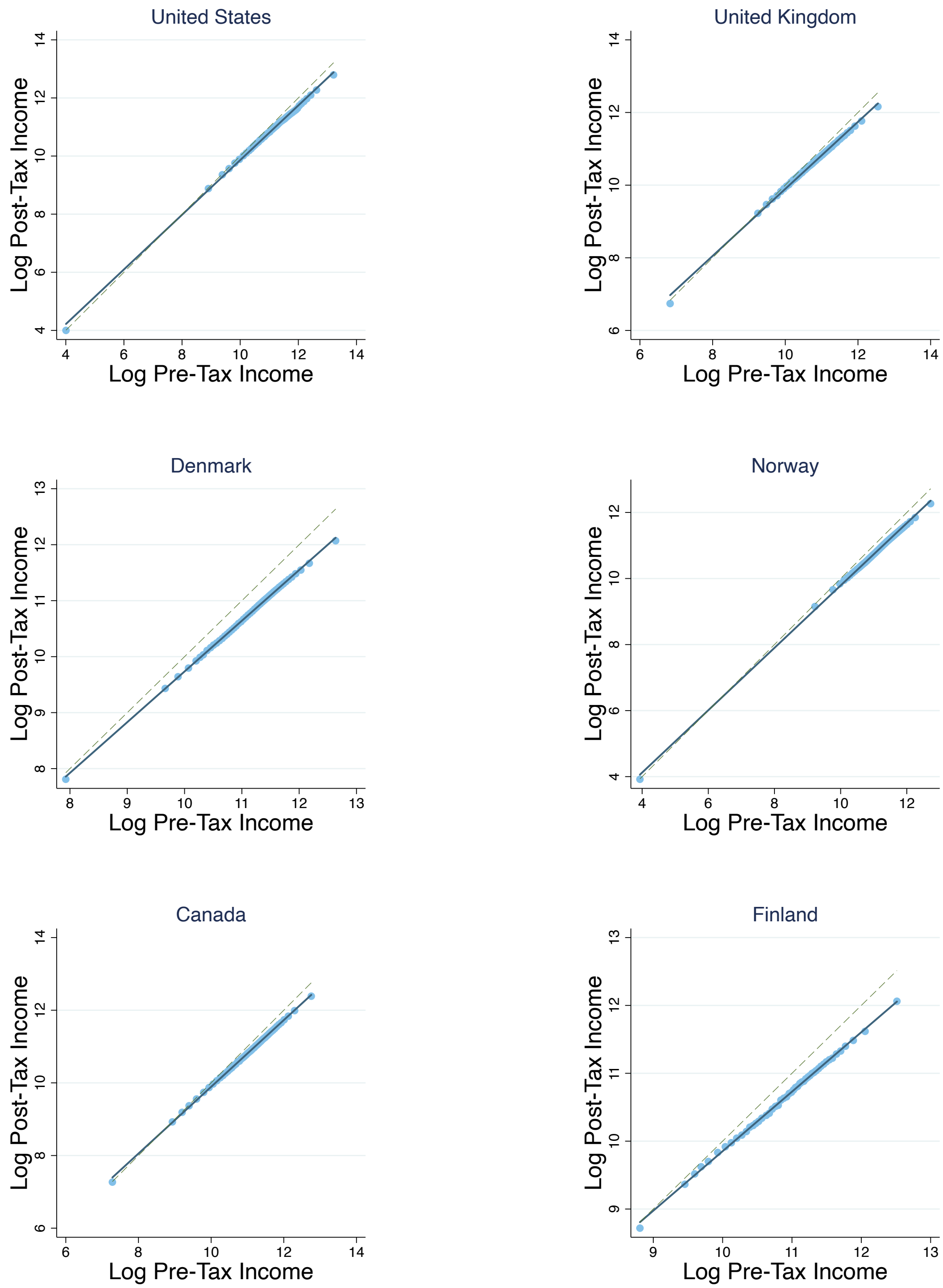

Figure 2: Log post-tax income as a function of log pre-tax income, Wave 10. Post-tax income is defined as pre-tax income minus income taxes. Each dot is a percentile of the log pre-tax income distribution. The dashed line is the 45 degree line. The solid line is the OLS fitted line.

tions is very high. We run the regression in Equation 4 wave-by-wave and country-by-country and we and report the distribution of the R^2 from these regressions in Figure 3. The distribution is significantly skewed to the right and has a mean of 0.976 and a median of 0.984. Even in the thin left tail, the R^2 is larger than 0.85, meaning that, at its worst, the log-linear tax functions still explain over 85 percent of the variation in post-tax income. In particular, the lowest R^2 is 0.86 and corresponds to Italy in wave 6. The results on R^2 corroborate our finding that a log-linear tax function well approximates the income tax systems of the countries in our sample.

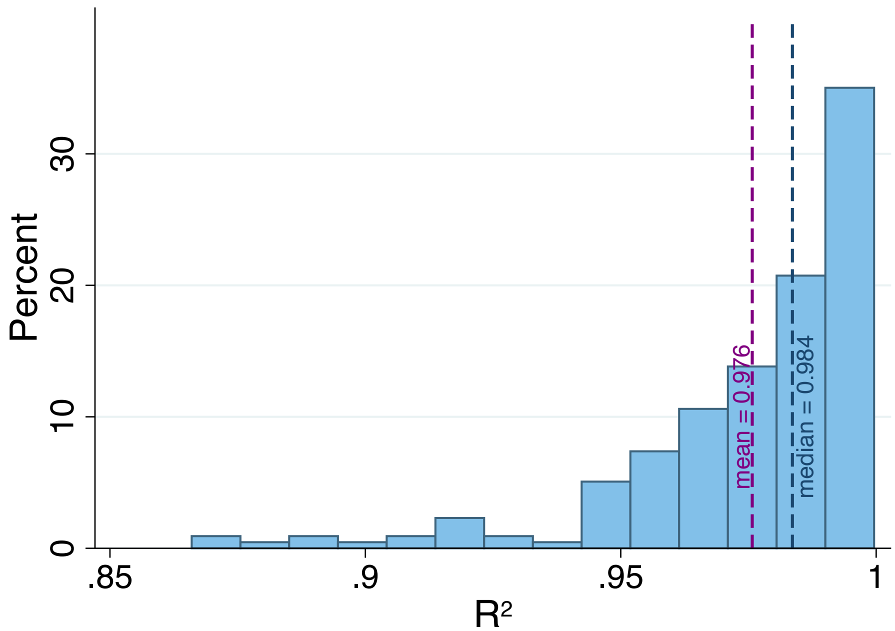

Figure 3: Distribution of the R^2 from year-by-year and country-by-country regressions of log post-tax income on log pre-tax income.

The validity of our results on the goodness-of-fit of our tax function is not challenged by the imputation and simulation procedures used by LIS and the country-specific datasets that LIS utilizes. While for numerous countries, such as Canada, Norway, and the United Kingdom, information on income taxes and social contributions is directly observed, for many other countries, such as Australia, Israel, and the United States, income taxes and social contributions are either imputed or simulated based on available information. Table 2 in Appendix A.1 shows whether taxes and contributions are imputed or not in each country and in each wave. If the imputation procedures rely on a log-linear tax function similar to ours, our goodness-of-fit measures could be grossly overestimated. However, to our knowledge, neither LIS nor any country-specific dataset uses a log-linear tax function to impute income taxes. Instead, they use more complex micro-simulations methods. For example, the data on income taxes for the United States come from the Current Population Survey (CPS) - Annual Social and Economic Supplement (ASEC.) This survey uses the Census Bureau's tax model, a micro-simulation model comparable to NBER's TAXSIM, to compute federal income taxes based on information from the CPS, the Internal Revenue Service, the American Housing Service, and the State Tax Handbook.

Figure 12 in Appendix B confirms that our results are not affected by imputation. Here we plot the distribution of R^2 obtained when we exclude from our sample all countries and waves for which taxes and social contributions were imputed rather than observed directly. This graph shows that both the mean and the median of the distribution of R^2 are untouched when we exclude imputed values.

5.2 Effective Income Taxes Across Countries

After establishing that the log-linear tax function is a good approximation of the income tax systems of the countries in our sample, we turn to discuss our estimated effective tax functions.

We start by comparing the average level of taxation and progressivity across countries. Figure 4 shows our results in wave 10. Here we plot progressivity, as measured by the parameter τ, as a function of the average tax rate for the median household in each country, that is, the household earning the median pre-tax income in each country. Figure 5 shows pre-tax median income in each country available in wave 10. Financial quantities are reported in 2017 dollars, as described in Section 4.3. Looking at these two figures together, we see that, for example, the average tax rate in the USA is about 19%, corresponding to a median pre-tax income of about $ 72,000. Online appendix ... shows the estimated tax parameters and the median pre-tax income for all waves other than wave 10.

Figure 4 shows that a higher level of progressivity is generally associated with a higher average tax rate for the median household. This is confirmed by the positive-sloped fitted line. We observe several interesting facts. First, numerous countries, such as Spain (ES,) the United Kingdom (GB,) and the United States (US,) are concentrated around an average tax rate between 15 and 20 percent and progressivity between 0.04 and 0.08. Second, Northern-European countries, such as Germany (DE), Belgium (BE), Finland (FI), and the Netherlands (NL,) are characterized by the highest degree of progressivity and high average tax rates. This is consistent with the high degree of social protection present in these countries.[4] Third, at the opposite extreme, we observe countries with a low level of average income taxation and low progressivity of the income tax system. These are South-American countries such as Colombia (CO) and Peru (PE.) Despite having progressive statutory income taxes, these countries exhibit very low effective tax progressivity.

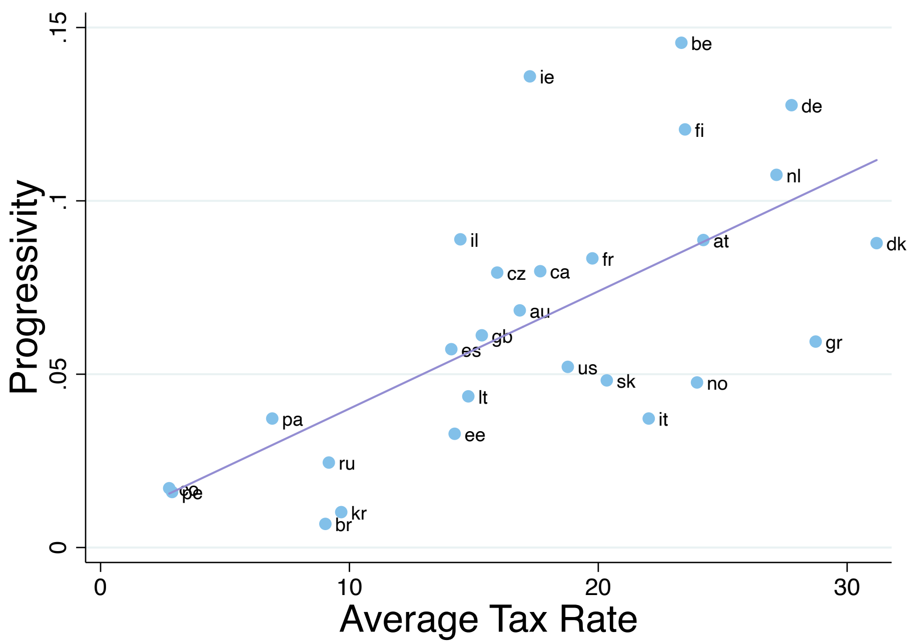

Figure 4: Average Tax Rate and Progressivity in Wave 10 (2015-2017). The average tax rate is evaluated at the median income of each country. Progressivity is measured by the parameter τ. The solid lavender line is the OLS fitted line.

5.3 Effective Income Taxes Over Time

To complete our description of the world's income tax systems, we present the evolution over time of the average tax rate for the median household and progressivity. We compute the average tax rate for the median household by applying Equation (2) to the median pre-tax income of each country in each wave. Figure 13 in Appendix B shows the evolution of median pre-tax income for the countries in Figure 6. We measure progressivity by the parameter τ in our tax function.

Figure 6 displays the evolution of λ and τ for the USA, Norway, Germany, the United Kingdom, Canada, and Finland. Explaining all the tax function changes requires investigating each country's tax legislation history, which goes beyond the scope of our paper.[5] However, we can still observe

[4]See Alesina and Glaeser (2006) for a discussion of the differences between the American and the European welfare state and for a classification of the European approaches to social insurance.

[5]Borella, De Nardi, Pak, Russo, and Yang (2020) do it for the United States.

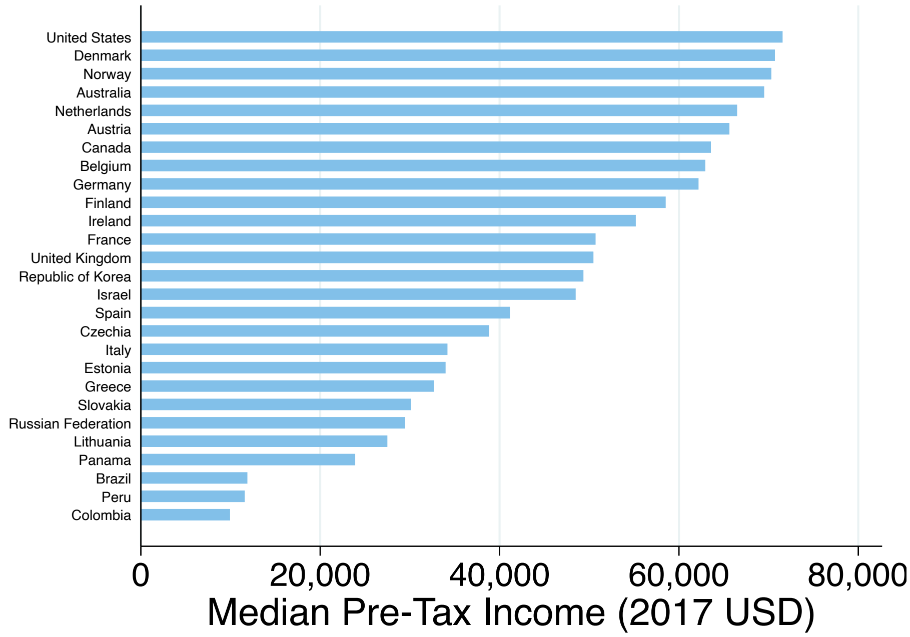

Figure 5: Median Pre-Tax Income in Wave 10. Income is measured in 2017 USD PPP.

interesting patterns in Figure 6.

First, we can observe interesting dynamics in the average tax rate for the median household. In the United States, Canada, Denmark, Norway, and Finland, the average tax rate has remained relatively stable over the past 40 years, despite a general increase in median income. For example, the average tax rate in Canada was 18 percent in 1985 - corresponding to a median income of 58,000 dollars - and 18 percent in 2018 - for a median income of 65,000 dollars. In turn, the average tax rate for the median household has changed substantially in the United Kingdom. It increased between 1980 and 1990, despite the substantial reductions in income taxes carried out by the Thatcher's government. It then decreased markedly between 1990 and 1995 and remained stable ever since. We also observe remarkable differences in average taxation across countries, even for similar income levels. For example, in 1985 median income in the United States was 67,000 dollars, while in Denmark, it was 63,000 dollars. The corresponding average tax rate in the United States was 19 percent, while the one in Denmark was 32 percent.

Second, we observe significant changes in the level of income tax progressivity across countries. To fix the scale of these changes, recall that the elasticity of post-tax income with respect to pre-tax income is $1-\tau$. Thus, a change in 0.01 in τ implies a one percentage point change in the response of post-tax income to the pre-tax one. The United States saw a general decrease in progressivity over the last 40 years. Progressivity in 2018 was about 40 percent lower than in 1980. The United Kingdom and Canada showed a similar evolution: progressivity increased between 1985 and 1995 and then declined. Compared to its 1995 level, progressivity in 2018 was a third lower in the United Kingdom and a quarter lower in Canada. The Scandinavian countries saw an increase in progressivity between 1990 and 1995 but then showed different dynamics. In Denmark, progressivity grew until 2000, decreased markedly between 2000 and 2006, rebounded, and stabilized after 2010. In Norway, it grew until 2004 but declined after then and in 2018 was about half the size of 2004. Finally, progressivity declined between 1995 and 2013 but rebounded to its 2000 level in 2018.

The remainder of the paper focuses on income tax progressivity and its determinants. While the average tax rate crucially depends on the income it is computed at, progressivity, as measured by the parameter τ in our tax function, is unaffected by the income level and thus allows for more meaningful cross-country comparisons.

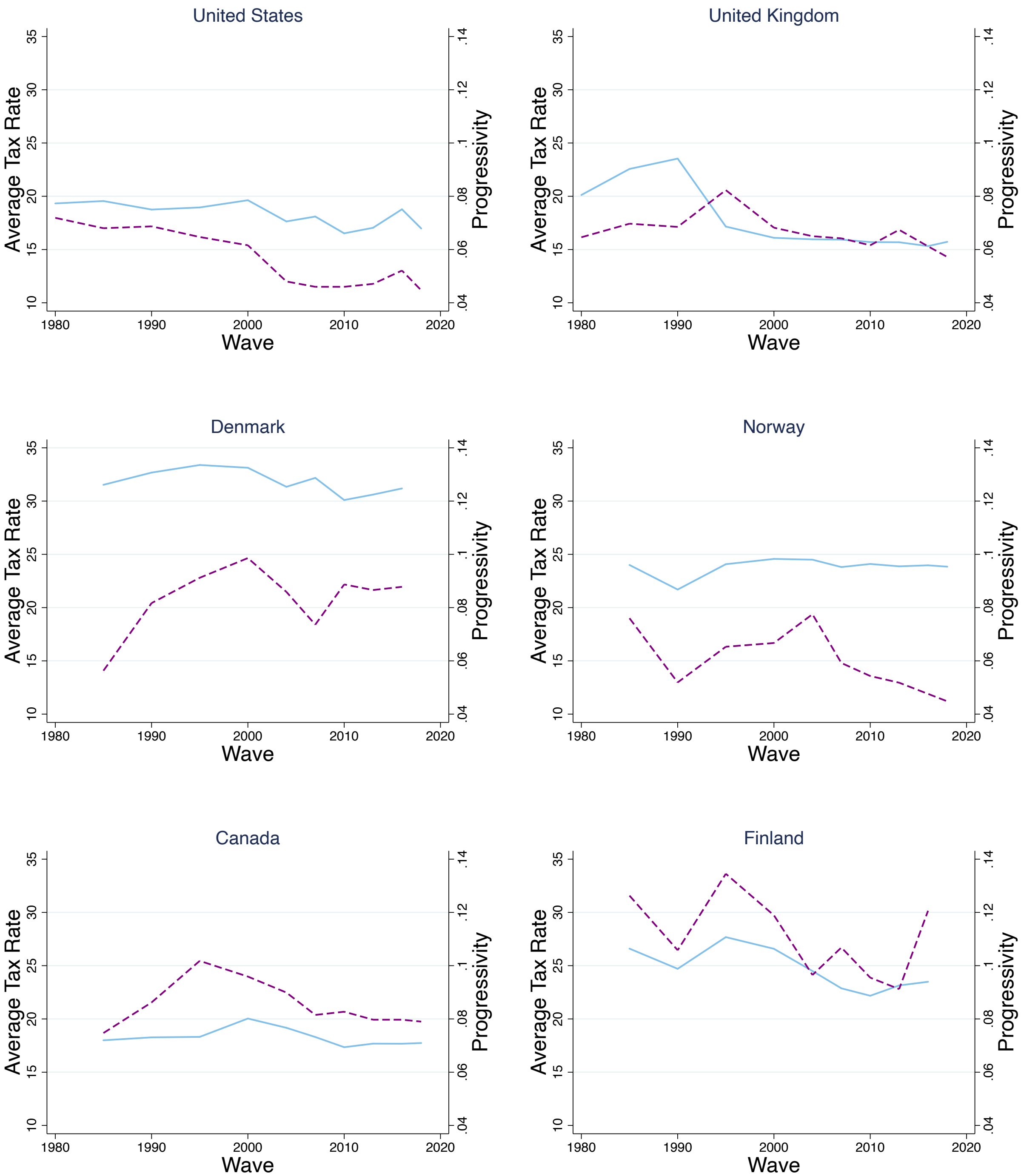

Figure 6: Average tax rate and progressivity over time for selected countries. The solid blue line is the average tax rate for the median household in each year, the dashed purple line is progressivity, measured by the parameter τ.

6 The Role of Transfers for Progressivity

This section analyzes the effects of government transfers on the progressivity of the income tax system. We do so by estimating a tax and transfer function, in which public social benefits enter the post-tax income, not the pre-tax one.

6.1 Progressivity gross and net of transfers

So far, we have ignored the role of transfers for redistribution, as we have treated public social benefits in the same way as the income earned in private markets. Now, we exclude all public social benefits from pre-tax income and include them in the post-tax income to study their effects on the estimated progressivity of the income tax system. We call gross progressivity the progressivity estimated using the tax function and net progressivity the one calculated using the tax and transfer function.

Figure 7 compares gross and net progressivity in six waves of LIS. Net progressivity is much higher than its gross counterpart in every country and wave. For example, net progressivity in the United States, United Kingdom, and Norway is about 12 times larger than its gross counterpart. Thus, transfers have a sizable effect on progressivity and redistribution worldwide.

Then, including transfers preserves the ranking of countries at the extremes of the progressivity distribution. Thus, countries with high gross progressivity tend to have high net progressivity. For example, in wave 9, Ireland has the highest gross and net progressivity, while in wave 2, France has the lowest values in both measures.

The significant differences between gross and net progressivity highlight the importance of the choice of the tax function when studying - and modeling - income tax systems. From an empirical point of view, using a gross or a net measure leads to significantly different assessments of the degree of progressivity in a specific country. As policymakers may want to act to increase - or decrease - income tax progressivity, its correct measurement is vital to guide income tax policy. From an economic modeling perspective, the choice of which tax function to use is critical for the magnitude of the after-tax income that enters the household's budget constraint.

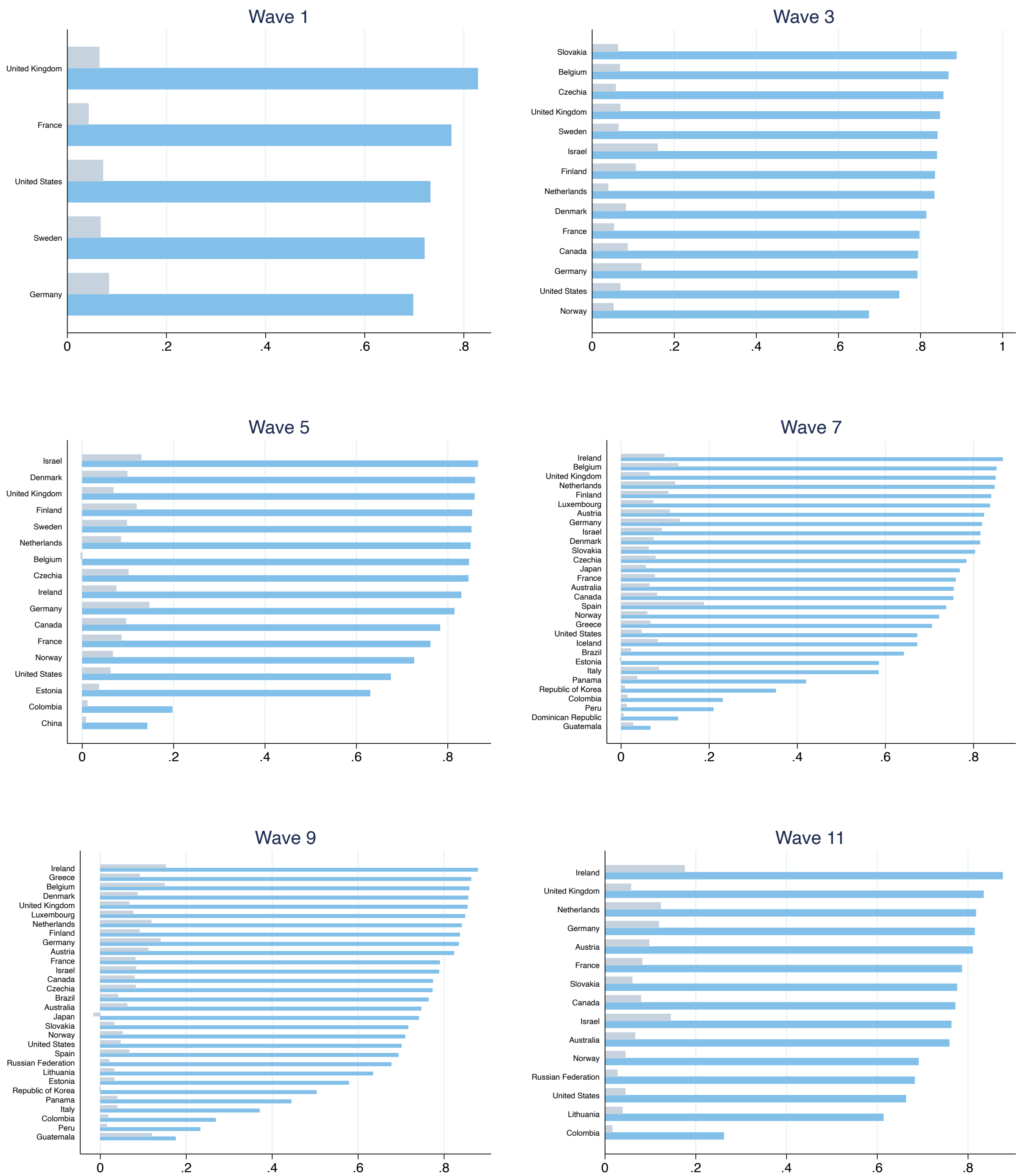

Figure 7: Comparison of progressivity gross and net of government transfers. The gray bars denote gross progressivity, the blue ones show net progressivity.

7 The role of family structure on progressivity

In the previous sections, we focused on standard households to get a comprehensive view of the dynamics of income tax progressivity. In this section, we estimate progressivity by household type to assess whether it differs for different family structures. We first present descriptive statistics about household composition in our sample, then we estimate gross and net income tax progressivity separately by household type.

7.1 Household Composition in our sample

We split our sample into the four categories that make up our notion of a standard household: (1) Married couples with children; (2) Married couples without children; (3) Single Parents; (4) Singles without children.

Figure 8 displays the dynamics of household composition for six countries in our sample and highlights several interesting trends. First, across all countries, the fraction of married couples with children decreases significantly over time, while the share of married couples without children is either stable or increasing. For example, half of the Norwegian households in 1985 were married with children, while only 11 percent were married without children. By 2018, the fraction of couples with children declined to 35 percent, while the fraction of married couples without children increased to 15 percent. Second, the share of singles without children has increased in most countries, while the fraction of single parents is relatively stable. For example, the share of singles in the United States increased by half between 1980 and 2018, while the fraction of single parents remained constant.

Figure 8 shows the shift from being married and having children to either not having children or, in large part, being single. These trends are consistent with the decline in marriage and fertility rates experienced by numerous countries across the world.

7.2 Progressivity by household type in the cross-section

In light of the demographic changes described in the previous section, we now turn to estimate progressivity separately by household type. We want to study whether different families face different degrees of gross and net income tax progressivity.

In Figure 9 we show gross progressivity by household types in six waves of our sample. There are significant differences in progressivity across household types in almost every country and

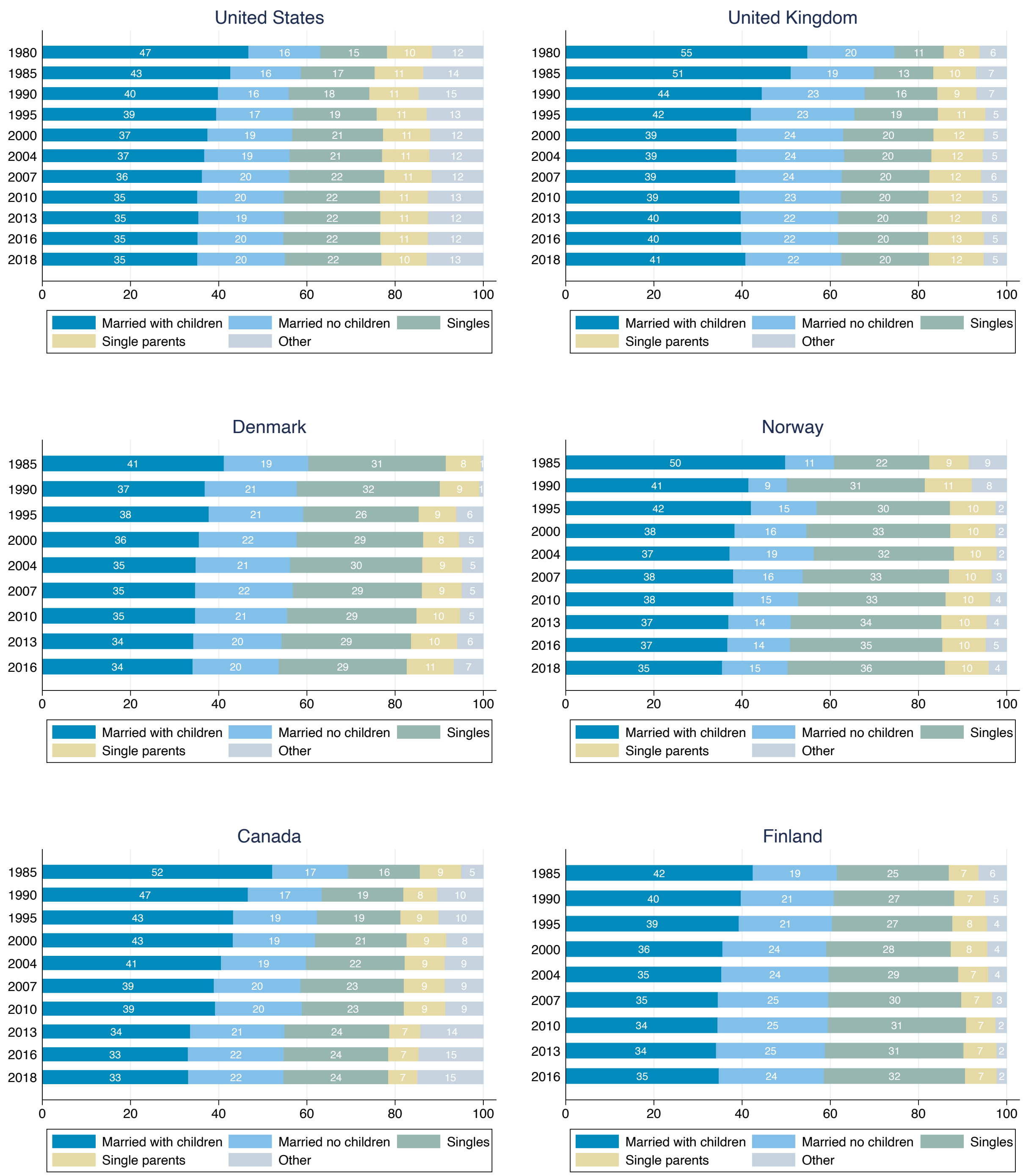

Figure 8: Household composition by wave for selected countries in our sample

wave. These differences are due to income tax systems generally distinguishing between married and single taxpayers and applying different statutory tax rates to each. Moreover, families with children may enjoy additional deductions and transfers when paying their income taxes. The nature of these differences depends on the country and the wave. For some countries - such as the United States and Israel - marriage always results in higher gross progressivity. However, the opposite is true for countries such as the United Kingdom (until wave 11,) France (after wave 5,) and Finland: in these countries, singles enjoy higher gross progressivity. Differences are considerable: in the United Kingdom, in wave 3, gross progressivity for single parents is almost three times larger than that for married couples with children, while gross progressivity for singles without children is twice as large as that of childless married couples. Then, in other cases, having children leads to higher gross progressivity. For example, families with children always face higher progressivity in Sweden, Finland, and the United Kingdom. The opposite case is rare and having children leads to lower gross progressivity only in a few instances—for example, Germany and Czechia in waves 1 through 5.

In Figure 10 we show net progressivity by household types. Studying net progressivity is particularly meaningful when we discriminate by household types, especially when looking at the role of children. Governments around the world use transfers to redistribute resources to families with children. For example, in the United States, the Temporary Assistance for Needy Families (TANF) provides cash transfers to low-income families with children. In the United Kingdom, the Child Benefit provides financial support to parents with children younger than 16. Several interesting trends emerge from Figure 10. First, as we observed in Section 6, net progressivity is much higher than gross progressivity in each country and wave. Second, for numerous countries, such as Canada, Germany, France, and the United States, net progressivity is higher for married couples without children than those with children. At the same time, it is higher for single parents than for singles without children. Single parents have higher net progressivity in almost every country and every wave. Thus, the presence of children leads to higher net progressivity mostly for singles and is due to single parents having lower incomes and receiving more child-related government transfers.

7.3 Progressivity by household type over time

In this section, we focus on three countries and study the evolution of gross and net progressivity over time. Figure 11 plots the dynamics of gross and net progressivity in Finland, the United

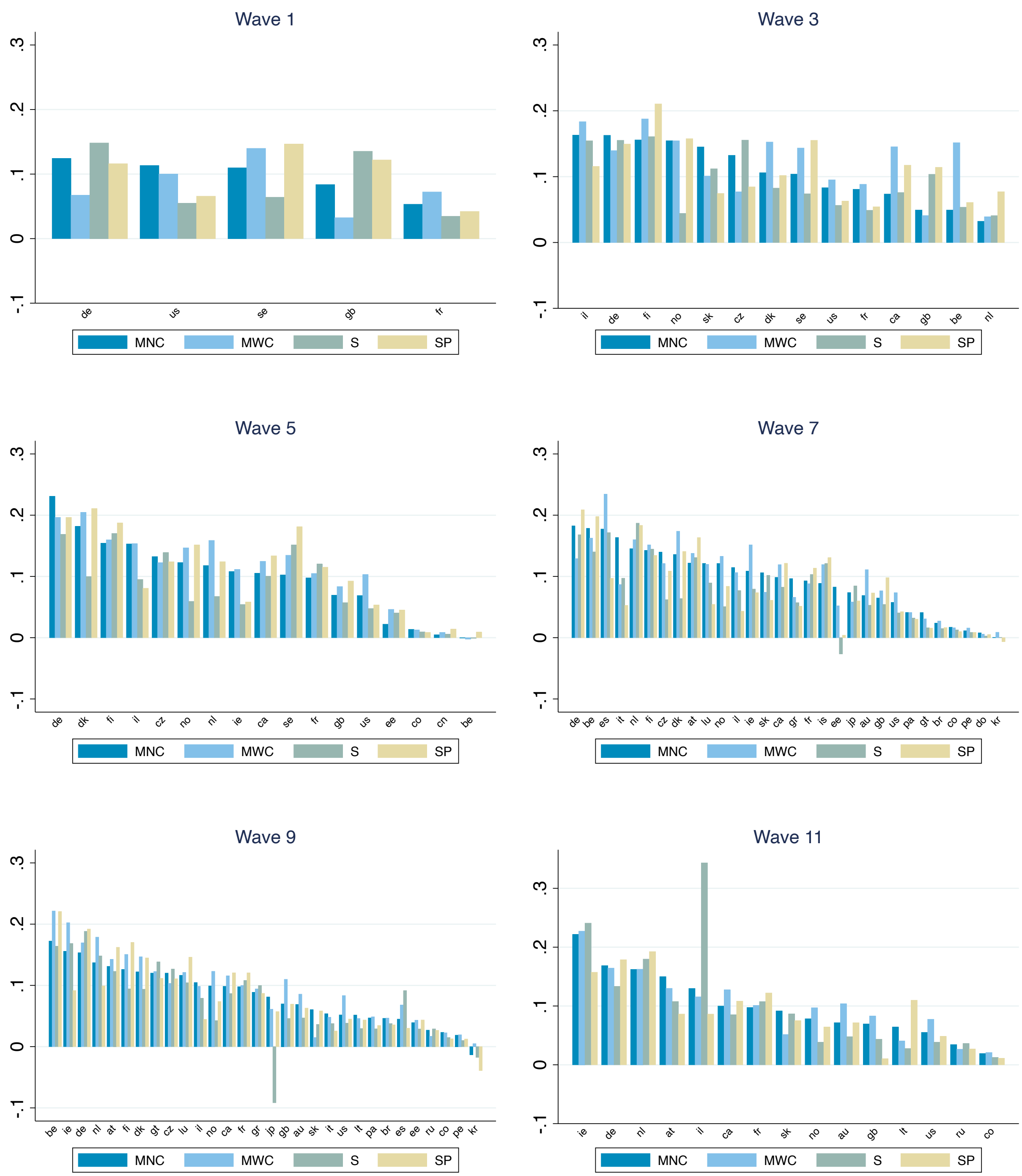

Figure 9: Gross income tax progressivity by household type. MNC denotes married couples without children, MWC married couples with children, S singles without children, and SP denotes single parents.

Figure 10: Net income tax progressivity by household type. MNC denotes married couples without children, MWC married couples with children, S singles without children, and SP denotes single parents.

Kingdom, and the United States.

Finland and the United Kingdom display similar dynamics. Gross progressivity is more volatile than its net counterpart, which tends to be relatively stable in both countries after 1995. In both countries, gross and net progressivity are highest for single parents. At the same time, gross progressivity is lowest for couples without children and singles. Net progressivity, in turn, is lowest for couples with children in Finland and couples without children in the United Kingdom. In both countries, there are large differences in gross progressivity between singles with and without children. These differences are almost eliminated by transfers, as net progressivity is very close for singles and single parents. In both countries, transfers considerably affect the progressivity of singles, who go from having the lowest gross value to having the second-highest net one.

The United States shows very different dynamics. First, gross progressivity is relatively stable for all household types, while its net counterpart is more volatile. Second, gross progressivity is highest for married couples with children and lowest for singles with and without children. This is the opposite of what happens in Finland and the United Kingdom. Third, although more volatile, the ranking of net progressivity in the United States is similar to that of the other two countries. Net progressivity is highest for single parents and lowest for married couples with children. In the United States, gross progressivity is similar within marital status groups. Transfers amplify the differences and create a larger gap between the net progressivity of singles and couples with and without children.

We conclude that, in these three countries, transfers have a larger effect on the progressivity of singles with and without children, but have a more limited effect on the progressivity of couples. Moreover, in Finland and in the United Kingdom, transfers reduce the differences in progressivity due to having children, while the opposite is true in the United States. In all countries, single parents enjoy the highest level of progressivity net of government transfers.

8 Conclusions

In this paper, we show that a two-parameter log-linear tax function provides a remarkably accurate approximation of income tax systems worldwide. We have compared income tax systems and shown that a higher average level of taxation is associated with a higher income tax progressivity.

We have studied the effects of government transfers and provided evidence that, on average,

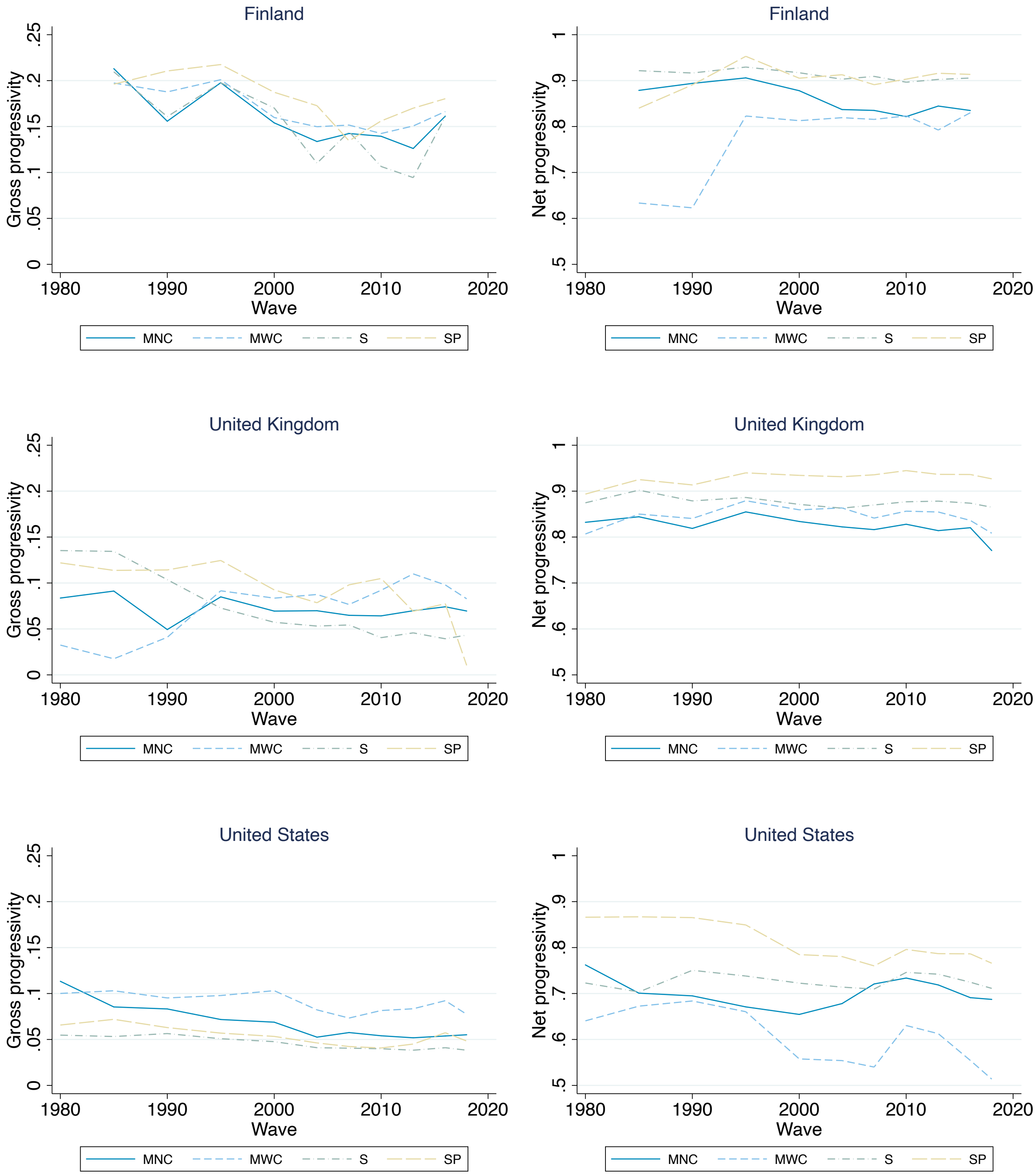

Figure 11: Gross and net income tax progressivity by household type over time. The panels on the left display gross progressivity, the ones on the right show net progressivity. MNC denotes married couples without children, MWC married couples with children, S singles without children, and SP denotes single parents.

the progressivity net of transfers is twelve times higher than its net counterpart. We have also analyzed the difference in income tax progressivity by household type. We concluded that marriage has the largest effect on progressivity in countries such as the United States. In countries such as the United Kingdom and Finland, the presence of children in the family generates the most significant differences in progressivity.

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A LIS data

A.1 Details on Our Sample

Country	**Code**	**Wave 1** 1980	**Wave 2** 1985	**Wave 3** 1990	**Wave 4** 1995	**Wave 5** 2000	**Wave 6** 2004	**Wave 7** 2007	**Wave 8** 2010	**Wave 9** 2013	**Wave 10** 2016	**Wave 11** 2019
Australia	au						7,375	5,844	10,121	8,381	9,812	8,149
Austria	at						9,355	11,046	11,491	10,653	10,670	6,865
Belgium	be			4,789	4,636	1,355	10,183	11,579	10,264	10,836	10,360	
Brazil	br							70,845	135,253	65,621	86,448	
Canada	ca		7,094	12,464	23,850	70,294	49,255	45,803	42,267	45,330	57,776	25,089
China	cn					12,155						
Colombia	co					101,550	224,936	270,445	360,223	356,371	351,783	228,934
Czechia	cz			9,828	16,700	4,768	2,501	6,149	4,693	3,980	4,388	
Denmark	dk		7,404	7,784	46,532	49,301	50,183	51,713	50,175	50,256	50,093	
Dominican Republic	do							4,346				
Estonia	ee					3,396	2,170	2,476	2,484	2,827	3,117	
Finland	fi		8,580	8,677	6,632	7,527	7,627	7,004	5,968	6,850	6,116	
France	fr	22,189	25,588	19,188	40,924	184,623	64,755	65,597	92,296	87,391	84,209	26,883
Germany	de	29,367	38,192	18,651	23,690	37,109	22,242	20,196	32,372	33,706	33,336	12,368
Greece	gr							3,054	2,659	3,854	9,577	
Guatemala	gt							7,737	7,483	6,505		
Iceland	is						1,981	1,960	2,002			
Ireland	ie					3,059	9,013	7,841	7,483	8,938	7,550	2,196
Israel	il		3,199	3,271	3,137	7,766	12,134	11,929	11,717	17,247	16,706	5,474
Italy	it						4,120	3,927	3,880	3,404	2,997	
Japan	jp							1,399	1,172	942		
Lithuania	lt								7,365	6,778	6,635	2,342
Luxembourg	lu						2,461	2,746	3,726	2,527		
Netherlands	nl			2,953	3,582	2,966	6,686	7,069	6,831	6,491	21,041	6,811
Norway	no		2,879	4,920	6,366	9,590	8,833	133,489	136,934	142,070	145,059	152,910
Panama	pa							6,801	6,868	6,055	5,624	
Peru	pe						9,923	11,822	11,134	15,250	18,826	
Poland	pl				19,318							
Republic of Korea	kr							17,540	7,709	7,189	5,495	
Romania	ro				34,508							
Russian Federation	ru								8,567	50,219	150,981	62,965
Slovakia	sk			9,920			3,187	3,061	2,877	5,593	7,545	2,386
Spain	es							6,923	6,797	6,186	6,805	
Sweden	se	7,302	6,570	8,645	9,522	8,699	9,839					
United Kingdom	gb	3,889	3,955	4,026	58,703	74,064	51,621	45,040	41,549	34,511	32,489	10,558
United States	us	37,907	33,734	68,128	156,838	211,945	145,505	143,646	138,279	119,357	119,007	71,083
Total obs.		100,654	137,195	183,244	454,938	790,167	715,885	989,027	1,172,639	1,125,318	1,264,445	625,013
Total countries		5	10	14	15	17	23	30	31	30	27	15

Table 1: Countries in our sample, associated ISO code, and number of observations in each wave. Blank cells denote waves for which we do not have the data we need to estimate tax functions for a certain country.

A.2 Income Components

We take the components which define our measures of pre-tax and post-tax income directly from LIS.[6]

Labor income. Total income from labor of all household members, including cash payments and value of goods and services received from dependent employment, profits/losses and value of goods from self-employment, as well as the value of own consumption.

Capital income. Cash payments from property and capital (including financial and non-financial assets), including interest and dividends, rental income and royalties, and other capital income from investment in self-employment activity. Excludes capital gains, lottery winnings, inheritances, insurance settlements, and all other forms of one-off lump sum payments.

Pensions. Total pension income from all pillars (private, occupational, public), all types (insurance, universal, assistance), all functions (old-age, disability, survivors). Includes voluntary individual pensions, mandatory individual pensions, occupational pensions, employment related public pensions, universal pensions and assistance pensions.

Public social benefits. Cash Social Security transfers (excluding public pensions) stemming from insurance, universal or assistance schemes, and in-kind social assistance transfers.

Private transfers. Cash transfers and value of in-kind goods and services of a private nature that do not involve any institutional arrangement between the individual and the government or the employer. Includes transfers provided by non-profit institutions, other private persons/households, and other bodies in the case of merit-based education transfers.

Income taxes and contributions. Income taxes and Social Security contributions paid.

[6] The definitions can be found in the codebook at: https://www.lisdatacenter.org/wp-content/uploads/files/data-lis_codebook.pdf

A.3 Details on Imputation

Country	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7	Wave 8	Wave 9	Wave 10	Wave 11
Australia						yes	yes	yes	yes	yes	yes
Austria						no	no	no	no	no	no
Belgium			yes	yes	yes	yes	yes	yes	yes	yes	
Brazil							yes	yes	yes	yes	
Canada		no	no	no	no	no	no	no	no	no	no
China					no						
Colombia					yes	yes	yes	yes	yes	yes	yes
Czechia			no	no	yes	no	no	no	yes	yes	
Denmark		no	no	no	no	no	no	no	no	no	
Dominican Republic							no				
Estonia					no	yes	yes	yes	yes	yes	
Finland		no	no	no	no	no	no	no	no	no	
France	no	no	yes	no	no	no	no	no	no	no	no
Germany	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Greece							yes	yes	yes	yes	
Guatemala							no	yes	yes		
Iceland						no	no	no			
Ireland					no	no	no	no	no	no	no
Israel		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Italy						yes	yes	yes	yes	yes	
Japan							yes	yes	yes		
Lithuania								no	no	no	no
Luxembourg						no	no	no	no		
Netherlands			yes	no	no	no	no	no	no	no	no
Norway		no	no	no	no	no	no	no	no	no	no
Panama							yes	yes	yes	yes	
Peru						no	no	no	no	no	
Poland				no							
Republic of Korea							no	no	no	no	
Romania				no							
Russian Federation								yes	yes	yes	yes
Slovakia			no			no	no	no	yes	yes	yes
Spain							no	no	no	no	
Sweden	no	no	no	no	no	no					
United Kingdom	no	no	no	no	no	no	no	no	no	no	no
United States	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Percent Imp.	20	20	43	27	35	35	40	45	53	52	47

Table 2: This table shows which country-wave pair has an imputed measure of income taxes. “yes" means taxes are imputed, while “no" means taxes are directly observed. In the last row, we compute the percentage of countries with imputed income taxes in each wave.

B Additional Figures

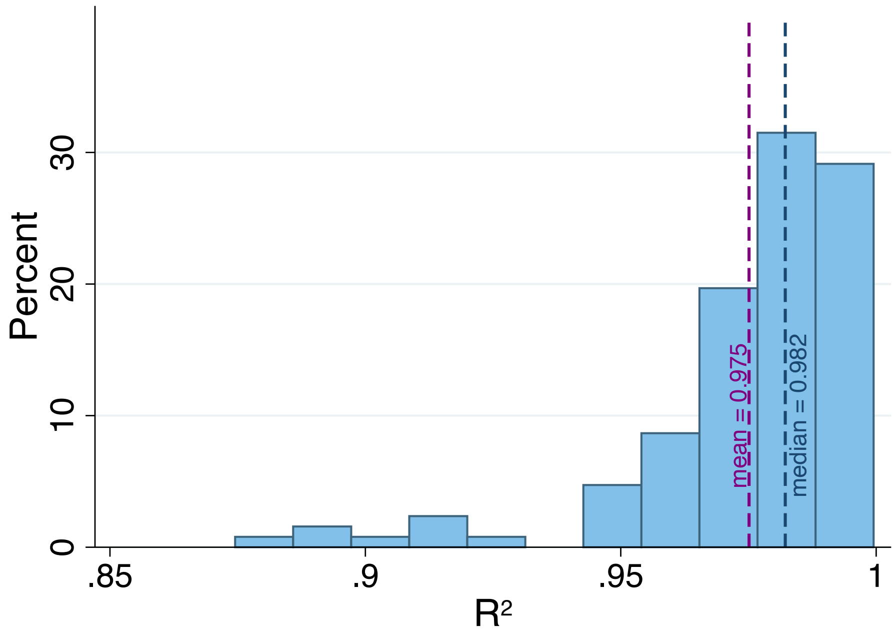

Figure 12: Distribution of the R^2 from year-by-year and country-by-country regressions of log post-tax income on log pre-tax income when we exclude imputed values

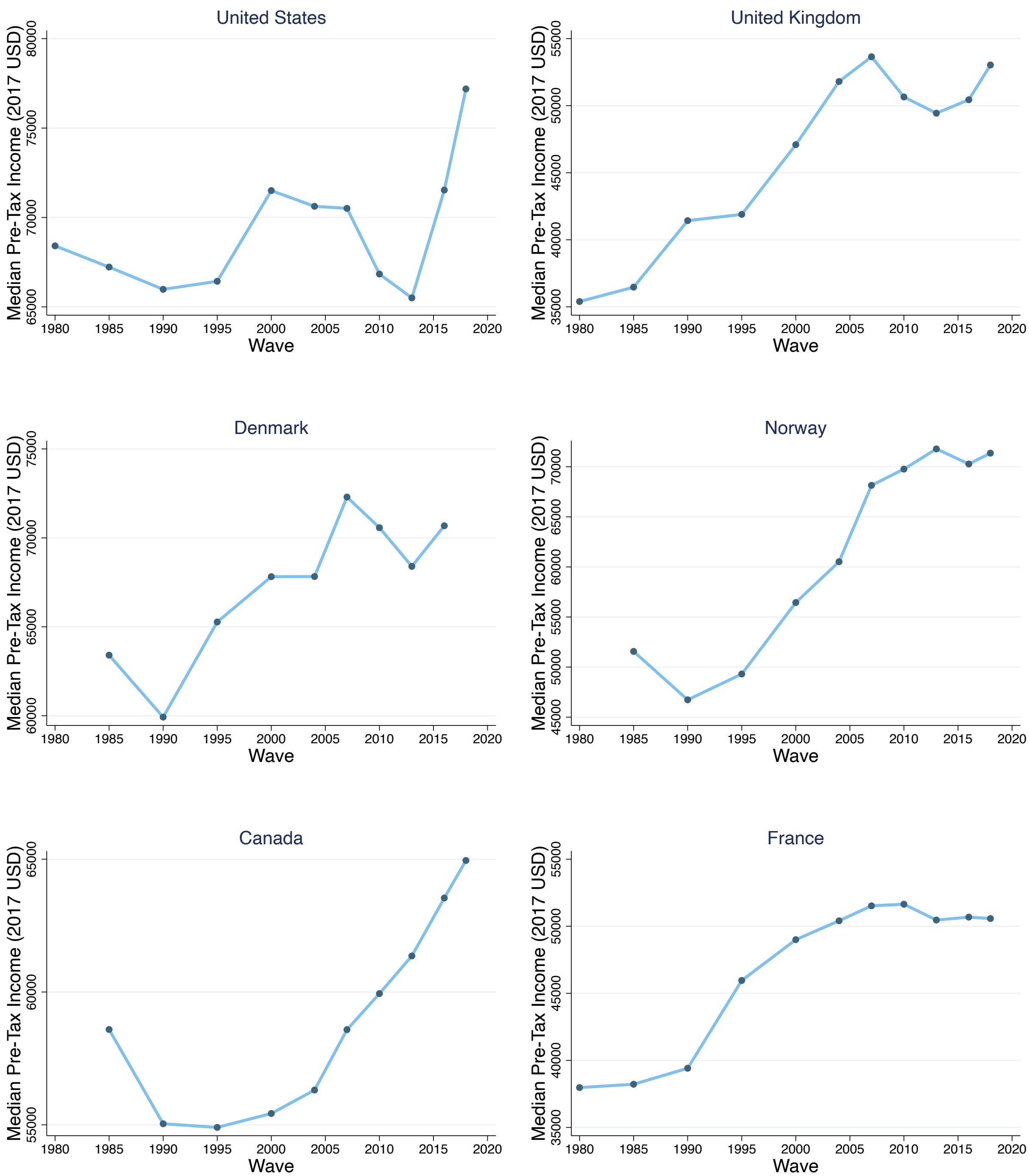

Figure 13: Median pre-tax household income for standard households in 2017 USD PPP.