The Inequality Impact of Consumption Taxes: An International Comparison

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Abstract

Consumption taxes are often considered as the most regressive component of the tax system. However, there are only few estimates, and even fewer international comparisons, of the redistributive impact of consumption taxes in the literature, due to scarce data on household expenditures. We use household budget and income surveys and microsimulation to provide consistent estimates of the regressivity of consumption taxes for a large panel of countries and years. We propose a new method for imputing household consumption expenditure across countries: this can be applied to any dataset that contains income information and potentially other socio-demographic variables. We stress that using housing rents, when available, to impute household consumption and calculate consumption taxes significantly improves the accuracy of the model. We have three results. First, in almost all countries, consumption taxes fall disproportionately on low-income households: the top income decile pays a share of its income in consumption taxes that is only 60 percent of what the bottom half pays. Second, income inequality is higher when calculated after consumption taxes, and this rise in inequality offsets one-third of the redistributive effect of tax-benefit systems. Last, cross-country differences in the inequality effect of consumption taxes are mainly explained by different implicit tax rates (from 7 to 30 percent in our sample), rather than variations in the distribution of household consumption patterns. Consumption taxes should therefore be taken into account when comparing income inequality and tax-benefit systems across countries, as the most-redistributive systems generally come with high consumption taxes.

Keywords: Consumption taxes; Distributional effects; Income inequality; Microsimulation; Tax-benefit model.

JEL classification: D31; H23; I38.

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1 Introduction

The distributive effect of consumption taxes is the blind spot in the comparative analysis of redistribution systems. Consumption taxes globally account for 30% of government revenue in developed economies, and there is a positive cross-country correlation between the level of consumption taxes and the size of the welfare state (Lindert, 2004; Kato, 2003). However, consumption taxes are also considered to be unfair, as they are a flat tax on consumption expenditure, and the share of income spent on consumption falls with income (Warren, 2008). How large is this effect? Should this change the way we view cross-country variation in terms of inequality and redistribution? It could indeed be the case that consumption taxes substantially narrow the gap between the countries perceived to have low redistribution and those perceived to have high redistribution. The standard view that the United States is more unequal than the Scandinavian countries, either in terms of market income or disposable income, may no longer hold when indirect taxes are taken into account.

The analysis of consumption taxes and inequality requires a considerable amount of data: detailed data on household expenditures and income, as well as precise data on the statutory tax rates applied to different types of goods (excise taxes, sales taxes, and various VAT rates). Most work on the redistributive effect of tax-benefit systems therefore actually leaves consumption taxes out of the equation (see, for instance, Guillaud, Olckers, and Zemmour, 2020; Causa and Hermansen, 2017; Piketty and Saez, 2007). When consumption taxes do appear, the research that focuses on international comparisons typically relies on the Euromod microsimulation tool (for example, Figari and Paulus, 2015), with the resulting limitation of the analysis to European countries. A second option is to use aggregate imputations of consumption taxes, as recently adopted in the work carried out by the Distributional National Accounts (DINA) project. This approach, however, estimates consumption by income group, by applying synthetic saving rates to disposable income. All of this estimated consumption is then assumed to be taxed (see Piketty, Saez, and Zucman, 2018 for the United States, and Bozio et al., 2018 for France). We here take a step forward in this research area by producing reliable estimates of the consumption taxes paid at the more fine-grained household level. We propose a straightforward method for the imputation of missing consumption data in survey datasets on household living standards. Applying implicit consumption-tax rates to this consumption data produces an accurate international comparison of the impact of consumption taxes on inequality in 27 countries over 36 years going from 1978 to 2013, yielding a total of 132 datasets. This allows us to evaluate the extent to which consumption taxes counteract the redistribution resulting from other tax-benefit policies.

Our method is as follows. Starting from micro-data on expenditure and income in household budget surveys, harmonized by the Luxembourg Income Study (LIS), we construct a simulation model of household consumption that allows us to obtain predictions of the distribution of the household-level propensity to consume for all country-years. Once we have this distribution, we apply a homothetic transformation of the data to match macroeconomic aggregates. We then apply a country-year-specific consumption tax rate on household-level consumption. This allows us to compare the distributions of consumption taxes and income, and evaluate the effect of the former on disposable-income inequality. In particular, we com-

pare the consumption tax-to-income ratios across households, and analyze the distribution of post-consumption-tax income.

After testing the robustness of our model, we show that taking the composition of the household consumption basket into account does not significantly change the estimates of the distributional effect of consumption taxes. On the other hand, we do require data on household income and composition, which systematically appear in cross-country micro-datasets. Moreover, while consumption data are rather scarce in international datasets, household income data often include specific information on housing costs (including imputed rents). We show that, where such data are available, this information can be exploited and clearly increases the predictive power of the model.

We show that (1) the consumption tax-to-income ratio for households in the top decile of equivalized income is 60% that of the bottom half; (2) consumption taxes undo one third of the impact of direct taxes and transfers on the Gini coefficient of household income; and (3) the average consumption tax rate, rather than the distribution of propensities to consume, drives the cross-country variation in the anti-redistributive effect of consumption taxes.

2 Literature

While there is significant redistribution using the revenue from consumption taxes, the direct anti-redistributive effect of their imposition has rarely been assessed. This latter effect is determined by the tax-rate structure, and household consumption patterns and average propensity to consume. This likely differs significantly from one country to another, as there is considerable cross-country variation in both the level of consumption taxes and the distribution of households' propensities to consume.

2.1 The determinants of regressivity in consumption taxes

The amount of consumption tax paid by each household depends on both the overall level of their consumption and the type of goods and services consumed. The distribution of tax rates across the population therefore reflects both the household propensity to consume and the basket of goods consumed, with the latter influencing the average effective rate applied to total household expenditure.

Regarding the first factor, it is widely thought that the propensity to consume falls with household income. If this is so, then for a given tax rate the relative amount of consumption tax paid by the household also falls with income. This is the main reason why consumption taxes are considered to be regressive. Second, for a given propensity to consume, each household's effective tax rate will depend on the bundle of goods and services it chooses to purchase. Country-specific analyses are required in order to assess how this 'bundle effect' affects the distribution of tax rates across income levels.

There has been a series of empirical analyses of this question, making use of detailed household budget surveys and using statutory tax-rate information for different types of

goods and services.[1] Some of these analyses are at the country level, for instance Savage (2017) for Ireland, and Bozio et al. (2012); Ruiz and Trannoy (2008) for France. Others use Eurostat data and Euromod microsimulation tools to compare different countries (Figari and Paulus, 2015; Decoster et al., 2010; O'Donoghue, Baldini, and Mantovani, 2004). Recently, Thomas (2022) applied VAT statutory rates on household consumption from surveys in 27 OECD countries, mostly covering the 2008-2012 period, to compare the distributional effect of VAT. This literature concludes that the bundle effect on the effective tax rate on household consumption is only limited, as compared to the other effects from the falling propensity to consume and the share of rents.

In France, VAT is slightly progressive (being one point higher for the top decile than for the bottom: see Boutchenik, 2015), but this is offset by regressive excise taxes so that the total tax rate on consumption is almost flat (Bozio et al., 2012; Ruiz and Trannoy, 2008). In Ireland, Savage (2017) finds that the profile of all consumption taxes is slightly regressive (two points higher for the bottom than for the top decile, and three points higher for deciles 2 to 4).

Using a larger sample of countries, O'Donoghue, Baldini, and Mantovani (2004) conclude that VAT rates on consumption are slightly progressive (zero to two points higher for consumption in the top decile) in each of the 12 European countries they consider; on the contrary, excise taxes are regressive everywhere (with a zero to three points difference). They overall find that consumption tax rates fall with consumption (and are thus regressive), but that the difference between the top and bottom deciles is rather limited: under one point in 8 out of the 12 countries, and between one and two points in France, Italy, Portugal and the United Kingdom. Applying the same method to more-recent data, Decoster et al. (2010) and Figari and Paulus (2015) find the opposite result: a slightly-increasing tax rate on consumption. In the former, the top decile pays between 0.5 (UK) and 2.6 points (Belgium) more than the bottom decile; in the latter this range is between 0.4 (UK) and 1.6 points (Belgium).

In Thomas (2022), VAT is generally either proportional or slightly progressive when measured as a percentage of consumption, while saving rates rise with income, thereby driving the regressivity of tax-to-income ratios in all 27 OECD countries analysed. The importance of taking housing rents into account is also underlined: the share of housing rents in household budgets affects the scope of taxable consumption. Thus, even though reduced tax rates on certain goods usually benefit the poor, resulting in (slightly) progressive effective tax rates on consumption, the decreasing propensity to consume has a much more important impact, driving the decreasing tax-to-income ratios in all countries.

We will here neglect the bundle effect by considering that this does not vary by income group, but do address housing rents, which are not subject to consumption tax: we apply a constant tax rate to non-rent consumption. We then test the sensitivity of our results to this assumption in Section 5.1, which considers a consumption tax rate that varies by

[1] As the national legislation on consumption taxes is sometimes very complex, the imputation of the tax rate for different goods is generally simplified: the analyses distinguish between a few dozen groups of goods and services and apply a tax rate to each, even if in practice the legislation can be much more detailed. However, this type of approach is by far the most-precise evaluation we have of the bundle effect.

income group. Last, we carry out a robustness check of our results by comparing implicit and statutory consumption tax rates in Section 5.2.

2.2 Issues in measuring consumption taxes

Unlike payroll or income taxes, which can be measured at the individual level using administrative data, consumption taxes such as sales taxes or value-added taxes are not registered at the individual level. It is therefore not straightforward to establish the consumption taxes that a household pays. The most-common way of measuring this amount is based on consumption data and microsimulation techniques: with information on household consumption and the country's tax system, the consumption taxes paid by the household can be derived.

There are three main issues with this technique. The first is the lack of time series on household consumption. Second, the definition of the tax rate on consumption that is to be applied to consumption expenditures. Last, it is useful to ask, in the context of comparing the redistribution of fiscal systems in a cross-country fashion, whether micro-data from different national surveys can be compared directly or if they should be harmonized via National Accounts. We consider these three in turn below.

Measuring consumption. Extensive empirical research has been carried out to estimate consumption data at the household level, starting with the use of traditional detailed budget surveys that ask respondents to report their disaggregated consumption expenditure (whether through diary or recall procedures). More recently, administrative tax data have been widely exploited to impute consumption expenditure based on the accounting identity that total household expenditure equals income plus capital gains minus the change in wealth over the period (see Browning, Crossley, and Winter, 2014 and Eika, Mogstad, and Vestad, 2020, for critical reviews of these different methods).

While all of these consumption data face measurement problems, researchers tend to believe that household income is easier to measure than household consumption. With regard to income, however, it is well known that the resources of low-income households are difficult to measure using tax data, while the resources of households at the top of the distribution are relatively poorly captured in surveys (see Yonzan et al., 2022, and the references therein). Moreover, as shown by Meyer and Sullivan (2003, 2011), consumption expenditure in surveys is actually better measured than income at the bottom of the living-standards distribution. Another lesson from this literature is that consumption from survey data is systematically underestimated as compared to the aggregate figures in National Accounts (Krueger et al., 2010), while administrative tax data needs to be coupled with fine-grained household financial data to be exploitable (see, for instance, Kolsrud, Landais, and Spinnewijn, 2020). As a result, research questions that would require the use of micro consumption data to be addressed are severely hampered by the lack of good and accessible time series on household consumption, be it from surveys or registry-based measures.

In this paper, we contribute to the literature by proposing a simple way of deriving household consumption from current income, housing costs and standard demographics. We

test the sensitivity of our imputations to the method used, by comparing the outcome of different regression models. We also check their robustness by comparing our results to those in the literature (see Section 5.1), and by taking advantage of the fact that for some datasets we do observe household consumption expenditures. Although our data are likewise subject to some measurement errors, which are identified and listed, they have the great advantage of using only standard easily-accessible data that are already well-known by researchers.

Measuring the tax rate. The most direct way of calculating the effective tax rates on consumption consists in using legal statutory tax rates (e.g. Thomas, 2022; Figari and Paulus, 2015; Decoster et al., 2010; O'Donoghue, Baldini, and Mantovani, 2004). This has the advantage of being an exact method, provided that we can decompose the household's consumption bundle in order to apply the corresponding tax to each good. However, the application of the correct tax rates according to the nature of the good or service purchased requires consumption data to be broken down into very fine categories. Existing consumption databases rarely exhibit this level of precision.[2] We discuss the limitations of this bottom-up approach in Section 5.2.

As proposed by Mendoza, Razin, and Tesar (1994), the most-workable solution to comparing the effect of taxation in multiple countries characterized by different and changing tax structures is to construct synthetic tax indicators. The effective tax rate is defined as the ratio of particular tax revenues to the corresponding tax bases obtained from the National Accounts. The effective tax rate on consumption is therefore the ratio of tax revenues from consumption taxes to the pre-tax value of consumption.[3]

Equivalently, we can define an *implicit* tax rate on consumption as a percentage of the post-tax value of consumption.[4] Implicit and effective tax rates on consumption embed the same information and their correlation coefficients are equal to 1, as clearly shown in Martinez-Mongay (2000) and Carey and Tchilinguirian (2000). Changing the tax base (pre-tax versus post-tax) only changes the level of the calculated tax rate, which is lower if expressed as a percentage of the post-tax value of consumption.

In this paper, as observed consumption is expressed in consumer prices in the micro-data, we adopt a tax base reflecting the post-tax value of consumption and therefore calculate implicit tax rates on consumption at the macro-level.[5] In addition, since we remove rents (actual and imputed) in the micro-data on consumption, we also remove them in the macro-computation of the tax base. While this is a sensible thing to do with micro-simulation tools (e.g. IFS, 2011), no analysis using implicit tax rates has actually consistently removed rents from the tax base.[6]

[2] See De Agostini et al. (2017); Akoğuz et al. (2020) for a discussion of the issues raised by using detailed consumption data such as Household Budget Survey data with statutory rates.

[3] At the micro level, it is thus the difference between the consumer price (post-tax) and the producer price (pre-tax), expressed as a percentage of the producer price (i.e. the wedge between consumer and producer prices).

[4] At the micro level, the difference between the consumer price (post-tax) and the producer price (pre-tax) is in this case expressed as a percentage of the consumer (post-tax) price.

[5] See Eurostat (2016) and Carey and Tchilinguirian (2000) for a similar computational choice.

[6] Mahler, Jesuit et al. (2018) opt for an intermediate method: they apply the "standard" statutory tax rate

International comparisons. There is always a gap between micro-data from surveys and aggregate National Accounts data. In this case, as we use individual income and consumption data in order to estimate the impact of consumption taxes, we want to make sure that the amounts can be compared across countries. National Accounts, as they are standardized, are more fit for international comparisons. The propensities to consume calculated at the national level do indeed vary significantly between countries, as measured in National Accounts. These differences, however, do not always appear in micro data (see Pistaferri, 2015; Sabelhaus et al., 2015, and the references therein).

We therefore combine micro- and macro-level data in order to produce information on the distribution of income and consumption for each country-year that is comparable at the international level. Many other researchers have noted this discrepancy between micro and macro data, and have dealt with it in a similar manner (e.g. Piketty, Saez, and Zucman, 2018). We discuss the implications of our scaling method extensively in the next section, and present sensitivity tests of this assumption in Section 5.3.

3 Method and data

Over a lifetime, the distributional impact of consumption taxes does not depend on the current propensity to consume; it instead depends on the difference between lifetime expenditure and lifetime income, which might vary across households.[7] We here seek to assess the distributional impact of consumption taxes at a given point in time (and compare this figure across countries): as such, our analysis does not provide any information on the distributional impact of consumption taxes over the life course, as households have the possibility to borrow and save.

We consider this methodological choice to be informative, as the households currently labeled as poor are affected by consumption tax-rates differently from those currently labeled as rich: this cross-section distributional impact, which we observe over a wide range of countries and years, is important. Our approach also has the advantage of allowing us to make straightforward comparisons with direct taxes and benefits, whose impact is usually measured on the current distribution of income.

Starting from cross-country micro-level databases on income and consumption, we estimate the consumption-tax amount each household pays. This allows us to define the household tax-to-income ratio as the ratio of consumption taxes paid to household income. This section presents the method and the data used in order to produce consistent estimates

to household consumption, adjusted by the actual tax revenue calculated from OECD data. This approach is close to that described here, except that the adjustment does not take into account that a considerable portion of the final consumption recorded in OECD data is not subject to taxation (e.g. rents and some parts of public consumption such as health and education).

[7] In economic theory, lifetime income and lifetime expenditure are generally considered to be equal, omitting gifts and bequests. Including gifts and bequests, economic theory would consider that net gifts are not part of the lifetime income of the giver but part of the lifetime income of the receiver, to avoid double counting (see Capéau, Decoster, and Phillips, 2014 for a discussion).

of the distribution of tax-to-income ratios over different country-years.[8]

3.1 Data

We use micro-level data from surveys on income and consumption in order to calculate households' propensities to consume. Implicit tax rates on consumption are calculated via National Accounts data on consumption-tax revenue and household consumption. National Accounts data on household consumption and income are also used in order to scale the micro data.

The Luxembourg Income Study (LIS) is a cross-national data center that collects survey and administrative data on household income, wealth, consumption, and other socio-economic characteristics. In most countries, the micro data comes from national household budget surveys carried out by National Statistical Institutes. This data is then harmonized by the Luxembourg Income Study.[9]

The initial dataset includes over 200 country-years, with over 30 different countries over the 1967 to 2016 period. Household consumption data is only available in about one quarter of those datasets. When consumption is not available, we impute it, as described in Section 3.2.

From consumption data, whether observed or imputed, we then require additional macro-data in order to calculate consumption taxes at the household level. This macro data, taken from National Accounts data in each country-year, is used for two reasons. The first is to scale the micro data on consumption and expenditure so that it is consistent with National Accounts, and thus comparable across countries. The second is to calculate consumption-tax rates, based on tax revenues and total consumption. These data, available from OECD Statistics, are produced by National Statistical Institutes, and cover not only OECD member countries but also a number of other cooperating countries.[10] This National Accounts data is not available for all of our country-years.

At the end of the day, we apply our method to 132 country-years for which we are able to calculate the effect of consumption taxes on inequality, covering 27 countries over 36 years from 1978 to 2013. Of these, 55 country-years fall under the core model, which uses information on rents to produce the most-accurate estimates of the impact of taxes. We also use a lighter version of our simulation model that is slightly less accurate but requires less data (in particular, it does not require rents data), in order to simulate consumption taxes for 77 additional country-years. The complete list of countries and years in our analysis, as well as the estimation method used for each of them, appears in Appendix H.

[8] The code that was used to build our cross-country dataset, as well as the main indicators and percentile data presented in this paper are available online at https://doi.org/10.5281/zenodo.4291984.

[9] For more information, see http://www.lisdatacenter.org/about-lis/.

[10] See http://stats.oecd.org.

3.2 Method

We use microsimulation to produce estimates of the consumption taxes paid by households: this requires information on households' consumption expenditures as well as on the taxes on consumption. Having calculated the consumption taxes paid, we can define the tax-to-income ratio (TIR) for household i in country c at year t:

$$TIR_{i,ct} = \frac{\tau_{ct} \cdot consumption_i}{disposable\ income_i} = \tau_{ct} \cdot prop_i \tag{1}$$

where τ_{ct} is the implicit tax rate on consumption in country c at year t, and $prop_i$ is household i's propensity to consume, i.e. the share of disposable income that is actually spent.

The distribution of this measure by income reveals the regressivity of consumption taxes in the country-year. The more the TIR falls with income, the more regressive are consumption taxes.

We can similarly define post-tax disposable income as the disposable income once consumption taxes have been paid:

$$\text{post-tax income}_i = (1 - TIR_{i,ct}) \cdot \text{disposable income}_i \tag{2}$$

We present below the method used to calculate the propensities to consume and render them consistent across country-years; we then define the implicit tax rates on consumption used to simulate consumption taxes. Last, we describe the imputation strategy when consumption data is missing.

3.2.1 Definition of the propensity to consume

Households' propensities to consume, which are the household-level term in eq. (1), represent the share of income that is effectively spent on goods and services. This is calculated at the household level using budget survey data, and is defined as the ratio of taxable consumption to disposable income. Thus, for every household i:

$$prop_i = \frac{taxable\ consumption_i}{disposable\ income_i} = \frac{hmc_i - rents_i}{dhi_i}$$

where *hmc* is household monetary consumption, *rents* household expenditure on rents and *dhi* disposable household income.

Taxable consumption thus includes all monetary expenditure but excludes rents, which are not subject to consumption taxes.[11] Rents represent a higher share of income at the lower end of the income distribution. Therefore, including rents in taxable consumption, as most international comparisons do, would produce a slight overestimation of the regressive effect of consumption taxes (see Appendix D).[12]

[11] Loan repayments are considered as savings, not consumption.

[12] While our core model sticks to this definition of taxable consumption, we also produce estimates for a larger set of countries where rents are not subtracted from consumption. The results from the lighter model applied to the full sample appear in Appendix E.

Disposable income is the amount of money that households have available for spending after accounting for direct taxes, social-security contributions and monetary transfers. All monetary variables are equivalized according to the OECD standard: income and consumption are divided by the square root of the number of household members.

As consumer expenditures are systematically under-reported in surveys, particularly 'vices' such as alcohol and tobacco, the effect of taxation on disposable income will be underestimated, especially for excise taxes (Capéau, Decoster, and Phillips, 2014). In addition, under-reporting is generally higher for taxed expenditures than for untaxed expenditures, hence the need to calibrate the data with National Accounts. We can define the aggregate propensities to consume for country c in year t, based on the aggregate values of consumption and income in the National Accounts:

$$P_{c,t} = \frac{C_{c,t}}{I_{c,t}}$$

In order to render the distribution of the propensities to consume consistent with National Accounts data, the micro-data on consumption and income is scaled according to these aggregates. Note that, to be consistent with our micro data, rents are removed from both consumption (for actual and imputed rents) and income (for imputed rents) in the scaling factor. See Appendix B for details of the economic aggregates used for this scaling. After this homothetic transformation, we have:

$$\sum_{households\ i} taxable\ consumption_i = C_{c,t}$$
$$\sum_{households\ i} disposable\ income_i = I_{c,t}$$

The combination of these two types of data allows us to use micro-data to estimate the distribution of consumption over income, while the relative average levels of income and consumption are scaled to match the National Accounts.

3.2.2 Implicit tax rates

Consumption taxes include value-added taxes (VAT), excise taxes, and other taxes on goods and services. To account for all of these taxes and their average respective weights in consumption, we calculate for each country-year an implicit tax rate based on national consumption-tax revenue and domestic monetary consumption.

There are two main definitions of the implicit effective consumption tax rate in the economic literature, as described in Eurostat (2016) and Carey and Tchilinguirian (2000), both inspired by Mendoza, Razin, and Tesar (1994). We draw on these contributions in order to propose a slightly-improved definition:

$$\tau_{c,t} = \frac{consumption\ tax\ revenue}{C - CGW - R}$$

where *consumption tax revenue* includes all revenue from consumption taxes, including value-added taxes (or sales taxes if applicable), excise taxes, taxes on specific services, etc. $C = CP + CG$ is total final consumption expenditure (private consumption and the consumption of general government). CGW are the wages of employees paid by the general government, and $R = R_{actual} + R_{imputed}$ are actual and imputed housing rents.

We take into account the fact that the value of housing (whether paid by tenants or imputed to homeowners) and some part of public consumption do not produce consumption-tax revenue.

We can then calculate the tax-to-income ratio for each household i in country c at year t:

$$TIR_i = \tau_{c,t} \cdot scaled\ prop_{c,t,i} = \underbrace{\tau_{c,t} \cdot \frac{C_{c,t}}{I_{c,t}}}_{macro\ data} \cdot \underbrace{\frac{\sum_i dhi_i}{\sum_i hmc_i - rents_i} \cdot prop_i}_{micro\ data}$$

where $\tau_{c,t}$ is the implicit consumption tax rate of country c at year t, $\frac{C_{c,t}}{I_{c,t}}$ the aggregate propensity to consume (consumption over income) in country c at year t, $\sum_i dhi_i$ the (weighted) sum in micro data of all households' disposable income, $\sum_i hmc_i - rents_i$ the (weighted) sum of all households' non-rent consumption, and $prop_i$ household-i's propensity to consume.

This implicit tax rate, which is a weighted average of the different rates on specific products, is thus the same for all households in a country-year. Based on the discussion in Section 2.1, we argue that the effect of having varying bundles of goods and rates across households is of only third-order compared to the decreasing propensity to consume and the falling share of rents in income. We run a sensitivity analysis of this assumption, and show that consumption-tax rates that increase with income in proportions consistent with the literature have a smaller effect than decreasing propensities to consume and a falling share of rent in consumption (see Section 5.1).

3.2.3 The imputation of consumption

We use a regression model to impute consumption from household characteristics when consumption data is not available. The key issue here is that the distribution of consumption has to be imputed in entire country-year datasets in which there are no expenditure observations. We therefore require a model that is generic enough to be calibrated on some countries and then used for others: this, in particular, has to be independent of cross-country differences in median incomes.

We proceed by applying medianization to all of the monetary variables (including income, consumption and the value of housing). As such, all monetary variables are expressed as a proportion of their median values in country c at year t. The **medianized disposable income** of household i is thus:

$$\widehat{income}_i = \frac{income_i}{\text{median}_{c,t}(income)}$$

Similarly, we define $\widehat{consumption}_i$ as medianized consumption and $\widehat{housing}_i$ as the medianized value of its housing. The value of housing is defined as the total cost of housing, including rents and utilities, as well as imputed rents for occupying owners. This is a very good proxy of the standard of living of the household, and appears much more often in income databases than does total consumption expenditure.[13] Moreover, while income can be subject to considerable transitory shocks that do not feed through to consumption, housing expenditure is smoothed, as consumption is expected to be.

We apply a generalized linear model with a logarithmic link function and Gaussian error.[14] In this model, $\widehat{consumption}$ follows a normal distribution conditional on income, housing and other socio-demographic variables X, with constant variance σ^2 and mean μ defined by:

$$\log(\mu) = \alpha + \beta \log(\widehat{income}) + \delta \log(\widehat{housing}) + \Delta^{\intercal} X \tag{3}$$

Importantly, socio-demographics include the age of the household head to account for the fact that consumption rates vary significantly over the life-cycle (Heathcote, Storesletten, and Violante, 2005). While this is our core model, we also consider a lighter version of the regression model for the country-year datasets where the cost of housing and/or the age of the household head is not available. See Appendix A for the full specification.

Accuracy of the imputation

We use this model to impute consumption in every dataset where it is missing but where income and other relevant socio-economic determinant variables appear. The relationship between the propensity to consume and income in the imputed consumption data is very similar to that calculated using observed consumption data. *In fine*, the same model seems to be applicable over a wide range of country-years, and the shape and downward slopes of the curves fit the data well. Figure 1 shows the results from nine imputation models using cross-validation: each model excludes the country for which consumption is estimated. For example, imputed consumption in Australia in 2010 comes from a regression model estimated on every country but Australia. Even in countries where imputed consumption appears to overstate observed consumption at the bottom and understate it at the top (such as in the United Kingdom or Poland), the imputation model produces reliable estimates of the post-consumption-tax Gini coefficients (Figure 2).

The estimated coefficients from our model appear in Table A.a, and the estimated implicit tax rates on consumption in Blasco, Guillaud, and Zemmour (2020). However, it should be noted that, while our imputation model produces reliable estimates of the impact of consumption taxes on inequality, it may well be inappropriate for other purposes, such as testing the permanent-income hypothesis, comparing consumption between social groups, or other questions for which researchers often rely on household consumption data.

[13] While consumption expenditure appears in 25% of the datasets, housing costs are listed in 60% of them.

[14] See Nelder and Wedderburn (1972) for the original description of these models, and Hardin and Hilbe (2018) for a description of their modern implementation in Stata.

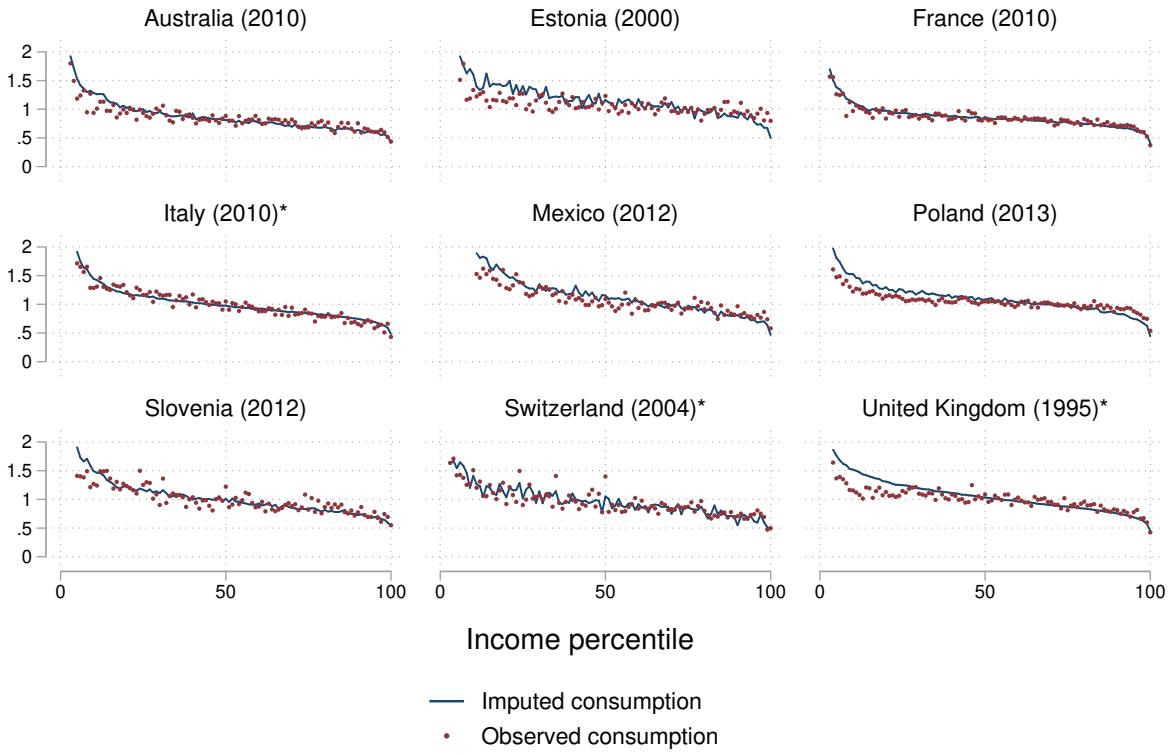

Figure 1: The imputed and observed propensities to consume, using cross-validation.

Notes: Imputation for Italy, Switzerland and the United Kingdom come from the lighter model.

We show that including the total cost of housing as an independent variable significantly increases imputation quality. This is the approach taken in the core model. However, this housing information is not available for some country-years, as is the age of the household head. In this case, we use imputations from the lighter model to increase the coverage of our international comparisons. We show in Appendix A that the lighter model produces fairly satisfactory results as well.[15]

[15]We present there the coefficients of the simpler imputation models, as these can be applied to datasets with little socio-demographic information, such as fiscal data.

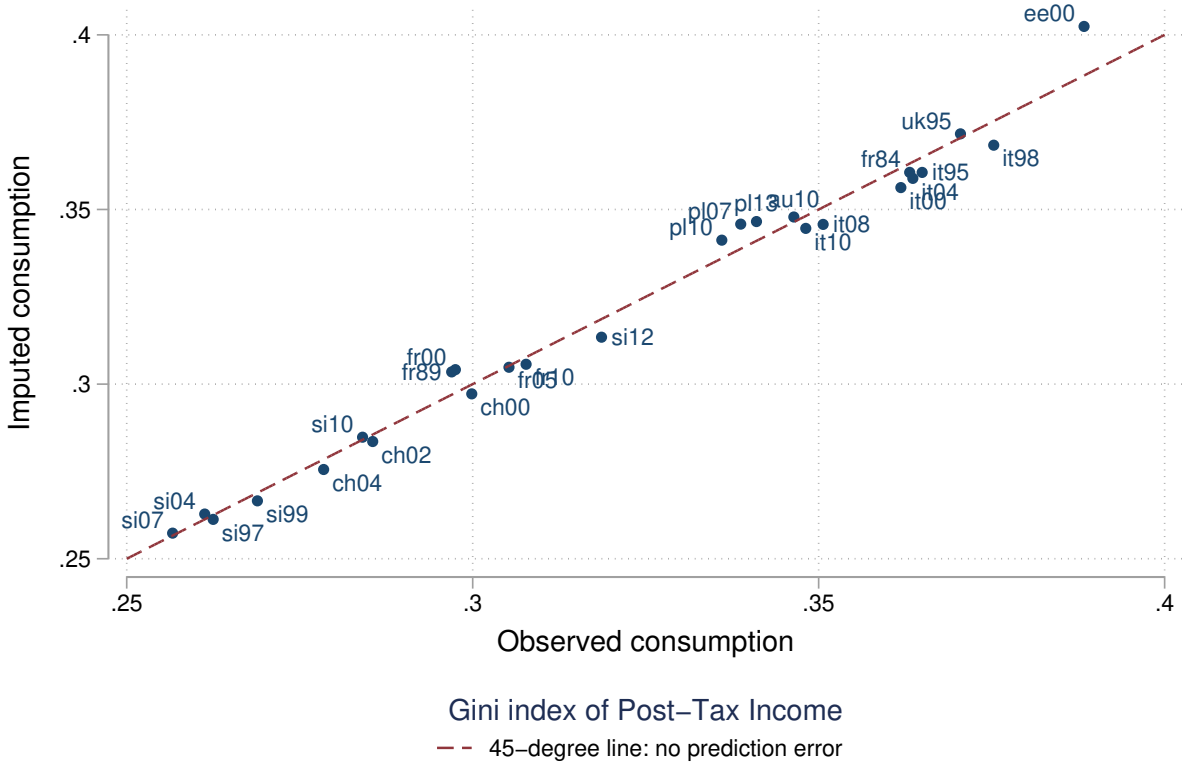

Figure 2: The observed and predicted Gini coefficients of post-tax income.

4 Results

In the following figures, we present the results from observed consumption data when available, or from the imputations of the core model or the lighter model, depending on the availability of the data needed to run the models. For clarity, the results shown for each country are that from its latest available year (see Table H.a for a full description of the available data for each country and year). All of our results, including those from the lighter model and the core model, are available at https://doi.org/10.5281/zenodo.4291984.

4.1 The tax-to-income ratio of the richest 10 percent is only 60% that of the poorest 50 percent

The first results that we present here refer to the global tax-to-income ratios for each percentile of income. We find that, in all countries and years, propensities to consume fall with income. In general, consumption exceeds disposable income in the first percentiles, indicating significant dis-saving. On the contrary, households in the highest percentiles of equivalized income consume about 50-60% of their income.

Tax-to-income ratios follow the same downward slope (Figure 3). Consumption taxes are

therefore significantly regressive: in France in 2010, the poorest households paid over 20% of their disposable income in consumption taxes, while this figure was under 10% in the richest households. The curve in Germany is very similar, both in level and slope. The estimated regressivity is slightly lower in France, as the consumption-propensity curves cross at the middle of the income distribution. The slope is also similar in other countries, even though the levels are different: in Denmark, the tax-to-income ratio is over 30% for almost half of households, while it is under 10% for most households in the United States.

For most countries, the tax-to-income ratio of the richest 10 percent is between 50% and 60% of that of the poorest 50 percent (Table 1). For the countries with the greatest inequality in propensities to consume, the tax-to-income ratio is even under half that of the bottom 50 percent: 46% in the United States, 47% in Spain and 49% in Italy. On the other hand, the gap is lower for less-unequal countries: the tax-to-income ratio of the top 10 percent represents 68% of that of the bottom 50 percent in Poland, 62% in Belgium, France and Sweden.

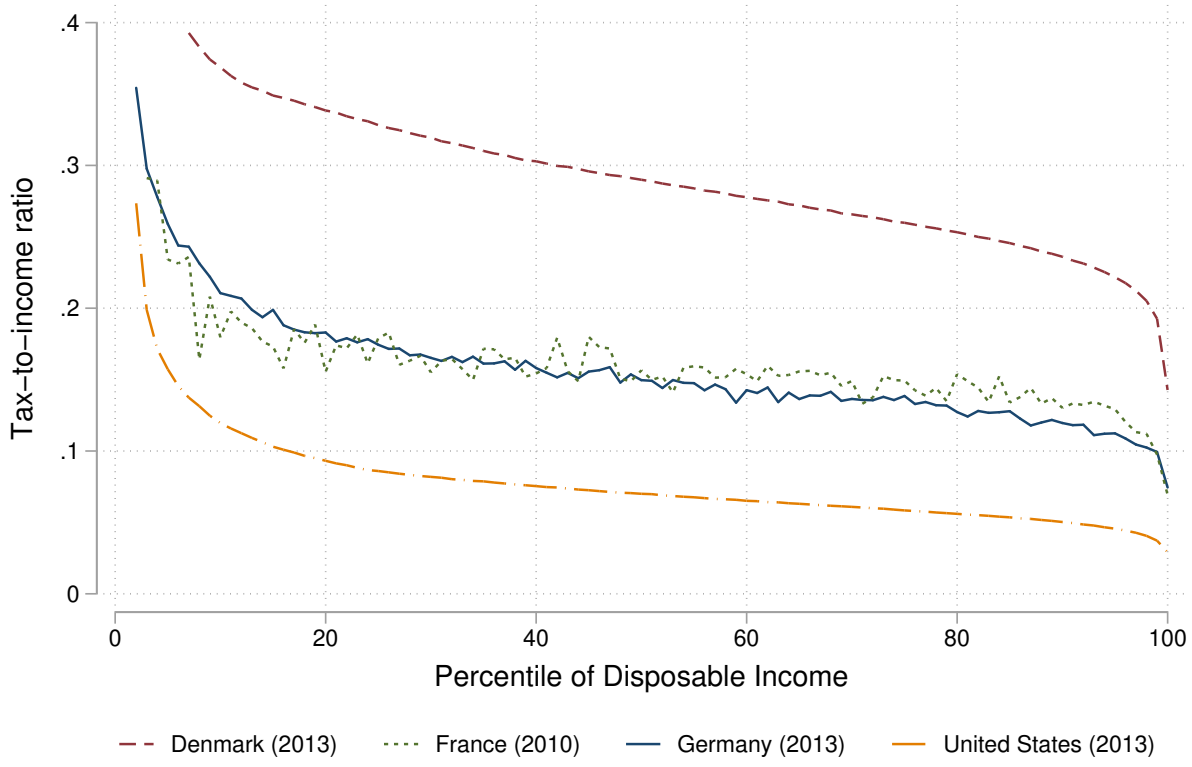

Figure 3: Tax-to-income ratios in Germany, Denmark, France and the United States.

Notes: The results for the US and Denmark come from the lighter model.

The changes in the propensities to consume along the income distribution are captured by the β coefficient of the consumption-imputation model, as shown in eq. (3). This coefficient being less than 1 means that consumption grows less quickly than income, and the propensity to consume falls with income. In the lighter specification, i.e. that where income is the only

	TIR of T10	TIR of B50	Ratio
United States (2013)	0.04	0.09	0.46
Spain (2013)	0.10	0.22	0.47
Italy (2010)	0.10	0.20	0.49
Estonia (2013)	0.17	0.34	0.50
Greece (2013)	0.15	0.30	0.50
United Kingdom (2013)	0.11	0.21	0.51
Austria (2013)	0.12	0.23	0.54
Switzerland (2013)	0.07	0.12	0.54
Hungary (2012)	0.20	0.36	0.56
Netherlands (2013)	0.12	0.21	0.56
Ireland (2010)	0.13	0.23	0.57
Germany (2013)	0.10	0.18	0.57
Czech Republic (2013)	0.14	0.25	0.57
Mexico (2012)	0.06	0.10	0.58
Slovenia (2012)	0.17	0.29	0.59
Finland (2013)	0.17	0.28	0.59
Australia (2010)	0.08	0.13	0.59
Denmark (2013)	0.20	0.33	0.61
Iceland (2010)	0.18	0.30	0.61
Norway (2013)	0.16	0.26	0.61
Belgium (1997)	0.12	0.19	0.62
France (2010)	0.11	0.18	0.62
Sweden (2005)	0.17	0.27	0.62
Poland (2013)	0.14	0.21	0.68

Table 1: Tax-to-income ratios of the top decile and the bottom half of equivalized income, and the ratio between them

continuous independent variable, the β coefficient is 0.57 over most of the income distribution (Table A.a). As such, a 1 percent rise in income leads to 0.57 percent higher consumption.[16]

In our core model (in column (3) of Table A.a), housing costs are strongly correlated with total consumption. The β coefficient for income when these costs are included is smaller, as part of the income effect passes via housing costs. For most of the income distribution, a 1 percent increase in income yields a 0.45 percent increase in consumption (as opposed to a figure of 0.57 when housing costs are not included), while a 1 percent increase in housing costs yields 0.33 percent higher consumption.

4.2 The anti-redistributive effect of consumption taxes is on average 1/3 of the size of direct redistribution

We measure the distributive effect of consumption taxes using synthetic measures of income inequality and progressivity. We first show that the effect of consumption taxes on income inequality is significant, but much smaller in magnitude than that of direct tax-benefit redistribution. We then decompose this distributive effect into its horizontal and vertical components, and show that the largest part of the between-country differences come from the differences in consumption-tax rates.

We measure the distributive impact of consumption taxes by defining post-tax disposable income:

$$\begin{aligned}\text{post-tax income} &= \text{disposable income} - \text{consumption taxes} \\ &= \text{market income} + \text{transfers} - \text{direct taxes} - \text{consumption taxes}\end{aligned}$$

We define the redistributive effect of consumption taxes as the difference in income inequality between disposable and post-tax disposable income, using the following index of effective redistribution:

$$\Delta G = G_{dhi} - G_{dhi-tax}$$

where G_{dhi} ($G_{dhi-tax}$) is the Gini coefficient on pre-tax (post-tax) disposable income. This measure is positive for a progressive tax and negative for a regressive tax. We expect a negative value for consumption taxes, corresponding to greater income inequality.

Not surprisingly, this is the case for all countries, as the propensity to consume falls with income. Figure 4 shows that the anti-redistributive effect of consumption taxes is between 0.010 and 0.056 Gini points, with the figure for most countries being in the 0.015-0.035 range. We can also consider alternative measures of inequality, such as the ratio of the top 10 to the bottom 50 percent of the income distribution. The same story emerges in this case (see Figure 5): the United States, Belgium and France are among the countries where the inequality impact of consumption taxes is the smallest, while this impact is the largest in Estonia, Greece and Denmark.

[16] We introduced a different slope at the bottom of the income distribution, i.e. where income is below 60 percent of the median (see Appendix A). For these poorest households, the β coefficient is 0.27 in the lighter model.

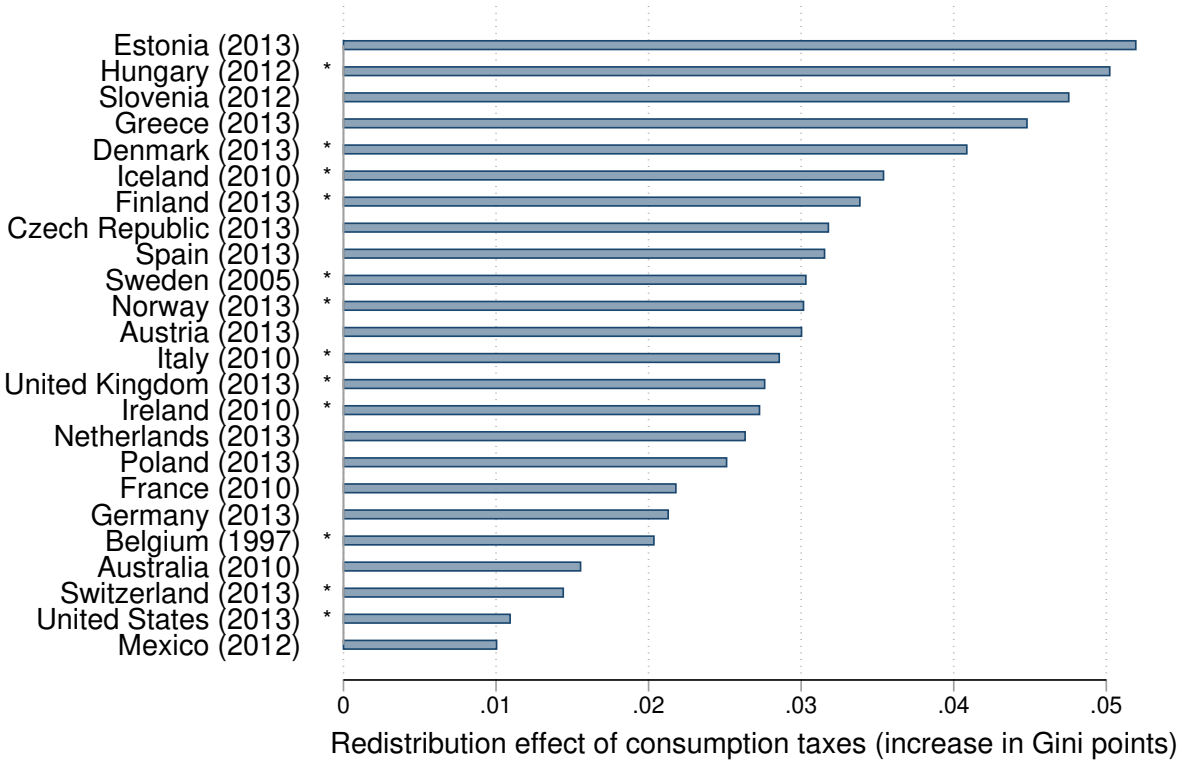

Figure 4: The estimated rise in the Gini coefficient due to consumption taxes.

Notes: Results for countries with a '*' come from the lighter model.

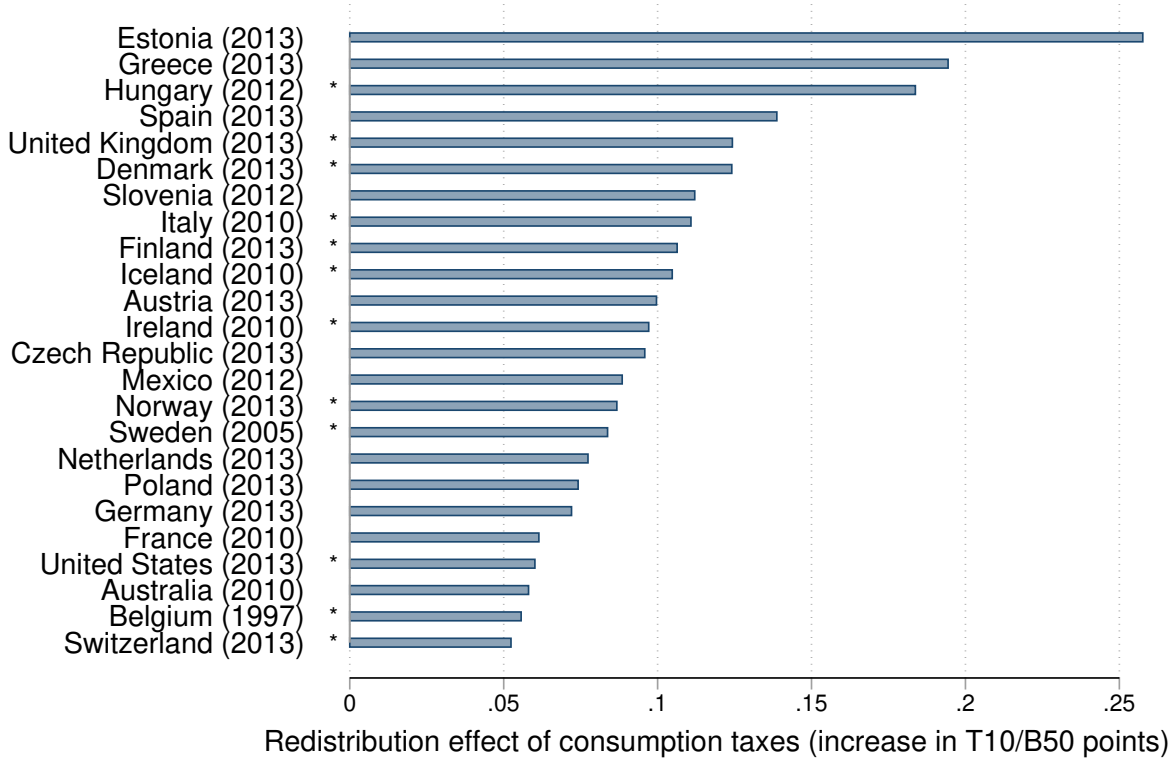

Figure 5: The estimated rise in the T10/B50 ratio due to consumption taxes.

Notes: Results for countries with a '*' come from the lighter model.

In Figure 6, we compare the Gini coefficients for four concepts of income: market income (income from labour, capital and pensions); gross income (market income after transfers); disposable income (gross income after direct taxes); and post-tax income (disposable income minus consumption taxes). These income concepts, similar to those in Guillaud, Olckers, and Zemmour (2020), allow for a sequential analysis of redistribution, and enable consistent comparisons of redistribution over the whole population between countries with different social security and pension regimes.[17]

Inequality is lower for post-tax income than for market income, and higher than for disposable income. Consumption taxes produce greater inequality, but of smaller size than the reduced inequality due to the remainder of the tax-benefit system. In almost all countries, the Gini coefficient of post-tax income is closer to that of disposable income than to that of market income.[18]

The anti-redistributive effect is thus significant, and large enough to change the income-

[17]These income concepts are defined to avoid common biases in cross-country comparisons: i) Market income includes all types of pensions, so that that pensioners in public-pension countries do not appear artificially poor at the market-income stage, and ii) Pre-tax labour income includes imputed employer contributions (as the divide between employer and employee contributions is largely artificial, and varies greatly across countries, so that including only employee contributions in labour income significantly biases the

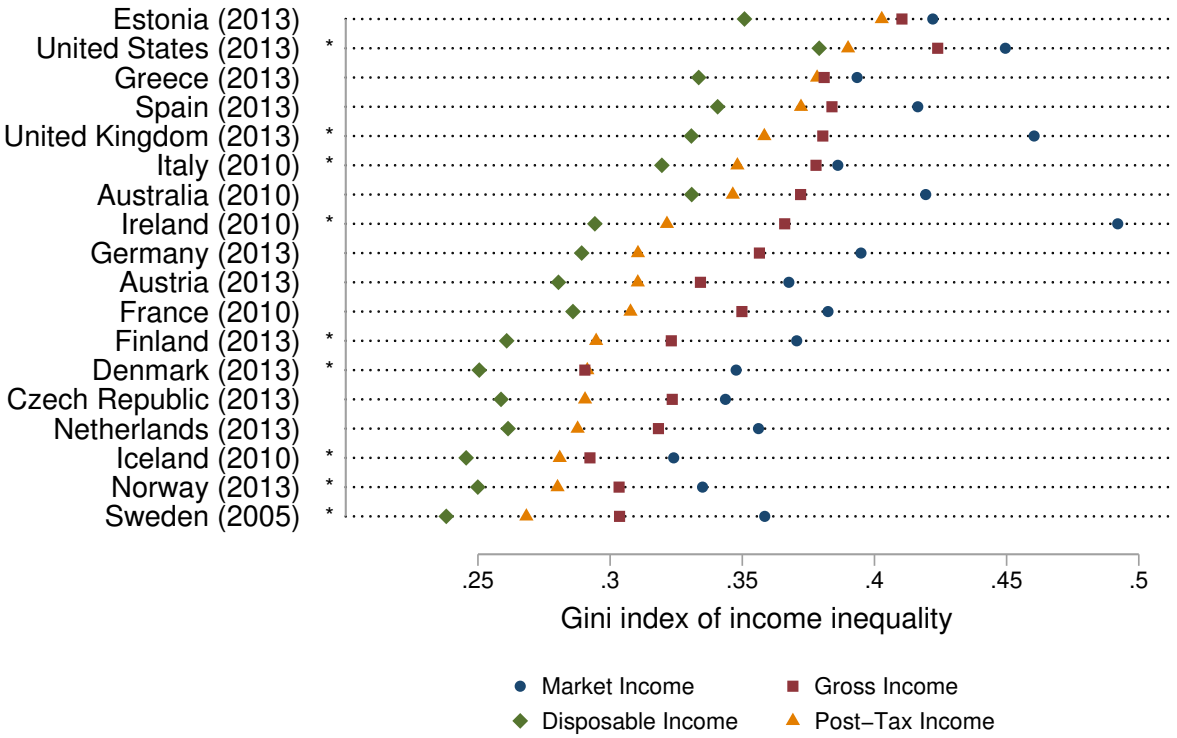

Figure 6: The Gini coefficients for market, gross, disposable and post-tax income.

Notes: Post-tax income is derived from the research presented here, while market, gross and disposable income are taken from Guillaud, Olckers, and Zemmour (2020). Our sample and that used in Guillaud, Olckers, and Zemmour (2020) do not always overlap: for example, we do not have all income concepts for Mexico, Poland or Switzerland. Results for countries with a '*' come from the lighter model.

inequality ranking between countries with similar levels of disposable-income inequality but different distributions of the propensities to consume and consumption-tax rates. For example, the Netherlands has similar disposable-income inequality to Finland (with Gini figures of 0.261), but lower post-tax income inequality (0.288 versus 0.295: see Figure 6). This is mainly due to the high VAT rate in Finland (24%, with two reduced rates of 10% and 14%), while that in the Netherlands is lower (21%, with a 9% reduced rate applied to many common products).

In general, the variation of the inequality effect of consumption taxes tends to reduce the gap between countries with high and low disposable-income inequality. For example, while the Gini index of disposable income is 0.251 for Denmark and 0.379 for the United States,

measure).

[18]The sole exceptions are countries that have high initial income inequality (and thus very-regressive consumption taxes) combined with either little redistribution via direct taxes and transfers or high consumption tax rates, such as Estonia or Greece.

the post-tax indices of inequality are respectively 0.291 and 0.390. The gap between the two countries is reduced by 23%, from +0.128 to +0.099.

On average in our sample, the increase in income inequality due to consumption taxes is equal to one third of the total redistribution from taxes and transfers. In a few countries such as Estonia and Greece, where redistribution is quite low, the increase in inequality represents three quarter of the total direct redistribution effect. In others, such as Australia, France, Germany, Ireland, the United Kingdom and the United States, it is under one quarter of total direct redistribution. Consumption taxes exceed half of the redistribution from direct taxes, and sometimes even all of the redistribution from these taxes in countries with low direct taxes (such as the United Kingdom) or high consumption taxes (such as Denmark or Norway).

4.3 The redistribution effect is mainly driven by the tax rate

We here investigate the drivers of the different redistributive effects of consumption taxes across countries: Are these completely explained by the average tax rate, as in the example of Finland and the Netherlands above? Or do they also reflect more- or less-unequal distributions of the propensities to consume? To answer these questions, we decompose the indicator of the redistributive effect.

Effective redistribution can be decomposed into vertical redistribution, measured by the Reynolds-Smolensky index RS, and horizontal redistribution, measured by the re-ranking index Re (see Appendix F.1 for details):[19]

$$\Delta G = RS - Re$$

While the former measures the redistribution due to the regressivity of taxes, the latter is orthogonal to the income distribution: it represents the redistribution effected between households with the same disposable income. In practice, vertical redistribution constitutes most of the redistributive effect of consumption taxes (see Figure F.a).

As shown in Kakwani (1977), the RS index is itself the product of two terms, respectively linked to the regressive nature of the tax and its average rate:

$$RS = K \cdot \frac{TIR}{1 - TIR} \tag{4}$$

Here TIR is the global tax-to-income ratio, defined as average consumption taxes paid over average disposable income, and K is the Kakwani index, a measure of the regressivity of consumption taxes (see Appendix F.2). Vertical redistribution can then be decomposed into one distributional parameter and one macro-level parameter. The Kakwani index is determined by the population pattern of consumption and income, and is not a policy parameter. On the other hand, the tax rate can be tuned by the policy-maker.

[19] Under these definitions, the Reynolds-Smolensky and Kakwani indices are negative if there is an increase in income inequality (the redistributive effect is negative). We will however present the absolute values of these coefficients in the following figures.

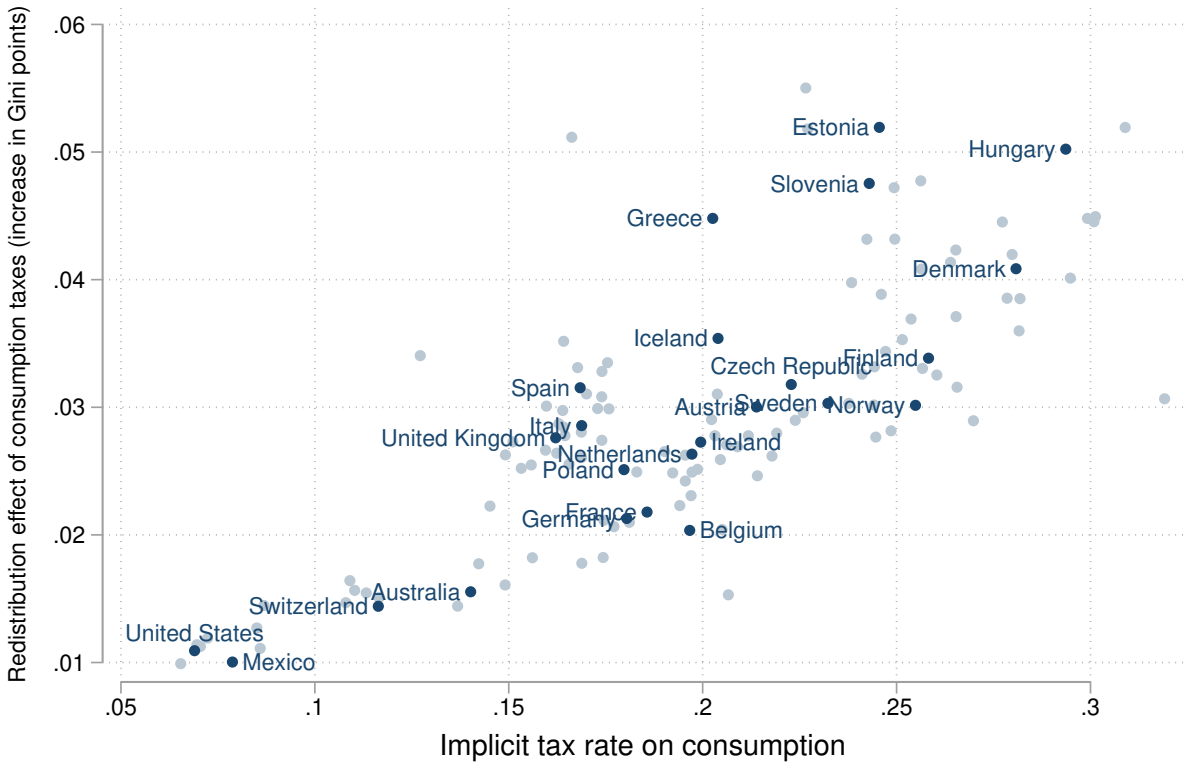

Figure 7: The redistributive impact is mainly driven by the tax rate.

Notes: The last year for each country is shown in bold and the other years appear in greyscale. These last years are 2013 for Austria, the Czech Republic, Denmark*, Estonia, Finland*, Germany, Greece, the Netherlands, Norway*, Poland, Spain, Switzerland*, the United Kingdom* and the United States*, 2012 for Hungary*, Mexico and Slovenia, 2010 for Australia, France, Iceland*, Ireland* and Italy*, 2005 for Sweden*, and 1997 for Belgium*. Results for countries marked with a '*' in this list come from the lighter model.

A first intuition can be grasped with Figure 7 which shows a positive correlation between the implicit tax rate on consumption and the anti-redistributive effect of consumption taxes across countries. Comparing Denmark to the USA, for instance, the sharp increase in inequality in Denmark (+0.04 Gini points) is four times that in the USA (+0.01 Gini points): this difference is driven by a high implicit tax rate on consumption in Denmark (28%), which is four times the tax rate in the USA (7%).

The analytical decomposition of this anti-redistributive impact of consumption taxes, exposed in eq. (4), is applied to our sample in Figure 8. Two insights can be gained from reading this graph. On the one hand, differences in redistribution between countries with similar tax-to-income ratios can be explained by different levels of tax regressivity. Comparing Greece with Norway, for example, the significant anti-redistributive impact of consumption taxes in Greece reflects the regressive nature of the tax. While both countries have the same tax-to-income ratio, the substantial income inequality in Greece produces considerable

inequality in consumption and saving rates, as witnessed by the higher Kakwani index.

The comparison between Greece and the United States, on the other hand, reveals the role of the tax-to-income ratio in the redistributive effect of consumption taxes. While the two countries have similar levels of tax regressivity, they face different increases in after-tax inequality (+0.01 Gini points for the United States, versus +0.045 Gini points for Greece). This is due to a much lower tax-to-income ratio in the United States than in Greece, because of a lower average tax rate.

In practice, the Kakwani index of regressivity varies only little, as compared to the variation in global TIRs. We calculate the Kakwani indices in all of the datasets with consumption information, whether or not consumption taxes can be calculated (77 country-years). Approximately half of the Kakwani indices lie between -0.10 and -0.15, and almost all lie between -0.05 and -0.20 (see Figure F.b). Vertical redistribution is then mainly driven by the tax rate, as the Kakwani indices are fairly similar to each other.[20]

4.4 Changes over time in the impact of consumption taxes

As the incidence of consumption taxes is determined by the average tax rate and inequality in consumption across households, our multi-year dataset allows us to analyze the change in the impact of taxes on consumption over time. Figure G.a in the Appendix plots the evolution of the impact of consumption taxes on inequality over time in the countries that have at least three data points over the 2000-2010 period. We generally find some re-ranking over time for countries with similar consumption-tax impacts, while the countries at the extremes (with the highest or lowest impacts of consumption taxes on inequality), maintain their ranks over the entire period.

We here demonstrate how our method can be used to assess the impact of changes in consumption-tax legislation on inequality, via the case of the United Kingdom over the 1995-2013 period. The UK adopted a lower VAT rate in the wake of the 2008 economic crisis: between December 1st 2008 and December 31st 2009 the standard VAT rate in the UK dropped from 17.5 percent to 15 percent.[21] It then reverted to 17.5 percent in 2010, and increased to 20 percent one year later, as part of an "emergency budget" presented by the coalition government. Our approach allows us to measure the inequality effect of these measures.

Figure 9 shows the impact of these policies on the standard VAT rate, the implicit tax rate on consumption, and the estimated inequality effect of consumption taxes. The lower-left panel shows, for context, the evolution of disposable income inequality. In general, the higher is income inequality, the higher is the inequality in propensities to consume. Therefore, as income inequality increases, all things remaining equal, the inequality impact of consumption

[20] Imputation produces a similar range of Kakwani indices in the datasets without consumption information: most lie between -0.10 and -0.15. The absolute difference between the Kakwani index calculated from imputed data and that from observed data is under 0.055 in 90% of country-years, and larger errors are found only in high income-inequality countries such as South Africa, India and Mexico.

[21] See Chirakijja et al. (2009) for a more in-depth analysis of this policy.

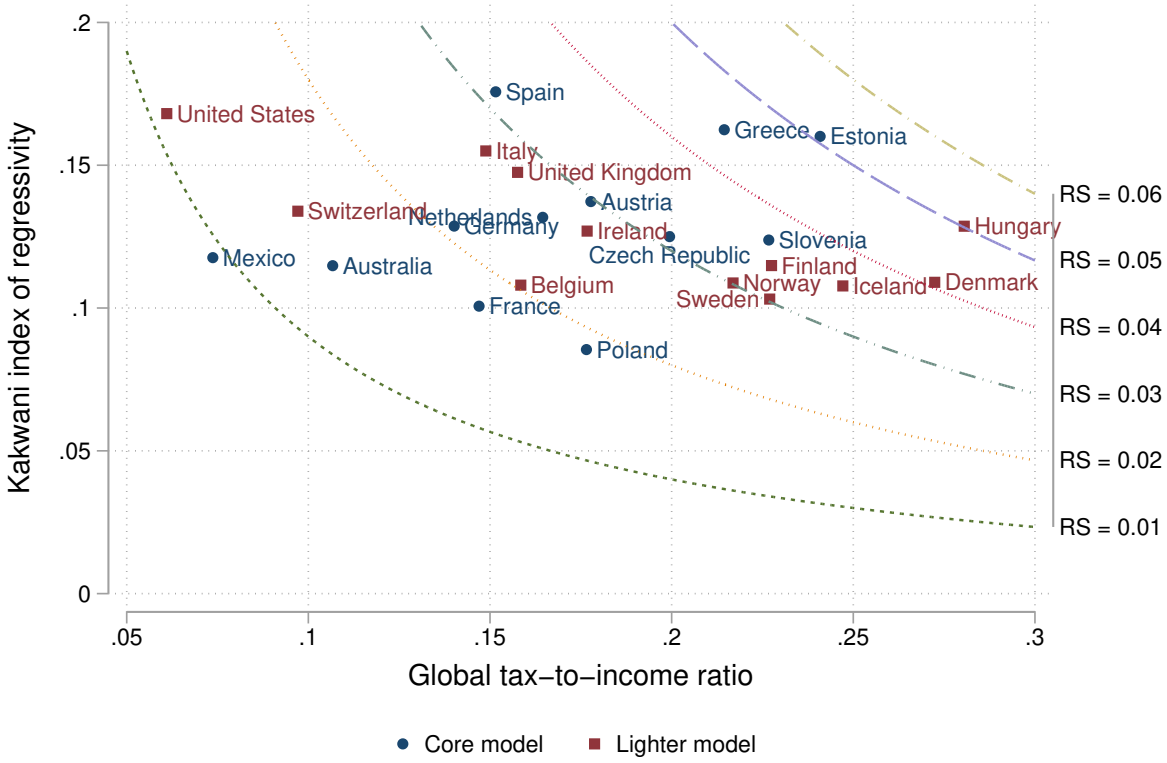

Figure 8: The Kakwani index of regressivity varies only little.

Notes: The curves are isolines of vertical redistribution (the Reynolds-Smolensky index): the further to the North-East of the graph, the greater the effect of the consumption tax on inequality. The years are 2013 for Austria, the Czech Republic, Denmark*, Estonia, Finland*, Germany, Greece, the Netherlands, Norway*, Poland, Spain, Switzerland*, the United Kingdom* and the United States*, 2012 for Hungary*, Mexico and Slovenia, 2010 for Australia, France, Iceland*, Ireland* and Italy*, 2005 for Sweden*, and 1997 for Belgium*. Results for countries marked with a '*' in this list come from the lighter model.

taxes goes up.

The effect of consumption taxes on disposable-income inequality (in the South-East panel), as we explained in Section 4.3, depends on two factors, namely the tax rate (the ITRC, in the North-East panel) and the distribution of propensities to consume, which in turn is affected by changes in the income distribution (in the South-West panel).

Over the 1995-2013 period, the UK experienced significant changes in the distribution of income: inequality increased during the growth period between 1995 and 2005, and then fell afterwards, especially during the 2008 economic crisis, due to a greater drop in income at the top of the income distribution than at the bottom (ONS, 2016). The effect of these fluctuations, coupled with a fall in the aggregate propensity to consume in 2009 (-6%, according to National Accounts), can be seen in the evolution of the inequality effect of consumption taxes between 1995 and 2010 (in the South-East panel).

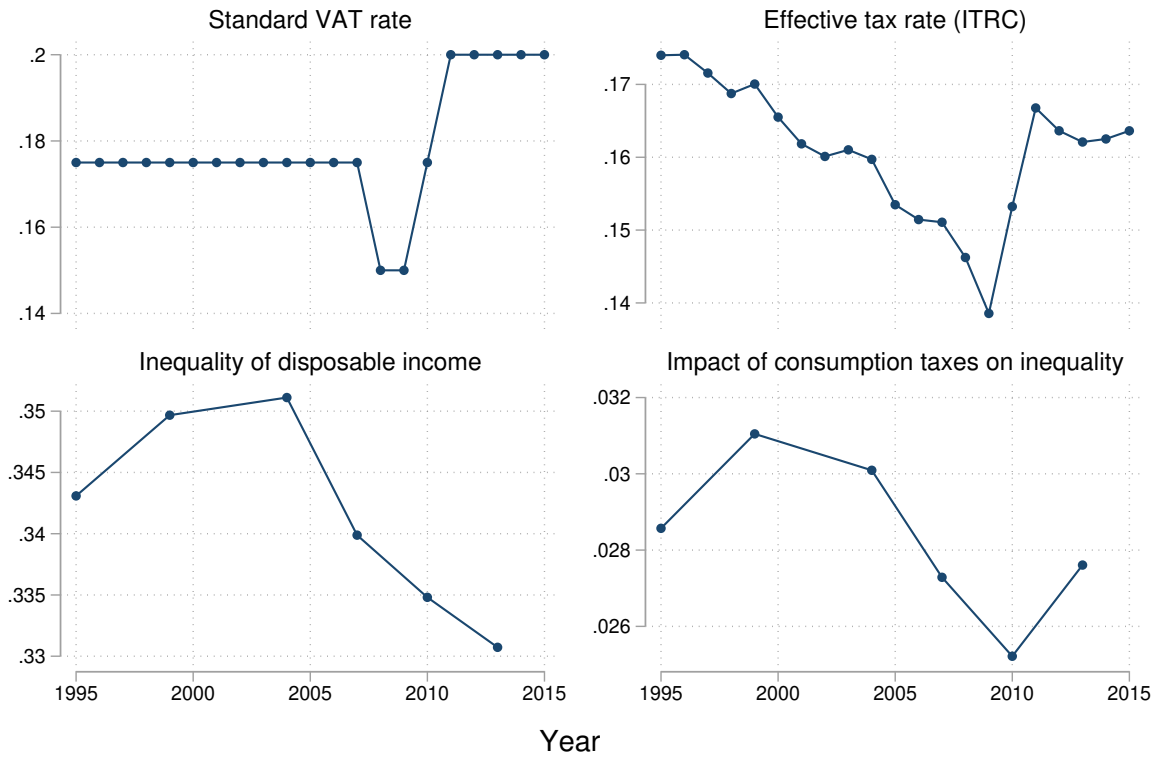

Figure 9: The effect of the VAT cut on some indicators in the United Kingdom

Second, the consequences of discretionary VAT shocks are also visible: the drop in the VAT rate in 2008 and its rise in 2010-2011 affected the implicit tax rate, and explain the movements in the inequality effect of consumption taxes between 2010 and 2013.

Other fluctuations in the ITRC do not reflect discretionary VAT shocks but rather the relative decline of excise taxes in the total share of consumption. For example, between 1995 and 2007, the fall in the ITRC was primarily due to the drop in the share of excise taxes. The main excise taxes on oil, tobacco and alcohol did not rise over this period, so that as prices rose the share of the tax as a proportion of the volume sold was a declining share of the value consumed. While excise duties accounted for 11.3 per cent of total tax revenues in the UK in 1995, this figure was only 8.0 per cent in 2007, while the share of VAT remained stable (IFS, 2016).

5 Robustness checks

We consider three critical methodological choices that have been made in our analysis: ignoring the bundle effect, calculating the average tax rate via National Accounts (a top-down approach) instead of via statutory rates (a bottom-up approach), and grossing up our micro data using a homothetic transformation (i.e. distributing missing consumption proportion-

ally to income). In this section, we perform a series of robustness checks to assess the extent to which these assumptions may affect our results.

First, the structure of consumption in terms of the goods that are subject to reduced or additional taxes may change along the income distribution. Using detailed household consumption data and statutory rates is one way of taking this bundle effect into account. This is the approach taken in the work by O'Donoghue, Baldini, and Mantovani (2004); Decoster et al. (2010); Figari and Paulus (2015), which applies the microsimulation model from Euromod to detailed consumption data in Household Budget Surveys. We apply our constant consumption-tax rate to their consumption data, and compare the resulting consumption tax-to-income ratios to their results: the measured bundle effect is relatively small (Section 5.1).

Second, the calculation of implicit tax rates on consumption with National Accounts data (ITRC, top-down approach) used here, and the calculation of average tax rates derived from detailed bundles and statutory rates (bottom-up approach), as in the work cited above, are different methods that may yield different results. We compare below the outputs from these two methods and establish the impact of their use on post-tax income inequality. We show that the main differences in the results reflect differences in the calculation of the tax rate, which in our approach is closer to what households actually pay (Section 5.2).

Third, the consumption data in the microdata sets are generally not consistent in volume with that in National Accounts data (Capéau, Decoster, and Phillips, 2014), producing an underestimation of the overall propensity to consume calculated using microdata. We therefore have to gross up the micro data, by adding household expenditure data from the National Accounts, which we do in a distribution-neutral way. However, some research has suggested that expenditures may be differentially underreported along the income distribution (Aguiar and Bils, 2015; Meyer and Sullivan, 2023; Sabelhaus et al., 2015). In this case, our imputation of missing expenditure in proportion to existing consumption will yield biased estimates: the regressivity of consumption taxes will be overestimated, as we underestimate the consumption taxes paid by the top decile. This also affects our imputation model, which is estimated on micro data, and in particular the β coefficient (the income elasticity of consumption). We test the robustness of our results to this assumption by using an alternative method to gross up micro-data to National Accounts data (Section 5.3).

5.1 The implications of not taking the bundle effect into account

We recalculate the tax-to-income ratios for a reduced sample of country-years by applying our implicit consumption-tax rate (which is, by construction, the same for all income deciles) to detailed household consumption and income data from O'Donoghue, Baldini, and Mantovani (2004); Decoster et al. (2010); Figari and Paulus (2015); ITEP (2018). We then compare these ratios, calculated with a constant tax rate that ignores the bundle effect, to those in these contributions that apply effective consumption-tax rates that vary by decile, and thus fully account for the bundle effect. As shown in Figure 10, the absolute differences in tax-to-income ratios along the income distribution are quite small when adjusting for differences in the average level of tax rates.

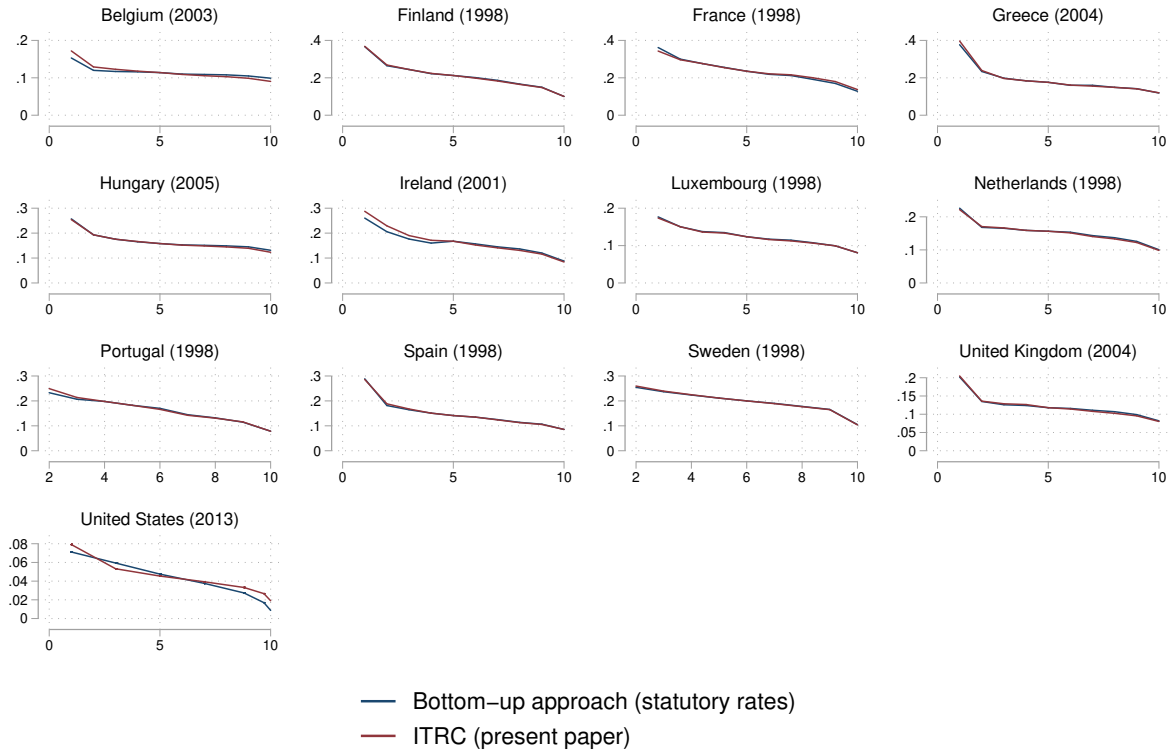

Figure 10: Tax-to-income ratios calculated from detailed consumption data, with uniform implicit tax rates (our method) and decile-varying effective tax rates (Euromod method) adjusted for differences in the average tax rate.

Notes: Data for Belgium, Greece and the UK come from Figari and Paulus (2015), Hungary and Ireland from Decoster et al. (2010), Finland, France, Luxembourg, the Netherlands, Portugal, Spain and Sweden from O'Donoghue, Baldini, and Mantovani (2004), and the United States from ITEP (2018). As the ITEP (2018) data does not include income, we take income from our datasets for the United States.

In the countries where the bundle effect is the most important, the gradient of tax-to-income ratios by income is significantly different when the bundle effect is taken into account. This is the case for Belgium, the country where the effective tax rate on consumption varies the most between high and low incomes, as shown in the literature (see Section 2.1). When the bundle effect is taken into account, we find that the tax-to-income ratio of the top income decile is 0.87 that in the fifth decile, and 0.65 that in the first decile. With a constant tax rate, the analogous figures are 0.79 (-0.08 points difference) and 0.53 (-0.12 points difference). In this specific case, ignoring the bundle effect then leads us to overestimate the regressivity of consumption taxes.

For most countries, however, the gradients of the tax-to-income ratios by income from the Euromod bundles are more similar to ours: the two methods lead to differences in the tax-to-income ratios in the top deciles (expressed as a proportion of that in the fifth and

the first deciles) of no more than 0.05 points. Moreover, they do not materially affect the cross-country picture of the regressivity of consumption taxes.

5.2 The implications of not using the statutory rates

The standard method of applying statutory rates to detailed consumption bundles, to simulate consumption taxes paid at the micro level, allows us to calculate aggregate effective tax rates. This is effected by taking the weighted sum of all the taxes paid by a representative sample of households and dividing it by the weighted sum of their incomes. Figure 11 compares the aggregate effective tax rates obtained with the data in O'Donoghue, Baldini, and Mantovani (2004), Decoster et al. (2010) and Figari and Paulus (2015) using this method (the bottom-up approach), and the implicit tax rates (ITRC) in our (top-down) National Accounts approach.[22] There are a number of explanations for the observed gap in the resulting average tax rates:[23]

- Fraud in consumption taxes, which biases upward the rates calculated with the bottom-up approach;
- Missing rules for excise duties and ad-valorem taxes (downward bias with the bottom-up approach);
- The under-reporting of consumption subject to excise duties (downward bias with the bottom-up approach);
- The non-reporting of excise duties paid on intermediate goods in household surveys (downward bias with the bottom-up approach, or upward bias with ITRCs).

Last, although the fact that households consume different baskets of goods is not supposed to lead to a gap between the *aggregate* measures of consumption taxes, whether using the bottom-up or National Accounts approaches, it can actually produce gaps in both directions (downward or upward biases) if some goods are coded inaccurately and are assigned the wrong tax rate in the bottom-up approach.

We argue that the top-down approach provides a more-complete and accurate measure of consumption taxes as it uses actual tax revenues to measure the taxes paid by households. In contrast, the bottom-up approach is confined to the strict application of statutory rules, potentially incompletely collected, to a surveyed basket of goods where the required degree of precision is substantial and therefore likely to be subject to error.

We measure the consequences of the different methods in terms of post-tax income inequality. Figure 12 decomposes the gap between our method and that in the literature using detailed household consumption and statutory rates into the two sources of differences: the

[22] The data from ITEP (2018) does not allow us to compare the average effective tax rates for the United States.

[23] See European Commission (2020) for an evaluation of the VAT gap in EU-28 Member States.

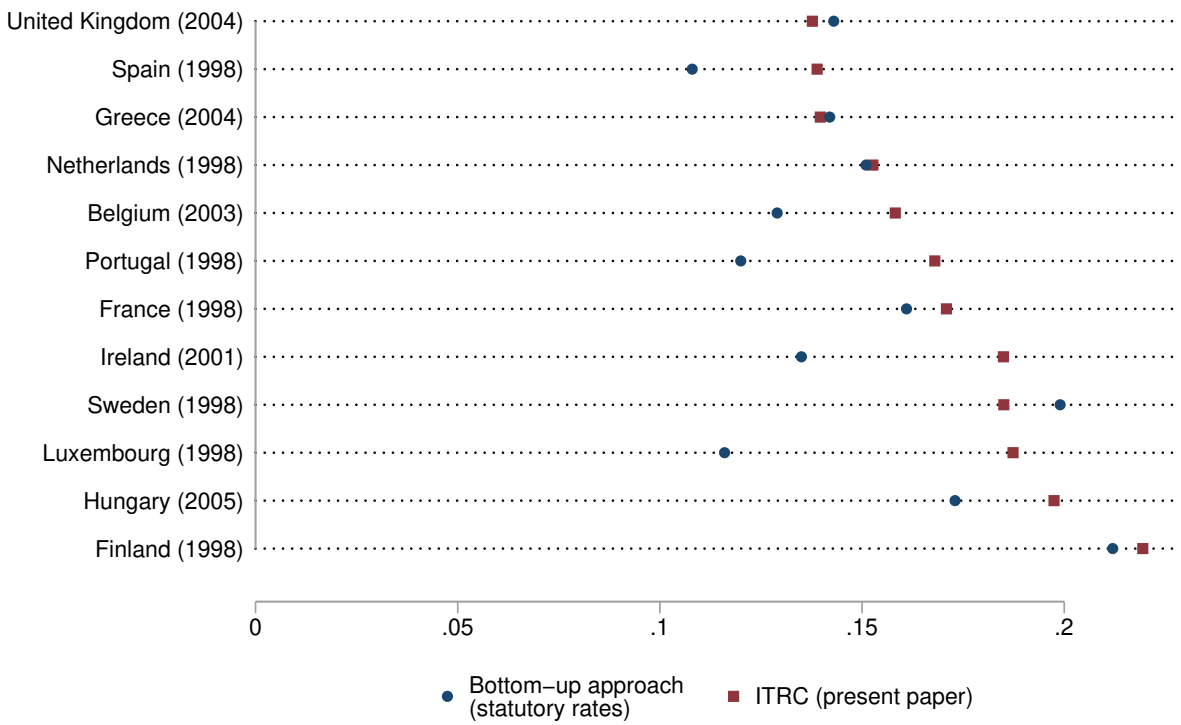

Figure 11: Effective tax rates on consumption, computed with the ITRC method (present paper) and with the bottom-up approach (statutory rates)

Notes: The following sources for statutory rates are used: O'Donoghue, Baldini, and Mantovani (2004) for Spain, the Netherlands, Portugal, France, Sweden, Luxembourg, Finland; Decoster et al. (2010) for Ireland, Hungary; Figari and Paulus (2015) for the United Kingdom, Greece and Belgium.

bundle effect and the method of calculating the tax rate. The differences in some countries are notable, such as Luxembourg 1998 and Portugal 1998. Applying different rates along the income distribution, instead of a constant tax rate, has a very small distributive impact overall and does not affect the findings in terms of the cross-national variation in the impact of consumption taxes on inequality. Ignoring the bundle effect does not then seem to produce major problems. The observed gaps mainly reflect differences in the *level* of effective consumption-tax rates, driven by the discrepancies discussed above between the micro and National Accounts approaches. Without ignoring these differences, we consider our estimates to be more reliable for our research purpose, which is to assess the distributive impact of the taxes that are effectively paid by households.

5.3 The implications of grossing up with homothetic scaling

The question of how consumption misreporting varies with income is still a matter of debate in the literature (see, for instance, Aguiar and Bils, 2015 and Meyer and Sullivan, 2023, for

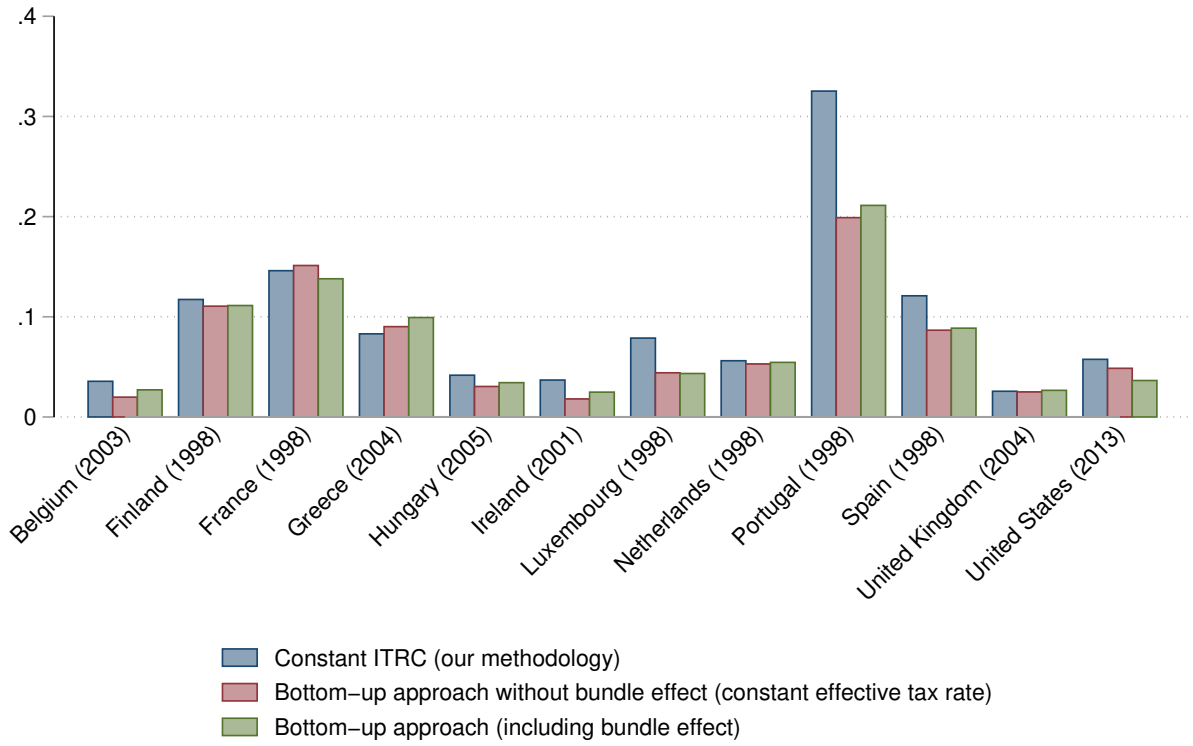

Figure 12: The effect of consumption taxes on income inequality in the bottom-up, constant effective tax rate and ITRC approaches (in T10/B50 points)

the United States). The homothetic scaling method we use in this study assumes that the amount of unreported consumption expenditures is proportional to the amount reported, which is the best approximation in the absence of additional data. There is evidence that consumption in surveys is in fact relatively well estimated at the bottom of the income distribution, while it is underestimated at the top (Sabelhaus and Groen, 2000; Sabelhaus et al., 2015). In this context, a homothetic transformation implies an over-concentration of consumption at the bottom of the income distribution, and therefore an overestimation of the regressivity of consumption taxes.

As a sensitivity analysis, we consider a non-linear distribution of missing consumption, which assigns more missing consumption to the top of the income distribution than does the proportional assumption in the main paper (see Appendix B). This changes the estimates of post-tax income inequality only for a few countries, mostly high-tax Nordic countries, by less than 2%. Estimates for the United States are not significantly affected, and this certainly does not change the cross-country outlook.

6 Discussion

The aims of this article were to establish the distributional effects of consumption taxes, and in a way that makes it possible to compare these effects to those from direct taxes and transfers, and to identify the variables that lie behind this distributional effect of consumption taxes.

The comparison to the distributional effect of direct taxes and transfers implies the analysis of current income, as no empirical work has produced a meaningful measure of the impact of direct taxes and transfers on permanent income. We identify the key drivers of the distributional effect of consumption taxes via the analysis of an extensive and comprehensive database covering a maximum number of country-years.

We contribute to the international distributional accounting literature by developing a simple way of using household survey data on income and consumption, which are readily available to researchers, and matching this household-level information to macroeconomic data on consumption-tax revenues and final consumption expenditure. We carry out this matching, as there are arguably no internationally-comparable datasets at the micro level covering all of income, consumption and consumption taxes.

As we carry out imputation analyses for consumption, an advantage of our approach is that it can be applied to micro-level datasets that do not contain consumption information, as long as they include income, or income and standard socio-economic variables. We consider this to be a major contribution to the field, as it solves the issue of including consumption taxes in the international or intertemporal comparisons of monetary redistribution.

We also contribute to the literature by measuring the distributional effect of consumption taxes for a wide range of country-years, and comparing this to the effect of direct taxes and transfers. We have shown that the anti-redistributive impact of consumption taxes (including value-added-taxes, sales taxes, excise taxes, and taxes on specific goods and services) is fairly large, but far from offsets the positive effect of direct taxes and transfers on inequality-reduction. While the gap in disposable-income inequality between the United States and Denmark is substantially narrowed after consumption taxes are accounted for, the former remains more unequal than the latter.

Taking advantage of our large sample of country-years, we identify the key determinants of the cross-country variation in the anti-redistributive effect of consumption taxes. This depends on two variables of different natures: a behavioral variable, the propensity to consume (which falls with income in all countries), and a more political one, the average consumption-tax rate (varying up to four times across countries). We show that the distributional effect of consumption taxes varies greatly from one country to another, due to the political parameter of the average rate. As such, countries with significant anti-redistributive effects of consumption taxes are generally those that have chosen to implement high tax rates. Denmark is a sound example of this kind of choice, which allows it to fund a large welfare state.

As has already been noted in the literature, countries with high levels of tax revenue and redistribution (in cash and in kind) do not put all of the tax burden on the upper end of the income distribution, and tend to have moderate tax progressivity. The analysis of taxes

on consumption reinforces this diagnosis. Even so, consumption taxes can be part of redistributive policies at the national level: under loose assumptions regarding the distribution of public goods, greater public good or service provision financed by an increase in consumption taxes will in fact increase equality among households (as the lower inequality due to public goods will offset the regressivity of the consumption tax that helps finance them).

Acknowledgements

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Appendix

The code used to construct our cross-country dataset, as well as the main indicators and percentile data presented in this paper is at https://doi.org/10.5281/zenodo.4291984. If reused, the data should be cited as Blasco, Guillaud, and Zemmour (2020).

A The consumption-imputation model

We construct three nested models, depending on the information available in the dataset.[24] The first of these, Model 0, is a generalized linear model where the only explanatory variables are household medianized disposable income and a dummy variable $\mathbb{1}_{nonpov}$ for the household being above the monetary-poverty threshold. This latter is defined as 60% of median equivalized income. Given our medianization, a household is poor if its medianized disposable income is below 0.6. We add this variable to reflect that, at the lowest income levels, consumption tends to be less correlated (or even uncorrelated) with income. In order to ensure the continuity of the consumption function with income, this dummy variable is multiplied by $\log(\widehat{dhi}) - \log(0.6)$, which equals zero when the income of the household is exactly equal to the monetary-poverty threshold. The estimated equation of $\widehat{hmc}$ conditional on $\widehat{dhi}$ is thus:

$$\log\left(\mathbb{E}\left[\widehat{hmc} \mid \widehat{dhi}\right]\right) = \alpha_0 + \beta_0 \log(\widehat{dhi}) + \beta_1 \mathbb{1}_{nonpov}\left(\log(\widehat{dhi}) - \log(0.6)\right), \quad \widehat{hmc} \sim \text{Normal} \tag{Model 0}$$

We do not use this first model (Model 0), but make the resulting coefficients available, as it can be used to produce a satisfactory distribution of consumption on any other national dataset that contains few socio-demographic variables other than income, such as fiscal data for example.

The next model, called the lighter model or Model 1, contains the same explanatory variables, as well as a small number of socio-demographic determinants X_1 (the number of household members and the marital status of the household head). We estimate the following equation.

$$\log\left(\mathbb{E}\left[\widehat{hmc} \mid \widehat{dhi}, X_1\right]\right) = \alpha_0 + \beta_0 \log(\widehat{dhi}) + \beta_1 \mathbb{1}_{nonpov}\left(\log(\widehat{dhi}) - \log(0.6)\right) + \Gamma^\intercal X_1, \quad \widehat{hmc} \sim \text{Normal} \tag{Model 1}$$

Last, in the core model, Model 2, we add the ownership status of the household, and information on the household head's age, as consumption changes over the life-cycle. We

[24] To reduce heterogeneity between countries, several countries with the most-extreme income distributions were removed from the training sample. These are countries with high income inequality or very low median income, as compared to the rest of the sample. The countries that are used in the regression are listed in Appendix H.

also add another important monetary variable, the total imputed or effective cost of housing. This can be the actual housing cost for the household or the non-monetary consumption of housing services (e.g. imputed rents for occupying owners). This variable is much more widely-available in household surveys than total consumption, and is a good proxy for the household's standard of living. The model is then:

$$\log\left(\mathbb{E}\left[\widehat{hmc} \mid \widehat{dhi}, X_2\right]\right) = \alpha_0 + \beta_0 \log(\widehat{dhi}) + \beta_1 \mathbb{1}_{nonpov}\left(\log(\widehat{dhi}) - \log(0.6)\right) + \delta \log(\widehat{housing}) + \Theta^\intercal X_2, \quad \text{(Model 2)}$$

$$\widehat{hmc} \sim \text{Normal}$$

The results of these three models appear in Table A.a.

We use the regression results to impute medianized values of household monetary consumption. These are then scaled using National Accounts data in order to be comparable with the observed values, as in Section 3.2.1.

Figure 2 presents the levels of post-consumption-tax inequality in the observed and imputed consumption data. Much of the country ranking is preserved. However, as shown in Figure A.a, there can be considerable error in the estimation of the effect of consumption taxes on inequality, as is the case for Estonia, one of the most unequal countries of our sample. In general, however, the two estimates are fairly similar to each other and provide accurate information for the comparison of post-consumption-tax levels of inequality.

Comparing the predictive power of Models 1 and 2

The initial LIS dataset contains 77 country-years where consumption data is available, of which 47 where we can apply our imputation model in order to compare the results to the observed data.

The imputation from Model 1, the lighter model, also yields satisfactory Gini coefficients, as can be seen in Figure A.b.

Table A.a: Coefficients and standard errors of the regression models of consumption[†]

Variable		Model 0	Model 1 "Lighter model"	Model 2 "Core model"
Intercept α_0		**-7.7** (0.4)	**-2** (0.5)	**-3.8** (0.8)
Logarithm of medianized income (households below poverty threshold) β_0		**27.9** (0.7)	**26.6** (0.7)	**7.2** (0.8)
Logarithm of medianized income (households above poverty threshold) $\beta_0 + \beta_1$		**57.8** (0.7)	**57.4** (0.7)	**44.8** (0.8)
Logarithm of housing costs (incl. imputed rents) δ				**32.8** (0.2)
Number of household members (Ref. = *1 member*)	*2*		**-5.2** (0.3)	**-5.5** (0.6)
	3		**-4.6** (0.3)	**-5.5** (0.6)
	4		**-3.7** (0.3)	**-4.1** (0.6)
	5		**-6.6** (0.4)	**-5.5** (0.6)
	6 or more		**-9.6** (0.4)	**-5.6** (0.6)
Head of household living with a partner (Ref. = *Single*)			**-6.6** (0.2)	**-9.4** (0.3)
Ownership status of household (Ref. = *Resident owner*)				
Rented housing				**3.8** (0.3)
Free housing				**-1.1** (0.7)
Age of household head (Ref. = *Below 30*)				
Between 30 and 49				**0.8** (0.4)
Between 50 and 64				**-2.8** (0.4)
65 or more				**-13.8** (0.5)
Dummy "single and over 65"				**-6.7** (0.9)
No. of datasets included		47	47	23
Individual-level observations		626,258	626,258	256,934

[†] All coefficients and standard errors are multiplied by 100 for ease of reading.

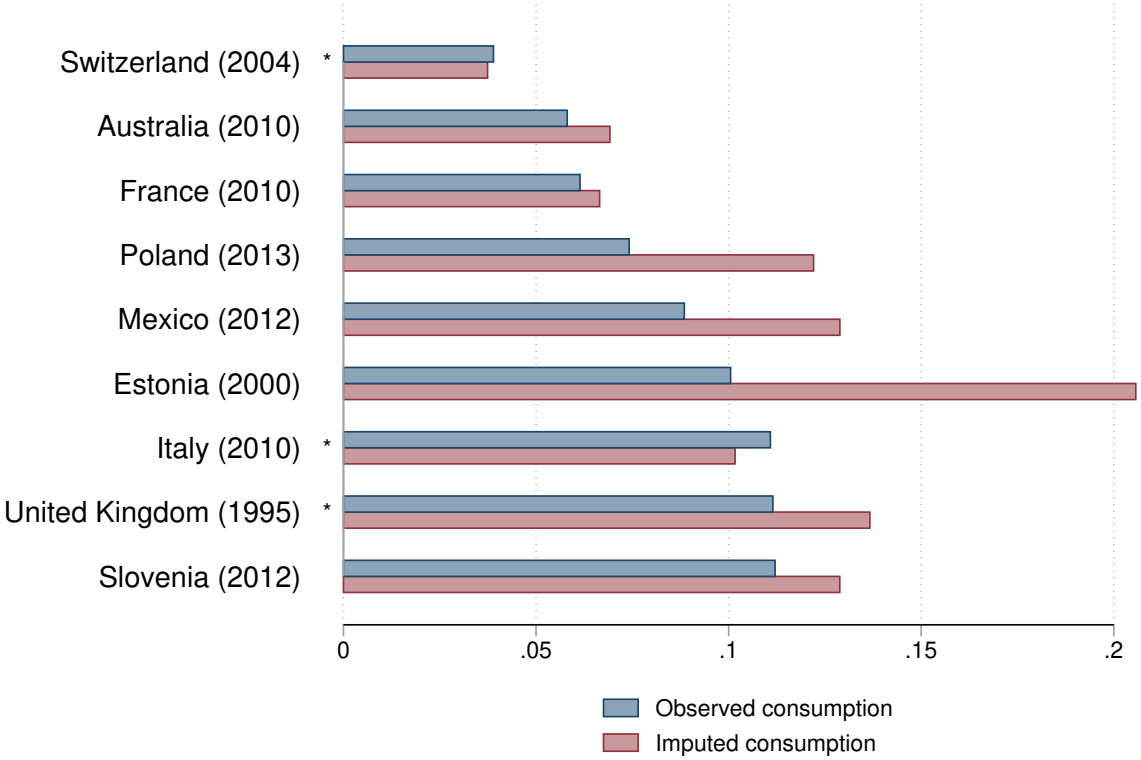

Figure A.a: Absolute error in the estimated effect of consumption taxes (in points of T10/B50)

Notes: The income data for Estonia (2000) comes from a household budget survey that is known for displaying unusually large income inequality. The model therefore overestimates consumption inequality. Results for Italy and the UK come from the lighter model.

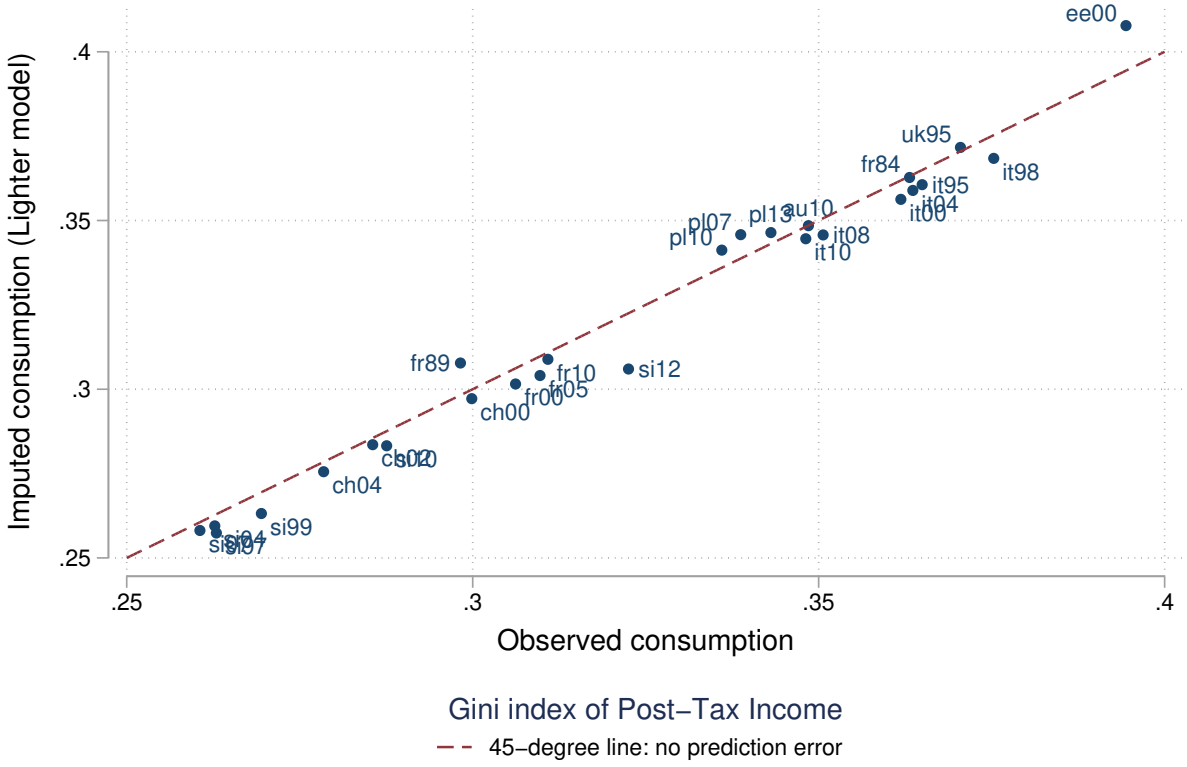

Figure A.b: The observed and predicted Gini coefficients of post-tax income, for the lighter model

B Scaling with National Accounts

After some pre-processing of the data (equivalization, bottom-coding), the propensities to consume are scaled according to National Accounts data. In order to carry out international comparisons, the micro-data is transformed to reflect national-level consumption and income. Conceptually, this means that micro-data are used to obtain the shape of consumption (its distribution as a function of income), while the total levels of income and consumption are matched to National Accounts.

$$scaled\ prop_{c,t,i} = scaling_{c,t} \cdot prop_{c,t,i}$$

$$scaling_{c,t} = \frac{CH - R}{I - R_{imputed}} \cdot \frac{\sum_i dhi_i}{\sum_i hmc_i - rents_i}$$

where:

- CH is household final consumption expenditure[25]
- $R = R_{actual} + R_{imputed}$ are the actual and imputed housing rents
- I is household gross disposable income
- $R_{imputed}$ are imputed rents for occupying owners

In National Accounts, the housing services that owners produce for themselves are included in both consumption expenditure and household income. We thus remove these terms from the scaling factor of the propensities to consume. Where rents are not separable between actual and imputed rents, an average correction coefficient is applied.

In the main paper, we assumed that missing consumption was proportional to existing consumption before estimating the consumption regressions; we now consider instead a non-linear distribution, with the missing consumption being proportional to the square of existing consumption (so that the scaling coefficient rises linearly with income, and thus assigns more missing consumption to the top of the income distribution than does the proportional assumption in the main paper).

Figure B.a shows the impact of these different scaling methods on calculated consumption by income decile: uniform scaling (our main hypothesis) versus heterogeneous scaling. The left side of the figure plots the unscaled consumption from the microdata for France in 2010 and the scaled consumption under the two hypotheses. Missing consumption data is mostly attributed to the top decile under both of these, but more so with the heterogeneous scaling. The right side of the figure (for the USA in 2010) plots the distributions of imputed consumption (no consumption data is observed for the USA in our initial sample) for the two scaling methods. Heterogeneous scaling again assigns relatively more consumption to the

[25] When this figure was not available, we used household expenditure and income including those of non-profit institutions serving households.

top of the income distribution. With homothetic scaling, 17% of the missing consumption in France 2010 was attributed to the top decile and 39% to the bottom 50 percent; under the alternative hypothesis this figure rises to 26% for the top decile and falls to 28% for the bottom 50 percent.

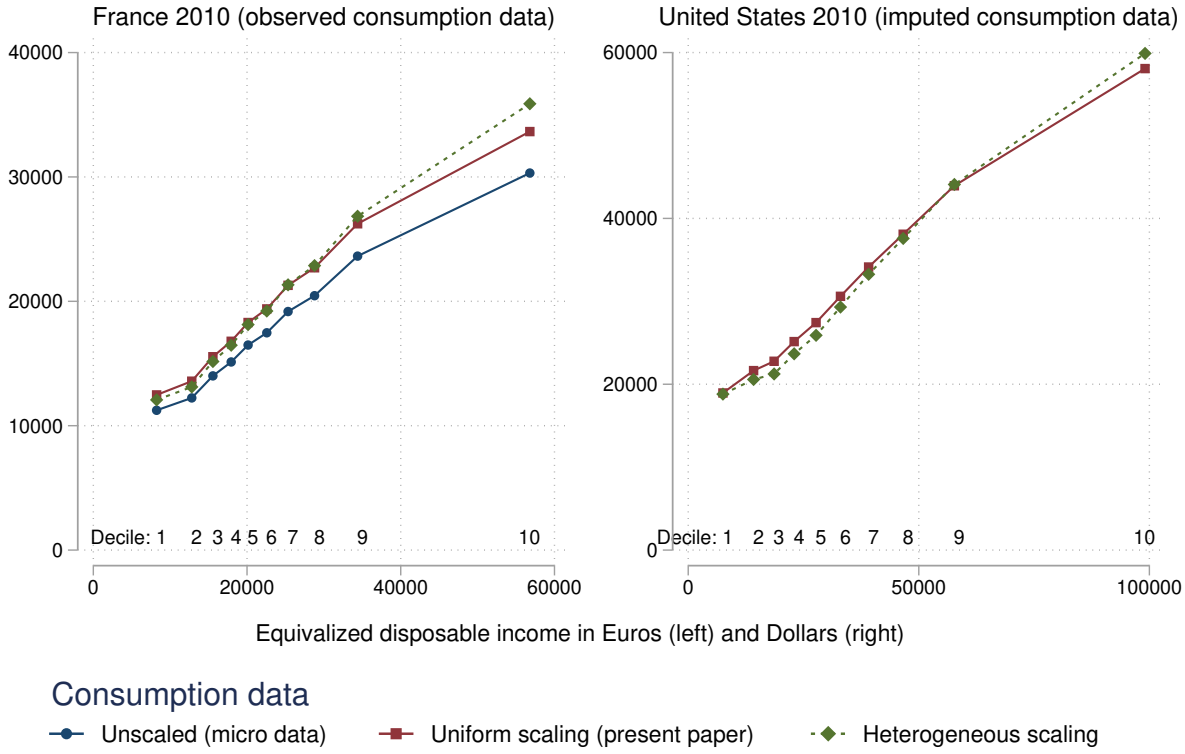

Figure B.a: Mean consumption by income decile with two scaling methods.

The scaling choice also affects the income elasticity of consumption calculated in our imputation models. β rises by about 10 percent with heterogeneous scaling, so that a 1% increase in income has a greater impact on consumption expenditures: 0.64% as opposed to 0.57% with homothetic scaling (see Table A.a).

We last compare the distribution of post-tax income from the two scaling methods. Figure B.b shows that the results are largely unchanged, except in Italy and in the high-tax Nordic countries (Denmark, Finland, Norway and Sweden), where post-tax income inequality is lower (by less than 2%) under the alternative assumption assigning more missing consumption to the top decile. For the remaining countries, including the United States, inequality is unaffected by the scaling choice. Our result that the income inequality gap between the Nordic countries and the United States is greatly reduced when consumption taxes are taken into account is hence robust to the scaling method.

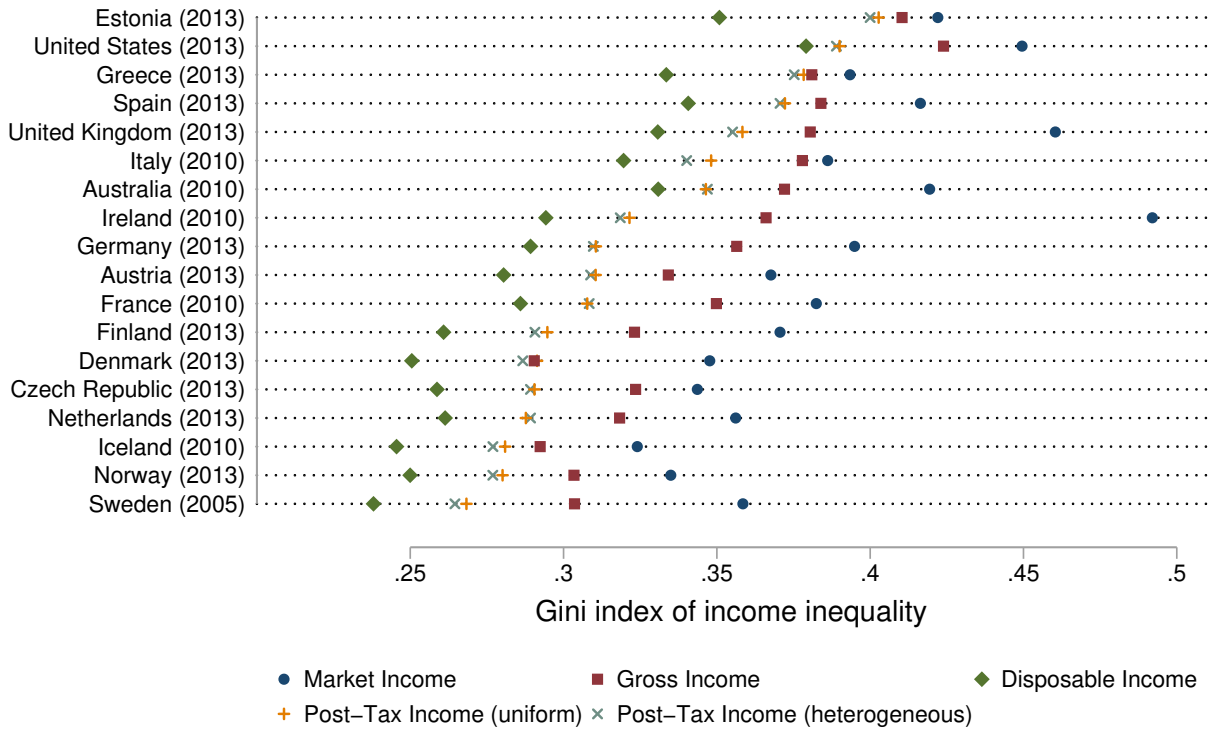

Figure B.b: The Gini coefficients on market, gross, disposable and post-tax income with two scaling methods.

C The definition of the implicit tax rate

The different definitions of the implicit tax rates are based on different definitions of taxable consumption.

In the paper, we define the implicit tax rate as follows:

$$\tau_{c,t} = \frac{consumption\ tax\ revenue}{C - CGW - R}$$

where *consumption tax revenue* includes all revenue from consumption taxes, including value-added-taxes (or sales taxes, if applicable), excise taxes, taxes on specific services, etc.According to the nomenclature in stats.oecd.org, this includes:

- General taxes on goods and services (including VAT)
- Taxes on specific goods and services
  - Excise taxes
  - Profits of fiscal monopolies
  - Customs and import duties
  - Taxes on specific services
  - Other taxes on specific goods and services

- Taxes on the use of goods and performances

C is the total final consumption expenditure (private consumption and the consumption of general government). The CGW figure corresponds to the wages of the employees paid by the general government, and $R = R_{actual} + R_{imputed}$ are the actual and imputed housing rents.

The definition in Eurostat (2016) relies on a narrower taxable base, covering only private consumption

$$\tau_{c,t} = \frac{consumption\ tax\ revenue}{CP} \tag{5}$$

while the definition in Carey and Tchilinguirian (2000) considers a broader definition, over all consumption

$$\tau_{c,t} = \frac{consumption\ tax\ revenue}{C} \tag{6}$$

The choice of whether to remove rents from the denominator depends on the definition of taxable consumption in the micro-data. As we account for rents not being subject to consumption taxes by removing them from the micro-data on consumption, we subtract rents from the denominator of the implicit tax rate.

If we do the same for the two alternative definitions described above, our implicit consumption tax rate is thus structurally bounded above by the tax rate defined in eq. (5) and below by that defined in eq. (6), as shown in Figure C.a. These alternative definitions can be used for robustness checks. When the tax rate cannot be calculated according to our definition due to missing values, we impute the rates using a regression model based on the other two rates.

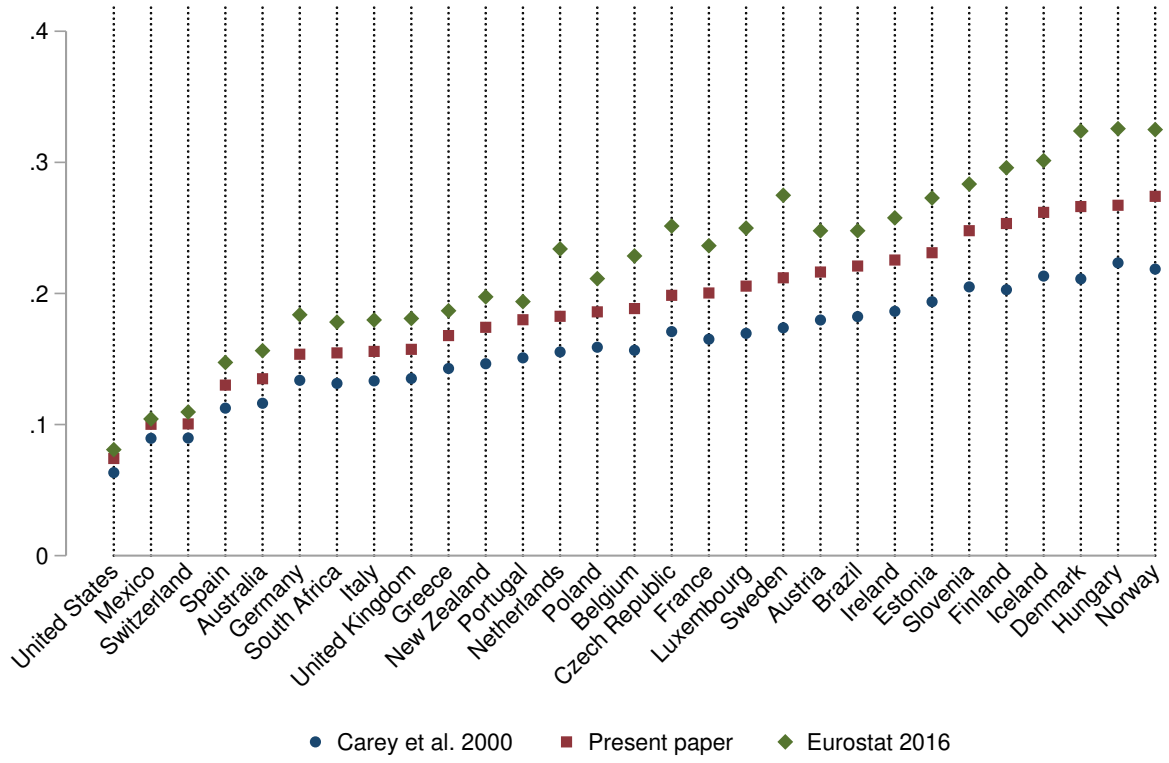

Figure C.a: Average implicit tax rates on consumption in each country.

D The importance of excluding rents from consumption

Our method allows us to account for housing rents not being subject to consumption taxes. Housing rents are an important part of household consumption, and represent a higher share of consumption for poorer households (Figure D.a). As a result, the downward slope in the propensities to consume becomes less pronounced when rents are removed from total consumption. We can therefore conclude that micro-simulation methods that apply tax rates to total consumption (including housing rents) somewhat overestimate the regressivity of consumption taxes.

In order to maximize our country-year coverage, we define another version of the effective tax rate, where actual housing rents are not deducted from private consumption in the denominator. This definition is used in our lighter model, where micro-data on consumption is not separable between housing rents and other consumption. This lower rate will be applied to a higher consumption figure.

$$\tau_{wr} = \frac{consumption\ tax\ revenue}{CP - R_{imputed} + CG - CGW}$$

As shown in Figure D.b, the estimated regressivity is lower when housing rents are taken

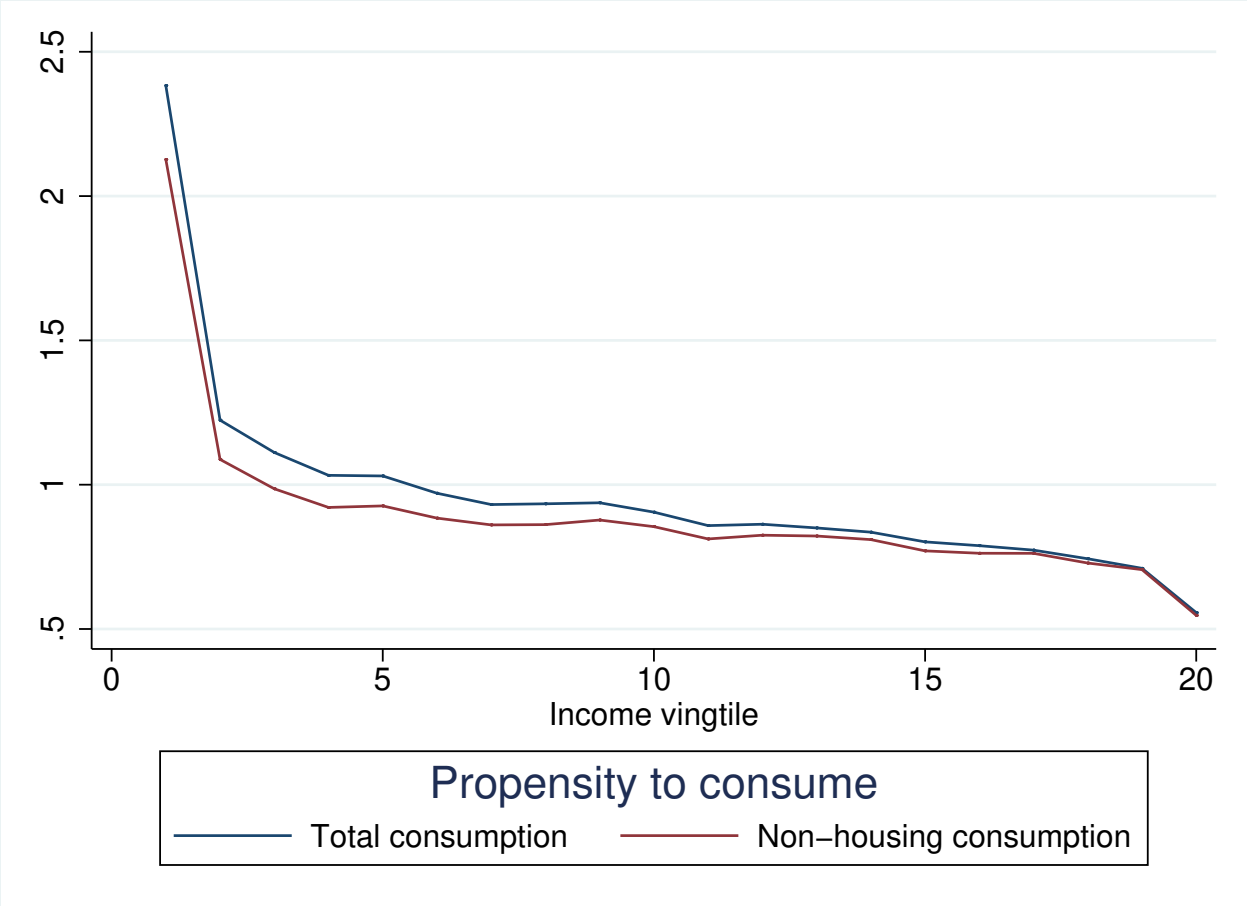

Figure D.a: Housing rents represent a higher share of consumption at the bottom of the income distribution (e.g. France in 2010, as shown here)

into account and removed from consumption: the absolute value of the Kakwani index of regressivity, and thus the anti-redistributive effect, is reduced by up to 20% in some countries.

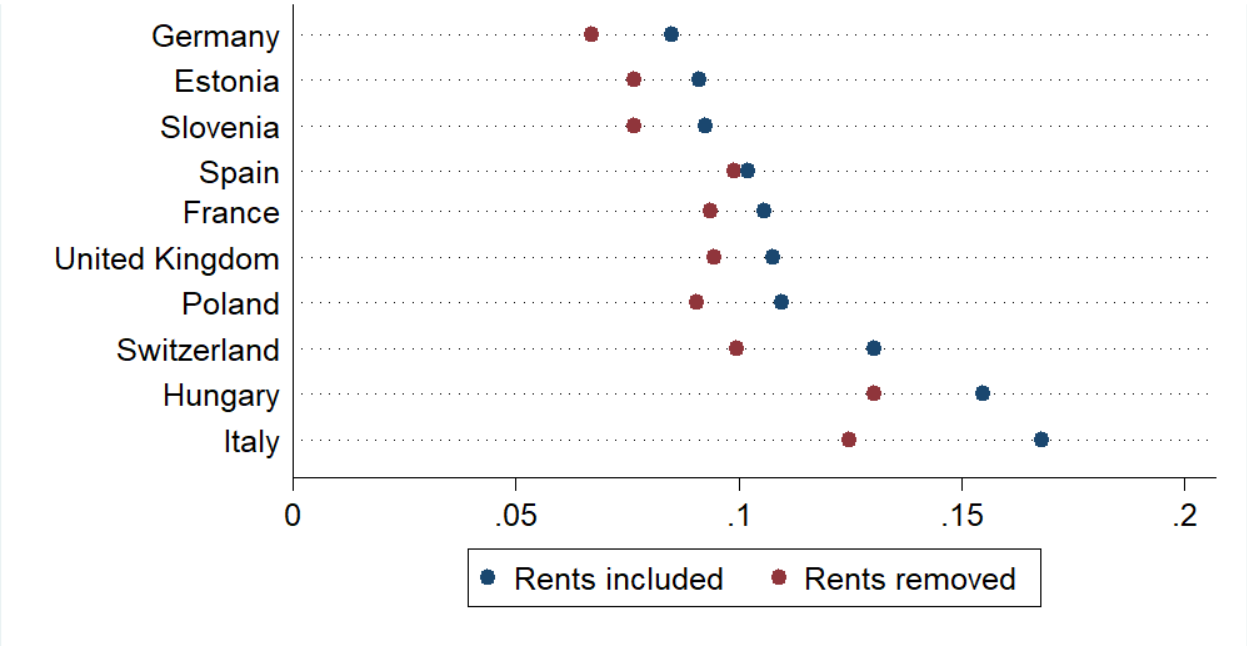

Figure D.b: The mean value (all years country-average) of the Kakwani index according to whether taxable consumption includes housing rents

E Results from the lighter model

We presented in this article the results for the core model of propensities to consume, when this more-precise version is available. We here present the results only from the lighter model, which requires fewer independent variables. We can see in Figure E.a that the range of the effect of consumption taxes is similar to that in the core model.

Moreover, the lighter model shows even more clearly that the anti-redistributive impact of consumption taxes is mainly driven by the tax rate, as shown in Figure E.b.

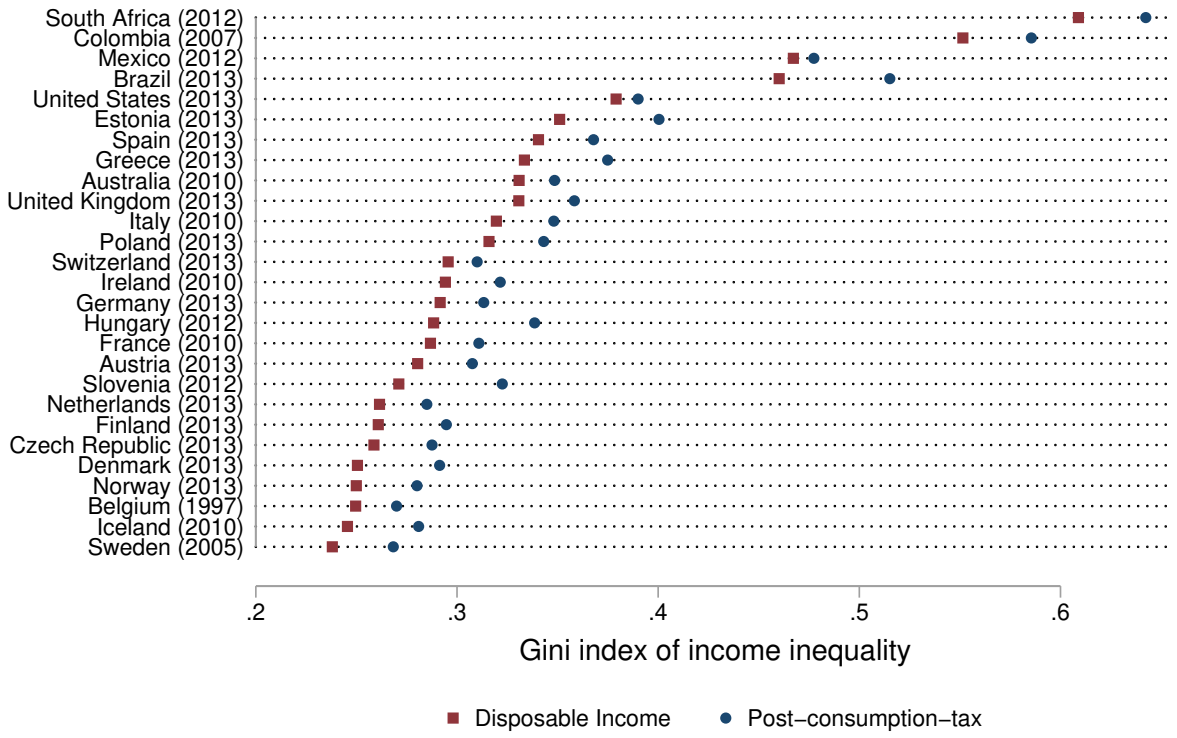

Figure E.a: Gini coefficients of income inequality for disposable income and post-consumption-tax income, with the lighter model

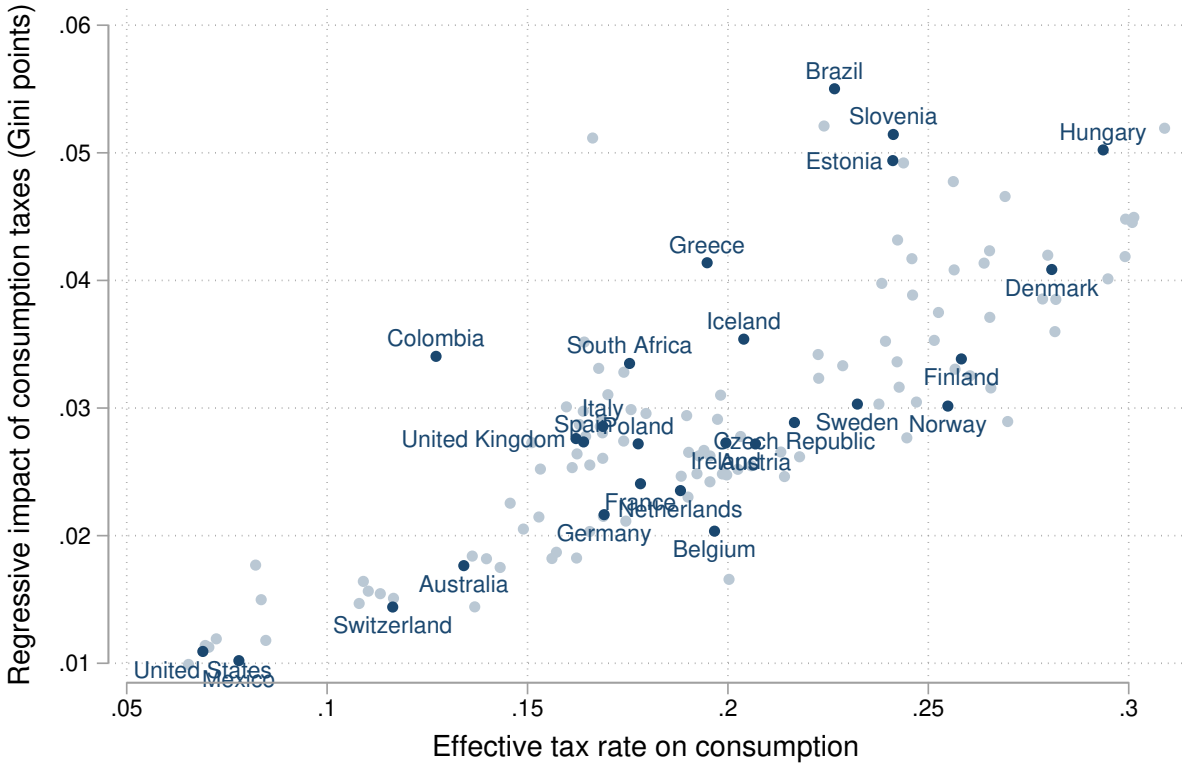

Figure E.b: The link between the effective consumption tax rate and the impact of consumption tax on inequality continues to hold

Notes: All available years in our datasets are displayed on the graph. The most recent year for each country is labelled and highlighted. The corresponding years are listed in Figure E.a.

F The decomposition of the redistributive effect

F.1 Vertical and horizontal redistribution

The effective redistribution of a tax or a transfer can be decomposed into vertical redistribution, as measured by the Reynolds-Smolensky index (RS), and horizontal redistribution, given by the re-ranking index (Re):

$$\Delta G = G_{dhi} - G_{dhi-tax} = RS - Re \tag{7}$$

Vertical redistribution refers to the amount of tax that is distributed in a progressive or regressive way as a function of income. One measure of vertical redistribution, the Reynolds-Smolensky index, is defined as follows (Kakwani, 1977):

$$RS = G_{dhi} - C(dhi - tax, dhi)$$

where G_{dhi} is the Gini index of pre-tax income and $C(dhi - tax, dhi)$ the concentration index of post-tax income ranked by pre-tax income. This term is thus relatively close to the Gini coefficient for post-tax income.

Horizontal redistribution is the amount of redistribution that is orthogonal to the distribution of income. The re-ranking index of horizontal redistribution is a measure of the amount of redistribution that is not due to tax regressivity, but rather inequality that is created between individuals in the same income range. This is defined as follows:

$$Re = G_{dhi-tax} - C(dhi - tax, dhi)$$

By definition, the re-ranking Re is non-negative, so by eq. (7) the Reynolds-Smolensky index is an upper bound for effective redistribution (when effective redistribution is positive) and is a measure of the maximum feasible redistribution if no re-ranking resulted from the tax or the transfer. In our case, if redistribution is negative, then the RS index is a lower bound for the anti-redistributive effect (in absolute value). The rise in income inequality due to taxes is thus the sum of the vertical anti-redistribution and the re-ranking due to the variation in propensities to consume between households at the same levels of income. In practice, the Reynolds-Smolensky index is close to the difference in the Gini coefficients (see Figure F.a): re-ranking generally accounts for less than 20% of the impact on inequality.

F.2 The Kakwani indices of regressivity

We have seen in eq. (4) that the vertical redistribution from consumption taxes can be viewed as the product of two independent terms: regressivity, a micro-level term linked to propensities to consume that fall with income, and the consumption-tax rate, a macro-level term:

$$RS = K \cdot \frac{TIR}{1 - TIR} \tag{4}$$

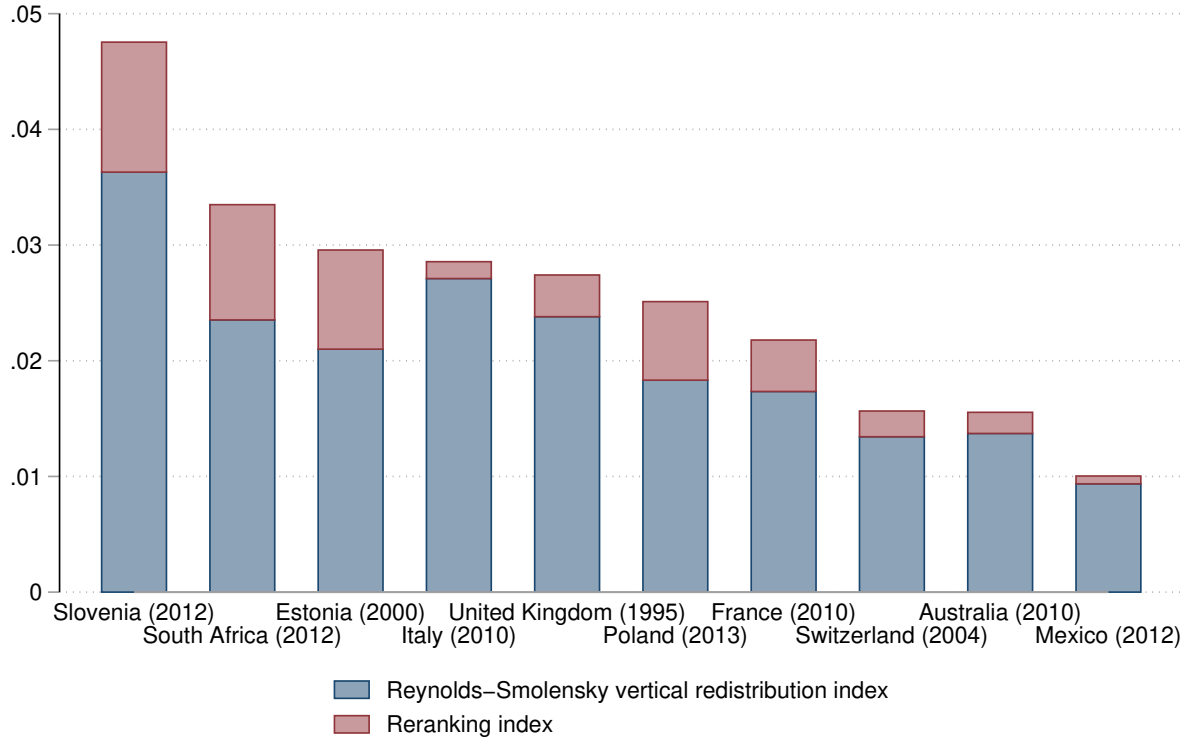

Figure F.a: The decomposition of the redistributive effect

We measure the regressivity of consumption taxes by the Kakwani index. This reflects how concentrated taxes are at one or the other end of the income distribution. It is equal to the difference between the concentration index of the tax relative to (pre-tax) disposable income and the Gini coefficient of disposable income (Kakwani, 1977). Namely:

$$Kakwani(tax, dhi) = C(tax, dhi) - Gini(dhi)$$

The concentration index $C(tax, dhi)$ is a measure of the extent to which the distribution of the tax payments is skewed towards the highest incomes. It takes on values [-1;1], with -1 indicating that all the tax payments are concentrated on the poorest individual, and 1 that these are concentrated on the richest individual. By subtracting the Gini index of income, the sign of the Kakwani index provides a simple piece of information: a positive Kakwani value means that the tax payments are more heavily concentrated towards the highest percentiles of income than is income itself, so that the tax is progressive. On the contrary, a negative Kakwani index reveals that the distribution of tax payments is less skewed to the right than is the distribution of income, so that the tax is regressive. For consumption taxes, we expect negative Kakwani indices.[26]

For one fixed tax rate, we can make assumptions on the Kakwani index and thus have a range of possible RS index values, based on eq. (4). When the Kakwani indices are derived from imputed consumption values, this will be useful to provide upper and lower bounds on the possible RS values.

We calculate the Kakwani index for all the datasets where consumption data is available (i.e. 77 country-years): the results are summarized in Figure F.b. Approximately half of Kakwani indices lie between -0.10 and -0.15, and almost all between -0.05 and -0.20.

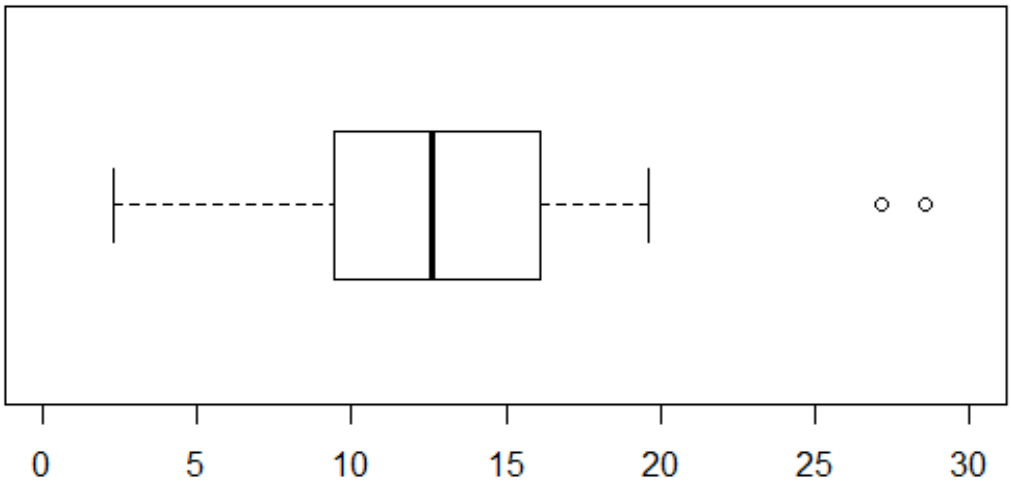

Figure F.b: The distribution of the Kakwani index on 77 datasets (x100)

Based on the different tax rates that we calculated earlier, we can now provide bounds

[26] In the subsequent figures, we plot the absolute values of the RS and Kakwani coefficients.

for the possible values of the RS index. As summarized in Figure F.c, most values for the Reynolds-Smolensky index will lie between -0.02 and -0.08.

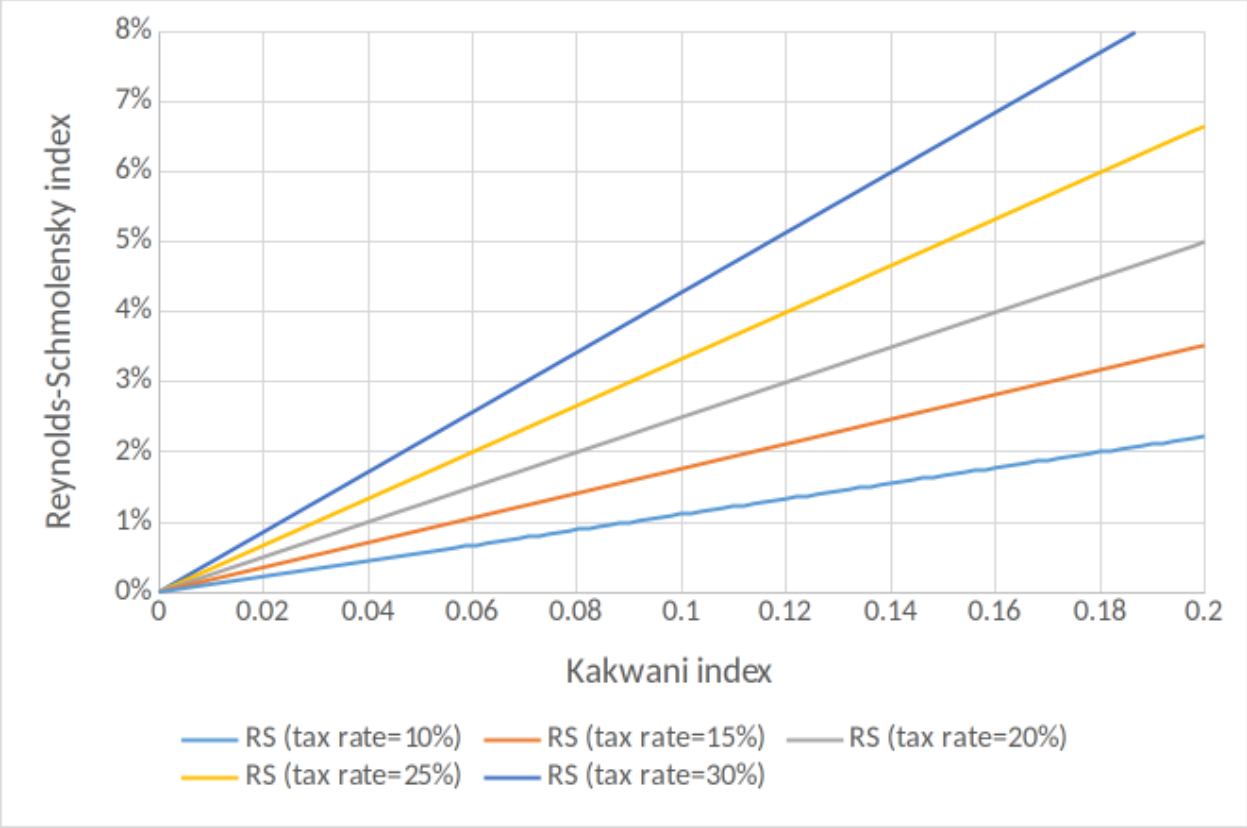

Figure F.c: The value of the Reynolds-Smolensky index depending on the tax rate and the Kakwani index

G Changes over time in the impact of consumption taxes in several countries

Figure G.a depicts the evolution over time of the inequality impact of consumption taxes for countries in our dataset with at least three data points over the 2000-2010 period.

Countries at the extremes of the estimated consumption-tax impact maintain their ranks throughout the period under study: the United States, Switzerland, and Mexico remain countries with a low consumption-tax impact, while Denmark remains the country with the highest consumption-tax impact. There is, however, some re-ranking among countries that have similar inequality effects of consumption taxes.

Last, some countries show large variations in the estimated impact of consumption taxes: for example, Greece joins Denmark at the end of the period as one of the countries with the highest inequality impact of consumption taxes. This may be related to the dramatic

changes in the Greek economy after the 2008 economic crisis, where income inequality rose sharply while VAT rates were increased in an attempt to raise more revenue.

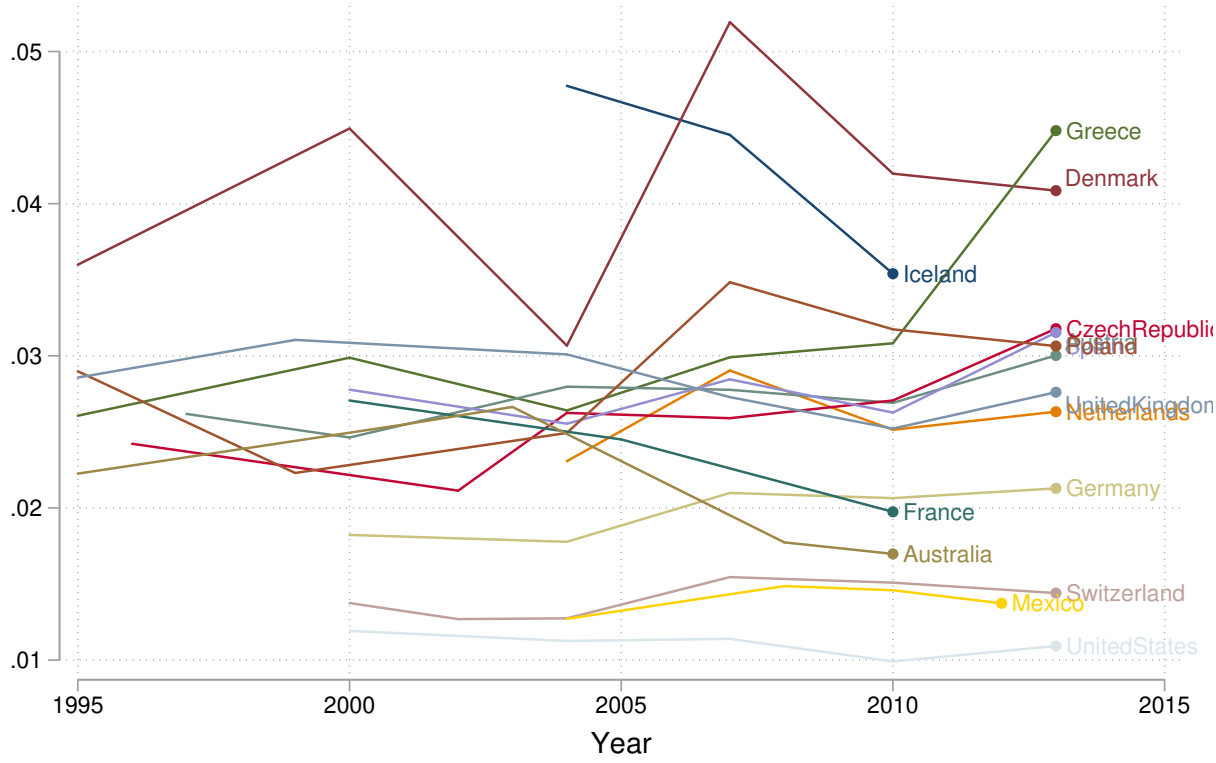

Figure G.a: Evolution over time of the inequality impact of consumption taxes in a number of countries

H Country and year coverage

To carry out the calibration of our imputation models of consumption data, 47 datasets from the following 12 countries are used: Estonia (2000), France (1978, 1984, 1989, 2000, 2005, 2010), Germany (1973, 1978, 1983), Hungary (1991, 1994), Italy (1995, 1998, 2000, 2004, 2008, 2010, 2014), Poland (2007, 2010, 2013), Slovenia (1997, 1999, 2004, 2007, 2010, 2012), South Korea (2006, 2008, 2010, 2012), Spain (1980, 1985, 1990), Switzerland (2000, 2002, 2004), Taiwan (1981, 1986, 1991, 2007, 2010, 2013) and the United Kingdom (1986, 1991, 1995).[27]

As described in Table H.a, we estimate the regressivity of consumption taxes for 132 LIS datasets, spanning 27 countries over 36 years from 1978 to 2013. Among those, 55 country-years are part of the core model, that is the model which provides the most-accurate estimates of the effect of consumption taxes on inequality. For the years with a * in the table, information on rents is missing, so the lighter model is used: for those 77 additional country-years, the regressivity of consumption taxes is slightly overestimated. Among those 132 country-years, 33 estimates come from observed data on consumption, and 99 come from imputed consumption data.

For each country in this paper, we use the latest year available in the core model, except for Belgium, Brazil, Denmark, Finland, Hungary, Iceland, Ireland, Italy, Norway, Sweden, the United Kingdom and the United States, where we use the lighter model. When observed consumption data is available, these are the figures that we use.

[27] For some of those datasets, tax data or other necessary National Accounts data is not available (South Korea and Taiwan, for instance). They therefore do not appear in the remainder of the analysis and are not listed in Table H.a.

Table H.a: Country and years used in the study

Country	Years with observed data	Years with imputed data
Australia	2010	1981* , 1985* , 1989, 1995, 2001, 2003, 2008
Austria		1997* , 2000* , 2004, 2007, 2010, 2013
Belgium		1997*
Brazil		2011* , 2013*
Colombia		2007*
Czech Republic		1996* , 2002* , 2004* , 2007, 2010, 2013
Denmark		1995* , 2000* , 2004, 2007* , 2010* , 2013*
Estonia	2000	2004, 2007, 2010, 2013
Finland		1995* , 2000* , 2004* , 2007* , 2010* , 2013*
France	1978* , 1984, 1989, 2000, 2005, 2010	1994*
Germany		2000, 2004, 2007, 2010, 2013
Greece		1995* , 2000* , 2004* , 2007, 2010, 2013
Hungary		2005* , 2007* , 2009* , 2012*
Iceland		2004* , 2007, 2010*
Ireland		2004* , 2007* , 2010*
Italy	1995* , 1998* , 2000* , 2004* , 2008* , 2010*	
Mexico	2008, 2010, 2012	2004
Netherlands		2004, 2007, 2010, 2013
Norway		1979* , 1986* , 1991* , 1995* , 2000* , 2004* , 2007* , 2010* , 2013*
Poland	2007* , 2010* , 2013	1995, 1999, 2004
Slovenia	1997, 1999, 2004, 2007, 2010, 2012	
South Africa	2008* , 2010* , 2012*	
Spain		2000* , 2004* , 2007, 2010, 2013
Sweden		1995* , 2000, 2005*
Switzerland	2000* , 2002* , 2004*	2007* , 2010* , 2013*
United Kingdom	1995*	1999* , 2004* , 2007* , 2010* , 2013*
United States		2000* , 2004* , 2007* , 2010* , 2013*

Notes: For the years with a * in the table, information on rents is missing so that the lighter model is used to estimate the regressivity of consumption taxes.