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Reducing Inequality via Taxation Reforms – a Macroeconomic Analysis

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Abstract

Since the 1980s income and wealth inequality has been increasing in Europe and the United States. This paper examines taxation reform scenarios to reduce inequality in Germany, while simultaneously observing the effects on macroeconomic variables. I employ an incomplete markets model, where households face uninsurable idiosyncratic income risk and choose labor endogenously. The stochastic earnings process, generating the income and wealth distribution, is calibrated to match German data in 2011/2012. Comparing reforms in capital tax, income tax and consumption tax, I find increasing income taxes to achieve the most redistribution, yet paired with substantial economic distortion. Weighing distributional benefits against economic distortions, higher consumption taxes do best in reducing inequality in an efficient way. However, raised consumption taxes redistribute evenly over the distribution, while higher capital taxes constitute a targeted measure, redistributing mostly from the top 20% to the bottom 20%.

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1. Introduction

During the last 40 years, wealth and income inequality has been rising in Germany, the US and the UK. Income inequality measured by the Gini coefficient has increased by 11% in Germany, by 22% in the US, and by 24% in the UK, for the time period 1978 to 2013 (Luxembourg Income Study). Besides other factors, the literature finds that cross country differences in income inequality, especially at the bottom of the distribution, can be explained by differences in tax and transfer systems (e.g. Joumard et al., 2012; Wang and Caminada, 2011; Garfinkel et al., 2006; Kenworthy and Pontusson, 2005).

Motivated by those empiric results, I assess the macroeconomic effects and distributional implications of variations in income, capital and consumption taxes. The model-based investigation of topics related to heterogeneity in income and wealth mostly relies on the incomplete markets model with heterogeneous households and idiosyncratic earnings risk developed by Huggett (1993) and Aiyagari (1994). This class of models has been used to account for income and wealth inequality (Castaneda et al., 2003), assess welfare implications and distributional implications of tax reforms (Heathcote, 2001; Domeij and Heathcote, 2004; Kindermann and Krueger 2014), or evaluate positive insurance effects of tax and transfer systems (Kindermann and Krueger, 2014; Flodén and Lindé, 2001). However, a comparative analysis between the three major tax classes, focusing on how inequality can be reduced is absent in the literature and will therefore be conducted in this paper.

I contribute to the literature in two ways. First, I simulate the income and wealth distribution for Germany using an incomplete markets model, which implies that households cannot fully insure against idiosyncratic earnings risk. To smooth consumption in the light of earnings risk, households can vary their saving behavior and their labor supply behavior. Incomplete insurance is the key determinant for heterogeneity in income and wealth levels, which is generated endogenously. The core mechanism is a stochastic earnings process, which is calibrated, for the model to match the German wealth distribution in 2012, as well as the market income distribution in 2011. Furthermore, capital income contributes to generating inequality because the persistence of the earnings process leads to wealth concentration at the upper end of the distribution, which implies an equally skewed capital income distribution. The lower half of the distribution barely accumulates any wealth and is consequently earning very little capital income. Furthermore, German capital and consumption taxes are matched, while the income tax is calibrated for the model economy to match the German government expenditure as a fraction of GDP.

Second, I answer the research question: "How effective and economically efficient are tax reforms in reducing inequality?", by first examining the macroeconomic effects of variations in income, capital, and consumption taxes to assess how distortionary the tax classes are and how aggregate welfare and tax revenue is affected. Then, assuming that additional tax revenue is entirely redistributed as a lump-sum transfer, I evaluate the same variations in taxation in terms of their effectiveness in reducing inequality. Finally, I contrast distributional gains with output reductions, due to higher taxation, in order to identify inequality reducing policies with minimized economic costs.

The main results are as follows: I find welfare gains for increasing income, capital, and consumption taxes, which is theoretically explained by the distributional component of welfare gains outweighing the aggregate component, which is the consumption loss due to output contractions. Furthermore, increased taxes reduce net income and consumption inequality, with income taxes having the most pronounced effect but also causing the largest output decline. In contrast, wealth inequality rises under increased taxation, due to reduced precautionary saving by low-income households, which increasingly rely on transfer payments

to insure against individual earnings risk. Finally, I identify consumption tax increases as the most prudent measure to reduce net income and consumption inequality. An increase in consumption taxes by 8 percentage points raises aggregate welfare by 0.49%, reduces the Gini coefficient for net income and consumption by 4.9% and 4.1%, respectively, while carrying the "tolerable" cost of a 4.3% output decrease.

The remainder of this paper is structured as follows. The next section reviews the existing literature and thereby motivates the research question posed. Section 3 outlines the model, the solution algorithm used to compute its equilibrium, and the calibration to the German economy. Section 4 presents and discusses the results, while section 5 outlines limitations and derives policy advice. Finally, section 6 concludes.

2. Related Literature

This section reviews some of the literature relevant for the research question posed. It firstly documents the evidence for growing income and wealth inequality in Europe and the US (Section 2.1). Then, the mostly adverse economic and societal effects of inequality are discussed (Section 2.2), the literature on determinants of inequality is summarized (Section 2.3) and measures to counter increasing levels of income and wealth inequality are reviewed (Section 2.4).

2.1. Growing Inequality in Europe and the US

Income and wealth inequality has been rising since the 1980s in Europe and the United States. Cingano (2014), in a study for the OECD, documents an increase of the household income Gini coefficient from 0.305 in 1980 to 0.39 in 2012, for the United States. The United Kingdom experienced an increase in income inequality from 0.285 in 1980 to 0.34 in 2011. For Germany the study documents a Gini coefficient of 0.25 in 1985, which rose to 0.3 in 2011. Those results are mirrored by data of the Luxembourg Income survey, which finds an increase in German income Gini coefficient from 0.24 in 1981 to 0.291 in 2013. In contrast, some European countries have not experienced a significant increase in income inequality, being Belgium, the Netherlands and France with fairly constant Gini coefficients of 0.26, 0.275 and 0.3, respectively. However, the overall trend for all OECD countries is an increase in income inequality, measured by the Gini coefficient, from 0.29 in 1985 to 0.32 in 2011/2012.

Piketty (2013) uses the wealth share of the distribution's top 10% as a measure for wealth inequality. For the United States he reports an increase in wealth share from 67% in 1980 to 71% in 2010 for the top 10%. Additional evidence is presented by Saez and Zucmann (2016), who estimate the distribution of wealth in the United States, by capitalizing income tax data. They find that the top 0.1% household's wealth share has risen from 7% in 1978 to 22% in 2012. For Britain Piketty (2013) finds a wealth share increase from 62% in 1980 to 70% in 2010, for the top 10%. Unfortunately, no long term data on the German wealth distribution has been compiled, but Grabka and Westermeier (2014) find that the wealth distribution's Gini coefficient has very moderately increased from 0.776 in 2002 to 0.78 in 2012, indicating a persistently high level of inequality. The study claims that German wealth inequality is among the highest in Europe but fails to provide details. However, the ECB's 2016 household finance and consumption survey finds a wealth Gini coefficient of 0.655 in 2014 for 20 EU member states, supporting the claim for above average inequality in Germany. In summation, the wealth distribution has followed similar dynamics as the income distribution, with growing wealth inequality in Anglo-Saxon countries and currently high level of inequality in Germany.

2.2. Economic and Societal Effects of Inequality

During the last decades, economists' interest in inequality has risen, as data availability improved and adverse consequences became salient. The following section addresses the question: "Is inequality harmful for society and if so, why?". A vast body of theoretical and empirical research discusses the effects of inequality on growth with ambiguous results. First, I review the literature identifying channels by which inequality affects economic growth, followed by empiric studies trying to directly identify growth effects of inequality. Then, I examine the relationship between inequality and health, happiness, and crime.

On the theoretical side the "endogenous fiscal policy" theory was developed by Bertola (1993), Alesina and Rodrick (1994), Persson and Tabellini (1994), and Bénabou (1996). The theory argues that increasing inequality becomes unacceptable to voters, leading them to demand higher taxation and regulation, which are widely perceived to have distortionary effects on the economy and harm growth. Additionally, support for business friendly policies and trust in businesses declines. Such a political and societal climate reduces incentives to invest and thereby restrains growth.

Moreover, the socio-political instability channel describes how high inequality might lead to political instability and social upheaval. Here, adverse economic effects come in the form of increased uncertainty, which deters investment (Alesina and Perotti, 1996; Keefer and Knack, 2002). More specifically, increasing inequality may increase polarization in society, which in turn reduces stability of government policy making and potentially leads to extreme future deviations from current government policies (Keefer and Knack, 2002). The theoretically sketched socio-political instability channel was robustly identified by Alesina and Perotti (1996) and Perotti (1996) in a cross-country panel study and a cross-country study, respectively. Furthermore, Svensson (1998) and Keefer and Knack (2002) find that the negative effect on growth by the socio-political instability channel mainly operates through the quality of private property rights, which is reduced in times of political and societal instability.

Galor and Zeira (1993) argue that financial market imperfections imply investment abilities contingent on one's income and wealth levels, leading to suboptimal resource allocations. For example, low wealth and income households may not sufficiently invest in education, if they cannot afford the tuition fees. This under-investment by the poor reduces aggregate output because their rate of return on education is high for themselves, as well as for society.

Intergenerational mobility fosters growth and economic development because it allows talented and hard-working people from all socioeconomic strata to develop and employ their economic potential. In contrast, low social mobility implies that children from lower class families do not obtain the optimal amount of skills and education, resulting in reduced aggregate output. Krueger (2012) finds a strong negative relationship between income inequality and intergenerational mobility in a cross country comparison based on data by Corak and Piraino (2011) and the OECD. In countries with high levels of income inequality a bigger fraction of economic advantage and disadvantage is passed on from parents to their children, which Krueger refers to as "The Great Gatsby Curve".

The following two paragraphs present theoretical explanations for positive effects of inequality on growth. Mirrlees (1971) and Lazear and Rosen (1981) argue that high inequality provides an incentive to work hard, invest in human capital and take risks. Especially, if high education is associated with high wages and education exhibits diminishing returns lower class households face much higher marginal returns to education, encouraging them to seek more formal training.

Furthermore, high income and wealth inequality fosters aggregate savings because low lifetime-income households save a smaller fraction of their income than high lifetime-income households (Dynan et al., 2004). As a consequence, higher inequality leads to higher savings, implying higher investments, accelerated capital accumulation, and faster economic growth (Bourguignon, 1981).

A large body of empirical research tries to establish the direction and magnitude in which inequality affects economic growth. However, the results are confounding and no consensus was reached thus far. The summary of empiric studies by Neves and Silva (2014) suggests that the effect of inequality on growth is mostly negative in cross-sectional studies, for less developed countries, and when wealth inequality is considered. In contrast, studies using panel data on a sample with mostly developed countries, regional dummies, and the income distribution find an insignificant or positive effect of inequality on growth. An OECD commissioned study by Cingano (2014) finds a sizeable significant negative effect of income inequality on growth for OECD countries during the last thirty years.

Another aspect of inequality, which has received ample attention, is its effect on health outcomes. Subramanian and Kawachi (2004) summarize the existing literature and find that the inverse relationship between income inequality and health outcomes only holds for the US, while studies conducted outside the United states do not find a significant relationship. Aother literature survey by Wagstaff and Doorslaer (2000) summarizes extensive evidence for the "Absolute Income Hypothesis", which states that individual health is a concave function of individual income. Consequently, if fairly equal health outcomes are a societal and political goal, income inequality needs to be kept at a moderate level or healthcare needs to be provided as a public good.

In an econometric study Alesina et al. (2004) investigate the relationship between self-reported happiness or well-being and measured levels of inequality, using survey data from 1972 to 1997. After controlling for various characteristics they find that US citizens are less affected by inequality than Europeans. Zooming further in, a strong negative effect of inequality on the happiness of European poor and politically left winged is identified. In the US no significant effect on low-income respondents and left-wingers is found, while high-income respondents see their happiness reduced when inequality is high.

Using social survey data from 1972 to 2008, Oishi et al. (2011) find that US Americans were on average happier in years with less national income inequality. In contrast, Alesina et al. (2004) identify this inverse relationship for low-income respondents but not for high-income respondents. Additionally, they demonstrate that the negative effect of income inequality on self-reported happiness is explained by perceived fairness and general trust, which are lower in years of high income inequality. In summation, both papers find an inverse relationship between self-reported happiness and inequality, pointing to the importance of income and wealth inequality for overall satisfaction in society.

Finally, researchers have investigated the relationship between inequality and crime. Kelly (2000) uses data from the FBI Uniform Crime Reports to identify the impact of income inequality on violent and property crime. The econometric study finds a strong and robust positive impact of inequality on violent crime but no relationship between inequality and property crime. A theoretical explanation for the link between inequality and violent crime is provided by Merton's (1938) strain theory, which identifies frustration and envy by financially unsuccessful members of society as a driver of crime. When inequality is high unsuccessful citizens are strongly confronted with their inferior position, become alienated from society, and commit crime in response. Furthermore, social disorganization theory focuses on informal social controls and how those are diminished by factors such as poverty, ethnic heterogeneity,

residential mobility and family stability (Shaw and McKay, 1942; Sampson, 1987). Here inequality causes crime indirectly via poverty, which affects the factors named above.

In an empiric cross country panel-data study Fajnzylber et al. (2002) confirm the results by Kelly (2000). The paper investigates the correlation between income inequality, measured by the Gini index, and homicide and robbery rates. After controlling for other crime determinants the study concludes that inequality and crime rates are positively correlated within and between countries, which the authors interpret as causation from income inequality to violent crime rates.

Overall, theoretical and empirical research has clearly identified negative consequences of inequality on health, happiness, and crime pointing to the importance of developing impactful policy measures to reduce inequality.

2.3. Determinants of Income and Wealth Inequality

In the following section I discuss determinants of inequality by first looking at rising concentration of capital income, then reviewing evidence on diverging labor earnings and finally considering the role of labor market institutions, such as minimum wages.

Piketty (2013) mostly attributes rising income and wealth inequality to an increasing share in capital income of the top 1% and top 0.1% households, which had largely inherited their wealth. He shows that today capital income is the main source of income for the top 0.1% in France and the US and concludes that this concentration of wealth and resulting capital income perpetuates itself and drives inequality.[1] Support for this disputed claim comes from Saez and Zucmann (2016), who use income tax data to show that the top 0.1% household's share in total capital income has increased from 15% in 1980 to 42% in 2012, in the United States.

Also, Duenhaupt (2012), wo analyses OECD national accounts finds an increase of relative retained earnings and relative net property income in the time period 1980 to 2005. In the United States relative retained earnings increased from 12% of net national income to almost 16%. Relative property income rose from 6% to slightly above 8%. For Germany relative retained earnings increased from 2% to around 5% of net national income, while net property income rose from around 10% to 17%. This evidence can be interpreted as an increasing share of capital income in total income and knowing that the wealth distribution is very unequal in both countries an increasing concentration of capital income can be inferred for Germany and the US.

The proclaimed pivotal role of capital income in exacerbating inequality is challenged by Acemoglu and Robinson (2015), who argue that the formulation of general laws of capitalism are misguiding and show that Piketty's central economic force, the relationship between the rate of return on capital and economic growth, is not correlated with inequality. Instead, they point to the role of technology, institutions and the political equilibrium in shaping markets and influencing how gains from economic activities are distributed. Their findings are confirmed by Góes (2016), who builds a set of panel SVAR models to conclude that inequality does not increase as the gap between return on capital and economic growth increases.

[1] Complementing his empirical work, Piketty also formulates a disputed theoretical outlook for inequality in the 21st century. He argues that the, net of tax, rate of return on capital will continue to be higher than the growth rate of developed economies, leading to continuously higher returns for capital holders as compared to laborers, which would result in an "endless inegalitarian spiral.".

Hence, evidence points to other factors besides the concentration of wealth and resulting capital income in determining inequality. Biewen and Juhasz (2012) examine the factors behind the rising income inequality in Germany for the period 1999/2000 to 2005/2006. As the key determinant of rising income inequality they identify the increasing dispersion in labor market incomes. The dispersion at the top of the distribution is mostly attributed to skill-biased technical change, while deunionization, and supply side effects can explain inequality increases at the lower tail of the distribution (For Germany: Dustmann et al., 2009; Antonczyk et al.,2010; For US and UK: Acemoglu and Aghion, 2001). Additionally, changes in unemployment and changes in the tax system are identified as significant contributors to income inequality. The study concludes that around 40% of the inequality increase can be attributed to labor income changes, while tax changes and unemployment dynamics each contribute 20%. They acknowledge that capital income increased and is unequally distributed. However, as the share of capital income comprised only 5% of total income in 1994 and 8% in 2007 the effects on income inequality are negligible.

The results for Germany are mirrored by Daly and Valletta (2006), who study determinants of income inequality and poverty in the period 1969 to 1989 in the United States. They find that changing distributions of men's labor income had the largest impact on inequality and poverty, explaining between one half to four-fifths of the increase. Furthermore, changes in family structure explained a substantial share of increased inequality among low-income households. Autor et al. (2008) confirm the salient role of diverging wages in determining inequality for the period 1963 to 2005.

In conclusion, the concentration of capital income at the top of the wealth distribution might contribute to rising inequality in the US, while for Germany only indirect evidence exists. Instead, divergence in labor earnings were identified as the main determinant of income inequality by Biewen and Juhasz (2012). Consequently, a modelling approach, seeking to capture income inequality dynamics in Germany should employ diverging wages as the key mechanism determining the income distribution.

2.4. Taxes and Transfers as a Measures to Counter Inequality

Logically following the previous sections, I know answer the question: "Can tax and transfer systems mitigate the inequality trends sketched above?" First, I discuss empirical findings on how taxation and transfer affect inequality and then turn to the model based literature closely related to this paper.

Joumard et al. (2012) document the redistributive impact of taxes and transfers within OECD countries in the late 2000s. They find that income inequality, as measured by the Gini coefficient, was about 25% lower for disposable income than for market income (before taxes and transfers). More precisely, about three quarters of the inequality reduction can be attributed to transfers, while one quarter accrues to taxes. Importantly, the study finds that some countries with a relatively small tax and transfer system (e.g. Australia) accomplish a similar redistribution than countries with higher taxes (e.g. Germany) because they rely more on progressive income taxation and well targeted transfers. These results are roughly mirrored by Wang and Caminada (2011), who use data by the Luxembourg Income Study (LIS), for 36 countries, finding a reduction of Gini coefficient measured income inequality of 30%. Here, 85% of the reduction are attributed to transfers and 15% to taxes. Also based on LIS data for 20 countries, Wang et al. (2013) find that two thirds of the average increase in primary income inequality, observed since the 1980s, were offset by tax and transfer systems.

Specifically addressing the role of progressivity in income taxation, Duncan and Peter (2012) use national tax data and inequality data from the World Institute for Development

Research, among other sources, in a cross-country study. They find a negative relationship between income tax progressivity and income Gini coefficient. The effect is strong for self-reported income and small but significant for a consumption-based inequality measure.

In context of the then political discussion Bach et al. (2014) investigate revenue and distributional effects of a one-time capital levy on net-wealth. Based on data of the German Socio-Economic Panel (SOEP), they find that wealth inequality would be strongly reduced for a net wealth levy with personal and child allowances of 1mil € and 250,000 €, respectively. Such a wealth taxation scheme would almost only charge the top 1% and thereby constitute a targeted redistribution measure.

Closely related to the empiric findings above, scholars have employed incomplete market models, which allow for capturing the wealth and income distribution, to assess economic and distributional effects of taxes and transfers. Already the literature's seminal paper by Aiyagari (1994) tries to account for the US wealth and income inequality but achieves only poor resemblance. Additionally, the author points to the importance of incomplete markets and heterogeneous households when assessing welfare implication of capital tax reductions. Using representative agent and complete market models Chamley (1986) and Lucas (1990) find the optimal capital tax to be zero. In contrast, Aiyagari (1995) shows that, given incomplete markets and heterogeneity, capital taxes are positive in the long run. However, distributional implications are disregarded. Addressing this limitation Domeij and Heathcote (2004) revisit the topic by solving an incomplete markets model for its transition path for capital taxes between 0% and 50%. They find welfare losses for reduced capital taxes and assess the distribution of welfare gains, finding that only between 25.3% and 27.1% of the population would benefit from capital tax reductions. In a related study Imrohoroglu (1998), employs an overlapping generations model with heterogeneous households to assess the claim of zero capital taxes being welfare maximizing. For the benchmark calibration he finds the welfare maximizing capital tax rate to be 10%, which is in line with the studies above finding positive welfare maximizing capital tax rates, when markets are incomplete and households heterogeneous.

Eliminating consumption taxes is briefly discussed in Domeij and Heathcote (2004) and results in an aggregate welfare loss because consumption gains on the aggregate level, due to less distortionary taxation, is more than offset by welfare losses due to redistribution from rich to poor. On a similar note, Correia (2010) examines the distributional and welfare effects of replacing the current US tax code with only a flat tax on consumption. The analysis finds improved economic efficiency and reductions in wealth inequality, when introducing the flat consumption tax, coupled with a nondiscriminatory transfer. The result is mainly driven by households in the lower 50% enjoying higher welfare after the reform.

Furthermore, incomplete market models have been employed to study effects of variations in income taxation. Conesa and Krueger (2005) identify the welfare optimizing progressivity of the income tax code for the US economy. They conclude that a flat tax rate schedule with a fixed deduction of about 9,400$ well approximates the optimal income tax code. Briefly discussing distributional implications of switching to optimal taxation, the study finds increased consumption inequality, indicating that the aggregate welfare gain is driven by efficiency gains in the economy. Moreover, Heathcote (2001) examines short run effects of changes in the timing of income taxes, testing the Ricardian Equivalence in a variety of model specifications with incomplete markets and aggregate uncertainty. He finds substantial declines in aggregate consumption for increased income taxation, where low-income low-wealth households' consumption is most sensitive to changes in the tax code. He primarily attributes this sensitivity to the borrowing constraint, which prevents those households from effectively smoothing consumption. While the paper broadly considers distributional characteristics in

calibrating the model economies, it does not examine how income and wealth distributions are affected by tax changes.

Moreover, Kindermann and Krueger (2014) enrich an incomplete markets model with overlapping generations and income tax progressivity to identify the welfare maximizing and optimally insuring marginal income tax rate for the top 1%. They find that a marginal tax rate around 90% provides optimal social insurance against idiosyncratic earnings risk and large positive distributional consequences. Their results are mirrored in Brüggemann and Yoo (2014). Finally, Flodén and Lindé (2001) assess the role of government's role in mitigating individual earnings risk via tax and transfer programs, in the US and Sweden. They estimate stochastic earnings processes for the US and Sweden and simulate the respective wealth distributions, based on the processes. The income taxes are varied on a range of 40 percentage points around the benchmark rate and a 10 percentage point tax increase in the US, as well as a 30 percentage point tax reduction in Sweden are identified as welfare maximizing. Additionally, wealth, earnings and total income inequality is evaluated and the paper concludes that, at least in the US, households are willing to give up consumption to insure against earnings risk.

Overall, the literature has put high emphasis on investigating economic distortions and welfare effects of variations in taxation, while distributional implications have mostly been a subordinate topic. Therefore, the following comparative analysis specifically examines distributional implications of variations in income, capital and consumption taxes. Furthermore, I aim at identifying inequality reducing policies, which simultaneously keep economic distortions minimal.

3. An Incomplete Markets Model with Endogenous Labor Supply and Taxes

I employ the workhorse incomplete markets model developed by Huggett (1993), and Aiyagari (1994). To study distributional effects of tax reforms, I abstract from aggregate productivity shocks, so no business cycle is modeled. This approach is motivated by previous studies, for example Imrohoroglu (1989) and Krusell and Smith (1999), indicating that aggregate uncertainty is negligible for assessing welfare and distributional implications of tax changes.

3.1. Model Specification

The environment: The economy is populated by a continuum of infinitely lived households, which chose consumption and leisure endogenously. Households maximize expected discounted utility from consumption and leisure. The aggregate capital stock and aggregate labor supply is determined endogenously by the households' savings decisions and hours choices. Then, aggregate capital and labor pin down aggregate output, the efficiency wage, and the interest rate, in the competitive production sector, using a Cobb-Douglas production function. There is a government levying taxes on wages, capital income and consumption. Every period the entire tax revenue is transferred to all households as a lump-sum payment.

In the economy modeled households face idiosyncratic labor productivity shocks, which are governed by a stochastic process. Markets that could theoretically allow complete insurance against the income risk do not exist because there is only a single savings instrument: The risk-free asset. The absence of state-contingent assets imply that households can only partially self-insure by accumulating precautionary asset holdings, as in Huggett (1993), Aiyagari (1994), and Aiyagari and McGrattan (1998). All households start with the same wealth endowment and incomplete financial market ensures that households' productivity shock

histories make them heterogeneous in asset holdings ex post. Additionally, no borrowing is permitted, which limits the ability of a low-wealth household to smooth consumption when experiencing a fall in income. I now turn to a more formal description of the model.

The household's problem: Each infinitely lived household provides $\mathrm{h_t}$ hours of labor and chooses consumption $\mathrm{c_t}$ for every period. Households maximize expected lifetime utility, where β is the subjective discount factor and θ weights preferences between consumption and leisure.

$$max\, E_0 \sum_{t=0}^{\infty} \beta^t\, u(c_t, h_t)$$

The households' consumer problem can be described by a Bellmann equation, where all households solve the same recursive consumer problem conditional on the states (a_t, z_t). Here $\mathrm{c_t}$ is consumption, $\mathrm{a_t}$ asset holdings, the net interest rate is $r_t = uc - \delta$, where uc is the user cost of capital (the rate firms pay to rent capital), δ is the depreciation rate, h_t is labor supply, $\mathrm{z_t}$ is the idiosyncratic productivity level, τ^{c} is the consumption tax, τ^{k} is the capital tax, τ^{h} is the income tax and T_t is the per capita lump-sum transfer in each period. The parameters are restricted to be $0 < \beta < 1$ and b, the borrowing constraint, is set to 0. The efficiency wage w_t and the net interest rate $\mathrm{r_t}$ are determined in the competitive production sector.

$$V(a_t, z_t) = \max_{\{a_{t+1}, h_t\}} u(c_t, h_t) + \beta E_t[V(a_{t+1}, z_{t+1})]$$

subject to

$$c_t(1+\tau^c) + a_{t+1} = \left(1 + r_t\left(1-\tau^k\right)\right) a_t + h_t z_t w_t\left(1-\tau^h\right) + Tr.$$

$$z_{t+1} \sim \Omega(z_t), \quad z_{t+1} \in Z = \{z_1, \dots, z_n\}, \;\; n < \infty$$

$$c_t \geq 0, \;\; h_t \geq 0, \;\; a_{t+1} \geq -b$$

The effective labor supply depends on the hours worked $\mathrm{h_t}$ and the stochastic labor productivity $\mathrm{z_t}$. Each period households' productivity takes on one of $n < \infty$ values in the set $Z \in R_+$. At each time t a productivity realization is drawn from the finite valued set Z. The evolution of productivity is governed by a first order Markov chain with transition probabilities defined by the $n \times n$ Matrix Ω. Each row in Ω has to add up to 1 and e.g. $\Omega_{2,1}$ defines the probability to transition from productivity state z_2 at time t to state z_1 at time $t+1$.

$$\Omega = \begin{bmatrix} \Omega_{1,1} & \dots & \Omega_{1,n} \\ \dots & \dots & \dots \\ \Omega_{n,1} & \dots & \Omega_{n,n} \end{bmatrix}$$

Let the state space, all possible combinations of asset holdings and productivity states, be defined by X. Then the position of a household is described by $x = (a, z)$. that belongs to the state space $X = A\; x\; Z$,where A is the set of possible asset holdings.

The firm's problem: There is one representative firm producing per capita output according to a Cobb-Douglas production function with aggregate capital and effective labor as inputs.

$$Y_t = K_t^{\theta} H_t^{1-\theta}$$

Here Y_t is aggregate output at time t produced from aggregate capital K_t and aggregate labor H_t. The firm's maximization problem is defined as follows with A being an exogenous production productivity parameter.

$$\max_{\{K_t, H_t\}} \{AK_t^{\theta} H_t^{1-\theta} - (r_t + \delta)K_t - w_t H_t\}$$

The FOC with respect to capital yields the interest rate.

$$r_t = A\theta \left(\frac{K_t}{H_t}\right)^{\theta-1} - \delta$$

Plugging this expression into the firm's first order condition for labor, the equilibrium wage rate can be written as a function of the interest rate.

$$w_t = (1-\theta)\left(\frac{A\theta}{r_t + \delta}\right)^{\frac{\theta}{1-\theta}}$$

Stationary equilibrium: Given no cyclically moving subsets, the first-order Markov chain has a stationary distribution to which it converges over time. Let the probability distribution of $\mathrm{z_t}$ at any time t over Z be represented by the vector $p_t \in R^n$ where $p_t \geq 0$ and $\sum_{i=1}^{n} p_{I,t} = 1$. Let the initial distribution be $\mathrm{p_0}$ then the distribution at date t is given by $\mathrm{p}_t = p_0 \Omega^t$. Under mild regulatory conditions Z has a unique ergodic set with no cyclically moving subsets, then p_t converges to a unique limit p^* for any p_0 and high enough t. This implies the existence of a, in steady state time-invariant, probability measure φ describing the mass of households for each level of wealth a and productivity z. It can be calculated using the policy function for asset holdings and the Markov process for the productivity shocks. The measure φ is defined on the sigma-algebra $\mathcal{F}$ containing all Borel subsets of X. φ is the economy's aggregate state. Call $P(x, M)$ the transition function, which gives the probability that a household in individual state x at time t will have an individual state that lies in the set $M \epsilon \mathcal{F}$ in $t + 1$. I denote the aggregate stock of capital and labor as $K(\psi)$ and $H(\psi)$, both functions of the aggregate state φ.

A stationary competitive equilibrium with incomplete markets is a set of functions (V, c, h, a, ψ, K, H) and prices (w, r) such that:

(1) V satisfies the Bellmann equation and $c(x)$, $h(x)$ and $a(x)$ are the associated policy functions, for optimal choices of consumption, labor and capital given (w, r).

(2) Aggregate capital and effective labor is generated by the households' policy functions, where the Lebesgue Integral is taken over all possible individual states X with respect to the measure φ, where $x = (a, z)$.

a. $\int_X a(x)\, d\psi = K(\psi)$

b. $\int_X zh(x)\, d\psi = H(\psi)$

(3) The equilibrium prices (w, r) clear the factor markets given $K(\psi)$ and $H(\psi)$.

a. $r_t = A\theta\left(\frac{K_t}{H_t}\right)^{\theta-1} - \delta \qquad t = 0, 1, \ldots$

b. $w_t = (1-\theta)\left(\frac{\theta}{r_t+\delta}\right)^{\frac{\theta}{1-\theta}} \qquad t = 0, 1, \ldots$

(4) The law of motion determined by the transition function P, implied by the decision rules, contains the stationary distribution ψ, as a fixed point (individual and aggregate behaviors are consistent).

a. $\psi(M) = \int_X P(x, M)\, d\psi \qquad$ for all $M \in \mathcal{F}$

The Government: Taxes are used for government consumption and transfers, so the government budget constraint has to clear every period.

$$T = \tau^c C(\psi) + \tau^k r K(\psi) + \tau^h w H(\psi)$$

Where $C(\psi) = \int_X c(x)\, d\psi$

Tax revenue is used to finance government consumption C^G, exogenously fixed as a percentage of GDP, and lump-sum transfers $Tr.$.

$$T = C^G + Tr.$$

3.2. Solution Algorithm and Welfare Measure

Solution algorithm: The algorithm is based on Flodén and Lindé (2001) and inspired by Huggett (1993) and Aiyagari (1994). It uses value function iteration, within loops for the market clearing interest rate and labor supply, to find value and policy functions over a discretized state space. Roughly sketched, the algorithm consists of the following steps: First, I define parameters and discretize the state space, being all possible combinations of asset holdings and productivities. Asset holdings are approximated by a grid of 50 different values, where the step size between asset levels is increasing in wealth. The productivity grid consists of 7 realizations for temporary productivity.

Second, I fix the tax rates and guess an initial interest rate r. Then, I make initial guesses for labor, consumption, and asset policy functions, and initiate the value function. Finally, I guess the aggregate effective labor supply, $\breve{H}$.

All following steps happen within a loop for capital and effective labor. The, outer, capital loop stops when aggregate savings, the capital supply, equals total capital demand by the representative firm. The, inner, effective labor loop stops when the implied labor supply equals the initial guess. Third, I solve for the capital stock as the firm's capital demand contingent on $\breve{H}$. Then, I calculate aggregate consumption, as output minus depreciation and government consumption and derive the wage rate, w, per unit of effective labor supply as a function of r and $\breve{H}$. Subsequently, I calculate the transfer level implied by the government budget constraint.

$$Tr. = \tau^c C(\psi) + \tau^k r K(\psi) + \tau^h w H(\psi) - C^G$$

Fourth, I find the households' policy functions and value function by iterating on the first order conditions until the value function converges, while labor and consumption policy functions are determined within the loop. The policy function for asset holdings is

approximated with piecewise linear functions. Policy functions for consumption and labor supply are solved as functions of asset choices, which allows them to be nonlinear between grid points.

Fifth, I calculate aggregate asset holdings and aggregate effective labor supply is calculated from simulations. I simulate an economy with 200 households for 3500 periods. The economy starts with evenly distributed asset holdings, which match the aggregate capital demand. I assign initial productivities based on a draw of random numbers. Based on the utility maximizing decision rules derived above and their position in the state space households make labor and savings choices. I then discard the observations in the first 500 periods, to allow the productivity distribution to converge to its stationary distribution. Using the remaining 600,000 observations I calculate aggregate asset holdings, aggregate effective labor supply, and further statistics for the economy.

Sixth, I update labor supply to the simulated value and the effective labor loop stops, if the simulated labor supply equals the initial guess, $\breve{H}$. Then the implied capital supply is contrasted with the firm's labor demand and the capital loop stops, if supply matches demand. If they do not match the algorithm updates the interest rate guess and the loop restarts. Consequently, the equilibrium for given tax rates is found when labor and capital markets clear.

Welfare Measure: The measure of welfare changes is standard, being the percentage change in consumption an individual would need to be as well off as it was in the benchmark economy. The welfare change Δ is therefore defined via the following equation, where utility over all households and all periods is aggregated. In the practical implementation the integral over households becomes the mean over the 200 households simulated 3500 periods forward. c_t^* and h_t^* are consumption and labor in the benchmark economy, while c_t and h_t are consumption and labor given variations in taxation.

$$\int_X \sum_{t=0}^{\infty} \beta^t \, u(c_t^*, h_t^*) \; d\psi = \int_X \sum_{t=0}^{\infty} \beta^t \, u((1+\Delta)c_t, h_t) \; d\psi$$

3.3. Calibration

My calibration strategy is to capture the German tax system, key national accounts ratios, as well as the income and wealth distribution. The data used for the distributional calibration is provided by the German Council of Economic Experts' annual report for 2014/2015. Details on the German income and wealth distribution are given for 2011 and 2012, respectively. National accounts data is retrieved for 2012. Tax data is retrieved from the German Federal Ministry of Finance.

Tax environment: The Consumption or VAT (value-added tax) rate is set to 19%, being the German standard VAT rate since 2007. Calibrating the models consumption tax to 19% abstracts from staple foods, cultural goods and a variety of other products being subject to a reduced VAT rate of 7%. Since 2009 the capital income tax is flat at 25%. Additionally, 5% solidarity surcharge, which redistributes tax revenue from West to East Germany, is levied on the tax amount to be paid. Consequently, a flat tax of 26.375% is levied on capital income. The models capital tax is calibrated to 26.375%, which abstracts from the fact that individuals with a personal progressive income tax rate below 25% only pay their income tax rate on capital income. German income tax is levied progressively with marginal rates between 0% and 47.475%, excluding additional charges to social security and healthcare. This tax progressivity is not modeled, instead the tax rate on income, including social security, is determined by the government budget constraint, when matching German government consumption. This approach yields an income tax rate, including social security, of 52.18%.

Based on this calibration the total government tax revenue in the benchmark economy consists of 76.2% income tax revenue, 20.1% consumption tax revenue, and 4.8% capital tax revenue. In Germany various taxes are levied at the municipal, state, and federal level making a comparison of the model generated tax revenue structure to empiric data difficult. As an indication: Consumption tax is only levied at the federal level and constituted 33.9% of the total federal tax revenue in 2010 (German Federal Ministry of Finance, 2017).

Macroeconomic Aggregates: As mentioned above, the model is calibrated to match key national account ratios of the German economy in 2012. Table 1 shows the national accounts data used and the ratios calculated for calibration.

Table 1: Macroeconomic Ratios

Data, 2012		**Ratios for Calibration**	
GDP[1]	2758260 m €	K/Y	2.81
Capital Stock[2]	7758100 m €		
Government Expenditure[1]	0.443 % of GDP	C^G/Y	0.255
Expenditure for social protection[1]	0.188 % of GDP	Tr./Y	0.188

Note: K is capital stock, C^G is government consumption excluding social transfers, Tr. is social transfers,[1] author's rendering of Eurostat data, [2] author's rendering of European Commission AMECO data

Preference, technology and government parameters: The utility function is assumed to have constant elasticity of substitution (CES) and unit elasticity of substitution between consumption and labor.

$$u(c_t, h_t) = \frac{(c_t^{\vartheta}(1-h_t)^{1-\vartheta})^{1-\mu}}{1-\mu}$$

The given utility function has been widely used in the literature and is line with the observation that, although real wages have increased sharply hours worked remained roughly constant during the last decades. Here, μ is the inverse of the intertemporal elasticity of substitution, which I set to 2. This implies a risk aversion towards consumption fluctuations of 1.5. The weighting parameter ϑ is set to 0.5, implying leisure being valued equally to consumption and an average of 26% of available time spent working, in the German benchmark economy. The subjective, individual discount parameter β is calibrated to have the model economy match the German capital to output ratio, which was 2.81 in 2012. I set the share of capital in the standard Cobb-Douglas production function to 0.36, as usually done in the literature. Moreover, I assume a depreciation rate of 10% yearly.

Table 2: Benchmark Model Economy Parameters, Yearly

Preferences		**Technology**		**Government**	
Parameter	Value	Parameter	Value	Parameter	Value
β	0.9686	δ	0.1	τ^h	0.5218
μ	2	θ	0.36	τ^k	0.2638
ϑ	0.5			τ^c	0.19

The earnings process: The literatures' standard approach for modeling earnings risk is to estimate a stochastic earnings process based on longitudinal data and then discretize the, mostly AR(1), process into a first order Markov chain (Domeij and Heathcote, 2004; Flodén and Lindé, 2001; Hubbard et al., 1995; Storesletten et al., 2001). However, for Germany only a parsimonious, random-walk, earnings process was estimated by Fuchs-Schündeln et al. (2010). As this process could not generate the German income and wealth distribution in the model economy, I follow the approach of Castañeda et al. (2003) to calibrate the productivity states and first order Markov chain in order to match empiric data. Table 3 shows productivities for seven different states, as well as sizes of the seven productivity cohorts.

Table 3: Relative Productivity States and Sizes of Productivity Groups

	z_1	z_2	z_3	z_4	z_5	z_6	z_7
Relative productivity	0.2432	0.6079	1.2401	1.6534	1.6534	3.0151	14.5890
Size productivity group	0.3139	0.2043	0.2263	0.1466	0.0518	0.0554	0.0016

Note: Relative productivity is absolute productivity over aggregate average productivity

The first order Markov chain given in Table 4 governs the transition probabilities from one productivity state to another. It was specified for the economy to match market income after taxes and wealth decile distributions for 2011 and 2012, respectively.

Table 4: Transition Matrix for Household Productivity Process

	z_1	z_2	z_3	z_4	z_5	z_6	z_7
z_1	0.97	0.015	0.0075	0.0075	0	0	0
z_2	0.019	0.962	0.019	0	0	0	0
z_3	0.01	0.0135	0.953	0.0235	0	0	0
z_4	0.005	0	0.03	0.93	0.035	0	0
z_5	0.005	0	0	0.05	0.89	0.0545	0.0005
z_6	0.04	0	0	0	0.01	0.949	0.001
z_7	0.004	0	0	0	0.01	0.00005	0.94995

Distributional properties: Table 5 compares the wealth deciles generated by the benchmark economy to German wealth deciles in 2012. The highest deviation is observed for the 8th decile, being 2.77 percentage points (p.p.). Also the 9th and 10th deciles deviate from the actual data by 2.33 p.p. and 2.63 p.p., respectively. Overall, the model resembles the wealth distribution along all ten deciles with deviations spread fairly evenly. The wealth Gini coefficient is 0.78 in the data and 0.7 in the model economy, which is a good fit, considering that the model has to generate high wealth inequality and simultaneously comparably low income inequality with a Gini coefficient of 0.49.

Table 5: Distributional Fit of Benchmark Model Economy. Wealth

		Data, 2012	Model	Deviation
Decile	1st	-1.60%	0.00%	-1.60 p.p.
	2nd	0.00%	0.00%	0.00 p.p.
	3rd	0.00%	0.16%	-0.16 p.p.
	4th	0.40%	1.6%	-1.20 p.p.
	5th	1.20%	3.66%	-2.46 p.p.
	6th	3.40%	5.57%	-2.17 p.p.
	7th	7.00%	7.23%	-0.23 p.p.
	8th	12.10%	9.33%	2.77 p.p.
	9th	19.90%	17.57%	2.33 p.p.
	10th	57.50%	54.87%	2.63 p.p.
Gini		0.78	0.70	0.08

Note: Author's rendering of German Council of Economic Experts (2014) data

As mentioned above, the main difficulty in the models calibration was generating high wealth inequality and only moderate income inequality. Table 6 reports market income inequality deciles for 2010 and the corresponding deciles generated by the model. Due to limited data availability I am calibrating the wealth distribution to 2012 data and the income distribution to 2011 data. However, it can be assumed that the income distribution is fairly stable over a one-year time horizon. The largest deviation in the model's income distribution is found for the 5th decile, being 2.64 p.p. Also, the 10th decile deviates by 2.22 p.p. Again, the overall distribution is closely matched and small deviations are spread over the whole range. The model generates an income Gini coefficient of 0.53, which is close to the actual income Gini coefficient of 0.49 in 2011.

Table 6: Distributional Fit of Benchmark Model Economy. Market Income After Transfers

		Data, 2011	Model	Deviation
Decile	1st	0.11%	0.12%	-0.01 p.p.
	2nd	1.16%	0.17%	0.99 p.p.
	3rd	2.77%	1.57%	1.20 p.p.
	4th	5.04%	3.96%	1.08 p.p.
	5th	7.20%	4.57%	2.64 p.p.
	6th	9.16%	11.17%	-2.01 p.p.
	7th	11.36%	12.45%	-1.10 p.p.
	8th	13.98%	14.85%	-0.87 p.p.
	9th	17.91%	17.60%	0.31 p.p.
	10th	31.31%	33.53%	-2.22 p.p.
Gini		0.49	0.53	-0.05

Note: Author's rendering of German Council of Economic Experts (2014) data

Although the model was not specifically calibrated to match the German net income distribution, Table 7 reports a close fit of the 2011 net income distribution and the one generated in the model economy. The largest deviations are 1.93 p.p. and 1.87 p.p. for the 6th and 10th decile, respectively. Furthermore, the net income Gini coefficient is 0.29 in the data and 0.35 in the benchmark economy. In summation, the calibration succeeded in resembling the wealth, market income and net income distribution of Germany.

Table 7: Distributional Fit of Benchmark Model Economy. Net Income

		Data, 2011	**Model**	**Deviation**
Decile	1st	3.60%	3.49%	0.11 p.p.
	2nd	5.28%	3.53%	1.75 p.p.
	3rd	6.35%	4.75%	1.60 p.p.
	4th	7.25%	6.03%	1.21 p.p.
	5th	8.17%	6.55%	1.62 p.p.
	6th	9.14%	11.08%	-1.93 p.p.
	7th	10.36%	11.36%	-1.00 p.p.
	8th	11.96%	13.09%	-1.12 p.p.
	9th	14.35%	14.73%	-0.38 p.p.
	10th	23.54%	25.41%	-1.87 p.p.
Gini		0.29	0.35	-0.06

Note: Author's rendering of German Council of Economic Experts (2014) data

Distributional properties of income types in total income: When interpreting distributional effects of taxation reforms, it is instructive to know how total income is composed. Table 8 reports the shares labor income, capital income, and transfers have in total income. Moreover, the shares are reported for deciles of the market income after transfers distribution and compared to data by the German Council of Economic Experts (2014). Self-employed and employed earnings are summarized as labor income, imputed rental income, capital income, private transfers, and private pensions are grouped as capital income, while public transfers and public pensions form transfer income. Including public pensions as transfers is motivated by the redistributive design of the German pension code. On the aggregate level, the model economy overstates transfers by 14.67 p.p. and understates the labor income share by 15.97 p.p. The share of capital income in total income matches the data closely with a deviation of only 1.32 p.p. For labor income and transfers the mismatch is mostly found in the lower 50% of the distribution, where the labor income share is drastically understated and transfers substantially overstated. Interestingly, the model generates capital income shares of 24.94% for the 3rd decile and 19.65% for the 6th decile. An intuitive explanation is that households which had high productivities for some periods accumulated sizable asset holdings and then rely on capital income instead of providing labor, when their productivity declines due to the stochastic productivity process. This reasoning is corroborated by the fact that the 4th decile provides more than 5 times the effective labor of the 3rd net income decile but only earns 27% more net income. The same holds for the relation between the 6th and 7th decile.

Table 8: Distributional Fit Labor, Capital, and Transfer Share in Total Income

		Labor income share			Capital income share			Transfers share		
		Data, 2011	Model	Deviation	Data, 2011	Model	Deviation	Data, 2011	Model	Deviation
Decile	1st	32.20%	1.78%	30.42 p.p.	8.06%	0.66%	7.40 p.p.	59.74%	97.56%	-37.82 p.p.
	2nd	50.99%	2.46%	48.53 p.p.	6.54%	0.95%	5.59 p.p.	42.45%	96.59%	-54.14 p.p.
	3rd	58.50%	4.12%	54.37 p.p.	6.48%	24.94%	-18.46 p.p.	35.02%	70.93%	-35.91 p.p.
	4th	61.59%	33.14%	28.45 p.p.	7.26%	11.16%	-3.90 p.p.	31.07%	55.70%	-24.63 p.p.
	5th	67.22%	39.51%	27.71 p.p.	7.42%	7.42%	0.00 p.p.	25.36%	53.06%	-27.71 p.p.
	6th	72.70%	49.73%	22.97 p.p.	6.74%	19.68%	-12.94 p.p.	20.56%	30.59%	-10.03 p.p.
	7th	74.79%	64.93%	9.86 p.p.	7.40%	5.09%	2.31 p.p.	17.80%	29.97%	-12.17 p.p.
	8th	74.96%	63.86%	11.10 p.p.	8.73%	10.19%	-1.46 p.p.	16.31%	25.96%	-9.64 p.p.
	9th	79.86%	70.39%	9.47 p.p.	8.31%	6.44%	1.87 p.p.	11.84%	23.17%	-11.34 p.p.
	10th	77.98%	74.47%	3.52 p.p.	13.78%	12.11%	1.67 p.p.	8.16%	13.43%	-5.26 p.p.
Total		71.39%	55.42%	15.97 p.p.	9.21%	10.53%	-1.32 p.p.	19.38%	34.05%	-14.67 p.p.

Note: Deciles are for market income after transfers distribution, author's rendering of German Council of Economic Experts (2014) data, data aggregated for Germany by population weighing the data for East and West Germany.

4. Results

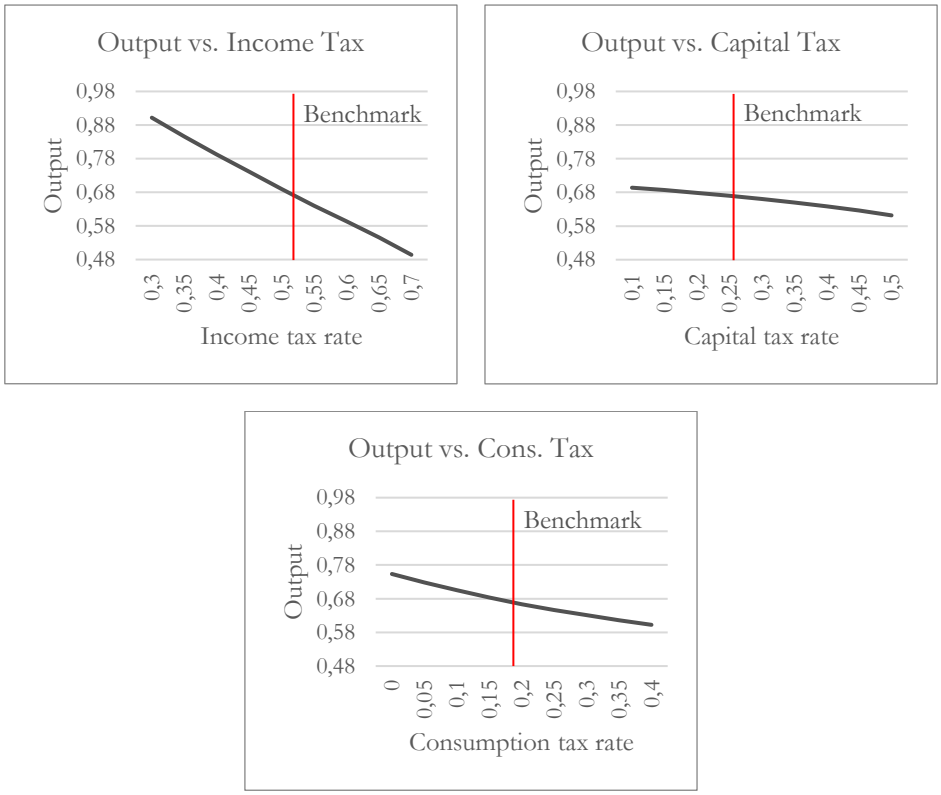
The following section sets out the main results, being an analysis of macroeconomic and distributional effects of taxation reforms. Throughout the section I will discuss effects on macroeconomic aggregates, income and wealth deciles and effective labor supply within those deciles. This information is laid out in detail in the appendix. After having calibrated the model to the German economy, I vary income, capital and consumption tax around its benchmark values. I always hold two tax rates fixed, at the benchmark value, while varying the third by increments of 5 percentage points. I set the range of tax variation so that its mean is close to the benchmark value. However, the range for income and capital tax rates is set to lower values, in order to keep the tax scenarios in a range that is "acceptable" for society. I examine income taxes from 30% to 70%, capital taxes from 10% to 50%, and consumption tax rates from 0% to 40%.

I first lay out the distortionary effects on economic output, discusses tax revenue implications and investigates welfare effects. The observed welfare gains can be explained by utility gains due to redistribution across ex-ante heterogeneous households, the distributional component, which is counteracted by distortionary effects of increased taxation, the aggregate component. Subsequently, I discuss the tax reforms' distributional implications in detail.

4.1. Economic Output

Figure 1 depicts economic output against income, capital, and consumption tax rate variations.

Figure 1: Output vs. Income, Capital and Consumption Tax



Economic distortions are biggest for variations in the income tax rate, which can largely be explained by the reduction of aggregate effective labor supply from 0.47 to 0.29 for income tax rates of 30% and 70%, respectively. As a consequence of reduced labor supply individual households have lower total income, leading to a decline in absolute savings and investments.

This effect is mitigated but not offset by an increase of the market clearing wage rate from 1.35 to 2.24. On the aggregate level, falling individual savings lead to a declining capital stock, being 2.83 for 30% income tax and only 1.31 for a 70% income tax rate. Moreover, the magnitude of the output decline is determined by the 55.42% percent share of labor income in total household income, which implies a substantial impact of variations in income taxation. Consequently, households adjust their consumption-savings and leisure-labor decisions drastically to maintain utility maximization under the new tax code.

The distortionary effects of increased capital taxation are much less pronounced, with output declining from 0.69 to 0.61 for capital taxes of 10% and 50%, respectively. In the model economy capital taxes are levied at a fixed rate on capital returns, which are defined as the market clearing interest rate on current asset holdings of a household. Consequently, capital taxes are linearly related to capital returns, which are linearly related to asset holdings, the wealth of a household. Therefore, capital taxes constitute an indirect taxation of wealth, leading to lower individual asset holdings and causing aggregate capital to decline from 2.03 to 1.56 for capital tax rates of 10% and 50%, respectively. Aggregate labor stays fairly constant over the tax range, only declining from 0.38 to 0.36. Accordingly, the economic distortion of capital taxation is largely explained by reduced capital, while changes in labor supply play only a minor role. The output decline's small magnitude is also due to the small share of capital income in total household income in the model economy, namely 10.53%. As a consequence, households' total income is only moderately affected by capital tax increases, leading to small adjustments in the consumption-savings and leisure-labor decisions.

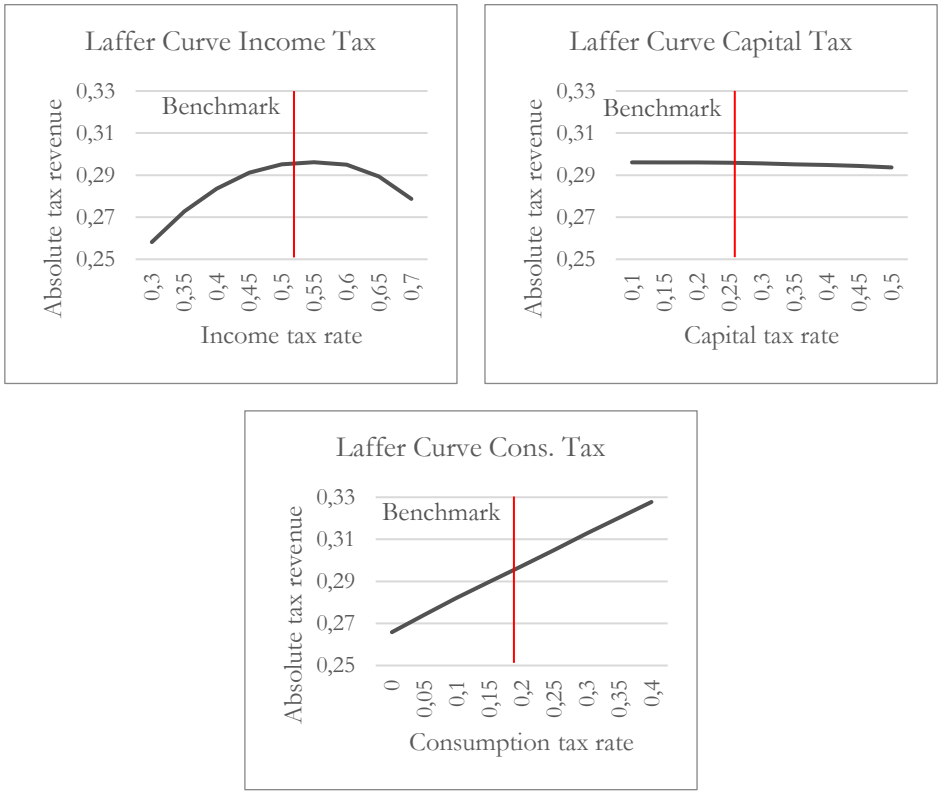
Over the range of consumption taxes, I find a decline in economic output from 0.75 to 0.6. The contraction is explained by a reduction in aggregate effective labor by 17.8% from 0.42 to 0.34 and aggregate capital declining by 23.6% from 2.17 to 1.66. An increase in taxation makes consumption relatively more expensive compared to leisure. This change in elasticity of substitution shifts households' time allocation from labor to leisure, causing the observed reduction in effective labor supply. As a consequence, households face reduced total income, leading to reduced absolute savings and ultimately to a declining capital stock.

4.2. Tax Revenue

Discussing tax revenue maximizing policies is of importance because a higher government budget increases the amount of transfers to be redistributed. Consequently, the capacity of taxation reforms in increasing total tax revenue is an important determinant of a tax reform's redistributive effectiveness. I find the typical hump shaped relationship between income tax and absolute tax revenue, plotted in Figure 2. The hump shape occurs because declining effective labor supply, at some point, offsets the tax gains from increasing the income tax rate. The curve peaks at an income tax rate of 55%, resulting in absolute tax revenues of 0.296. Therefore, moderate tax revenue increases can be achieved by raising income taxes from 52.2%, in the benchmark economy, to 55%. Furthermore, how tax revenues are allocated changes significantly over the income tax range. For 30% income tax, 10.9% of total tax revenue goes to transfers, while for an income tax of 70% around 54.5% of total tax revenue is spend on transfer payments. The model generates this result because government consumption is exogenously fixed at the benchmark level, so changes in tax revenue are entirely attributed to transfers. This specification is chosen to evaluate policy scenarios, which aim at reducing inequality. Moreover, data roughly supports the idea of levying high income taxes in order to finance social transfers. I find a positive relationship between the budget share spend on social protection transfers and income tax levels. In 2011, Denmark, France, Finland and Austria spend the highest fractions of their budget on social protection transfers, being

24.3%, 23.7%, 22.7%, and 20.8%, respectively (Eurostat, 2017). McDaniel (2014) finds the highest average income tax rates in Europe for Belgium, France, Austria, and Germany, being 41.2%, 39.3%, 39%, and 37.8%, respectively, which points to a positive relation between income tax level and budget share spend on transfer payments.

Figure 2: Tax Revenue vs. Income, Capital and Consumption Tax



Increasing capital taxation has only a very small effect on overall tax revenue, which decreases from 0.3 to 0.29 over the range of capital taxes. The very modest change in tax revenue is explained by the small share of capital income in overall income, implying a small share of capital income taxes in overall tax revenue, namely 4.8% in the benchmark economy. The decline in tax revenue, when increasing capital taxes, is explained by the substantially decreasing capital holdings of individual households, leading to a 23.4% decline in aggregate capital stock, over the range of capital taxes. As a consequence, capital income is reduced, which more than offsets potential tax gains through higher capital tax rates.

When varying consumption taxes from 0% to 40%, I find an increase in total tax revenue of 23.3% going from 0.27 to 0.33. Those large tax gains are explained by the less distortionary nature of consumption taxes, as discussed in the section above. Output does not fall as much as for changes in income taxation but consumption taxes constitute a large enough part of overall tax revenue, 20.1% in the benchmark economy, to have a substantial effect on total tax revenue. Accordingly, raising consumption tax embodies an effective measure to increase total tax revenue because the adverse effects on labor supply and capital stock are less pronounced. This result hinges on the assumption that all households optimize their utility according to the same function and allocate accordingly between consumption and savings. The empirical literature, finds decreasing consumption relative to savings/investments for households at the upper end of the income and wealth distribution. According to Klär and Slacalek (2006), households in the 1st net income decile consume more than their total income, while households in the 9th and 10th decile consume around 72% and 61% of their net income.

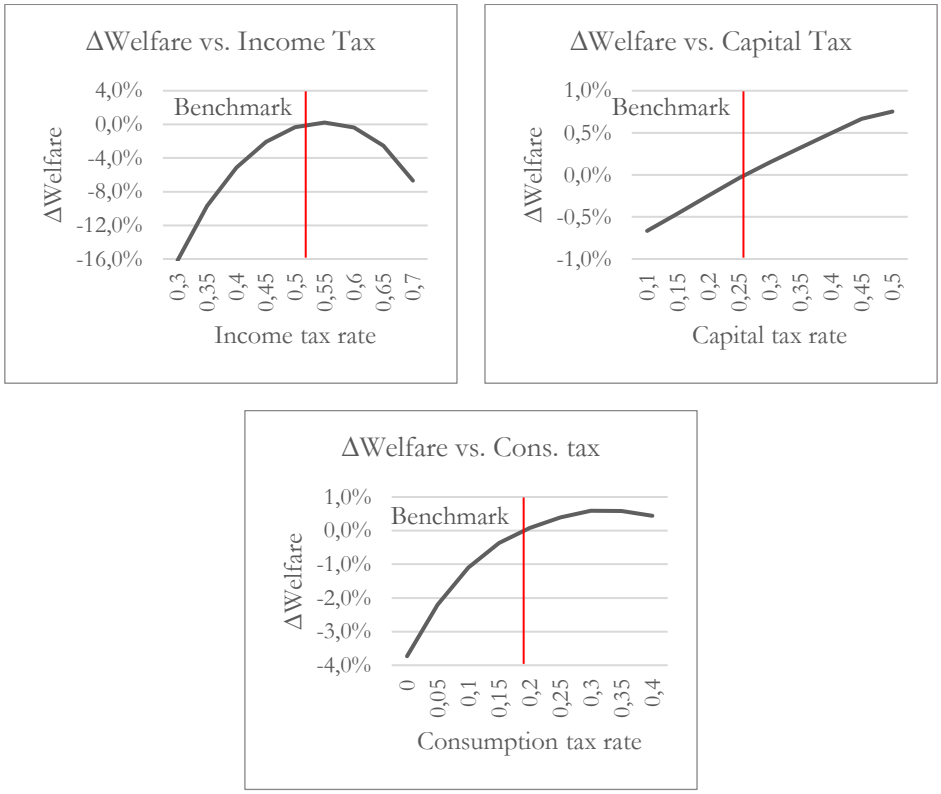
The benchmark economy roughly reflects this with consumption rates of 87.7% for the 1st decile, as well as 82% and 51.8% for the 9th and 10th decile, respectively.

Overall, redistributive policies should not raise income tax rates significantly above 55%. Under a tax revenue maximizing perspective, consumption taxes can be raised up to the maximum value examined, 40%. Capital tax revenue considerations are negligible because total revenue stays roughly unchanged for capital taxes between 10% and 50%.

4.3. Welfare

In Figure 3 I plot welfare changes relative to the benchmark economy. I use the standard utilitarian welfare measure and aggregate it over all simulated households. The welfare changes are measured as the consumption compensation required to obtain the welfare level of the benchmark economy. So a welfare change of x given taxes τ means that welfare would be the same as in the benchmark economy when consumption is changed by x percent for all households in the benchmark economy.

Figure 3: Welfare Changes vs. Income, Capital and Consumption Tax



I find welfare gains of 0.22% for increasing the income tax rate from its benchmark value 52.2% to 55%, while further increases or decreases below the benchmark rate result in substantial welfare losses. The observed welfare gains can be explained by the distributional effects of increased income taxes, which reduce consumption inequality and thereby increase overall welfare because low-income households have higher marginal rates of return on consumption. For an income tax of 55% tax revenue is maximized and the distributional component outweighs the aggregate component, resulting in aggregate welfare gains.

The relationship between the capital tax level and welfare is almost linear, with an increase of capital taxes to 50% resulting in welfare gains of 0.75%. Again, welfare gains can be explained by distributional effects because previous studies, using representative-household

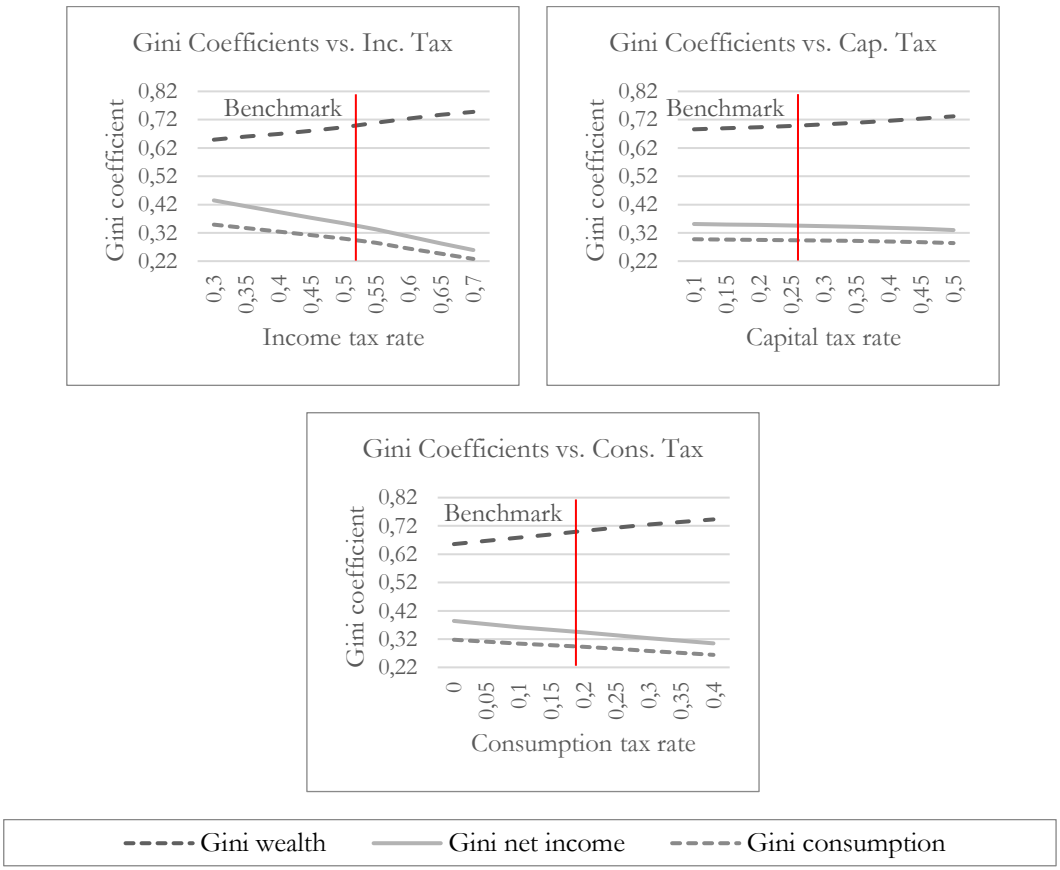
frameworks, consistently find significant welfare gains for reducing or removing capital taxes (e.g. Lucas 1990) and consequently welfare losses for increased taxation of capital income. The linear relationship is largely determined by the fact that 54.9% of capital income is earned by the 10th decile of the wealth distribution, implying that increased capital taxes mostly affect the upper end of the income and wealth distribution. Therefore, income and consumption are redistributed without significantly reducing economic output.

Over the range of consumption taxes welfare is maximized at a tax rate of 30%, yielding welfare gains of 0.59% compared to the benchmark economy. For tax rates above 30% welfare gains through redistribution are offset by the aggregate component's negative effect and aggregate welfare gains decline gradually. The result of overall welfare gains for increasing consumption taxes is in line with previous studies, for example Imrohoroglu (1998) and Judd (2001), who examine the effects of moving from capital to consumption and labor taxes.

4.4. Synopsis Distributional Implications

Figure 4 shows the development of wealth, net income, and consumption Gini coefficients for variations in income, capital, and consumption tax rates.

Figure 4: Gini Coefficients vs. Income, Capital and Consumption Tax



Along the income tax range, I find a significant increase in wealth inequality, as the wealth Gini coefficient rises from 0.65 to 0.75 for 30% and 70% income tax rates, respectively. The model mechanism determining this result is decreasing precautionary saving of low-wealth households, when income taxes are increased. As rising taxes imply substantially higher transfers, an increasing part of the individual earnings risk low-wealth households face is insured by transfer payments. Therefore, private saving and capital accumulation becomes less

important for consumption smoothing of low-wealth households. While the lower 50% of the wealth distribution hold 7% of total wealth for 30% income tax, their share falls to 3% for 70% income tax. Especially the 1st, 2nd, and 3rd decile almost entirely rely on transfers and only hold 1% of total wealth, given a 70% income tax rate. The main caveat of this result is the limited applicability to the real economy, due to households not having complete information and not acting fully rationally when adjusting their savings rate, given variations in taxation. For net income inequality the Gini coefficient decreases from 0.43 to 0.26, over the range of income tax rates. The consumption Gini coefficient falls from 0.35 to 0.23, being a smaller relative decrease than for net income.

Changes in capital taxes exhibit the largest effect on the wealth distribution with the wealth Gini coefficient increasing from 0.69 to 0.73. This increase is determined by an increased concentration of wealth in the 10th decile, going from 53.2% to 59.1% of total wealth, over the range of capital taxes. In contrast, the net income and consumption distribution are almost unchanged for capital taxes between 10% and 50%. The net income Gini falls from 0.35 to 0.33 and the consumption Gini declines from 0.3 to 0.28. Net income redistribution through capital taxes occurs from the upper to the lower half of the distribution, while consumption is redistributed from the top 40% to the lower 60%.

Consumption tax reforms affect the wealth distribution similarly to income tax reforms. The wealth Gini coefficient rises from 0.66 to 0.74 for consumption tax rates of 0% and 40%, respectively. Net income and consumption inequality is reduced to a smaller extent, with the net income Gini coefficient falling from 0.38 to 0.3 and the consumption Gini coefficient decreasing from 0.32 to 0.26. For both, net income and consumption, the redistribution occurs from the upper 50% to the lower 50%.

In the following sections I separately discuss the effectiveness of tax reforms in reducing wealth, net income, and consumption inequality. In summation, wealth inequality rises for higher taxation, with changes in income taxes having the strongest effect. Net income and consumption inequality falls substantially for increased income and consumption taxes, while changes in capital tax only have a moderate effect.

In Table 8, 9, and 10 I present wealth, net income and consumption Gini coefficients, shares of the lower 50% households, and shares of the top 10% households. Those indicators capture the distribution of wealth, net income and consumption among households. Furthermore, I report percentile ratios, which describe the distance between two percentiles. For example, the P90/P50 ratio captures the distance between the 90th percentile and the median. By using percentile ratios, the distribution can be assessed in terms of its range and distributional effects can be broken down into the benefits for upper and lower 50% of the distribution.

Finally, the absolute distributional impact of the three tax classes hinges on their relative share in total tax revenue, which is also their share in the associated transfer increase, redistributing wealth, income and consumption. Income taxes contribute 76.2%, consumption taxes contribute 20%, and capital taxes only contribute 4.8% to the government budget.

4.5. Distributional Implications: Wealth

As already discussed above, increased income, capital, or consumption taxation increase wealth inequality because low productivity households reduce their precautionary savings. Consequently, insights on the effects on wealth inequality are a subordinate topic in this paper and I will only briefly discuss some insights.

An important finding is the comparably strong effect of capital taxation on the wealth distribution. The Gini coefficient increases by 0.04 and the P90/P50 ratio rises by 1.8 over the range of capital taxes. In contrast, the net income and consumption distribution is largely unaffected by changes in capital taxes, with Gini coefficient decreases of around 0.02. As discussed above, the strong effect on the wealth distribution is driven by an increased wealth concentration in the 10th decile, perpetuating itself by increasing returns on capital. The market clearing interest rate reaches 4.16% for a 50% capital tax, higher than in any other scenario. The second, subordinate, driver for the wealth concentration in the 10th decile is the increase of effective labor supply by 0.7 p.p. in the 10th wealth decile, while households in the 1st to 4th decile reduce labor supply, for rising capital taxes.

Moreover, it is striking that changes in income taxation have the biggest effect on the wealth Gini coefficient but the wealth share of top 10% households increases more for changes in consumption taxes. Investigating the individual wealth deciles, I find a wealth share increase of 1.5 p.p. for the 9th decile and 9.6 p.p. for the 10th decile over the range of consumption taxes. For income taxes going from 30% to 70%, I observe an increase of the wealth share by 5.1 p.p. in the 9th decile and 8.4 p.p. in the 10th decile. Consequently, the misalignment of Gini coefficient and top 10% wealth share changes can be largely attributed to wealth gains of households in the 9th decile for rising income taxes.

Over the range of income taxes the P90/P50 ratio increases by 6.58, which corroborates the observation of substantially increasing wealth concentration in the 10t decile. While the household at the 90th percentile owned 4 times the wealth of the median household for a 30% income tax, the distance more than doubles for a 70% income tax. Surprisingly, this wealth concentration occurs although the 10th decile reduces effective labor supply from 19.7% to 18% of the total labor supply. The 4th to 8th decile increase their effective labor supply but still end up with declining wealth shares. The intuition behind this is that higher income taxes lead to lower household income, resulting in lower absolute savings, which means less capital supply, a falling capital stock and therefore an increasing interest rate. As the 9th and 10th decile always hold more than 65% of total assets they benefit strongly from increased returns on their capital and can afford to allocate more time to leisure, when consumption becomes costlier.

The P75/P50 ratio for all three tax classes only increases moderately, with the strongest augmentation over the range of income taxes where it increases from 1.77 to 2.94. This less than two-fold increase corroborates the insight of wealth redistribution to upper 20% households.

Table 9: Comparison of Income, Capital and Consumption Tax. Wealth Distribution

	Distribution, income tax						**Distribution, capital tax**						**Distribution, cons. tax**				
τ^h	Gini	Low 50%	Top 10%	P90 /50	P75 /50	τ^k	Gini	Low 50%	Top 10%	P90 /50	P75 /50	τ^c	Gini	Low 50%	Top 10%	P90 /50	P75 /50
Benchmark						Benchmark						Benchmark					
0.5218	0.70	0.05	0.55	6.01	1.98	0.26	0.70	0.05	0.55	6.01	1.98	0.19	0.70	0.05	0.55	6.01	1.98
Scenarios						Scenarios						Scenarios					
0.3	0.65	0.07	0.50	4.00	1.77	0.10	0.69	0.06	0.53	5.57	1.94	0.00	0.66	0.07	0.50	4.51	1.81
0.35	0.66	0.07	0.51	4.27	1.79	0.15	0.69	0.06	0.54	5.68	1.95	0.05	0.67	0.07	0.51	4.84	1.84
0.4	0.67	0.06	0.52	4.57	1.80	0.20	0.69	0.06	0.54	5.82	1.97	0.10	0.68	0.06	0.53	5.21	1.89
0.45	0.68	0.06	0.53	5.04	1.85	0.25	0.70	0.05	0.55	5.97	1.98	0.15	0.69	0.06	0.54	5.62	1.93
0.5	0.69	0.06	0.54	5.66	1.93	0.30	0.70	0.05	0.55	6.16	2.00	0.20	0.70	0.05	0.55	6.13	2.00
0.55	0.71	0.05	0.56	6.59	2.08	0.35	0.71	0.05	0.56	6.37	2.02	0.25	0.71	0.05	0.56	6.71	2.07
0.6	0.72	0.04	0.57	7.73	2.30	0.40	0.72	0.05	0.57	6.63	2.04	0.30	0.72	0.04	0.58	7.33	2.15
0.65	0.74	0.04	0.58	9.08	2.59	0.45	0.72	0.04	0.58	6.97	2.07	0.35	0.73	0.04	0.59	7.97	2.23
0.7	0.75	0.03	0.58	10.58	2.94	0.50	0.73	0.04	0.59	7.37	2.11	0.40	0.74	0.04	0.60	8.67	2.31

4.6. Distributional Implications: Net Income

Increasing income taxes is most effective in reducing net income inequality, as indicated by the decline of 0.17 in Gini coefficient, an increase of the lower 50% net income share by 14 p.p. and substantial decreases in all percentile ratios, over the range of income tax rates investigated. Especially, the distance between the 10th and the 1st decile is strongly reduced, as shown by a more than three-fold decrease of the P90/P10 ratio. This result is entirely driven by a large increase in transfer payments for rising income tax rates. Absolute total transfers increase from 0.03 to 0.15, approximately a five-fold increase, which more than offsets the income losses households in the 1st and 2nd decile face by reducing their effective labor supply to zero, for income tax rates of 55% and above. The P90/P50 ratio decreases only a bit more than two-fold, over the range of income tax rates, indicating that the lower 50% over proportionally collect distributional gains. Within the lower half I find a decline in the P50/P10 ratio by less than two-fold, implying that inequality between the lower five deciles is only moderately reduced.

In contrast, increasing capital taxes only moderately reduce net income inequality. The Gini coefficient declines from 0.35 to 0.33 and the P90/P50 ratio decreases by only 3%, over the range of capital taxes examined. Consequently, the distance between the median net income and the one at the 90th percentile is mostly unchanged, which indicates that middle class households barely benefit from higher capital taxes. Instead, redistribution occurs from households in the highest three deciles, who see their net income share decline by 18%, to households in the lowest three deciles, who's net income share increases by 11%. The 13% decrease of the P90/P10 ratio reflects this insight. Additionally, I find reduced net income inequality within the lower 50% households, indicated by the decline in P50/P10 ratio by 11%. An explanation lies in the relatively large net income gains of the lowest three deciles.

For variations in consumption tax from 0% to 40%, I find a decline in net income Gini coefficient by 0.08, being around half the decline found for a 40 percentage point increase in income taxes. The effectiveness of consumption taxes is moved is moved by two effects. First, the more equal distribution of consumption makes them a less targeted measure. Net income has a Gini coefficient of 0.35, while the consumption Gini coefficient is only 0.29. Second, high-income high-wealth households rely more on capital income and therefore their consumption is less reduced than their income given increased consumption taxes. This increases the effectiveness because the relative tax burden of wealthy households rises for higher consumption taxes. Furthermore, I obtain a 30% decrease in the P90/P50 ratio, while the P50/P10 ratio only declines by 10%. Consequently, only little redistribution occurs within the lower half, while redistribution within the upper half of the net income distribution is more pronounced. Those distributional effects are the opposite to the ones occurring under increased capital taxation, making capital taxes more effective in reducing net income inequality within the lower 50%. Consumption taxes, in turn, redistributed more effectively within the upper half. A somewhat surprising result is that the 10th decile contributes 48% of the total redistribution, over the range of consumption taxes, while it only contributes 45%, over the range of income taxes. Intuitively one would expect the top decile to contribute less under increased consumption taxes, due to the more equal distribution of consumption and the resulting smaller absolute increase in tax burden for the 10th decile. The 10th decile receives 25.4% of total net income but only 21.4% of total consumption, in the benchmark economy. The explanation lies in the 10th deciles' above average reliance on capital income, which makes its consumption level less dependent on labor income, which is affected by income tax increases. I assume that deciles of the net income distribution are roughly comprised of the same households as decile of the market income after transfers distribution because all taxes.

Table 10: Comparison of Income, Capital and Consumption Tax. Net Income Distribution

	Distribution, income tax							**Distribution, capital tax**							**Distribution, consumption tax**					
τ^h	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10	τ^k	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10	τ^c	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10
Benchmark							Benchmark							Benchmark						
0.5218	0.35	0.24	0.25	4.22	1.66	2.55	0.26375	0.35	0.24	0.25	4.22	1.66	2.55	0.19	0.35	0.24	0.25	4.22	1.66	2.55
Scenarios							Scenarios							Scenarios						
0.3	0.43	0.18	0.29	7.82	2.75	2.84	0.1	0.35	0.24	0.26	4.36	1.67	2.61	0	0.38	0.21	0.27	5.15	2.05	2.51
0.35	0.41	0.19	0.28	6.35	2.67	2.38	0.15	0.35	0.24	0.26	4.32	1.67	2.59	0.05	0.37	0.22	0.26	4.81	1.92	2.51
0.4	0.39	0.21	0.27	5.38	2.56	2.10	0.2	0.35	0.24	0.26	4.28	1.67	2.57	0.1	0.36	0.23	0.26	4.57	1.81	2.53
0.45	0.37	0.22	0.26	4.78	2.10	2.28	0.25	0.35	0.24	0.25	4.23	1.66	2.55	0.15	0.35	0.24	0.26	4.36	1.72	2.54
0.5	0.35	0.24	0.26	4.38	1.77	2.47	0.3	0.34	0.24	0.25	4.19	1.66	2.53	0.2	0.34	0.24	0.25	4.19	1.64	2.55
0.55	0.33	0.25	0.25	3.90	1.52	2.56	0.35	0.34	0.25	0.25	4.14	1.65	2.51	0.25	0.33	0.25	0.25	3.92	1.58	2.49
0.6	0.31	0.27	0.24	3.27	1.33	2.47	0.4	0.34	0.25	0.25	4.04	1.64	2.46	0.3	0.32	0.26	0.25	3.64	1.52	2.40
0.65	0.28	0.29	0.23	2.80	1.29	2.17	0.45	0.33	0.25	0.25	3.91	1.64	2.39	0.35	0.31	0.27	0.24	3.41	1.47	2.32
0.7	0.26	0.31	0.23	2.43	1.29	1.89	0.5	0.33	0.26	0.25	3.78	1.63	2.32	0.4	0.30	0.27	0.24	3.22	1.43	2.26

are levied as flat taxes. Therefore, I infer from Table 8 that the 10th decile receives 12.11% of its total income from capital, while the 8th and 9th decile receive only 10.19% and 6.44% from capital income, respectively. As a consequence, higher consumption taxes hit the 10th decile harder because households maintain a relatively high consumption level, even when their labor income drops significantly. Over the range of income taxes, net income falls by 21%, while consumption declines only by 15% for households in the 10th decile.

4.7. Distributional Implications: Consumption

Finally, I examine the distributional effects on consumption because individual utility is partly determined by consumption, making higher consumption equality a societal goal to improve the well-being of those at the lower end of the distribution and thereby improve overall economic welfare. For the benchmark economy consumption is more equally distributed than net income, having a Gini coefficient of 0.29 while net income has a Gini coefficient of 0.35. The consumption Gini simulated by the model roughly matches the German data, assuming that consumption inequality increased moderately from 2005 onwards where it stood at approximately 0.26 (Fuchs-Schündeln et al., 2009). Net income does not directly translate into consumption because diminishing returns given in the utility function cause high-income households to save over proportionally, in order to insure their high income level against earnings risk.

The strongest decrease of consumption inequality happens over the range of income taxes where the Gini coefficient decreases by 0.12, while it only declines by 0.05 for a 40% reduction in consumption taxes. Variations in capital taxation only have a small effect on the consumption Gini. In contrast to the income distribution, I find a more than two-fold reduction in the P50/P10 ratio for the consumption distribution, over the range of income taxes, indicating that the distributional effect of increasing income taxes is further augmented by the households' consumption decision. However, this stronger decline in consumption inequality than in net income inequality holds only within the lower 50%. For all other indicators net income is redistributed more than consumption, given raised income taxes. I find an explanation in the 5th net income decile, which experiences a 40% increase, while the 5th consumption decile only sees its consumption increase by 22%. This keeps the consumption median lower, which results in the observed strong reduction in consumption P50/P10 ratio. Furthermore, the 10th consumption decile raises effective labor supply by 4 p.p., while the 8th decile raises labor supply even more, by 4.6 p.p., over the range of income taxes examined. An intuitive explanation is the much higher level of wealth and resulting capital income in the 10th decile, which buffers against losses due to higher income taxation. Households in the 8th decile, in contrast, obtain a smaller share of their total income from capital income and are therefore hit more drastically by rising income taxes. Consequently, they have to adjust their labor supply to a larger extent, in order to maintain their utility maximizing level of consumption.

Increased capital taxes have barely any effect on the consumption distribution. The Gini coefficient decreases by only 0.02 and the P90/P10 ratio falls by 13%, over the range of capital taxes. Overall, just 0.9% of total consumption is redistributed mostly from the top 40% to the bottom 40% of the distribution. Therefore, higher capital taxes are not very effective in redistributing consumption but constitute a targeted measure, redistributing from top to bottom, while leaving the middle class mostly unaffected. The 10th decile contributes 52% of the total amount redistributed. Those targeted transfers cause the 1st and 2nd consumption decile to reduce their effective labor supply to zero for capital tax rates at 35% and above. In contrast, for increasing income taxes only the 1st consumption decile reduces effective labor supply to zero.

Table 11: Comparison of Income, Capital and Consumption Tax. Consumption Distribution

	Distribution, income tax							Distribution, capital tax							Distribution, consumption tax						
τ^h	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10	τ^k	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10	τ^c	Gini	Low 50%	Top 10%	P90 /10	P90 /50	P50 /10
Benchmark							Benchmark							Benchmark						
0.5218	0.29	0.28	0.21	4.24	1.42	2.98	0.26375	0.29	0.28	0.21	4.24	1.42	2.98	0.19	0.29	0.28	0.21	4.24	1.42	2.98
Scenarios							Scenarios							Scenarios						
0.3	0.35	0.24	0.23	6.29	1.53	4.10	0.1	0.30	0.28	0.22	4.37	1.43	3.05	0	0.32	0.27	0.22	5.05	1.48	3.42
0.35	0.34	0.25	0.23	5.67	1.50	3.77	0.15	0.30	0.28	0.21	4.33	1.43	3.03	0.05	0.31	0.27	0.22	4.78	1.46	3.27
0.4	0.32	0.26	0.22	5.16	1.48	3.49	0.2	0.30	0.28	0.21	4.29	1.43	3.01	0.1	0.30	0.28	0.22	4.56	1.45	3.15
0.45	0.31	0.27	0.22	4.74	1.45	3.26	0.25	0.29	0.28	0.21	4.25	1.42	2.99	0.15	0.30	0.28	0.22	4.37	1.43	3.05
0.5	0.30	0.28	0.22	4.38	1.43	3.07	0.3	0.29	0.29	0.21	4.21	1.42	2.97	0.2	0.29	0.29	0.21	4.21	1.42	2.97
0.55	0.28	0.29	0.21	3.95	1.41	2.79	0.35	0.29	0.29	0.21	4.16	1.41	2.94	0.25	0.29	0.29	0.21	3.96	1.41	2.82
0.6	0.26	0.31	0.21	3.37	1.41	2.39	0.4	0.29	0.29	0.21	4.06	1.41	2.89	0.3	0.28	0.30	0.21	3.69	1.40	2.64
0.65	0.25	0.32	0.20	2.96	1.42	2.09	0.45	0.29	0.29	0.21	3.94	1.40	2.82	0.35	0.27	0.30	0.21	3.46	1.39	2.49
0.7	0.23	0.34	0.20	2.63	1.43	1.84	0.5	0.28	0.29	0.21	3.81	1.39	2.74	0.4	0.26	0.31	0.20	3.27	1.38	2.37

Over the range of consumption taxes, I find a decrease in consumption Gini coefficient of around 0.06, which is half the reduction obtained by a 40 percentage point increase in income taxes. As for increased capital taxes it is mostly the lower half that benefits and particularly the 1st and 2nd decile, which receive 34% and 31% of the total redistributed consumption. This is also reflected in reduced distance between the percentiles, as shown by reductions of the P50/P10 ratio by 31% and the P90/P10 ratio by 35%. The redistribution effects for households in the 4th to 7th decile are moderate with consumption shares changing by less than 0.5%, which is also reflected by the P90/P50 ratio only decreasing by 7%.

5. Discussion

To answer the research question "How effective and economically efficient are tax reforms in reducing inequality?" and derive viable policy recommendations, this section contrasts macroeconomic effects with distributional implications of the tax reforms investigated. Furthermore, I discuss limitations and implications of the results.

5.1. Discussion of Main Results and Policy Recommendations

Income tax increases lower economic output via two main channels. First, higher taxation of labor makes working less attractive relative to leisure, known as the substitution effect, leading to reduced supply of the production input labor. Second, reduced labor supply results in lower aggregate household income, causing lower absolute savings and consequently reduced capital supply, the second input for production. This is generally called income effect, which causes an increase in labor supply, as households seek to maintain a utility maximizing consumption level. For the model economy the substitution effect outweighs the income effect resulting in reduced effective labor supply. The results reflect those theoretical insights, as a 40 p.p. increase in income taxes reduces output by 45%, which is determined by a 40% decrease in effective labor supply and a 53% decline in capital stock. The overall effect on aggregate welfare can be decomposed in an aggregate component, welfare losses due to reduced output, and a distributional component, welfare gains due to redistribution from high-income households with low marginal returns to consumption to low-income households with high marginal returns to consumption. In the model economy the aggregate component outweighs the distributional component for income tax rates below 52% and above a tax rate between 55% and 60% (the precise number is not determined, as taxes are increased in 5% increments), leading to a welfare maximizing income tax rate around 55%. Moreover, income tax increases have the strongest distributional effect among the tax reforms examined. Net income and consumption inequality, as measured by the Gini coefficient, decrease by 40% and 35%, respectively, over the range of income taxes. Assuming the German government is similarly concerned with reducing inequality and fostering economic growth, a reasonable policy advice is to increase income taxes by 3 p.p., which would raise aggregate welfare by 0.22% and reduce net income and consumption inequality based on the Gini coefficient by 3.7% and 3.2%, respectively. The cost associated would be a decline in output by 4%, which is substantial but "acceptable" in the light of aggregate welfare and redistribution gains.

For capital taxes the distortionary effect is mainly determined by reduced asset holdings, due to lower returns on capital. As capital taxes increase, precautionary savings become less attractive and especially low-income households rely predominantly on transfers to insure against idiosyncratic earnings risk. As a consequence, aggregate savings decrease, relative consumption increases, and the capital stock declines. For a capital tax increase from 10% to 50% the model predicts an increase in consumption relative to output by 8.5%, a decline in capital stock by 23.5%, and a resulting output contraction of 11.9%. The welfare effect is

predominantly driven by its distributional component because aggregate distortions are less pronounced, due to largely unaffected labor supply. Capital income is highly concentrated at the top of the distribution with the 10th decile collecting 54.9% of total capital income in the benchmark economy. This makes higher capital income taxation a measure, which redistributes in a targeted manner. Especially for consumption redistribution, where the 10th decile contributes 52% of the total amount redistributed. I find welfare gains of on average 0.18% per 5 percentage point increase in capital taxes. Assuming a 4.3% decrease in output to be "tolerable", the resulting policy advice would be to raise capital taxes by 13.6 p.p., which implies aggregate welfare gains of 0.49%. Net income and consumption inequality, as measured by the Gini coefficient, would decrease by 2% and 1.5%, respectively.

As discussed above taxes distort the economy by moving individual decisions away from their optimal choices via altered price signals. In this respect, consumption taxes are less distortionary than income taxes because they only affect the labor and savings choice indirectly through consumption. Two effects of increased consumption taxes move economic output downwards. First, a higher cost of consumption lowers consumer spending, which reduces demand and thereby lowers output. Second, a higher cost of consumption makes labor less attractive, relative to leisure, reducing the aggregate labor supply. Simultaneously, savings become relatively more attractive, leading to increased saving rates, which accelerate capital accumulation and raise the capital stock. Surprisingly, I find a 2.8% increase in consumption relative to output and a 23.6% decline in absolute capital stock, over the range of consumption taxes examined. The consumption increase can be explained by the distributional effect outweighing the higher cost of consumption because of higher taxes. Given higher consumption taxes more capital is redistributed to low-income households, which have higher marginal returns on consumption than marginal returns on leisure, even for consumption taxes of 40%. So income that would have been saved by high-income households is now spend on consumption by low-income households. The decline in capital stock is caused by reduced labor supply and resulting lower absolute household income causing lower absolute savings, which offsets the effect of higher saving rates. Overall, output declines by 20%, determined by reductions in the factor inputs capital (23.6%) and labor (17.9%). Furthermore, I find the welfare maximizing consumption tax rate at 30%, implying welfare gains of 0.59% compared to the benchmark economy. For tax rates above 30% the aggregate welfare component exceeds distributional gains and aggregate welfare declines. Accepting a 3.2% decrease in output the German government could lower, Gini coefficient based, net income and consumption inequality by 3.4% and 2.8%, respectively, through raising consumption taxes by 6 p.p. The associated welfare gains amount to 0.39%. Approximating the effects for a 4.3% output decline, I find a reduction in net income and consumption Gini coefficient of 4.9% and 4.1%, respectively, while aggregate welfare increases by 0.49%, for a consumption tax increase by 8.5 p.p.

Comparing the three policy recommendations, which cause 4% to 4.3% output reductions, the 8.5 p.p. increase in consumption taxes yields the same welfare gains as the capital tax increase, while being more than twice as effective in reducing income and consumption inequality. Moreover, the consumption tax reform yields higher welfare and distributional gains than a 3% rise in income taxes. As a result, my foremost policy advice is an 8.5 p.p. increase in consumption taxes, with the additional tax revenue being entirely redistributed as a lump-sum transfer.

Finally, raising taxes above their benchmark levels quickly leads to households in the 1st and 2nd decile of the net income distribution reducing their labor supply to zero. Those bottom 20% households entirely rely on transfers for income taxes of 55% and above, capital tax rates of 35% and above, and consumption taxes of 25% and above. This certainly constitutes an undesirable outcome of the reforms proposed. However, as shown in Table 8, transfer

payments to households in the bottom 20% are substantially overstated in the model economy, suggesting that the recommended consumption tax reform would not raise transfers sufficiently, so that bottom 20% households could entirely rely on them.

5.2. Limitations

The model economy abstracts from a couple of characteristics, which I will discuss in the following section. In the model all taxes are levied as flat taxes, which reflects the German taxation framework for capital and consumption taxes. However, the German government levies income taxes progressively, contingent on personal earnings, marital status, and various other factors affecting the progressive tax rate an individual faces. As a consequence, income taxes paid by low-income households are overstated and high-income households' taxes are understated. Despite this abstraction, the policy experiment for income taxes captures the contributions to redistribution, if we assume the variation in flat income tax translates into an evenly distributed variation over all progressive tax levels. Then the percentage point increase in income taxes for a given household, yields the same amount of additional contribution, no matter what the household's initial tax rate was. Naturally, the limitation here is that taxes targeted at wealthy households cannot be evaluated, although such a policy would redistribute more effectively and should also receive more acceptance by the majority of households.

Moreover, social security transfers are distributed as lump-sum payment, which is the same absolute amount for all households. The German welfare system, in contrast, distributes the vast majority of transfers to the unemployed, to very low income households, to the elderly, to students, and to families with children. This caveat causes a substantial understatement of inequality reductions, as households in the lower 50% only benefit because the absolute increase in transfers affects their total income relatively more, while high-income high-wealth households are worse off because additional taxation of their high wages, capital gains and consumption exceeds the increase in transfers they receive.

Furthermore, the capital tax experiment suffers from an imprecise model calibration to the wealth shares of the top 1% and top 0.1%. Bach et al. (2015) find a wealth share of 32.7% for the top 1% and 17.3% for the top 0.1% households, in Germany for 2011. The model has difficulties in generating such a skewed distribution without losing precision in lower deciles. As a consequence, top 1% households own 11.9% and top 0.1% households hold 1.8% of total wealth, in the benchmark economy. Based on the chosen calibration, wealth and thereby capital income of the very richest households is lower than in the data causing an understated distributional effect of capital tax increases.

A minor caveat are the implied saving rates and resulting consumption in the model economy. Especially for households in the 10th decile and top 1% of the net income distribution savings do not match empirical findings. In the benchmark economy households in the 10th decile and top 1% save 30.38% and 48.2% of their net income**,** respectively. In contrast, Klär and Slacalek (2006) find savings of 21% and 39% of net income, for the 10th decile and the top 1%. As a result, consumption at the upper end of the distribution is understated in the model economy, implying too low consumption tax payments by those households. Fortunately, this limitation strengthens the result of higher consumption taxes being the most prudent measure for redistribution because a larger than modeled consumption share of high-income households implies that consumption tax increases would redistribute even more effectively, than suggested by the models' results.

5.3. Future Research

Model based research has been done on identifying the welfare maximizing progressivity of income taxes (Conesa and Krueger, 2005; Kindermann and Krueger, 2014) or deriving the long run wealth distribution, given progressive income taxes (Carroll and Young, 2008). However, a comparative analysis on the distributional effects of variations in income, capital, and consumption taxes, using such a framework, is yet to be conducted. Furthermore, such an incomplete markets model could be calibrated to an existing transfer scheme, which to my knowledge is missing in the literature.

Bach et al. (2015) find in an empiric study, based on Swedish data, that returns on financial wealth are on average 4% higher for households in the top 1% as compared to the median of the wealth distribution. Incorporating such heterogeneity in returns on capital in an incomplete markets model would better reflect the importance of capital income for households at the upper end of the distribution. Therefore, improving models aiming to assess distributional implications of changing capital taxes (e.g. Domeij and Heathcote, 2003) or specifically taxing the top 1% (Kindermann and Krueger, 2014). Additionally, Piketty's (2013) hypothesis of increasing importance of capital taxes could be better assessed in such a framework.

Moreover, an empiric examination of the results presented above would help in better understanding distributional implications of taxation reforms. The 3 percentage point consumption tax increase in Germany in 2007 lends itself to such an investigation.

6. Conclusion

This paper demonstrates that the German wealth and income distribution can be closely matched by an incomplete markets model, even though the distributions are strongly skewed to the right and wealth is much more unequally distributed than income. Furthermore, distributional implications and macroeconomic effects of changes in income, capital, and consumption taxes are examined and contrasted between the tax classes.

Two main conclusions can be drawn from this article. First, in an economy with high wealth and income inequality welfare gains can be achieved by raising taxes and redistributing the additional revenue. However, these distributional gains come at the cost of lower investment and labor supply, reducing aggregate output and total consumption in the long run. Second, distributional implications of an expanded transfer system differ between tax classes in their magnitude and impact on different groups along the income and wealth distribution. For increased income and consumption taxes distributional gains are spread fairly evenly over the net income distribution, while higher capital taxes mostly benefit the lower 20%.

Assessing output, welfare, and distribution effects combined, I identify increased consumption taxes as the most prudent measure in reducing net income and consumption inequality, as measured by the Gini coefficient. However, if the goal is to efficiently redistribute consumption from the top 20% to the bottom 20% households, one should resort to raising capital taxes instead. In the context of international tax competition raising capital taxes is rather improbable policy measure to be taken. Therefore, the pivotal policy recommendation is an increase in consumption to raise total tax revenue and achieve distributional gains via higher transfer payments. Considering the poor economic condition of single parent households in Germany, transfer increases should be targeted at those families to improve their economic condition and thereby enhance educational outcomes and professional prospects of children raised by a single parent. In the long run, the economic cost associated with the redistribution could be more than offset by increased productivity of children raised in lower class households.

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A1 Income Tax Experiment

Table A1: Results for Variations in Income Tax Rates. Economic Variables and Aggregates

		Economic variables and aggregates													
τ^h	W.g.	Y	C/Y	C	H	h	Tr./Y	Tr.	T/Y	T	K/Y	K	r	w	U
Benchmark															
0.5218		0.67	0.46	0.31	0.37	0.26	0.19	0.13	0.44	0.30	2.81	1.88	2.81%	1.71	-2.33
Scenarios															
0.3	-16.17%	0.90	0.43	0.39	0.47	0.41	0.03	0.03	0.29	0.26	3.14	2.83	1.48%	1.35	-2.51
0.35	-9.71%	0.85	0.44	0.37	0.45	0.38	0.07	0.06	0.32	0.27	3.05	2.58	1.82%	1.42	-2.44
0.4	-5.12%	0.79	0.45	0.36	0.43	0.34	0.10	0.08	0.36	0.28	2.97	2.35	2.13%	1.49	-2.39
0.45	-2.07%	0.74	0.46	0.34	0.41	0.31	0.14	0.10	0.39	0.29	2.90	2.15	2.42%	1.57	-2.35
0.5	-0.34%	0.69	0.46	0.32	0.38	0.27	0.17	0.12	0.43	0.30	2.84	1.96	2.70%	1.67	-2.33
0.55	0.22%	0.64	0.47	0.30	0.36	0.24	0.21	0.13	0.46	0.30	2.78	1.78	2.95%	1.78	-2.33
0.6	-0.36%	0.59	0.47	0.28	0.34	0.22	0.24	0.14	0.50	0.29	2.73	1.62	3.19%	1.90	-2.33
0.65	-2.52%	0.55	0.48	0.26	0.31	0.20	0.28	0.15	0.53	0.29	2.69	1.47	3.39%	2.05	-2.36
0.7	-6.67%	0.49	0.48	0.24	0.29	0.17	0.31	0.15	0.56	0.28	2.65	1.31	3.57%	2.24	-2.41

Note: W.g. is welfare gain as percent of consumption in relation to benchmark economy, Y is aggregate output, C is aggregate consumption, H are aggregate effective hours worked, h is average hours worked (intensive margin), Tr. is total transfer payments, T is total tax revenue, K is aggregate capital, r is real interest rate, w is wage rate, U is aggregate utility

Table A2: Results for Variations in Income Tax Rates. Wealth Distribution

	Distribution measures					Wealth deciles in %										Effective labor supply in wealth deciles in %									
τ^h	Gini	Low 50%	Top 10%	P90 /50	P75 /50	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.5218	0.70	0.05	0.55	6.01	1.98	0.0	0.0	0.2	1.6	3.7	5.6	7.2	9.3	17.6	54.9	1.9	2.1	3.7	7.6	10.7	12.6	13.9	14.9	13.4	19.3
Scenarios																									
0.3	0.65	0.07	0.50	4.00	1.77	0.0	0.1	0.5	2.0	4.7	7.3	9.2	10.8	15.4	50.0	2.2	3.3	5.9	7.2	9.6	11.5	12.9	14.1	13.6	19.7
0.35	0.66	0.07	0.51	4.27	1.79	0.0	0.1	0.3	1.9	4.5	7.0	8.9	10.5	15.7	51.1	1.9	3.3	5.6	7.3	9.7	11.7	13.1	14.3	13.5	19.6
0.4	0.67	0.06	0.52	4.57	1.80	0.0	0.0	0.2	1.8	4.4	6.7	8.5	10.2	16.1	52.0	1.5	3.2	5.3	7.5	9.9	11.9	13.2	14.4	13.5	19.6
0.45	0.68	0.06	0.53	5.04	1.85	0.0	0.0	0.2	1.8	4.1	6.3	8.0	9.8	16.6	53.2	1.0	3.1	4.9	7.6	10.1	12.1	13.5	14.6	13.5	19.5
0.5	0.69	0.06	0.54	5.66	1.93	0.0	0.0	0.2	1.7	3.8	5.8	7.5	9.5	17.2	54.3	2.1	2.2	3.9	7.6	10.4	12.4	13.7	14.8	13.4	19.4
0.55	0.71	0.05	0.56	6.59	2.08	0.0	0.0	0.1	1.5	3.4	5.2	6.9	9.2	18.1	55.7	1.8	2.0	3.3	7.8	10.9	12.7	14.0	14.9	13.4	19.1
0.6	0.72	0.04	0.57	7.73	2.30	0.0	0.0	0.1	1.2	3.0	4.6	6.3	8.9	19.0	56.8	1.7	1.8	2.9	8.2	11.3	13.0	14.2	14.8	13.3	18.7
0.65	0.74	0.04	0.58	9.08	2.59	0.0	0.0	0.1	1.1	2.6	4.1	5.8	8.9	19.8	57.7	1.5	1.6	2.7	8.6	11.7	13.3	14.4	14.6	13.3	18.3
0.7	0.75	0.03	0.58	10.58	2.94	0.0	0.0	0.1	0.9	2.2	3.6	5.4	8.9	20.5	58.4	1.1	1.2	2.3	9.3	12.2	13.7	14.7	14.2	13.4	18.0

Table A3: Results for Variations in Income Tax Rates. Net Income Distribution

	Distribution measures					Net income deciles in %										Effective labor supply in net income deciles in %									
τ^h	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.5218	0.35	0.24	4.22	1.66	2.55	3.5	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.7	25.4	0.1	0.1	0.8	4.2	3.6	10.6	13.3	15.4	18.4	33.5
Scenarios																									
0.3	0.43	0.18	7.82	2.75	2.84	1.5	2.4	2.6	5.1	5.9	10.9	12.3	14.2	16.2	28.8	0.6	2.0	1.8	4.3	6.0	10.7	12.8	14.7	17.0	30.0
0.35	0.41	0.19	6.35	2.67	2.38	2.0	2.7	3.1	5.4	6.0	10.9	12.1	13.9	15.9	28.0	0.5	1.7	1.4	4.3	5.9	10.5	12.9	14.8	17.3	30.7
0.4	0.39	0.21	5.38	2.56	2.10	2.5	3.0	3.5	5.6	6.1	11.0	11.9	13.7	15.5	27.2	0.4	1.5	1.0	4.4	5.7	10.1	13.0	14.9	17.6	31.5
0.45	0.37	0.22	4.78	2.10	2.28	2.9	3.2	4.0	5.8	6.2	11.0	11.7	13.4	15.2	26.5	0.3	1.0	0.8	4.3	4.9	10.1	13.1	15.1	18.0	32.3
0.5	0.35	0.24	4.38	1.77	2.47	3.3	3.4	4.5	6.0	6.4	11.1	11.5	13.2	14.9	25.7	0.2	0.5	0.7	4.3	4.0	10.4	13.2	15.4	18.1	33.2
0.55	0.33	0.25	3.90	1.52	2.56	3.7	3.8	5.0	6.1	6.7	11.0	11.2	12.9	14.5	25.0	0.0	0.0	0.9	4.1	3.1	11.1	13.2	15.2	18.8	33.6
0.6	0.31	0.27	3.27	1.33	2.47	4.3	4.4	5.4	6.2	7.2	10.8	10.9	12.7	14.0	24.1	0.0	0.0	1.1	3.8	2.0	12.3	13.3	14.4	19.5	33.6
0.65	0.28	0.29	2.80	1.29	2.17	4.9	4.9	5.8	6.3	7.7	10.5	10.6	12.5	13.6	23.3	0.0	0.0	1.1	3.4	1.7	12.7	13.3	13.8	20.3	33.5
0.7	0.26	0.31	2.43	1.29	1.89	5.4	5.5	6.0	6.3	8.2	10.2	10.3	12.3	13.1	22.6	0.0	0.0	1.1	2.6	2.1	13.0	12.4	14.4	20.6	33.8

Table A4: Results for Variations in Income Tax Rates. Consumption Distribution

	Distribution measures					Consumption deciles in %										Effective labor supply in consumption deciles in %									
τ^h	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.5218	0.29	0.28	4.24	1.42	2.98	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.4	0.2	0.1	3.4	4.1	4.5	12.8	11.7	16.1	17.5	29.6
Scenarios																									
0.3	0.35	0.24	6.29	1.53	4.10	2.5	2.8	4.9	6.0	7.7	11.2	12.0	14.1	15.7	23.1	2.2	1.9	2.6	5.7	4.1	12.4	12.1	14.5	16.7	27.9
0.35	0.34	0.25	5.67	1.50	3.77	2.8	3.0	5.2	6.1	7.9	11.1	11.9	14.0	15.4	22.7	1.9	1.6	2.6	5.5	4.1	12.5	12.1	14.7	16.9	28.2
0.4	0.32	0.26	5.16	1.48	3.49	3.0	3.3	5.4	6.2	8.1	11.1	11.8	13.8	15.1	22.3	1.5	1.1	2.8	5.2	4.1	12.5	12.1	14.9	17.1	28.6
0.45	0.31	0.27	4.74	1.45	3.26	3.2	3.5	5.7	6.3	8.3	11.0	11.6	13.7	14.8	21.9	1.0	0.7	3.0	4.9	4.2	12.6	12.1	15.3	17.3	29.0
0.5	0.30	0.28	4.38	1.43	3.07	3.4	3.8	5.9	6.4	8.5	10.9	11.5	13.6	14.5	21.5	0.5	0.2	3.3	4.4	4.4	12.7	11.9	15.8	17.4	29.4
0.55	0.28	0.29	3.95	1.41	2.79	3.7	4.2	6.1	6.5	8.7	10.8	11.3	13.4	14.2	21.1	0.0	0.0	3.5	3.8	4.6	12.8	11.4	16.6	17.5	29.8
0.6	0.26	0.31	3.37	1.41	2.39	4.3	4.7	6.2	6.6	8.9	10.6	11.2	13.1	13.8	20.6	0.0	0.0	3.7	2.9	5.1	12.8	10.6	17.7	17.1	30.1
0.65	0.25	0.32	2.96	1.42	2.09	4.9	5.3	6.3	6.7	9.2	10.4	11.1	12.7	13.4	20.2	0.0	0.1	3.6	1.8	5.9	12.7	10.0	18.6	16.5	30.8
0.7	0.23	0.34	2.63	1.43	1.84	5.4	5.8	6.3	6.9	9.3	10.1	11.0	12.4	13.1	19.7	0.0	0.5	2.5	0.6	7.3	12.4	9.9	19.1	15.7	31.8

A2 Capital Tax Experiment

Table A5: Results for Variations in Capital Tax Rates. Economic Variables and Aggregates

		Economic variables and aggregates													
τ^k	W.g.	Y	C/Y	C	H	h	Tr./Y	Tr.	T/Y	T	K/Y	K	r	w	U
Benchmark															
0.26375		0.67	0.46	0.31	0.37	0.26	0.19	0.13	0.44	0.30	2.81	1.88	2.81%	1.71	-2.33
Scenarios															
0.1	-0.67%	0.69	0.45	0.31	0.38	0.26	0.17	0.12	0.43	0.30	2.93	2.03	2.29%	1.69	-2.34
0.15	-0.46%	0.69	0.46	0.31	0.38	0.26	0.18	0.12	0.43	0.30	2.90	1.99	2.43%	1.69	-2.34
0.2	-0.25%	0.68	0.46	0.31	0.38	0.26	0.18	0.12	0.44	0.30	2.86	1.94	2.58%	1.70	-2.33
0.25	-0.04%	0.67	0.46	0.31	0.37	0.26	0.19	0.12	0.44	0.30	2.82	1.89	2.76%	1.71	-2.33
0.3	0.15%	0.66	0.47	0.31	0.37	0.25	0.19	0.13	0.45	0.30	2.78	1.84	2.96%	1.72	-2.33
0.35	0.32%	0.65	0.47	0.31	0.37	0.25	0.20	0.13	0.45	0.30	2.73	1.77	3.19%	1.73	-2.33
0.4	0.49%	0.64	0.48	0.30	0.37	0.25	0.21	0.13	0.46	0.29	2.68	1.71	3.46%	1.74	-2.32
0.45	0.67%	0.63	0.48	0.30	0.36	0.25	0.22	0.13	0.47	0.29	2.61	1.64	3.78%	1.76	-2.32
0.5	0.75%	0.61	0.49	0.30	0.36	0.24	0.23	0.14	0.48	0.29	2.54	1.56	4.16%	1.77	-2.32

Note: W.g. is welfare gain as percent of consumption in relation to benchmark economy, Y is aggregate output, C is aggregate consumption, H are aggregate effective hours worked, h is average hours worked (intensive margin), Tr. is total transfer payments, T is total tax revenue, K is aggregate capital, r is real interest rate, w is wage rate, U is aggregate utility

Table A6: Results for Variations in Capital Tax Rates. Wealth Distribution

	Distribution measures					Wealth deciles in %										Effective labor supply in wealth deciles in %									
τ^k	Gini	Low 50%	Top 10%	P90 /50	P75 /50	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.26375	0.70	0.05	0.55	6.01	1.98	0.0	0.0	0.2	1.6	3.7	5.6	7.2	9.3	17.6	54.9	1.9	2.1	3.7	7.6	10.7	12.6	13.9	14.9	13.4	19.3
Scenarios																									
0.1	0.69	0.06	0.53	5.57	1.94	0.0	0.0	0.2	1.8	3.9	5.9	7.6	9.7	17.6	53.2	2.0	2.2	4.0	8.0	10.6	12.4	13.7	14.7	13.3	19.1
0.15	0.69	0.06	0.54	5.68	1.95	0.0	0.0	0.2	1.8	3.9	5.8	7.5	9.6	17.6	53.6	2.0	2.2	3.9	8.0	10.5	12.5	13.8	14.8	13.3	19.1
0.2	0.69	0.06	0.54	5.82	1.97	0.0	0.0	0.2	1.7	3.8	5.7	7.4	9.5	17.6	54.2	1.9	2.1	3.8	7.8	10.6	12.5	13.8	14.8	13.4	19.2
0.25	0.70	0.05	0.55	5.97	1.98	0.0	0.0	0.2	1.6	3.7	5.6	7.3	9.4	17.6	54.7	1.9	2.1	3.7	7.7	10.6	12.6	13.8	14.9	13.4	19.3
0.3	0.70	0.05	0.55	6.16	2.00	0.0	0.0	0.1	1.5	3.6	5.5	7.1	9.2	17.5	55.4	1.8	2.1	3.5	7.7	10.6	12.6	13.9	14.9	13.4	19.4
0.35	0.71	0.05	0.56	6.37	2.02	0.0	0.0	0.1	1.4	3.5	5.3	7.0	9.1	17.5	56.1	1.8	2.0	3.2	7.7	10.7	12.7	14.0	15.0	13.5	19.5
0.4	0.72	0.05	0.57	6.63	2.04	0.0	0.0	0.1	1.3	3.3	5.2	6.8	8.9	17.5	57.0	1.8	2.0	3.0	7.6	10.7	12.8	14.0	15.1	13.5	19.6
0.45	0.72	0.04	0.58	6.97	2.07	0.0	0.0	0.1	1.2	3.2	5.0	6.6	8.7	17.4	57.9	1.8	2.0	2.7	7.5	10.8	12.8	14.0	15.1	13.5	19.7
0.5	0.73	0.04	0.59	7.37	2.11	0.0	0.0	0.0	1.1	3.0	4.8	6.3	8.4	17.3	59.1	1.8	2.0	2.3	7.6	10.9	12.8	14.1	15.2	13.6	19.8

Table A7: Results for Variations in Capital Tax Rates. Net Income Distribution

	Distribution measures					Net income deciles in %										Effective labor supply in net income deciles in %									
τ^k	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.26375	0.35	0.24	4.22	1.66	2.55	3.5	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.7	25.4	0.1	0.1	0.8	4.2	3.6	10.6	13.3	15.4	18.4	33.5
Scenarios																									
0.1	0.35	0.24	4.36	1.67	2.61	3.4	3.4	4.6	6.0	6.5	11.1	11.4	13.2	14.8	25.6	0.2	0.4	0.8	4.3	3.7	10.6	13.2	15.4	18.2	33.2
0.15	0.35	0.24	4.32	1.67	2.59	3.4	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.8	25.6	0.2	0.3	0.8	4.3	3.7	10.6	13.2	15.4	18.3	33.3
0.2	0.35	0.24	4.28	1.67	2.57	3.4	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.8	25.5	0.2	0.2	0.8	4.2	3.7	10.6	13.2	15.4	18.3	33.4
0.25	0.35	0.24	4.23	1.66	2.55	3.5	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.7	25.4	0.1	0.2	0.8	4.2	3.6	10.6	13.2	15.4	18.4	33.5
0.3	0.34	0.24	4.19	1.66	2.53	3.5	3.6	4.8	6.1	6.6	11.1	11.3	13.1	14.7	25.4	0.1	0.1	0.8	4.2	3.6	10.6	13.3	15.4	18.4	33.6
0.35	0.34	0.25	4.14	1.65	2.51	3.6	3.6	4.8	6.1	6.6	11.1	11.3	13.0	14.7	25.3	0.0	0.0	0.8	4.2	3.5	10.6	13.3	15.4	18.4	33.7
0.4	0.34	0.25	4.04	1.64	2.46	3.6	3.7	4.9	6.1	6.6	11.0	11.3	13.0	14.6	25.2	0.0	0.0	0.7	4.1	3.5	10.7	13.3	15.4	18.5	33.8
0.45	0.33	0.25	3.91	1.64	2.39	3.7	3.8	4.9	6.2	6.6	11.0	11.3	12.9	14.6	25.0	0.0	0.0	0.7	4.1	3.4	10.7	13.2	15.4	18.5	33.9
0.5	0.33	0.26	3.78	1.63	2.32	3.9	3.9	5.0	6.2	6.7	11.0	11.2	12.9	14.5	24.9	0.0	0.0	0.7	4.0	3.4	10.7	13.2	15.4	18.6	34.1

Table A8: Results for Variations in Capital Tax rates. Consumption Distribution

	Distribution measures					**Consumption deciles in %**										**Effective labor supply in consumption deciles in %**									
τ^k	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.26375	0.29	0.28	4.24	1.42	2.98	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.4	0.2	0.1	3.4	4.1	4.5	12.8	11.7	16.1	17.5	29.6
Scenarios																									
0.1	0.30	0.28	4.37	1.43	3.05	3.4	3.9	6.0	6.4	8.6	10.8	11.5	13.5	14.4	21.5	0.4	0.2	3.5	4.2	4.6	12.7	11.6	16.1	17.3	29.3
0.15	0.30	0.28	4.33	1.43	3.03	3.4	3.9	6.0	6.4	8.6	10.8	11.5	13.5	14.4	21.5	0.3	0.2	3.5	4.2	4.5	12.8	11.6	16.1	17.4	29.4
0.2	0.30	0.28	4.29	1.43	3.01	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.4	0.3	0.1	3.4	4.2	4.5	12.8	11.7	16.1	17.4	29.5
0.25	0.29	0.28	4.25	1.42	2.99	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.4	0.2	0.1	3.4	4.2	4.5	12.8	11.7	16.1	17.5	29.6
0.3	0.29	0.29	4.21	1.42	2.97	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.3	0.1	0.1	3.3	4.1	4.4	12.8	11.7	16.1	17.5	29.7
0.35	0.29	0.29	4.16	1.41	2.94	3.6	4.0	6.0	6.5	8.6	10.9	11.4	13.5	14.3	21.3	0.0	0.0	3.3	4.1	4.4	12.8	11.7	16.1	17.6	29.9
0.4	0.29	0.29	4.06	1.41	2.89	3.6	4.0	6.1	6.5	8.6	10.9	11.4	13.5	14.3	21.2	0.0	0.0	3.2	4.1	4.3	12.8	11.8	16.1	17.6	30.0
0.45	0.29	0.29	3.94	1.40	2.82	3.7	4.1	6.1	6.5	8.6	10.9	11.4	13.4	14.3	21.1	0.0	0.0	3.2	4.1	4.2	12.9	11.8	16.1	17.7	30.1
0.5	0.28	0.29	3.81	1.39	2.74	3.9	4.1	6.1	6.5	8.6	10.9	11.3	13.4	14.2	21.0	0.0	0.0	3.1	4.1	4.1	12.9	11.8	16.1	17.7	30.2

A3 Consumption Tax Experiment

Table A9: Results for Variations in Consumption Tax Rates. Economic Variables and Aggregates

		Economic variables and aggregates													
τ^c	W.g.	Y	C/Y	C	H	h	Tr./Y	Tr.	T/Y	T	K/Y	K	r	w	U
Benchmark															
0.19		0.67	0.46	0.31	0.37	0.26	0.19	0.13	0.44	0.30	2.81	1.88	2.81%	1.71	-2.33
Scenarios															
0	-3.73%	0.75	0.46	0.34	0.42	0.32	0.10	0.07	0.35	0.27	2.88	2.17	2.48%	1.54	-2.37
0.05	-2.20%	0.73	0.46	0.33	0.40	0.30	0.12	0.09	0.38	0.27	2.86	2.08	2.58%	1.59	-2.36
0.1	-1.10%	0.71	0.46	0.32	0.39	0.28	0.15	0.10	0.40	0.28	2.84	2.00	2.67%	1.63	-2.34
0.15	-0.37%	0.68	0.46	0.32	0.38	0.27	0.17	0.12	0.42	0.29	2.82	1.93	2.75%	1.68	-2.33
0.2	0.08%	0.66	0.46	0.31	0.37	0.25	0.19	0.13	0.45	0.30	2.81	1.86	2.82%	1.72	-2.33
0.25	0.39%	0.65	0.47	0.30	0.36	0.24	0.22	0.14	0.47	0.30	2.79	1.80	2.90%	1.76	-2.33
0.3	0.59%	0.63	0.47	0.29	0.36	0.24	0.24	0.15	0.50	0.31	2.78	1.75	2.96%	1.80	-2.32
0.35	0.58%	0.62	0.47	0.29	0.35	0.23	0.26	0.16	0.52	0.32	2.77	1.70	3.02%	1.84	-2.32
0.4	0.44%	0.60	0.47	0.28	0.34	0.22	0.29	0.17	0.54	0.33	2.76	1.66	3.07%	1.88	-2.33

Note: W.g. is welfare gain as percent of consumption in relation to benchmark economy, Y is aggregate output, C is aggregate consumption, H are aggregate effective hours worked, h is average hours worked (intensive margin), Tr. is total transfer payments, T is total tax revenue, K is aggregate capital, r is real interest rate, w is wage rate, U is aggregate utility

Table A10: Results for Variations in Consumption Tax Rates. Wealth Distribution

	Distribution					**Wealth deciles in %**										**Effective labor supply in wealth deciles in %**									
τ^c	Gini	Low 50%	Top 10%	P90 /50	P75 /50	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.19	0.70	0.05	0.55	6.01	1.98	0.0	0.0	0.2	1.6	3.7	5.6	7.2	9.3	17.6	54.9	1.9	2.1	3.7	7.6	10.7	12.6	13.9	14.9	13.4	19.3
Scenarios																									
0	0.66	0.07	0.50	4.51	1.81	0.0	0.1	0.4	2.3	4.6	6.8	8.6	10.4	16.9	50.1	1.3	3.6	5.5	7.9	10.1	11.9	13.2	14.4	13.3	18.9
0.05	0.67	0.07	0.51	4.84	1.84	0.0	0.0	0.3	2.1	4.4	6.5	8.2	10.1	17.0	51.3	1.0	3.4	5.2	7.8	10.2	12.1	13.4	14.5	13.3	19.0
0.1	0.68	0.06	0.53	5.21	1.89	0.0	0.0	0.3	1.9	4.1	6.1	7.9	9.8	17.2	52.6	0.7	3.4	4.7	7.9	10.3	12.3	13.6	14.7	13.3	19.1
0.15	0.69	0.06	0.54	5.62	1.93	0.0	0.0	0.2	1.8	3.9	5.8	7.5	9.6	17.4	53.9	2.0	2.2	3.9	7.8	10.5	12.5	13.7	14.8	13.4	19.2
0.2	0.70	0.05	0.55	6.13	2.00	0.0	0.0	0.1	1.6	3.6	5.5	7.2	9.3	17.6	55.2	1.8	2.1	3.6	7.6	10.7	12.6	13.9	14.9	13.4	19.3
0.25	0.71	0.05	0.56	6.71	2.07	0.0	0.0	0.1	1.4	3.3	5.2	6.8	9.0	17.8	56.4	1.8	2.0	3.0	7.8	10.8	12.8	14.0	15.0	13.4	19.4
0.3	0.72	0.04	0.58	7.33	2.15	0.0	0.0	0.1	1.2	3.1	4.8	6.4	8.7	18.1	57.6	1.8	1.9	2.6	7.8	11.0	12.9	14.1	15.1	13.4	19.4
0.35	0.73	0.04	0.59	7.97	2.23	0.0	0.0	0.0	1.1	2.9	4.6	6.1	8.5	18.3	58.6	1.7	1.9	2.4	7.6	11.2	13.0	14.2	15.1	13.4	19.5
0.4	0.74	0.04	0.60	8.67	2.31	0.0	0.0	0.0	0.9	2.6	4.3	5.8	8.2	18.4	59.7	1.7	1.8	2.0	7.8	11.2	13.1	14.3	15.2	13.4	19.5

Table A11: Results for Variations in Consumption Tax Rates. Net Income Distribution

	Distribution					Net income deciles in %										Effective labor supply in net income deciles in %									
τ^c	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.19	0.35	0.24	4.22	1.66	2.55	3.5	3.5	4.7	6.0	6.5	11.1	11.4	13.1	14.7	25.4	0.1	0.1	0.8	4.2	3.6	10.6	13.3	15.4	18.4	33.5
Scenarios																									
0	0.38	0.21	5.15	2.05	2.51	2.7	3.0	3.9	5.7	6.1	11.1	11.7	13.6	15.3	26.9	0.4	1.3	1.0	4.4	4.9	10.1	13.2	15.1	17.8	31.9
0.05	0.37	0.22	4.81	1.92	2.51	2.9	3.2	4.1	5.8	6.2	11.1	11.6	13.4	15.1	26.5	0.3	1.0	0.8	4.4	4.5	10.2	13.2	15.2	17.9	32.4
0.1	0.36	0.23	4.57	1.81	2.53	3.2	3.3	4.4	5.9	6.3	11.1	11.5	13.3	15.0	26.1	0.3	0.7	0.7	4.3	4.2	10.3	13.2	15.4	18.0	32.8
0.15	0.35	0.24	4.36	1.72	2.54	3.4	3.4	4.6	6.0	6.5	11.1	11.4	13.2	14.8	25.7	0.2	0.4	0.7	4.3	3.9	10.5	13.2	15.4	18.2	33.2
0.2	0.34	0.24	4.19	1.64	2.55	3.5	3.6	4.8	6.0	6.6	11.1	11.3	13.1	14.7	25.3	0.1	0.1	0.8	4.2	3.6	10.7	13.3	15.4	18.4	33.6
0.25	0.33	0.25	3.92	1.58	2.49	3.7	3.8	5.0	6.1	6.7	11.0	11.2	12.9	14.5	25.0	0.0	0.0	0.8	4.1	3.2	10.9	13.2	15.3	18.6	33.8
0.3	0.32	0.26	3.64	1.52	2.40	4.0	4.0	5.1	6.2	6.8	11.0	11.1	12.8	14.4	24.6	0.0	0.0	0.9	4.0	2.9	11.1	13.2	15.1	18.8	34.0
0.35	0.31	0.27	3.41	1.47	2.32	4.2	4.2	5.3	6.2	6.9	10.9	11.1	12.7	14.2	24.3	0.0	0.0	0.9	3.9	2.6	11.3	13.2	15.0	19.0	34.2
0.4	0.30	0.27	3.22	1.43	2.26	4.4	4.4	5.4	6.3	7.0	10.9	11.0	12.6	14.1	24.0	0.0	0.0	0.9	3.7	2.4	11.5	13.1	14.8	19.2	34.4

Table A12: Results for Variations in Consumption Tax Rates. Consumption Distribution

	Distribution					**Consumption deciles in %**										**Effective labor supply in consumption deciles in %**									
τ^c	Gini	Low 50%	P90 /10	P90 /50	P50 /10	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Benchmark																									
0.19	0.29	0.28	4.24	1.42	2.98	3.5	3.9	6.0	6.4	8.6	10.9	11.4	13.5	14.4	21.4	0.2	0.1	3.4	4.1	4.5	12.8	11.7	16.1	17.5	29.6
Scenarios																									
0	0.32	0.27	5.05	1.48	3.42	3.0	3.4	5.6	6.2	8.3	10.9	11.7	13.7	14.8	22.2	1.3	0.8	3.4	4.8	4.5	12.5	11.9	15.4	17.0	28.4
0.05	0.31	0.27	4.78	1.46	3.27	3.2	3.6	5.7	6.3	8.4	10.9	11.6	13.6	14.7	22.0	1.0	0.6	3.4	4.6	4.5	12.6	11.8	15.6	17.1	28.7
0.1	0.30	0.28	4.56	1.45	3.15	3.3	3.7	5.8	6.4	8.5	10.9	11.5	13.6	14.6	21.7	0.7	0.4	3.4	4.4	4.5	12.6	11.8	15.8	17.3	29.1
0.15	0.30	0.28	4.37	1.43	3.05	3.4	3.8	5.9	6.4	8.6	10.9	11.5	13.5	14.5	21.5	0.4	0.2	3.4	4.3	4.5	12.7	11.7	16.0	17.4	29.4
0.2	0.29	0.29	4.21	1.42	2.97	3.5	4.0	6.0	6.4	8.6	10.9	11.4	13.5	14.3	21.3	0.1	0.1	3.4	4.1	4.4	12.8	11.7	16.2	17.5	29.7
0.25	0.29	0.29	3.96	1.41	2.82	3.7	4.1	6.1	6.5	8.7	10.8	11.4	13.4	14.2	21.1	0.0	0.0	3.4	3.9	4.4	12.8	11.6	16.4	17.6	29.9
0.3	0.28	0.30	3.69	1.40	2.64	4.0	4.3	6.2	6.5	8.7	10.8	11.3	13.3	14.1	20.9	0.0	0.0	3.3	3.7	4.4	12.8	11.4	16.5	17.6	30.1
0.35	0.27	0.30	3.46	1.39	2.49	4.2	4.5	6.2	6.5	8.8	10.7	11.2	13.2	14.0	20.7	0.0	0.0	3.3	3.5	4.4	12.8	11.3	16.7	17.6	30.4
0.4	0.26	0.31	3.27	1.38	2.37	4.4	4.7	6.3	6.5	8.8	10.7	11.2	13.2	13.9	20.5	0.0	0.0	3.2	3.3	4.4	12.8	11.2	16.9	17.6	30.6