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The effect of top tax rates on income inequality

An empirical study of the effect of top tax rates on income inequality, across 34 OECD countries during the period of 2000-2020

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1. Introduction

The World Social Report (2020), published by the United Nations, finds a concerning trend: income inequality has increased in most developed countries. Income inequality has been linked with numerous of negative outcomes, such as reducing economic growth, investment and innovation. Also, different health and social problems such as drug abuse, obesity and infant mortality are positively related to income inequality (Polacko, 2021). Other research shows a negative relationship between income inequality and happiness for lower-income respondents (Oishi et. al, 2011). Therefore, decreasing income inequality has lots of benefits.

The question rises what governments can do to reduce income inequality. In this research I will be looking at the effects of one policy option: increasing top statutory personal income tax rates. The top tax rate can affect income inequality in several ways. The most direct mechanism is through redistribution. The rich are taxed higher and transfers money to the poor. Thus, increasing top tax rates reducing the inequality of disposable income compared to taxable income. Second, increasing top tax rates incentivizes high earners to reduce labor supply, since the cost of an extra hour of work might overrule the marginal benefit of disposable income. The research question will therefore be:

What is the impact of the top statutory personal income tax rates on after tax income inequality in 34 OECD countries between 2000-2020?

The height of top tax rates is a large topic in policy discussions. In the United States lots of tax reforms happened. In 1986, for example, the top individual tax rate dropped below the corporate tax rates and in 2017 Trump introduced the Tax Cuts and Jobs Act, lowering top tax rates (CBNC, 2020). Decreasing top tax rates are a global trend, while income inequality rises. One possible reason for this could be raised elasticities of taxable income (hereafter abbreviated as ETI) through globalization, tax evasion and more avoidance opportunities. The ETI includes margins of behavioral response that labor supply elasticity does not include. Responses included in the ETI are reduced labor supply, but also increased charitable contributions or increased expenditures for tax professionals (Saez et. al, 2009). The ETI can therefore more accurately measure taxpayer response, which is why it is a worthy topic of investigation. In this research the ETI will therefore be estimated to be able to investigate the possible cause of decreasing top tax rates.

To be able to find the effect of top tax rates on income inequality I will exploit income inequality trends in 34 OECD countries between 2000-2020. More specifically, the effect of top statutory tax rates on the after-tax income Gini coefficient of the World Bank database will be used. The top statutory tax rates (%) for the combined central and sub-central governments and are found in the

OECD database. The Two Way Fixed Effects method (hereafter abbreviated as TWFE) will be used. The method allows to control for country as well as time fixed effects. Multiple time-varying control variables are added to the regression to limit omitted variable bias. In policy economics reverse causality is a great issue, since government's redistributive choices might be based on income inequality. The endogeneity issue of reverse causality is addressed by using an instrumental variable model, in which tax competition is used as an instrument for top statutory tax rates. Tax competition is a good instrumental variable, since it has a causal effect on the top statutory tax rate. Secondly, it is not uncorrelated with the error term. Thirdly, it does not have a direct effect on the Gini index, but only through top tax rates (further explained in Section 3.4). Besides the main results, the ETI will be measured, which is a possible cause of a decreasing trend in top tax rates. The elasticity is calculated as the change in natural logarithm of taxable income divided by the change natural logarithm of the net-of-tax rate. An alternative variable for taxable income is the after-tax income share of the highest percentile or ventile, which is the method that will be used to calculate the ETI.

The main result of this paper is that the effect of top statutory tax rates has a significant effect on income inequality, when using the TWFE method. At first, the results from TWFE in Table 2 show that increasing the top tax rate by one percentage point significantly decreases the Gini index, and thus income inequality. However, when including an instrument and thus accounting for reverse causality, no significant effect is found. It can therefore be stated that increasing the top statutory tax rates does not significantly decrease income inequality. Interesting findings are that when measuring heterogeneous treatment effects, the coefficient of interest becomes positively significant for countries with high income inequality. In addition, when using the alternative dependent variable income share of the richest top 10% results become positively significant. Also, the ETI is found to be negative, but insignificant. A negative ETI can occur when the income effect dominates the substitution effect. What is in line with earlier research is that the ETI seems higher for the top 10% income earners than for top 20% income earners (Gruber and Saez, 2000).

It is however very important to keep in mind that examining a single policy such as the top tax rate might not lead to a causal interpretation, since such a policy is often complemented with other changes in tax systems. Decisionmakers need to be informed with the right information, since wrongly interpreted results can lead to policy implementation with opposite effects than aimed for. It therefore is important to measure if raising top tax rates has the intended effect of decreasing income inequality. In addition, the taxpayer response will be accurately measured by estimating the ETI. Also, in contrast to earlier research that has not accounted for the problem of reverse causality, an instrument will be used. Not accounting for reverse causality gives biased estimators that cannot be interpreted as a causal effect.

The structure of this paper is as follows: Section 2 discusses the related literature; in Section 3 the data will be explained; Section 4 elaborates on the used methodology of this research; Section 5 show the results of the regression and in Section 6 the robustness check is performed; Section 7 is the discussion and conclusion; lastly Section 7 is the bibliography and Section 8 is the appendix.

2. Literature review

The effect of taxes on income inequality is a widely studied topic. However, the debate on the effect of certain tax structure on income inequality is mostly theoretical. There is much literature on tax incidence, but empirical evidence is scarce.

One of the empirical papers researching the effect of tax structure on income inequality is Duncan and Peter (2016). More specifically, they investigated the effect of progressivity of national tax systems on after-tax income inequality in the period of 1981-2005 in the United States. They measure effects on both observed and actual income inequality. There is a difference between these, since not all income is fairly reported. Actual inequality is therefore approximated by the consumption-based Gini coefficient, while the observed income inequality is measured as income-based Gini. Similar like this paper, one of the measures for progressivity of tax systems is the top statutory personal income tax rate. The method used includes a regression with time fixed effects. In addition, they use an instrumental variable, the tax progressivity of the country's neighbor, is constructed to eliminate reverse causality. To minimize omitted variable bias, they add control variables: the log of population, major religion in a country, average inflation rate and a 1 year lagged log of per capita GDP in quadratic form. They find that increasing progressivity of national tax systems reduces observed income inequality. However, a significantly smaller effect is found on actual income inequality, measured by consumption based Gini. In contrast to this paper, country fixed effects will be added in this paper to control for unobserved time invariant factors.

Instead of estimating the effect of progressivity of tax systems, I will be estimating the effect of the top tax rates on income inequality. A higher top tax rate in one country does not imply that a tax system is more progressive than in another country. Gale et. al (2015) research the effect of increasing the top income tax rate on the after-tax Gini coefficient. They conduct a simulation analysis in the United States for three possible reforms: raise the top tax rate from 39.6% to 45%, alternatively to 50% and thirdly raise top rate to 50% for income greater than $1 million for joint filers and $750.000 for single filers. In their initial analysis, no behavioral responses are taken into account, meaning that pre-tax income does not change. The only effect thus is the reduction in post-tax income due to the higher top tax rate. They find that even a significant increase in top tax rate

would not have a significant effect on income inequality. The nonsignificant effect reflects the large middle class that does not have a high enough income to pay top tax rates.

For good instrumental variables, I look at the article of Iosifidi and Mylnodis (2016) who estimate the redistributive effect of labor, consumption and capital tax rates for 17 OECD countries between 1970-2001. To examine the relationship between tax rates and income inequality, the ordinary least squares method is used. Control variables are population, education, economic growth, price stability and government involvement. To eliminate reverse causality, two instrumental variables are used. The first instrumental variable is tax competition which is the weighted average of other countries' tax rates at time t-1. In this paper, tax competition will also be used as an instrumental variable. The model for tax competition in this paper is similar as in Iosifidi and Myldonis and will further be explained in Section 3.4. The second instrumental variable in the article is land area (km^2) and is found to be statistically valid. However, country size is not a good instrumental variable, since it can influence income inequality through omitted variables instead of through top tax rates. Also, land area is not a variable that can be used in this research because it will be eliminated by fixed effects. Therefore, only tax competition will be used as an instrument.

Another interesting paper regarding the effect of top statutory taxes on income inequality is the paper of Klemm et. al (2018). This paper researches the ETI for top income earners. ETI measures how taxable income changes in response to net-of-tax rate changes (1 minus the marginal tax rate). Bigger responses to changes in taxation result in smaller optimal top tax rates. The ETI thus captures all adjustments that taxpayers make, including their labor supply and tax evasion. The first way to calculate the ETI is to find a tax reform and data around this reform. The elasticity is calculated as the change in natural logarithm of taxable income divided by the change natural logarithm of the net-of-tax rate. An alternative variable for taxable income is the after-tax income share of the highest percentile or ventile. Only the highest income class will respond to a change in the top tax rate. In this paper I will use income share of the highest decile to measure the ETI. The income share has an advantage since it controls for broad-based changes in real income. Secondly a direct average elasticity is obtained through a fixed effects regression. This regression equation will be similar in my paper and will therefore be further discussed in Section 4. The added control variables are output gap and capital account openness. The average ETI is found to be 0.2

Another more theoretical paper regarding the ETI is the paper of Saez et. al (2012). The paper states that the ETI captures all behavioral responses to a change in tax rates. Also, it finds that long term responses are difficult to isolate, something that will also be difficult to estimate in this research, because of a possible lack of causal interpretation.

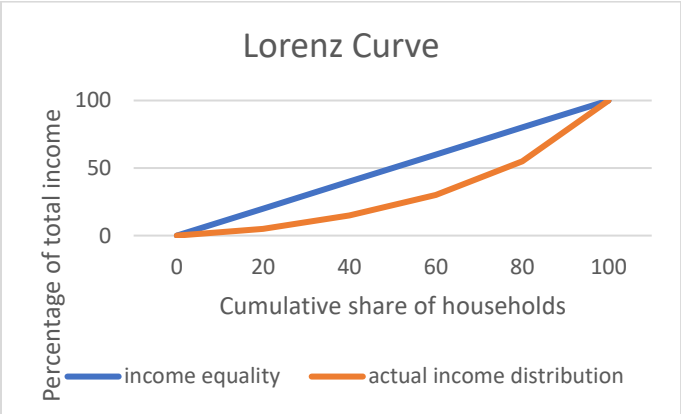
3. Data

3.1 Dependent Variable

A lot of variety in measures for income inequality are available. The most widely used measure is the Gini coefficient, which is derived from the Lorenz curve. The Lorenz curve gives a graphical representation of the income distribution. It shows the percentage of total income that the cumulative share of households has. Figure 1 presents an example of the Lorenz curve. The blue line shows what perfect income equality looks like. The Gini index is calculated by dividing the area between the blue and orange line by the area underneath the blue line and multiplying it by 100. The Gini Index thus presents perfect equality when it equals 0 and perfect inequality when it equals 100. The Gini Index is from the database of the World Bank and is based on household survey data.

Figure 1:

An example of the Lorenz Curve



Note: Figure 1 shows an example of a possible Lorenz Curve, which compares the distribution of income. The percentage of households is plotted on the x-axis while the percentage of total income is plotted on the y-axis. The first 10% households represent the lowest income decile, while the last 10% represent the highest income decile. The blue line represents perfect equality, meaning that the cumulative share of households is equal to the percentage of total income they have.

As said in literature, income inequality has increased in the past years. As can be seen in Figure 2 this is true for most countries, however this increase does not seem significant, since most Gini indexes seem to be relatively constant over time. In Mexico, Chile and Colombia even a significant decrease in income inequality can be seen.

Figure 2:

Income inequality trends 2000-2020

Note: Figure 2 shows the trends in income inequality in the period of 2000-2020 for all 34 OECD countries in the dataset. The dependent variable is the Gini index.

However, there are some caveats with the Gini Index since it measures relative wealth and not absolute wealth. This means that the number of people in absolute poverty can decrease while income inequality increases. For example, when the lowest income class earns more, but middle-income class start to earn less, and the richest decile start to earn even more. The Lorenz curve thus obscures information about the shape of inequality.

The World Bank also warns for non-comparability across countries and years because surveys can differ in using income or consumption expenditure as an indicator for life-expenditure. However, in the data subset all Gini indexes are all calculated from Luxembourg Income Study. Therefore, the indexes are comparable between countries and years.

Because of these caveats I will include an alternative measure of income inequality in the robustness check. Alternative measures such as the after-tax income share (%) of the highest 10% earners and the highest 20% earners can also be found on the website of the World Bank. Income share is measured by household surveys and include all types of (registered) income. Inequality of income distribution is reflected when the share of the top 10% is higher than 10%.

3.2 Independent Variable

For the independent variable I will make use of data from OECD on top statutory personal income tax rates. These are the top statutory tax rates (%) for the combined central and sub-central governments. The combined rate takes into account the effects of tax credits and the deductibility of sub-central taxes in central government taxes. This data is available for 34 OECD countries in 21 periods (2000-2020).

3.3 Control Variables

Regression results can only be interpreted as causal when all relevant variables are controlled for. To deal with omitted variable bias some control variables will be included in the Two Way Fixed Effects model. These control variables should be time-varying, since all time fixed effects are controlled for. A good control variable influences income inequality, because otherwise they would not be in the error term. Also, a good control variable should influence top statutory tax rates, otherwise there is no relationship between the error term and top tax rates.

Lots of research has been done on the sources of income inequality. Kuznets (1955) developed ideas about the relationship between economic growth and income inequality. The relationship is an inverted "U" meaning that income inequality rises until a certain point of economic growth and decreases afterwards. Lower economic growth can cause less tax revenue than expected through lower personal income. This can then lead to an increase in personal income tax rates to be able to cover government expenditures.

Besides economic growth, unemployment is also considered as a source of income inequality. Several studies have researched the impact of unemployment on income distribution. One of which researched the effect of unemployment in Sweden, which concluded that unemployment gives rise to a more unequal income distribution of gross income (Björklund, 1991). Also, unemployment can cause top tax rates to be set higher. The government needs more financial resources to pay for unemployment benefits.

Economic growth will be measured as the quadratic logarithmic function of real GDP per capita. This is to allow for the nonlinear effects that Kuznets found (1955). In the robustness check annual GDP growth and real GDP per capita will be used as different measures of economic growth. The data is retrieved from the World Bank. High economic growth causes more income, which is taxed. Consequently, government tax revenue increases. An increase in revenue, assuming government costs stay constant, allows governments to lower income tax in order to cover existing expenditures. Unemployment is measured as a percentage of the population and is also retrieved from the World

Bank database. Increasing unemployment causes less income and therefore tax revenue decreases. This might mean top statutory tax rates need to be increased to cover government expenditures.

3.4 Instrumental Variable

To create the instrumental variable of tax competition I will use the method of Iosifidi and Mylnodis (2016). Tax competition for country i at time t is defined as the weighted average of other countries at time t-1:

$$tc_{i,t-1} = \sum_{j=1}^{N} w_{ij} t_{j,t-1} \qquad (1) \qquad \text{for which } w_{ij} = \frac{\frac{ln(pop_j + 1)}{d_{ij}^2}}{\sum_{k \neq j} \frac{ln(pop_k + 1)}{d_{ik}^2}} \qquad (2)$$

with $w_{ij} \geq 0$ when i≠j and $w_{ij} = 0$ when i=j. pop_j is the population of country j, d_{ij} is the distance from country i to country j measured in kilometers as the crow flies. This distance is measured from the center of country i to the center of country j. Distance is included since the effect of tax rates in country j is higher when it is closer to country i. The population is included to measure country size. A bigger country is more likely to influence the tax rates of country i than a small country. It is common that GDP is used as a measure of country size. However, this is likely to be an endogenous factor since economic growth in country i can affect tax rates in this country. The denominator is the summation of the other k countries. Iosifidi and Mylnodis (2016) in addition use country size, measured in land area, as an instrumental variable. This however is not a good variable to use since land area is a characteristic of a country and therefore might influence income inequality through other channels. Country size can, as discussed before, affect tax rates through tax competition since small countries have more incentives to engage aggressively in tax competition.

A good instrumental variable should first have a causal effect on the top statutory tax rate. Secondly, it should be uncorrelated with the error term. Thirdly, it should not have a direct effect on the Gini index, but only through top tax rates. Tax competition is a measurement of top tax rates in other countries, considering distance and size of the country. Tax competition especially has a causal effect on top tax rates with big countries or neighboring countries. Lower top rates in neighboring country *j* can for example cause migration from high income earners to country *j*. This stimulates country *i* to keep top rates lower than in neighboring country *j*. Also, following related literature (Carr et. al, 2016), transaction and information costs increase as geographical distance increases. Therefore, information about tax rates in countries far away from country *i* is more 'expensive' to get, which is why these countries are less of a competition. The second assumption cannot be verified since the error term is not observed. Randomization is an ideal instrumental variable, since treatment is then unaffected by anything else. However, top tax rates are not likely to be randomly set by governments. Therefore, this assumption will be informally checked by checking the correlation

between tax competition and observed characteristics. Thirdly, tax competition should only affect income inequality in country *i* through tax rates and not through other factors such as economic openness or government size. By including measures for economic openness and government size, those channels are controlled for in the first stage of the IV regression (Iosifidi and Myldonis, 2016). Another factor through which tax competition could affect income inequality is through the erosion of social cohesion. Trust in public institutions may be lowered, resulting in social unrest and eventually leading to broader economic consequences such as income inequality. This is not accounted for in the IV regression, which makes it important to interpret results with caution since they may be over or underestimated.

3.5 Descriptive Statistics

In Table 1 descriptives of all used variables are shown. The top statutory tax rate is the highest tax bracket. Important to note is that most countries have a progressive tax system except for Hungary (PWC, 2022) and Lithuania (PWC, 2023) having flat tax rates.

The mean Gini Index is 33.567 in the sample of OECD countries. OECD countries are overall rich countries with low Gini indexes, while poor countries have higher Gini indexes and thus more income inequality. The lowest real GDP per capita is earned by Colombia, while the highest GDP per capita is earned by Luxembourg, which is also due to the number of inhabitants.

The mean unemployment rate is 7.474%. The unemployment rate of Greece lied above 20% between 2012 and 2017, when the Greek Debt Crisis took place. In the early 2000's unemployment rates also reached 20% in Colombia, Poland and the Slovak Republic. Tax competition forms the instrument which is computed with Formula 1 and 2.

The income share of the top 10% is on average much higher than 10%. Also, the minimum is almost twice as high as 10%, meaning that the richest decile owns about twice as much as it would with perfect equality. For the top 20% the same holds. The table shows that on average the second richest decile owns about 15% of all income, which is still way more than it would with perfect equality, but is also much less than the richest decile owns.

Table 1:

Descriptive Statistics 2000-2020

Classification	Mean	Minimum	Maximum	Observations
Top Statutory Tax Rate	41.142	15	62.3	714
Gini Index	33.567	23.2	58.7	586
Real GDP per capita	34,000.54	2,305.083	123,678.7	714
Unemployment	7.474	1.81	27.47	714
Tax Competition	41.316	38.3212	45.1879	714
Income share top 10%	26.3102	18.4	47	586
Income share top 20%	41.31638	32.6	62.2	586

Note: Table 1 shows the descriptive statistics of the dependent variable and the independent variables. To describe the data the simple means, minima and maxima are shown in this table. For Gini index there are a few missing values, resulting in 586 observations for all regressions that are run. Top statutory tax rate and unemployment is expressed as a percentage. Gini index is expressed as an index, where a value of 100 means perfect inequality and 0 means perfect equality. Moreover, real GDP per capita is measured in US dollars.

Interesting to see is that Figure 3 and Figure 4 show, not identical, but very similar trends to income inequality trends as in figure 2. Therefore, it can be stated that the income share of the top 10% and top 20% are good alternative measures for income inequality.

Figure 3:

Income share trends top 10% 2000-2020

Note: Figure 3 shows the trends in income share in the period of 2000-2020 for all 34 OECD countries in the dataset. The dependent variable is the Income share of the top 10% richest households.

Figure 4:

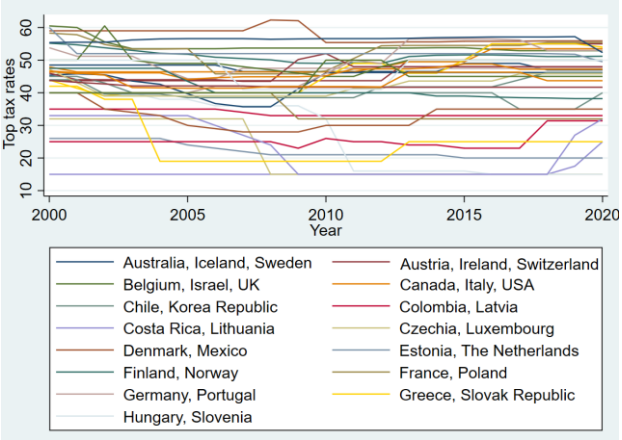
Income share trends top 20% 2000-2020

Note: Figure 4 shows the trends in income share in the period of 2000-2020 for all 34 OECD countries in the dataset. The dependent variable is the Income share of the top 20% richest households.

Interesting to see in Figure 5 is that top tax rates are not constantly changing, since they are captured in the law and the parliament needs to vote when tax rates are adjusted. In 21 countries out of this sample, tax rates were lower in 2020 than in 2000. Therefore, it can be said that there is a global trend of decreasing top statutory tax rates.

Figure 5:

Top tax rates trend 2000-2020



Note: Figure 5 shows the trends in top tax rates in the period of 2000-2020 for all 34 OECD countries in the dataset.

4. **Methodology**

To be able to select whether a fixed or random effects model must be used a Hausman test is conducted. It tests if there is correlation between the error term and the independent variables. The null hypothesis is that they are not related. In other words, the null hypothesis is that the random effects method should be used. The p-value of the test is 0.000, meaning that the variation between countries is not random and the fixed effects model should be used. Fixed effects allow for variation in country-specific characteristics that are not time-varying.

The two-way fixed effects method (TWFE) is used to estimate the effect of the height of top statutory tax rates on income inequality. The method allows to use multiple countries and time periods, which is why the method is suitable. This method assumes both country fixed effects as time fixed effects. I will be using a linear regression model to estimate the regression, just like Duncan and Peter (2016).

For the TWFE method it is important to include control variables. When a variable, that affects both the dependent variable as the independent variable, is omitted the coefficient of interest is biased. Only time varying observable factors can be considered as good control variables since the TWFE method already accounts for fixed effects. Unemployment and economic growth are examples of time varying observable factors, which will be included in the regression.

The constant treatment effect assumption can be checked by regressing top tax rates on sub-samples. If the treatment effect of sub-samples differs from the total treatment effect, this indicates heterogeneous treatment effects. If the total treatment effect and treatment effect for sub-groups does not significantly differ, this adds power to the constant treatment effect assumption.

By including control variables the regression equation will look like this:

$$Gini_{it} = \alpha + \beta_1 T_{it} + \beta_2 U_{it} + \beta_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it} \quad (3)$$

$Gini_{it}$ = net income Gini index, α = a constant, β_1 = the effect of top statutory tax rates on income inequality, T_{it}= top statutory tax rates for central and sub-central governments (%), U_{it} and $log(GDP)_{it}^2$ = control variables, which are the unemployment rate and the quadratic logarithmic function of GDP per capita, η_i= country fixed effect, γ_t= time fixed effect, ε_{it} = error term of country i in period t with t *= 2000, 2001…2019, 2020 (21 periods) and* i *= 34*

A 1 percentage point increase in T_{it} is associated with a change of $Gini_{it}$ with β_1 units. A 1 percentage point increase in U_{it} is associated with a change of $Gini_{it}$ with β_2 units. A 1 percentage increase in $log(GDP)_{it}^2$ is associated with a change of $Gini_{it}$ with β_3 units.

The two way fixed effects model allows to eliminate bias from unobservable factors that differ over time but are constant over countries and from unobservable variables that do differ across countries but are constant over time. Therefore, only time-variant unobserved factors cannot be addressed. Another caveat of the two-way fixed effects model is that it cannot solve one of the greatest endogeneity issues in policy economics: reverse causality. Meltzer and Richard (1981) established a reverse relationship between income inequality and taxes. Government's redistribution choices are responsive to existing income distribution. Simply regressing inequality on government policy ignores this endogeneity issue. To account for possible delayed effects of top tax rates on income distribution, a lagged variable of top statutory tax rates for one or more periods will be included. This is because it is unlikely that past rates are impacted by current income inequality. However, a lagged variable cannot solve reverse causality. Lagging a variable does not allow for an instantaneous effect. Since an instantaneous effect is a possibility, there is only one way to solve for reverse causality: by using a good instrumental variable.

A good instrumental variable should be strongly correlated with the potentially endogenous regressor and should only influence the dependent variable through the potentially independent variable. In Section 3 the instrumental variables are carefully explained. The second model in this paper will be the two-stage least-squares model (2SLS) with an instrumental variable. The first stage equation is:

$$T_{it} = \delta + \varphi_1 Z_{it} + \varphi_2 U_{it} + \varphi_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it} \quad (4)$$

T_{it} = the predicted value for top statutory tax rates, Z_{it} = One of the instrumental variables: tax competition, U_{it} and $log(GDP)_{it}^2$ = control variables, which are the unemployment rate and the quadratic logarithmic function of GDP per capita, or $log(GDP)$ = *linear logarithmic function of GDP*

per capita, η_i= country fixed effect, γ_t= time fixed effect, ε_{it} = error term of country i in period t with t *= 2000, 2001…2019, 2020 (21 periods) and i = 34*

The second stage equation is:

$$Gini_{it} = \alpha + \beta_1 \overline{T}_{it} + \beta_2 U_{it} + \beta_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it} \quad (5)$$

β_1 = the coefficient of interest. All the other variables have the same values as in equation (4) and (5).

To account for a possible delayed effect of top tax rates on income inequality, the coefficient lagged variable of top tax rates will be measured to discover possible other effects.

$$Gini_{it} = \alpha + \beta_1 T_{it-1} + \beta_2 U_{it} + \beta_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it}$$

T_{it-1} = the lagged variable of top statutory tax rates. All the other variables have the same values as in equation (4) and (5).

Also, to account for the possibility of a linear relationship between economic growth and income inequality a regression will be measured with economic growth as a linear term to discover a possible linear relation between economic growth and income inequality.

$$Gini_{it} = \alpha + \beta_1 T_{it} + \beta_2 U_{it} + \beta_3 log(GDP)_{it} + \eta_i + \gamma_t + \varepsilon_{it} \quad (6)$$

$log(GDP)_{it}$= the linear logarithmic function of GDP per capita. All the other variables have the same values as in equation (4) and (5).

A 1 percentage point increase in T_{it} is associated with a change of $Gini_{it}$ with β_1 units. A 1 percentage point increase in U_{it} is associated with a change of $Gini_{it}$ with β_2 units. A 1 percentage increase in $log(GDP)_{it}$ is associated with a change of $Gini_{it}$ with β_3 units.

In addition, I will use alternative measures of inequality. Possible variables are the income share of the highest 10% and the highest 20%. The equation below will estimate β_1: the change in income share of the highest 10% or 20% when top tax rates increase by one percentage point.

$$Share_{it} = \alpha + \beta_1 T_{it-1} + \beta_2 U_{it} + \beta_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it} \quad (9)$$

In addition, to be able to interpret β_1 as the elasticity of taxable income this equation is ln-linearized, as done in the paper of Klemm et. al (2018).

$$ln(Share_{it}) = \alpha + \beta_1 ln(1 - T_{it-1}) + \beta_2 U_{it} + \beta_3 log(GDP)_{it}^2 + \eta_i + \gamma_t + \varepsilon_{it} \quad (10)$$

A one percentage increase in top tax rates results in a β_1 percentage increase in the income share of the highest 10% and 20% earners. By measuring the income share of the top 10% as well as the top 20%, it is possible to conclude if ETI is increasing with income, as other research finds (Gruber and Saez, 2000). High income earners have less third party reported income, and are therefore more likely to manipulate their income. Hence, it is expected that the ETI is higher for top 10% earners than for top 20% earners.

5. Results

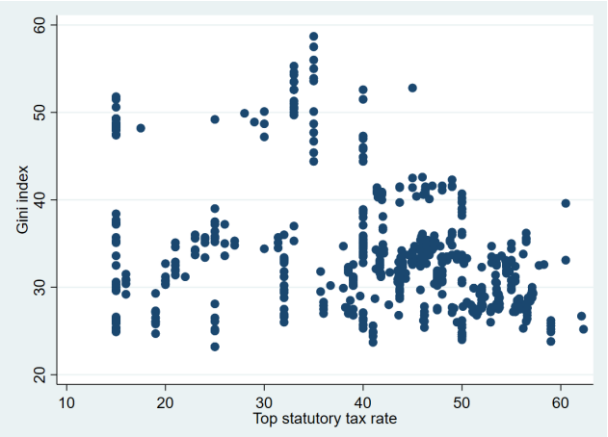
In this section I present the results of the Two Way Fixed Effects method. After that an instrument is added to solve for reversed causality.

5.1 Two Way Fixed Effects Method

First, the relationship between top tax rates and income inequality is shown in Figure 2. No clear linear relationship can be seen from this graphical representation. Important to note is that the vertical dots are likely to present one country since top tax rates do not change every year and income inequality does. Therefore, what can be said is that there is lots of variation between countries. Yet, there is much less variation in tax rates across years.

Figure 6

Relationship between top statutory tax rates and Gini index



Note: The scatterplot shows the relationship between the top statutory tax rates (x-axis) and Gini index (y-axis).

Heteroskedasticity may be present in the data. There may be cross-country variation in different variables, or temporal changes that lead to heteroskedasticity. Also, if countries implemented major policy changes related to top tax rates this could lead to heteroskedasticity. Also, the Wald test is done to check for heteroskedasticity. The null hypothesis of homoskedasticity is rejected with probability 0.000 and therefore robust standard errors are used. This helps to ensure that policy decisions will be made on reliable statistical evidence.

Column (1) of Table 2 presents a simple OLS regression of the effect of top statutory tax rates on income inequality. The coefficient is negative, meaning that income inequality decreases as top statutory rates are rising. This coefficient is highly significant. In column (2) time and country fixed effects are added. The coefficient of interest is increasing, but becomes insignificant and negative.

The regressions of column (1) and (2) are likely to contain omitted variable bias, which is why control variables are added. The control variables are gradually added to the regression every column. In column (3) the quadratic logarithm of GDP per capita is added. The coefficient of interest is becoming more negative and significant. On the other hand, economic growth seems to have a significant negative quadratic effect on income inequality.

In column (4) the last control variable is added: unemployment. The coefficient of interest decreases even more and is significant. Economic growth also stays significant, but becomes less negative because part of its significance is taken by the coefficient of unemployment. As in line with related literature, the higher the unemployment in a country, the higher income inequality within a country (Björklund, 1991). In this column a one percentage point increase is associated with a decrease in the Gini Index of 0.0524.

To account for a possible linear effect of economic growth on income inequality, the logarithm of economic growth is added in column (5). Interesting to see is that the standard error becomes larger and thus more imprecise. This research paper will therefore continue with the quadratic logarithm of economic growth, as expected and found by Kuznets (1955).

In column (6) a lagged variable of top tax rates is used in column (6), since there is a possibility that a change in tax rates have a delayed effect on income distribution. The coefficient of interest becomes more negative and stays significant suggesting that a change in top tax rates is negatively associated with income inequality. The coefficients of economic growth and unemployment do not change a lot. On the other hand, an instantaneous effect of a change in top tax rates on income inequality cannot be measured by the lagged variable.

Table 2:

Regression results TWFE

Dependent variable: Gini Index	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Top statutory tax rates	-.1669***	-.0192	-.0367*	-.0524***	-.0553***	
	(.0258)	(.0174)	(.0186)	(.0192)	(.0193)	
Top statutory tax rates at t-1						-.0604***
						(.0164)
Ln(GDP per capita)^2			-.1000***	-.0453***		-.0710***
			(.0268)	(.0278)		(.0269)
Ln(GDP per capita)					-1.4056***	
					(.5323)	
Unemployment				.1437	.1317***	.1194***
				(.0304)	(.0294)	(.0289)
Constant	40.4044	35.6840	46.76075	41.2145	50.9798	44.3209
Time fixed effects		X	X	X	X	X
Country fixed effects		X	X	X	X	X
Observations	586	586	586	586	586	551

Note: the dependent variable is the Gini index ranging from 0-100. Column (1) presents a basic OLS regression without country and time fixed effects. In column (2) country and time fixed effects are added. Column (3) adds controls for economic growth and in column (4) unemployment is added as a control variable. The lagged variable of top tax rates is added in column (5). The lagged variable of tax causes observations to decrease, since the first year of every country is excluded. *p < 0.10, **p < 0.05, and *** p < 0.01.

5.2 Instrumental Variable Method

A way to solve for reverse causality is by using the instrumental variable method. Table 3 shows the results of the instrumental variable model with tax competition as an IV. In the first stage the potentially endogenous variable top tax rates is regressed on the instrumental variables tax competition. It is of great importance that there is a strong first stage, since this shows a strong causal relationship between the instrument and top tax rates. The first stage results of the instrument can be found in Table A1 of the Appendix and the F-statistics in Table A2. The instrument tax competition is significant in all three columns. However, the sign of the coefficient of interest changes when including the control variables economic growth and unemployment. It is expected that the variables tax competition and top tax rates are positively correlated. Hence, when other countries have low top statutory tax rates, and thus tax competition has a lower value, top tax rates of country i might be lower as well. When including control variables, the sign of the coefficient of interest turns positive, just as expected. The strong first stage turns out the significant coefficient of tax competition. Therefore, the assumption of a causal relationship is satisfied.

In column (1) of Table 3 the IV regression with top tax rates is conducted, including time and country fixed effects. For this regression robust standard errors are used as well as in the earlier regression. The coefficient of interest in this column is negative and significant. However, the regression still suffers from omitted variable bias. Therefore, the control variables are gradually added in column (2) and column (3). In column (2) economic growth is added to the regression. In comparison to column (1), the coefficient of interest is increasing and even becomes positive and insignificant. In column (3) the last control variable is added, which increases the coefficient of interest even more. A one percentage point increase in top tax rates increases the Gini index and therefore increases the Gini index with 0.0462. This is not in line with expectations, since taxing the rich higher should lead to more after tax income equality. The insignificance of the coefficient however makes it impossible to conclude that top tax rates affect income inequality. Since the confidence interval centers around zero, an accurate null effect is measured. The quadratic form of the logarithm of economic growth is highly significant meaning that a strong negative relationship exists between economic growth and the Gini index.

In column (4) of Table 3 the independent variable top tax rates is replaced with the lagged variable of top tax rates. It is possible that change in tax rates do not have an immediate effect on income inequality. Tax measures often have delayed effects because they can influence investment decisions, labor market behavior and economic growth. The coefficient of interest did not become significant. Since results are somewhat similar for column (3) and (4), only top tax rates will be used

in further regressions. This means that only instantaneous effects will be captured in the regression coefficient.

Table 3:

Full regression results with tax competition as an IV

Dependent variable: Gini Index	**(1)**	**(2)**	**(3)**	**(4)**
Top statutory tax rates	-.1821***	.0388	.0462	
	(.0269)	(.0281)	(.0298)	
Top statutory tax rates at t-1				.0293
				(.0293)
Ln(GDP per capita)^2		-.2788***	-.2901***	-.2714***
		(.0246)	(.0282)	(.0290)
Unemployment			-.0784	-.0690
			(.0697)	(.0694)
Constant	41.0266	61.4437	62.9274	61.5693
Time fixed effects	X	X	X	X
Country fixed effects	X	X	X	X

Note: the dependent variable is the Gini index ranging from 0-100. Column (1) presents the results regressing top statutory tax rates on income inequality with tax competition as an IV. Country and time fixed effects are included in all columns. In column (2) economic growth is added as a control variable and in column (3) unemployment is added. *p < 0.10, **p < 0.05, and *** p < 0.01.

5.3 Heterogeneous treatment effects

So far this study only estimates an average treatment effect, assuming that a similar treatment effect across different countries. The effect within subgroups might differ substantially from the average treatment effect. It is to be expected that high and low income inequality countries differ in the effect of top tax rates on income inequality. Therefore, the sample of countries is divided into high and low income inequality countries to examine the heterogeneity in the effect of top tax rates on income inequality. Two sub-samples are created for the ten highest and ten lowest income inequality countries. In Table A3 of the Appendix a ranking of those countries is presented together with their average Gini index over the period 2000-2020. In column (1) and (2) a regression is performed with the TWFE method.

In column (1) of Table 4results for high income inequality countries are shown and in column (2) results for low income inequality countries are shown. The coefficient for low income inequality countries becomes insignificant and is lower than in column (1), meaning that the effect of raising top tax rates would have less effect on income inequality than in high income inequality countries. However, since confidence intervals overlap this difference is insignificant. Especially because the sample size is much reduced to about one-third of the full sample.

To consider possible reverse causality, the instrument tax competition is included in the regression. In columns (3) and (4) tax competition is used as an instrument. The negative correlation between top tax rates and income inequality disappears and turns into a positive one. This is interesting because reverse causality would lead to an upward bias, since higher inequality causes top statutory tax rates to be set higher. In column (3) the results become significant, meaning that increasing top tax rates lead to higher inequality. In column (4), however, the coefficient of interest is insignificant. A positive effect of increasing top tax rates on income inequality is counterintuitive since increasing tax rates usually decrease income inequality. However, increasing top tax rates could encourage wealthy individuals to accumulate capital instead of getting income from labor would increase the after-tax income share. Another reason could be that a higher top tariff encourages wealthy individuals to avoid or even evade taxes. This might happen more in higher income inequality countries since relatively more income is owned by the richest households.

For policy, this would mean that increasing top tax rates in countries with high income inequality would have a reverse impact on income inequality than expected. In contrast, no significant change is observed in countries with low income inequality. It is therefore important to examine a specific country's income inequality before implementing certain policy measures.

Interesting to see is that, in contrast to earlier results, unemployment also has a significant effect on income inequality. The difference in sign cancels out this significant effect in earlier results. Unemployment thus has an ambiguous effect on income inequality. In low income inequality countries, the higher unemployment the more income inequality. In high income inequality countries, higher unemployment would lead to less income inequality. Interesting to see is that, with an IV model, there are also major differences in the effect of economic growth on income inequality for the two subgroups. The main instrumental variable tax competition shows us that the same ambiguous relationship exists as for unemployment.

Table 4:

Heterogeneous Treatment Effects

Note: the dependent variable is the Gini index ranging from 0-100. In all columns we have included country and time fixed effects as well as

	TWFE		IV: tax competition	
Dependent variable: Gini Index	**(1) high inequality**	**(2) low inequality**	**(3) high inequality**	**(4) low inequality**
Top statutory tax rates	-.0647*	-.0436	.1089***	.0101
	(.0357)	(.0312)	(.0401)	(.0128)
Ln(GDP per capita)^2	-.0452	.0796	-.3760***	.0749*
	(.0487)	(.0811)	(.0319)	(.0197)
Unemployment	.0639	.4375***	-.4819***	.2741**
	(.0567)	(.0985)	(.1027)	(.0450)
Constant	54.8954	19.8442	77.6053	17.1706
Time fixed effects	X	X	X	X
Country fixed effects	X	X	X	X

robust standard errors. Column (1) regresses the treatment effect on a sub-sample of countries with relative high income inequality. The sub-sample consists of the ten highest income inequality countries of Table A3 in the appendix. Column (2) regresses the treatment effect on a sub-sample of countries with relative low income inequality. The sub-sample consists of the ten lowest income inequality countries of Table A3 in the appendix. In column (3) and (5) the same is done as in column (1), however the IV tax competition and country size are added. In column (4) and (6) the same is done as in column (2), however the IV tax competition and country size are added. *p < 0.10, **p < 0.05, and *** p < 0.01.

6. **Robustness**

For the robustness check alternative measures of income inequality are used. The dependent variables will be income share of the highest top 10% and income share of the highest top 20%. The top 10% and 20% earners on average earn double as much income as they would have earned with perfect income equality.

In Table 5 the regression results for the robustness check are shown with tax competition as an IV. In column (1) the earlier regression results are shown, but Gini index is replaced with the income share of the top 10% income earners. In contrast to Table 3, where the Gini Index was used as dependent variable, the coefficient of interest is significant. As said before, a positive relationship is counterintuitive. However, increasing top tax rates could encourage wealthy individuals to accumulate capital instead of getting income from labor would increase the after-tax income share. This is a plausible reason since top tax rates only include labor income and the income share of the top 10% also includes income from capital. Another reason could be that a higher top tariff encourages wealthy individuals to avoid or even evade taxes.

Table 5 is in line with the findings of Table 4 where it is found that there is a significant positive relationship between top tax rates and income inequality in countries where income inequality is highest.

In column (2) the independent variable is replaced with the income share of the top 20% income earners. The coefficient of interest becomes less significant, but is still significant and positive, meaning that an increase in top tax rates also increases the income share of the top 20%. Interesting to see is that the confidence interval enlarges with income share of the top 20% as the dependent variable in comparison to the top 10%. This is logical since the top 20% richest households is a group twice as big as the top 10% richest households. This allows for more variability in the sample.

While increasing top tax rates significantly affects the income share of the top 10%, it does not significantly affect the Gini Index. A possible explanation is that the income share of the poorer deciles increases even more such that the Gini Index does not significantly change, as explained in Section 3.1.

Another more realistic explanation is that the confidence interval of the Gini Index is larger than that of the income share. The confidence interval of the Gini Index is likely to be larger because of variability, which is logical since it requires a larger sample size and is a more complex measure of income inequality, resulting in a greater uncertainty and a greater standard error.

Table 7 also shows a negative significant effect of unemployment on the income share of the richest 10% and 20%. More unemployment leads to a lower income share of the richest ventile. Firstly, rich households might lose their jobs as a result of increasing unemployment, resulting in less income. Also, wealthy households are more likely to have shares and assets. Higher unemployment can lead to a lower turnover and thus to capital losses.

Table 5:

Regression results with tax competition as IV

	Income share top 10%	**Income share top 20%**
	(1)	**(2)**
Top statutory tax rates	.0484**	.0413*
	(.0212)	(.0241)
Ln(GDP)^2	-.2361***	-.2476***
	(.0221)	(.0236)
Unemployment	-.1503***	.-1269**
	(.0511)	(.0569)
Constant	50.4260	66.7615
Time fixed effects	X	X
Country fixed effects	X	X

Note: In this table the IV method is used with tax competition as an instrument. In column (1) the dependent variable is the income share of the top 10% whereas in column (2) it is the income share of the top 20%. Both country and time fixed effects are added and robust standard errors are used. *p < 0.10, **p < 0.05, and *** p < 0.01.

In Table 8 the elasticity of taxable income is measured via the regression equation in Section 4. In column (1), (2) and (3) the elasticity of taxable income of the top 10% richest in the country is measured and in column (4), (5) and (6) the elasticity of taxable income of the top 20% richest in the country is measured. As earlier results have shown, the TWFE method includes the endogeneity issue of reverse causality. At first, it seems like there is a positive ETI. This means that when the net-of-top-tax rate decreases, taxable income of the top 10% increases. Reverse causality in this case would mean that governments increase top tax rate and thus decrease net-of-top-tax-rate when observing a higher income share for top 10% income earners.

The IV-method takes away reverse causality and presents a negative elasticity of taxable income. As a result of the decrease in top tax rates, and thus an increase of net-of-top-tax rates, the taxable income share of the top decreases. An increase in net-of-top-tax rate means that work becomes more profitable than leisure time (substitution effect), but at the same time less income is needed to maintain the same consumption (income effect). A negative ETI occurs when the income effect exceeds the substitution effect. The insignificance of the coefficient however makes it impossible to conclude that top tax rates affect income inequality. Since the confidence interval centers around zero, an accurate null effect is measured. What can be said however is that the TWFE model is likely to overestimate the ETI. Also, the ETI is higher for the top 10% income earners than for top 20% income earners. These results are in line with earlier research (Gruber and Saez, 2000), concluding that ETI increases with income. According to them, this is most likely due to less third party reported income for higher income earners, so more income might be manipulated. The rich are therefore more sensitive to changes in net-of-top-tax rates, since they can hide their income more easily.

As for robustness, it seems like the independent variable Gini index is a robust measure for income inequality.

Table 6:

Estimating the elasticity of taxable income

	Income share top 10%		Income share top 20%	
	(1) TWFE	**(2) IV: tax competition**	**(4) TWFE**	**(5) IV: tax competition**
Ln(1-T_{it-1})	.1219***	-.0295	.0855	-.0084
	(.0314)	(.0440)	(.0195)	(.0326)
Ln(GDP_{it})^2	-.0014*	-.0067***	-.0009*	-.0047***
	(.0008)	(.0007)	(.0005)	(.0005)
Ln(U_{it})	.0263***	-.0252	.0196	-.0118
	(.0071)	(.0165)	(.0046)	(.0122)
Constant	2.8947	4.1252	3.4649	4.2628
Time fixed effects	X	X	X	X
Country fixed effects	X	X	X	X

Note: In this table the ETI is measured for the top 10% earners in column (1)-(3) and for top 20% earners in column (4)-(5). In column (1) the TWFE method is used, in column (2) the IV method with tax competition as an instrument and in column (3) country size is the instrument. In column (4) the TWFE method is used, in column (5) the IV method with tax competition as an instrument and in column (6) country size is the instrument. *p < 0.10, **p < 0.05, and *** p < 0.01.

7. Discussion and Conclusion

At first sight, the findings from TWFE in Table 2 seem to present that increasing the top tax rate by one percentage point significantly decreases the Gini index with 0.0524. This would mean that raising the top rate has the effect of decreasing income inequality. However, when taking into account reverse causality by using tax competition as an IV a one percentage point increase in the top tax rate suggests an increase in Gini index of 0.0462, and thus even increasing income inequality. This coefficient however is not significantly different from 0, so therefore not a lot can be said about the effect of increasing top tax rates on income inequality. What can be said is that increasing top tax rates do not necessarily decrease income inequality.

Very interesting to see in the results is that the impact of unemployment and economic growth has an ambiguous relationship for the sub-groups of high income inequality and low income inequality. Those are however external factors, so no policy recommendation can be given.

In addition the ETI is calculated in Section 6. These results are most interesting since earlier research shows a positive ETI through fixed effects methods. By adding an IV to the model, we see that those estimations are biased by reverse causality. In Table 8 insignificant elasticities are shown, but they are negative. This can be due when the income effect dominates the substitution effect. The results are however not significantly different from 0 and are therefore not meaningful to interpret. What is in line with earlier research is that the ETI seems higher for the top 10% income earners than for top 20% income earners (Gruber and Saez, 2000).

For policy, these results conclude that it cannot be rejected that increasing the top tax rate has no significant effect on income inequality. This however does not mean that changing the tax system does not have an effect on income inequality. The Gini Index is a complex measure, making it difficult to isolate the effects of one variable, such as the top tax rate, because income inequality is the result of an interplay of multiple forces.

Also, some other caveats are found in this research that could explain these results. For example, there might have been other changes in the tax system at the same time of changing top tax rates that affected, for example, progressivity. This would mean increasing progressivity and therefore increasing the top tax rate, ceteris paribus, could possibly reduce income inequality. Because of the other changes that might have happened when changing the top tax rates, this research might not have estimated a causal relationship between top tax rates and income inequality.

Also, variables such as economic growth, income shares and the Gini Index do not take into account shadow and informal activities, which do form part of the economy. The variables can therefore be

biased in both ways. On one hand, it could be that the rich take part in fraud or other non-registered activities. On the other hand, it is likely that the poorest decile undertakes activities to earn some extra money.

In addition, to establish a causal relationship two assumptions have to hold. First, the parallel trends assumption has to hold. As discussed, we cannot conclude parallel trends. Therefore, sub-optimally control variables are added. In this model omitted variable bias is still an endogeneity problem that cannot be solved for since time-varying unobservable variables are not accounted for. In addition there might be observed time varying variables that are not included in the model. Examples of these factors could be governments' transfer programs from rich to poor. Moreover, the crisis in 2008 is included in the analyzed time span, leading to an asymmetric shock in the economy. It is plausible that the crisis influences the relationship between economic growth and income inequality. Another assumption that should hold for the TWFE model is the constant treatment effects assumption. Section 5.3 however explains that the null hypothesis of homogeneity cannot be rejected. This adds power to the constant treatment effects assumption, but it cannot be concluded with certainty.

As mentioned earlier, misreporting of income is much more likely to happen in the upper tail of the income distribution. This finding suggests that effect of increasing top tax rates on income inequality is underestimated in this research, as we are measuring observed income. If the upper tail misreports a lot of income, actual income inequality might even be higher and therefore might increase even more than measured in this research. Therefore, a great caveat is that there is no data available on actual income, but only on observed income.

For future research, it would be interesting to estimate a causal relationship between top tax rates and income inequality with more variability in countries. As seen in this report, there is a difference between high and low income inequality countries even within OECD countries. When researching the effect for more high income inequality countries such as South-Africa, results might differ a lot.

In addition, it would be interesting to research the effect of progressivity of a tax system instead of just increasing top tax rates, like Duncan and Peter (2016). This because the relationship is more likely to be interpreted as a causal effect. Also, for policy implementation this is relevant information.

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Appendix

Table A1

The effect of tax competition on top statutory tax rates (first-stage results)

Dependent variable: top tax rates	**(1)**	**(2)**	**(3)**
Tax competition	-1.0719***	.8209***	1.2689***
	(.1140)	(.2763)	(.2790)
Ln(GDP per capita)^2		.4330***	.5120***
		(.0246)	(.0272)
Unemployment			5.2434***
			(.8482)
Constant	85.2402	-37.6025	-74.1884
Time fixed effects	X	X	X
Country fixed effects	X	X	X

Note: the dependent variable are the top statutory tax rates. Column (1) presents the results tax competition on top statutory tax rates. Country and time fixed effects are included in all columns. In column (2) economic growth is added as a control variable and in column (3) unemployment is added. *p < 0.10, **p < 0.05, and *** p < 0.01.

Table A2

F-statistic IV method

First stage results IV: top tax rate	F-statistic	Prob > F	R-squared
Tax competition	18.3823	.0000	.9379

Note: In this table the first stage results are shown for tax competition and country size. Both instruments have a strong first stage, since the F-statistic is bigger than 10. A strong first stage means that the instrument is strongly correlated with the potentially endogenous variable top tax rates.

Table A3

Ranking average income inequality 2000-2020

Highest income inequality countries		Lowest income inequality countries	
Country	**Gini index**	**Country**	**Gini index**
1. Colombia	53.5105	**1. Slovenia**	24.7882
2. Costa Rica	48.9286	**2. Slovak Republic**	26.0813
3. Mexico	48.8333	**3. Czechia**	26.1333
4. Chile	47.1222	**4. Denmark**	26.9053
5. United States	40.8048	**5. Norway**	27.3389
6. Israel	40.6056	**6. Finland**	27.4790
7. Portugal	36	**7. Iceland**	27.8067
8. Lithuania	35.8059	**8. Sweden**	27.9053
9. Latvia	35.7471	**9. Belgium**	28.3263
10. Italy	34.6632	**10. The Netherlands**	28.4529

Note: In this table countries are ranked on average income inequality. Income inequality is measured by the Gini index. In the first column the 10 countries with highest income inequality within the country are shown. In the second column the Gini indexes are shown. In the third column 10 countries with lowest income inequality within the country are shown. The fourth column presents the Gini indexes per lowest income inequality country.