The Macroeconomic Effects of Income Taxes on Labor Markets*

Claudia Udroiu†
Free University of Bolzano-Bozen

Francesco Ravazzolo‡
Free University of Bolzano-Bozen

Aicha Kharazi§
University of Exeter

March 17, 2024

Abstract

In this paper, we analyse the inequalities arising from the redistributive channel of income taxation. We construct a Real Business Cycle (RBC) model with two agents. Through impulse response functions, we show that a shock to income taxes affects differently the two agents, suggesting a heterogeneous and negative response of labour supply. To test these results, we provide microeconomic evidence from the US Current Population Survey. We find that the bottom 10% of the income distribution pays a higher tax percentage proportional to their earned income with respect to the top 10%. Additionally, we find that the labour elasticity with respect to the income tax is positive.

Keywords: income tax, labor supply, elasticity of labor supply

JEL Codes: E24, J20, H24, H31

*Very Preliminary Draft

†Claudia Udroiu: Claudia.udroiu@unibz.it

‡Francesco Ravazzolo: francesco.ravazzolo@unibz.it

§Aicha Kharazi (Corresponding Author): a.kharazi@exeter.ac.uk

1 Introduction

In 2012 the wealth share of the top 0.1% of the population in the United States was 22% compared to 7% at the end of the 1970s (Saez and Zucman, 2016). (Saez and Zucman, 2016) not only show that wealth inequality increased substantially with respect to five decades ago but also that the growth has been continuous since then. Given the impact of the 2008 Great Recession and the COVID-19 recession, the issue of wealth inequality has gained even greater importance, particularly in the United States.

(Blanchet et al., 2022) explore real-time data and demonstrate that recovery of income has been both swifter and more equitable after the COVID-19 recession in comparison to the 2008 Great Recession. Although the authors observed a decrease in income inequalities after the COVID-19 pandemic, they also found that the top 1% still experienced a greater growth in labor income compared to all other subgroups. One of the drivers of income inequality is income taxation, which in the US is set on a progressive basis. However, (**?**) show that tax progressivity has declined over the recent decades.

Income taxation has broad implications on macroeconomic dynamics. The trade-off between redistribution and economic efficiency of labor income taxes has become a key topic in public debate. In 2020 in the US, for example, a worker faced an average labor income tax of 28.3%. Changes in income taxes can generate several indirect effects. For instance, an increase in income taxation can induce workers to work more in order to increase the after-tax income. Furthermore, a higher tax wedge can have adverse effects on employment and labor productivity. Substitution effects may also occur, when there is a higher tax burden on the workers, this may plausibly lead them to shift away towards less taxed economic activities. The transmission mechanism of a tax shock is complex and yet the response of labor supply to changes in income taxation deserves in-depth studies.

This paper focuses on the impact of income taxation across different working groups and the elasticity of labor supply to income taxation. We first construct a Real Business Cycle (RBC) model with two agents. The model introduce heterogeneity in the flow budget constraint faced by households, specifically wealthy and hand to mouth households. Through impulse response functions, we show that a shock to income taxes affects differently the two agents. We then provide micro evidence on the labor supply elasticity to income tax based on the Current Population Survey (CPS) data over the period 2009 - 2022.

Firstly, facts resulting from the data clearly show a heterogeneous impact of income taxation on different income subgroups. Similarly, we observe a heterogenous impact of income taxation on the intensive margin (hours worked) across different income subgroups. Our paper contributes to the existing body of literature on the redistributive mechanisms of fiscal policy. Additionally, we address the issue of inequalities in the income distribution. Secondly, we estimate the elasticity of labor supply to income taxes and accordingly calibrate the inverse of the Frisch parameter in a small DSGE model with heterogeneous agents. Impulse response functions allow us to highlight the redistributive channels of income taxation. We finally show that income taxation impacts heterogenous agents differently.

2 Related literature

Our paper is related to literature about the implications of taxation on labor productivity and employment. A seminal work by Mirrlees (1971) shows that taxing labor earnings causes a large decline in work effort and output. A different results is obtained by Summers (1981), who consider a overlapping generations framework and finds that the income tax has no effect on labor supply. In a related work, Gabrovski and Guo (2022) examine how progressive taxation under nominal wage rigidity cause labor supply curve to shift. Golosov et al. (2013) assess the optimal policy mix that involves redistribution of labor income inequality using a labor earning tax and an unemployment benefit. Carbonell-Nicolau and Llavador (2021) characterize the optimal income taxation that reduces endogenous income inequality in two frameworks that assume constant elasticity of substitution (CES) and the quasi-linear preferences. (Alpert and Powell, 2020) find statistically significant and economically meaningful effects of taxes on labor force participation for older workers. (Bick and Fuchs-Schündeln, 2018) find very low cross country correlation between hours worked by married men and women. They investigate insofar taxes on consumption and on income contribute to the low correlation, and they find this result is driven by the different tax treatment (progressivity and joint taxation) of married couples and by different taxes on consumption across countries. (Attinasi et al., 2016) examine the influence of labor income taxes on labor market performance in a sample of 30 OECD countries. They specifically focus on two performance indicators: the unemployment rate and employment levels. The findings of the study indicate that a more progressive tax system has a less distortionary impact on lower-income individuals compared to higher-income individuals.

Other studies focuse on estimating the Frisch elasticity, that is the elasticity of labor supply to changes in wages, both along the extensive margin (employment) and along the intensive margin (hours worked).

(Gottlieb et al., 2021) and (Martinez et al., 2021) estimate Frisch elasticieties across different groups using tax holiday data in Iceland and Switzerland. By employing data during tax holidays, their studies isolate the impact of a change in wage to the labor supply from other frictions, such as human capital accumulation, permanent variations in wages etc. (Martinez et al., 2021) employ administrative social security earnings data matched with Census data to estimate the Frisch elasticity of labor supply parameter during a unique period in Switzerland when income was not subject to taxation. Using a difference-in-differences methodology, the authors observe a remarkably low Frisch elasticity parameter od 0.025 on an aggregate level. Furthermore, their analysis along the intensive margin reveals that men exhibit higher Frisch elasticities compared to women, self-employed individuals demonstrate higher elasticities than wage earners, and the highest earners exhibit the highest elasticities. Notably, the authors find no response along the extensive margin. (Gottlieb et al., 2021) build a simple general equilibrium framework to investigate whether Frisch elasticities estimated with reduced-form evidence align with those estimated in models. The authors find that the range of values generally used in macro models to calibrate the Frisch elasticity parameter align with those from reduced-form estimates. (Keane, 2011) finds large Frisch elasticities for men. The author also uncovers substantial labor supply elasticities for women, especially in the long run, by considering the dynamic interplay of wages with factors like marriage, work experience, etc. Other studies focus on quantifying the Frisch elasticity. (Chetty et al., 2013) for example, find Frisch elasticities estimations of 0.5 for aggregate hours worked, while (Chetty, 2012) finds a maximum of 0.47 Frisch elasticity implied by a Hicksian elasticity of 0.33.

Our paper is also related to the strand of literature on wage inequalities and the tax structure. (Piketty and Saez, 2003) present a new series on top share incomes and wages from 1913 until 1998. The authors show that top wage shares dropped during the WWII, and started recovering only since the 1970s. The authors suggest that steep progressive taxation have prevented the top incomes to fully recover from the war shock. (Keane, 2022) reviews frontier research in the field of optimal tax literature. His work underscores the significance of incorporating human capital investment and the participation margin in models accounting for labor supply. His findings suggest that labor supply elasticity increases with age and is larger for married women. (Diamond and Saez, 2011) analyze optimal taxation from a policy perspective. Their findings suggest that high and rising marginal tax rates on earnings are more appropriate for individuals with very high incomes. Additionally, they propose that low-income families should be incentivized to work through earnings subsidies. The authors also advocate for the taxation of capital income. (Wu and Krueger, 2021) analyse the impact of wage shocks and the optimal progressive taxation structure in a two-earner household. (Gerber et al., 2018) find that a downward trend in corporate income taxes over the past years driven by international tax competition has contributed to reducing overall progressivity. This trend may in turn put downward pressure on personal income tax rates. According to (Erosa et al., 2016) considering preference heterogeneity is crucial when assessing the impact of taxes on labor supply. The authors build a model and provide an aggregation theory using micro evidence to study implications of aggregate labor supply.

Additionally, our work is linked to literature about heterogeneity of agent behavior in macro models. Despite the seminal work of (Krusell and Smith, 1998), that demonstrated that business cycle features can be described through the mean of the wealth distribution, the literature on heterogeneous agents has focused on developing models that incorporate household-level risk factors. Since the work of (Aiyagari, 1994) on uninsured idiosyncratic risks, inequality of wealth and income distribution has gained increased attention in literature. (Heathcote, 2005) analyzed the impact of taxes on consumption within a model that considers households facing borrowing constraints. More recent literature, including extensive research conducted by (Kaplan et al., 2018), (Auclert et al., 2018), (Patterson, 2023) highlight an indirect channel of monetary policy trasmission, that impacts households differently. In this paper we follow (Debortoli and Galí, 2021), who show that a two agents new keynesian model (TANK) can provide a good approximation of the behavior of a more computably challenging HANK model, when considering the impact of monetary policy shocks in the two models. To simplify our model, we omit nominal rigidities and instead focus on the heterogenous effects of income taxation through the redistributive channel.

The rest of the paper is structured as follows. Section xxx describes the theoretical framework. In section xxx the quantitative analysis, including the calibration, the model results and the micro-data evidence is presented and section xxx concludes.

3 Theoretical Framework

We develop a model that consist of two type of households: wealthy and hand-to-mouth households. Representative firm and a central government.

Government In this environment, we assume that the level of government spending g_t and the tax rate τ_t is determined exogenously. The tax rate shock is given by $\tau_t = \kappa_\tau \tau_{t-1} + \epsilon_t^\tau$, and the government spending shock is also defined as $g_t = \kappa_g g_{t-1} + \epsilon_t^g$. We further assume that the government debt dynamics is defined by

$$d_{t+1} = s_t + (1 + r_t)d_t$$

where d_{t+1} is the newly issued government debt and $(1 + r_t)d_t$ is the servicing cost of the previous debt. s_t denotes the government's fiscal deficit if $s > 0$ (fiscal surplus if $s < 0$). The government takes the interest rate on debt r_t as given and choose the level of debt d_{t+1}. To capture the feedback effects of debt burden, we assume that a non optimizing government has a fiscal rule that capture the idea that government will raise taxes or reduces spending to reduce debt burden, with $s =$ government spending $-$ tax revenues $= g_t - \tau_t(\omega_t^w h_t^w + (1 + r_{t-1})a_{t-1} + \Pi_t^w) - \tau_t(\omega_t^s h_t^s + \Pi_t^s)$. If the government's financing needs s is positive, this will guarantee an increase in government debt d_{t+1}. The definition of the fiscal rule rule is close to Lorenzoni and Werning (2019), but we abstract from the assumption that government could default.

Wealthy Households: (saver) There is a continuum of households indexed by $j \in [0, 1]$ with utility function

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t \frac{(c_{j,t}^w)^{1-\sigma}}{1-\sigma} - \phi_{j,t}^w \frac{(h_{j,t}^w)^{1+\eta}}{1+\eta}$$

where $\beta \geq 0$ is the discount factor and σ is the coefficient of relative risk aversion. The household budget constraint is given by $c_{j,t}^w + a_{j,t} = (1 - \tau_{j,t})e_{j,t}^w$, with total taxable income defined as $e_{j,t}^w = \omega_{j,t}^w h_{j,t}^w + (1 + r_{t-1})a_{j,t-1} + \Pi_t^w$. The variable $c_{j,t}^w$ denotes consumption and $h_{j,t}^w$ represents labor and $\phi_{j,t}^w$ denotes a labor supply shock. Given our budget constraint specification, we refer to $\omega^w_{j,t}$ as the hourly wage rate and r_t is the interest rate. Household is subject to a an income tax shock $\tau_{j,t}$. We assume that households type w accumulate assets $a_{j,t}$ over time and receive lump sum transfer Π^w_t. The household optimality conditions with respect to consumption: $c^w_{j,t}$, asset accumulation $a_{j,t}$, hours worked: $h^w_{j,t}$ are given by

$$\begin{aligned}\lambda_{j,t} &= (c^w_{j,t})^{-\sigma},\\ \phi^w_{j,t}(h^w_{j,t})^{\eta} &= \lambda_{j,t}(1-\tau_{j,t})\omega^w_{j,t},\\ \lambda_{j,t} &= \beta E_t\lambda_{j,t+1}(1-\tau_{j,t})(1+r_t).\end{aligned}$$

Hand to mouth Households (spender) Household s derive utility from consumption $c^s_{j,t}$ and disutility from hours worked $h^s_{j,t}$

$$\max \quad E_0\sum_{t=0}^{\infty}\beta^t\frac{(c^s_{j,t})^{1-\sigma}}{1-\sigma}-\phi^s_{j,t}\frac{(h^s_{j,t})^{1+\nu}}{1+\nu}$$

where β represents the discount factor, σ denotes the risk aversion parameter, and $\phi^s_{j,t}$ is a household preference shifter for labor. The budget constraint is given by $c^s_{j,t}=(1-\tau_{j,t})e^s_{j,t}$, and the taxable income of the hand to mouth housholds is defined as: $e^s_{j,t}=\omega^s_{j,t}h^s_{j,t}+\Pi^s_t$. The specification of household budget constraint states that labor income $\omega^s_{j,t}h^s_{j,t}$ and dividends Π^s_t received are the only source of income. Household consume $c^s_{j,t}$ and face an income tax shock $\tau_{j,t}$. The household optimality conditions with respect to consumption: $c^s_{j,t}$ and hours worked $h^s_{j,t}$ are as follow

$$\begin{aligned}\lambda_{j,t} &= (c^s_{j,t})^{-\sigma},\\ \phi^s_{j,t}(h^s_{j,t})^{\eta} &= \lambda_{j,t}(1-\tau_{j,t})\omega^s_{j,t}.\end{aligned}$$

Capital Producers We follow Greenwood Hercowitz and Krusell 1997, and assume that capital k_t evolves according to $k_t=(1-\delta)k_{t-1}+i_t$, where δ is the capital depreciation rate, and i_t is the new investment. In each period, capital producers can make investment subject to adjustment cost and sell capital to firms. Capital producers choose investment and capital with the flow of funds of capital producers constraint is given by $q_t i_t = r^k_t k_{t-1}$, where q_t is the price of installed capital (Tobin's marginal q) and r^k_t is the capital rental rate.

Firms and market clearing condition There is a continuum of final good firms, they combine capital k_t and two type of labor h_t^s and h_t^w to produce y_t:

$$y_t = (k_t)^\alpha a_t \left((h_t^s)^{\frac{1}{\theta}} + (h_t^w)^{\frac{1}{\theta}}\right)^{(1-\alpha)\theta},$$

where $\alpha \in (0.1)$ is the Cobb Douglas parameter, the exogenous variable a_t denotes the productivity shock. We assume that $\ln(a_t)$ follow an AR(1) such that $\ln(a_t) = \rho^a \ln(a_{t-1}) + \epsilon_t^a$. The goods market equilibrium condition that states that output is used for consumption, investment and government spending is given by $y_t = c_t^w + c_t^s + i_t + g_t$.

Equilibrium Definition We define an equilibrium as a collection of prices and quantities such that, (i) Government chooses $\{d_t^y\}$; (ii) Wealthy households choose $\{c_t^w,\ l_t^w,\ a_t,\ r_t\}$ in order to maximize their utility subject to the budget constraints; (ii) hand to mouth households choose $\{c_t^s,\ l_t^s\}$ in order to maximize their utility subject to the budget constraints; (ii) Producers choose how much labour and capital input to use for production $\{l_t^w,\ l_t^s,\ k_t\}$ to minimize their production cost. The first order conditions yields the market prices at the equilibrium $\{\omega_t^w,\ \omega_t^s,\ r_t^k\}$. (iii) Equilibrium requires that the market for assets clears $a_t = a_{t-1}(1 + r_{t-1})$. The model is driven by three exogenous shocks: a tax shock τ_t, a government spending shock, and a technology shock A_t.[1]

Solution Method We use perturbation techniques as in Schmitt Grohe Uribe 2003 to solve our dynamic general equilibrium model, specifically second-order method. This numerical approximation techniques of the policy function emerges as a convenient approach to compute the approximation in the neighborhood of particular non-stochastic steady state that can deliver reasonably accurate solution. The equilibrium conditions can be expressed by equation

$$E_t f(y_{t+1}, y_t, x_{t+1}, x_t) = 0$$

where the E_t is the conditional expectation operator, y_t denotes the vector of non-predetermined variables, in our example variables l_t^s, l_t^w, k_t, r_t^k, and r_t belong to the vector y_t, and x_t denotes

[1] Detailed model derivations are contained in the technical appendix.

the vector of predetermined variables a_t, g_t, and τ_t. Note that all the predetermined variables are essentially exogenous states variables.

4 Quantitative Analysis

4.1 Calibration

First, we set as a target debt to gross domestic product ratio to 90 percent in the US, this consistent with the observed data. This ratio varied between 70 and 100 percent during the period 2009 and 2022. We parametrize the government spending to be equal to 20 percent, and total investment to 10 percent which are both in-line with the US macro data. Additionally we set the persistence parameter of government spending shock to 0.9.

Second, we set the values for the curvature on the disutility of labor supplied by wealthy households η^w at 1.05, and for the curvature on the disutility of labor supplied by hand to mouth households η^s at 1.20. The weight on the disutility of labor for the two type of households ϕ^w and ϕ^s are assumed to be equal to 1. The discount factor is set at standard value 0.97 for the two agents, which can pin down the value of interest rate r ($1/\beta - 1 = r$). Additionally, the depreciation rate on capital equals 0.025. Given the depreciation rate we can calculate the capital k in this economy, we can compute total consumption since we have an initial guess for output, investment and government spending.

Third, the tax rate τ is set at the value of 0.30, which is close to the top bracket of income tax rate that range from 10 percent to 37 percent in the US. The share of wealthy household consumption to total consumption is assumed to be 60 percent of total consumption. This is consistent withKaplan et al. (2018) and Bilbiie (2020). The risk aversion parameter for wealthy household and hand to mouth households equal 1, as in Kopiec (2022).

Next, we assume that the average hourly earnings for wealthy households 22 per hour (normalized to 22/100= 0.22), and that the average hourly earnings for hand to mouth households 14 per hour (normalized to 14/100= 0.14), which is close to value of average hourly wage rate in the US of 19.

Finally, the Cobb Douglas parameter α is set a the value of 0.4. The coefficient on lagged productivity shock is equal to 0.95, and the standard deviation of the shock is equal to 0.52 in-line with the value reported in Christiano et al. (2014). We assume that the labor elasticity of substitution parameter between wealthy and hand-to-mouth households is assumed to be 0.928.

Parameter	Description	Value
β	Discount rate	0.97
κ	The share of wealthy household consumption to total consumption	0.6
η_w	The curvature on the disutility of labor supplied by wealthy households	1.05
η_s	The curvature on the disutility of labor supplied by hand to mouth households	1.10
ϕ^w	The weight on the disutility of labor for the wealthy households	1
ϕ^s	The weight on the disutility of labor for the hand to mouth households	1
τ	Income tax rate	0.30
σ^w	The risk aversion parameter for wealthy households	1
σ^s	The risk aversion parameter for hand to mouth households	1
ω^w_{ss}	The average hourly earnings for wealthy households	0.22
ω^s_{ss}	The average hourly earnings for hand to mouth households	0.14
δ	Depreciation rate on capital	0.025
α	Cobb Douglas parameter	0.4
θ	The labor elasticity of substitution parameter between wealth and hand to mouth households	0.928
κ^g	The persistence parameter of government spending shock	0.9
ρ^A	The coefficient on lagged productivity shock	0.95
σ^A	Standard deviation of the shock	0.52

Table 1: Calibrated Parameters

4.2 Effects of Income Tax Changes: Model

Responses of Hours worked to tax shock We investigate the impact of an increase in income tax on hours worked, as implied by our model, which is solved using a second-order approximation solution method. A second-order approximation method serves as a suitable approach when accounting for non-linearities that may arise in the model framework. Generally, the model solution obtained with a first-order approximation around the steady state should suffice for a small RBC model like ours. Therefore, we also solve the model with a first-order approximation and compare the IRFs. With both solution methods, we find that a positive one-standard deviation tax shock leads to a decrease in hours worked by both wealthy households and hand-to-mouth households. This one-standard deviation negative tax shock experiment indicates that, conditional on household economic behavior, a tax rise can generate heterogeneity in the household's labor supply response. We find that the decrease in labor supply caused by an income tax shock is twice as much for wealthy households as for hand-to-mouth households.

The result that an increase in the income tax rate gives an incentive for households to reduce work efforts appears to confirm a previous result obtained by Born et al. (2013). The authors analyse the impact of fiscal shocks on labor supply and other macroeconomic aggregates in a dynamic general equilibrium framework. In an estimated New Keynesian model, they find that labor supply responds negatively on impact to an income tax cut, but soon after labor supply increases. In an RBC framework, the impact on labor supply is positive on impact and for the entire adjustment period after the shock hits the eocnomy. In our specification, an income tax increase translates in less disposable income for the household and this produces negative substitution effects, leading the households to cut labor efforts. This, in turn, induces firms to substitute labor for capital. Similarly, Zubairy (2014) found that a labor tax cut can lead to a significant rise in labor supply, driven by intertemporal substitution effetcs in an estimated New Keynesian model.

Conterfactuals Consider now two experiments where tax rate τ is high and equal 30 percent, and low when tax rate is equal to 10 percent. We use our model to simulate and compare the time series of labor supply of the two agents under high and low tax environment, as depicted in figure. The effects of low and high tax environment shows that hours worked fluctuations will be either amplified or dampened. Low tax environment leads to an amplification of hours worked by hand-to mouth and wealthy households. The change in tax rate does develop into an amplification of the labor supply, but does not exhibit a change in the pattern of labor supply fluctuation.

4.3 Income tax and hours worked: Micro-data Evidence

We extract cross sectional data from the CPS data. This data allows us to observe the state income tax after credit at the individual level, taxable income over the period 2009-2022 annual level. We first construct a measure of average tax rate as follows:

$$\textit{Average tax rate} = \frac{\textit{State income tax after credits}}{\textit{Taxable income}} \times 100$$

where taxable income, as defined in the current population survey, is composed of the adjusted gross income with the allowable itemized deductions and exemptions subtracted. The state income tax after credits represent total amount paid on taxes. We then use these

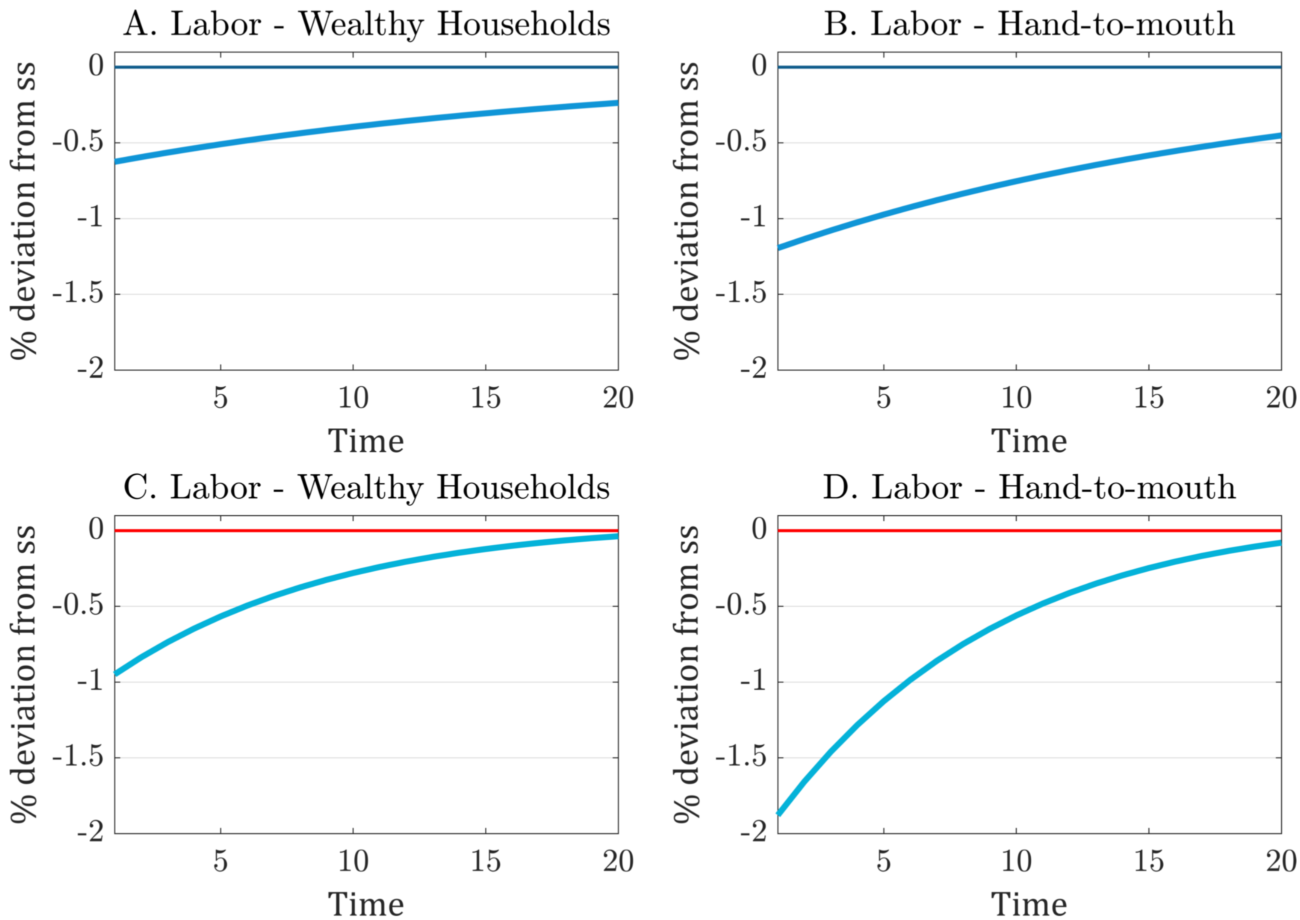

Figure 1: Tax Shock - labor response

<u>Notes</u>: The figure depicts the impulse responses to a positive tax shock, Panels A and B represent the response using first order approximation and Panels C and D represent the response using second order approximation.

two observations to calculate the individual-specific average tax rate. We also construct a measure for hours worked

$$\textit{Hours worked} = \textit{Hours worked per week} \times \textit{Number of weeks}$$

Since we are interested in the total hours worked in a yearly term, we multiply the hours worked per week by 52, the number of weeks in a year.

Figure 3 reports the distribution of weekly hours worked in the US between 2009 and 2022. Notice that there are few households that report lower hours worked in a week, with a log value that varies between 6 and 7. While the average of the log value of hours worked is around 7.5 and 8. It is also evident from the figure that there is an upper limit for log hours worked is 8.5.

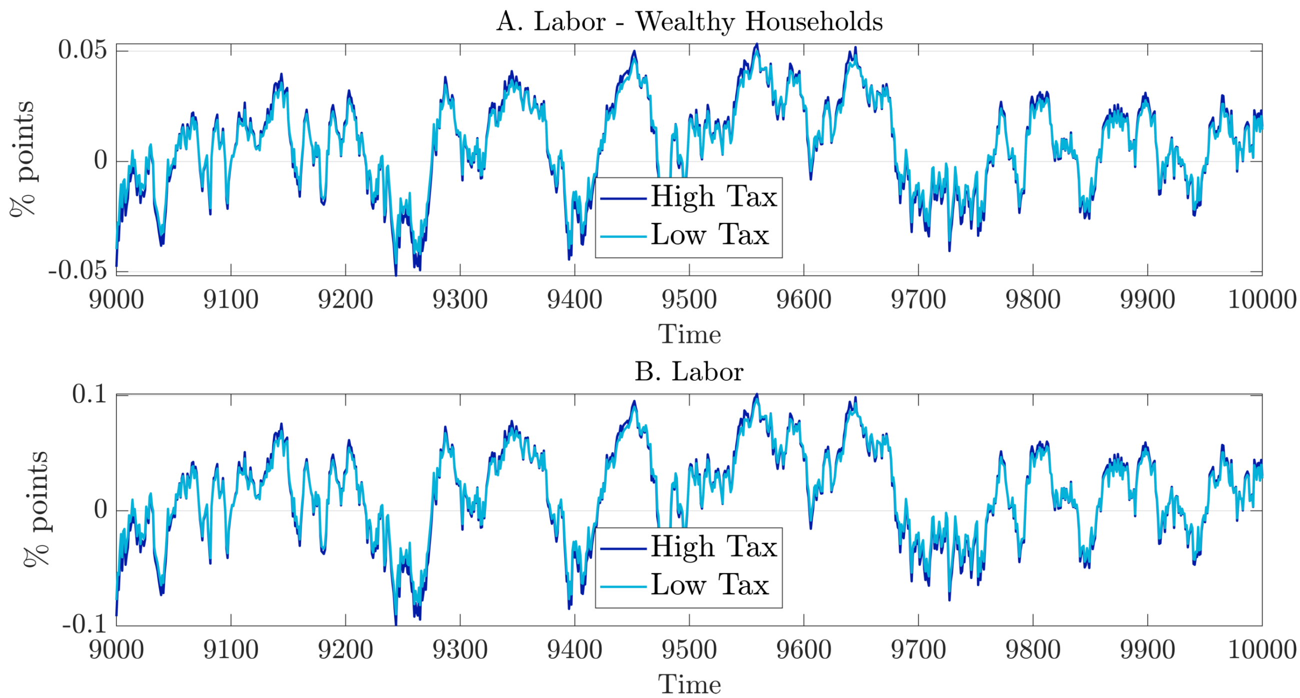

Figure 2: Counterfactuals

Notes: Model simulation under high and low taxation.

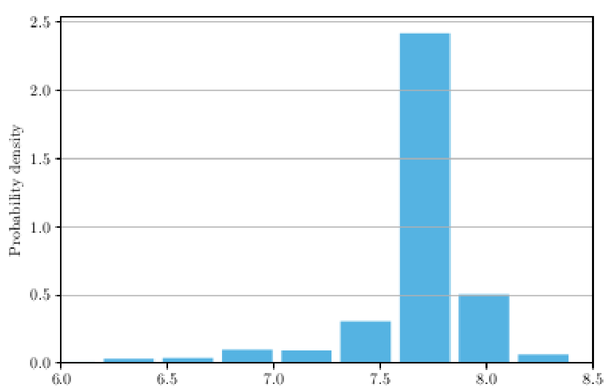

Figure 3: Log hours worked

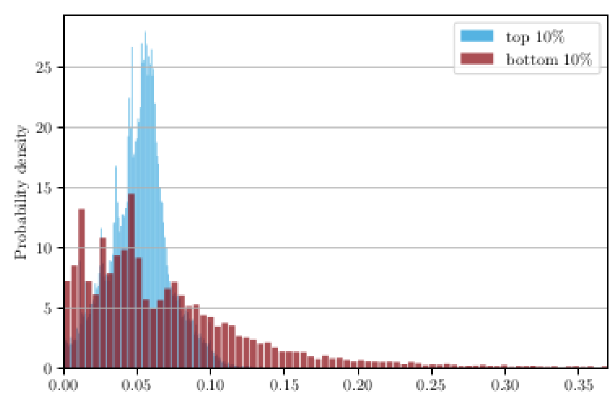

Figure 4: Tax rate top 10% vs bottom 10%

Notes: Based on the data from the Current Population Survey between 2009 and 2022.

Salient observations from figure 4 point out differences in the way high and low-income individuals are taxed. It turns out that, on average, the tax rate for wealthy individuals is roughly 5%. On the other hand, the tax rate for the bottom 10% of the income distribution varies widely. Zooming in on the right side of the figure suggests that wealthy individuals are taxed less in proportion to their income compared to low-income individuals. This contradicts the idea that the tax schedule in the US exhibits equal sacrifice across the income distribution, as evidenced in (Young, 1990).

Table 2: Average Tax Rate and Average Annual Hours Worked between 2009 and 2022

Average tax rate	2009-2022	2009	2013	2017	2021	2022
Panel A: Average tax rate						
Bottom 10%	0.072	0.065	0.077	0.070	0.079	0.081
Bottom 50%	0.054	0.050	0.056	0.054	0.055	0.056
Top 50%	0.052	0.048	0.052	0.052	0.052	0.052
Top 10%	0.054	0.050	0.054	0.054	0.053	0.053
Panel B: Hours worked						
Bottom 10%	1847.880	1875.527	1846.871	1843.237	1852.900	1811.337
Bottom 50%	2044.741	2058.551	2058.948	2051.796	2041.024	2032.643
Top 50%	2150.402	2141.796	2175.178	2163.700	2144.775	2145.028
Top 10%	2195.593	2196.981	2233.946	2208.996	2184.967	2184.403

Notes: The table present the effective average tax rate and annual hours worked across the income distribution between 2009 and 2022. Source: Current Population Survey Data.

Table 2 reports the average hourly earnings and the average annual hours worked during the reference period of 2009-2022. Panel A presents the tax rates for different income quantiles. It appears that tax rates slightly increased between 2009 and 2022, rising from 6.5 percent to 8.1 percent for bottom 10 % of income earners. While top 10 % of the income distribution experienced a modest increase in tax rate, going from an average of 5 % in 2009 to 5.3 % in 2022. There has been a similar increase from 5 percent to 5.6 % for the bottom 50 %, and from 4.8 % to 5.2 % for the top 50 %. This evidence points to the idea that taxes were burdensome for low-income households compared to high-income households

Panel B shows hours worked dynamics across income distribution between 2009 and 2022. The average annual hours worked by top 50 percent and top 10 percent of income distribution remain the largest with 2150 and 2195, respectively. Average total hours worked does not changed much and makes negligible fluctuations, for example, slight decrease is observed in 2017 for all income categories. Although not reported here average total hours worked should exhibit a large decline during the Covid recession.

Estimation of the labor elasticity with respect to income tax. To get a better understanding of the influence of tax wedge on hours worked, we consider a simple regression at the individual level by regressing log hours worked on the tax rate:

$$\log h_{j,t} = \alpha + \alpha^{\tau} \log \tau_{j,t} + \alpha_j + \alpha_t + \epsilon_{j,t},$$

where $\alpha^{\tau} = \frac{cov(\log h_{j,t}, \log \tau_{j,t})}{var(\log \tau_{j,t})}$ is the labor supply elasticity with respect to tax rate, α_j and α_t denote the household and time fixed effects, respectively. $\epsilon_{j,t}$ is the error term, standard errors are two-way clustered at households and year level. We augment our model specification with time and household fixed effects to control for time trends and households specific factors that could affect our estimates. We use the current population survey data to estimate this elasticity over the sample period 2009 to 2022. This data ideally provide information on income, labor supplly and income taxation which is useful for our research purpose.

Table 3: Results of Ordinary Least Squares Estimation of the Relationship Between Tax Rate and Hours Worked

	Dependent Variable: Log Hours Worked			
	(1)	(2)	(3)	(4)
constant	7.63496***	7.63463***	7.64284***	7.64342***
	(0.00787)	(0.00811)	(0.00503)	(0.00488)
Log average tax rate	0.00642**	0.00631**	0.00898***	0.00917***
	(0.00264)	(0.00264)	(0.00170)	(0.00170)
Covariance Type:	Clustered	Clustered	Clustered	Clustered
Household Fixed Effects:	Yes	Yes	No	No
Year Fixed Effects:	No	Yes	Yes	No
F-statistic:	25.46	24.56	74.57	77.88
No. Observations:	214573	214573	214573	214573

Notes: This table reports the ordinary least squares regression; (1) with time and household fixed effects, (2) with time fixed effects, (3) with household fixed effects, (4) with no fixed effects. Statistical significance (Std. error in parentheses): 0.1*, 0.05**, 0.01***. Standard errors are clustered at household and year level. Data sources: Current Population Survey (2009-2022).

Empirically, we find a positive elasticity of labour supply to tax. The point estimate is positive and statistically different from zero (the estimate of α^{τ} equals 0.006) implying that households work effort, interpreted here as hours worked, increases when the tax rate goes up. Our estimates are largely robust to a specification that controls for time and household fixed effects, and when we use a sample that exclude financial crisis and Covid recession,

Table 4: Results of Ordinary Least Squares Estimation of the Relationship Between Tax Rate and Hours Worked

	Dependent Variable: Log Hours Worked			
	Top 10 Income	Top 50	Bottom 10	Bottom 50
	(1)	(2)	(3)	(4)
Constant	7.7010***	7.7269***	7.4594***	7.5976***
	(0.0138)	(0.0073)	(0.0089)	(0.0063)
Log average tax rate	0.0120***	0.0248***	0.0015	0.0054***
	(0.0048)	(0.0025)	(0.0028)	(0.0020)
No. Observations:	21338	106688	21246	106688
R-squared:	0.002	0.002	0.000	0.000
F-statistic:	8.2264	175.5	0.2992	16.73
Covariance Type:	Clustered	Clustered	Clustered	Clustered

Notes: This table reports the ordinary least squares regression. Statistical significance (Std. error in parentheses): 0.1*, 0.05**, 0.01***. Standard errors are clustered at household and year level. Data sources: Current Population Survey (2010-2019).

additional results are reported in Appendix Table 6. It is worth to mention that this empirical evidence is radically different from the model prediction that states that a positive tax shock leads to a decline in hours worked.

We now quantitatively analyze the heterogeneous effects of tax shock across income distribution. Table 4 reveals that high income households are the most responsive to tax shocks than low-income households. Column 1 records a positive and statistically significant point estimate of 0.02 for households at the top 10% of income distribution. In comparison, Column 4 reports a point estimate of 0.005 for low-income households. Our results are robust to controlling for time and household fixed effects and various robustness checks are performed and reported in Appendix 7. These results suggest that wealthy households are more tax sensitive than low-income households, which is broadly consistent with our model predictions. Indeed, our theoretical framework generates differential responses of hours worked to tax changes by agent type, wealth households versus hand to mouth households, and predicts that hours worked by wealthy households are more responsive to tax changes. Overall, the idea that low-income households are slightly less responsive to tax shock, is an interesting results, although, the effects seems quantitatively small, it indicates that accounting heterogeneity of household behavior is essential to provide an assessment of tax policy implications on labor supply.

Two views that emerges from this analysis on how would tax wedge affects labor supply.

Indeed we puzzle over the fact that tax increase can lead to a increase in hours worked as evidenced by the micro data. Households would compensate for the wage cute and increase their work effort, and increase their labor productivity. In a related study, Kleven and Schultz (2014) find that labor income elasticities to tax reform variation in Denmark are quite modest and vary between 0.05 and 0.10, for wage earners and self employed individuals respectively. See also Prescott (2004) who studies the role of taxes and provided some factors that might explain low labor supply using cross country analysis. On the other hand tax increase could be associated with a decline in hours worked. A conclusion from our general equilibrium model that considers the intensive margin of labor supply, hours worked.

5 Heterogeneous reponse of labor to unanticipated tax shock

Augment the model with HA: Wealthy and hand-to mouth.

Solve the model and show the distribution of the response (no need to reduce the dimension of the matrix). Plot a kernel density plot.

- add table on the average response by quantile.

Local projections To empirically analyze the response of the hours worked to changes in average tax rate, we use local projection technique as in (Jordà, 2005). We obtain the average impulse response function for both high and low income individuals at horizon h. This is specified for the two types $j \in s, w$, high income and low income individuals:

$$\ln(h_{s,t+h}) = \alpha_{s,h} + \beta_{s,h} \ln(\tau_{s,t}) + \gamma_s + \gamma_t + \epsilon_{s,t}$$
$$\ln(h_{w,t+h}) = \alpha_{w,h} + \beta_{w,h} \ln(\tau_{w,t}) + \gamma_w + \gamma_t + \epsilon_{w,t+h}$$

In both specification we control for individual fixed effects γ_w, γ_w and time fixed effects γ_t.

Figure **??** suggests that the response of ours worked after a positive income tax rate shock is mostly insignificant for both wealthy and low-income households. Within the wealthiest population, we observe an increase in hours worked by 2 percent, but the effect is rapidly subdued, see panel A. On the other hand, the response of hours of low-income households was quite different from that of wealthy households. An increase in tax rate is merely near zero and only 6 years after the impact the response turns positive.

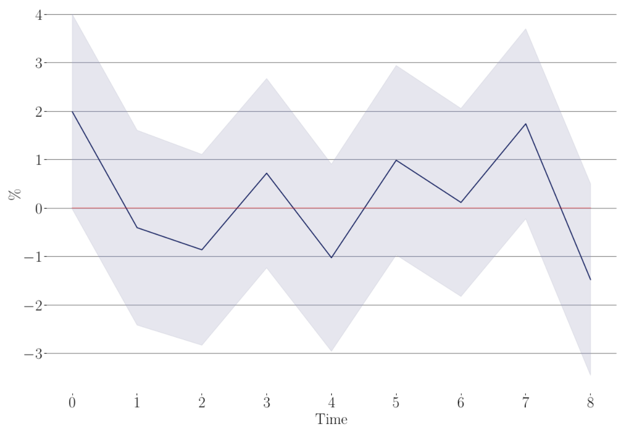

Figure 5: Labor response top 10% to Tax shock

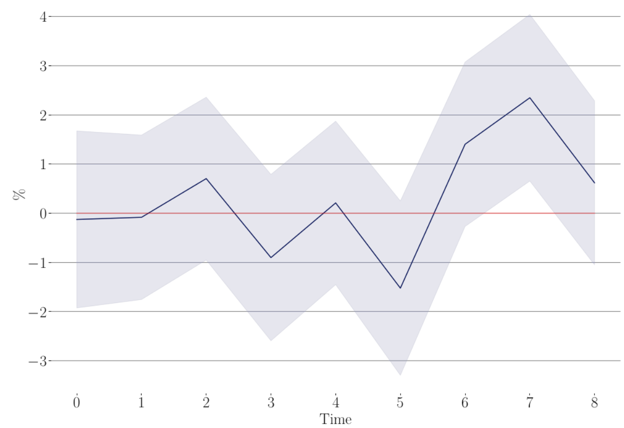

Figure 6: Labor response bottom 10% to Tax shock

Notes: Results LP.

6 Conclusion

This paper examines the effects of taxation on the labor market and its role in explaining hours worked dynamics. We consider a framework with two heterogeneous agents and demonstrate that an increase in income taxes leads to a decline in hours worked, although the magnitude of the shock varies between wealthy and hand-to-mouth households. The model clarifies that accounting for heterogeneity in household's economic behavior can generate differential impacts on labor supply. To test our general equilibrium model's results, we provide a microeconomic evidence on the relationship between hours worked and effective tax rate using the Current Population Survey. We document that high-income individuals are taxed proportionally less than low-income individuals. Additionally, we find that the labor elasticity with respect to income tax is positive. The elasticities at the top and bottom of the income distribution are also positive, although much weaker elasticity for low-income households.

References

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *The Quarterly Journal of Economics*, 109(3):659–684.

Alpert, A. and Powell, D. (2020). Estimating intensive and extensive tax responsiveness. *Economic Inquiry*, 58(4):1855–1873.

Attinasi, M., Berardini, F., De Stefani, R., and Osterloh, S. (2016). The effects of labor income taxes on labor market performance: An empirical analysis. *https://www. bancaditalia. it/pubblicazioni/altri-atti-convegni/2016-current-issues-fiscal-policy/Attinasi_Berardini_DeStefani_Osterloh. pdf*.

Auclert, A., Rognlie, M., and Straub, L. (2018). The intertemporal keynesian cross. Technical report, National Bureau of Economic Research.

Bick, A. and Fuchs-Schündeln, N. (2018). Taxation and labour supply of married couples across countries: A macroeconomic analysis. *The Review of Economic Studies*, 85(3):1543–1576.

Bilbiie, F. O. (2020). The new keynesian cross. *Journal of Monetary Economics*, 114:90–108.

Blanchet, T., Saez, E., and Zucman, G. (2022). Real-time inequality. Technical report, National Bureau of Economic Research.

Born, B., Peter, A., and Pfeifer, J. (2013). Fiscal news and macroeconomic volatility. *Journal of Economic Dynamics and Control*, 37(12):2582–2601.

Carbonell-Nicolau, O. and Llavador, H. (2021). Elasticity determinants of inequality-reducing income taxation. *The Journal of Economic Inequality*, 19:163–183.

Chetty, R. (2012). Bounds on elasticities with optimization frictions: A synthesis of micro and macro evidence on labor supply. *Econometrica*, 80(3):969–1018.

Chetty, R., Guren, A., Manoli, D., and Weber, A. (2013). Does indivisible labor explain the difference between micro and macro elasticities? a meta-analysis of extensive margin elasticities. *NBER macroeconomics Annual*, 27(1):1–56.

Christiano, L. J., Motto, R., and Rostagno, M. (2014). Risk shocks. *American Economic Review*, 104(1):27–65.

Debortoli, D. and Galí, J. (2021). Monetary policy with heterogeneous agents: Insights from tank models. Technical report, Department of Economics and Business, Universitat Pompeu Fabra.

Diamond, P. and Saez, E. (2011). The case for a progressive tax: From basic research to policy recommendation. *Journal of Economic Perspectives*, 25(4):165–190.

Erosa, A., Fuster, L., and Kambourov, G. (2016). Towards a micro-founded theory of aggregate labour supply. *The Review of Economic Studies*, 83(3):1001–1039.

Gabrovski, M. and Guo, J.-T. (2022). Progressive taxation as an automatic stabilizer under nominal wage rigidity and preference shocks. *International Journal of Economic Theory*, 18(3):232–246.

Gerber, C., Klemm, M. A. D., Liu, M. L., and Mylonas, V. (2018). *Personal income tax progressivity: trends and implications*. International Monetary Fund.

Golosov, M., Maziero, P., and Menzio, G. (2013). Taxation and redistribution of residual income inequality. *Journal of Political Economy*, 121(6):1160–1204.

Gottlieb, C., Onken, J., and Valladares-Esteban, A. (2021). On the measurement of the elasticity of labour. *European Economic Review*, 139:103879.

Heathcote, J. (2005). Fiscal policy with heterogeneous agents and incomplete markets. *The Review of Economic Studies*, 72(1):161–188.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review*, 95(1):161–182.

Kaplan, G., Moll, B., and Violante, G. L. (2018). Monetary policy according to hank. *American Economic Review*, 108(3):697–743.

Keane, M. P. (2011). Labor supply and taxes: A survey. *Journal of Economic Literature*, 49(4):961–1075.

Keane, M. P. (2022). Recent research on labor supply: Implications for tax and transfer policy. *Labour Economics*, 77:102026.

Kleven, H. J. and Schultz, E. A. (2014). Estimating taxable income responses using danish tax reforms. *American Economic Journal: Economic Policy*, 6(4):271–301.

Kopiec, P. (2022). The government spending multiplier in the heterogeneous agent new keynesian model. *European Economic Review*, 145:104125.

Krusell, P. and Smith, Jr, A. A. (1998). Income and wealth heterogeneity in the macroeconomy. *Journal of political Economy*, 106(5):867–896.

Lorenzoni, G. and Werning, I. (2019). Slow moving debt crises. *American Economic Review*, 109(9):3229–3263.

Martinez, I. Z., Saez, E., and Siegenthaler, M. (2021). Intertemporal labor supply substitution? evidence from the swiss income tax holidays. *American Economic Review*, 111(2):506–546.

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *The review of economic studies*, 38(2):175–208.

Patterson, C. (2023). The matching multiplier and the amplification of recessions. *American Economic Review*, 113(4):982–1012.

Piketty, T. and Saez, E. (2003). Income inequality in the united states, 1913–1998. *The Quarterly journal of economics*, 118(1):1–41.

Prescott, E. C. (2004). Why do americans work so much more than europeans? Technical report.

Saez, E. and Zucman, G. (2016). Wealth inequality in the united states since 1913: Evidence from capitalized income tax data. *The Quarterly Journal of Economics*, 131(2):519–578.

Summers, L. H. (1981). Capital taxation and accumulation in a life cycle growth model. *The American Economic Review*, 71(4):533–544.

Wu, C. and Krueger, D. (2021). Consumption insurance against wage risk: Family labor supply and optimal progressive income taxation. *American Economic Journal: Macroeconomics*, 13(1):79–113.

Young, H. P. (1990). Progressive taxation and equal sacrifice. *The American Economic Review*, 80(1):253–266.

Zubairy, S. (2014). On fiscal multipliers: Estimates from a medium scale dsge model. *International Economic Review*, 55(1):169–195.

Technical Appendix

Appendix A Model derivation

Households optimality conditions: We solve the household maximization problem by the Lagrange's method

$$\mathcal{L}^w_{j,t} = E_0 \sum_{t=0}^{T} \left[\beta \left\{ \frac{(c^w_{j,t})^{1-\sigma}}{1-\sigma} - \phi^w_{j,t} \frac{(h^w_{j,t})^{1+\nu}}{1+\nu} + \lambda_{j,t} \Big((1-\tau_{j,t})(\omega^w_{j,t} h^w_{j,t} + (1+r_{t-1})\, a_{j,t-1} + \Pi^w_t) - c^w_{j,t} - a_{j,t} \Big) \right\} \right]$$

$$\mathcal{L}^s_{j,t} = E_0 \sum_{t=0}^{T} \left[\beta \left\{ \frac{(c^s_{j,t})^{1-\sigma}}{1-\sigma} - \phi^s_{j,t} \frac{(h^s_{j,t})^{1+\nu}}{1+\nu} + \lambda_{j,t} \Big((1-\tau_{j,t})(\omega^s_{j,1} h^s_{j,t} + \Pi^s_t) - c^s_{j,t} \Big) \right\} \right]$$

The household optimality conditions with respect to consumption: $c^w_{j,t}$, $c^s_{j,t}$, asset accumulation $a_{j,t}$, hours worked: $h^w_{j,t}$, $h^s_{j,t}$ are derived as follow

$$\frac{\partial \mathcal{L}^w_{j,t}}{\partial c^w_{j,t}}: \qquad \lambda_{j,t} = (c^w_{j,t})^{-\sigma} \tag{A.1}$$

$$\frac{\partial \mathcal{L}^w_{j,t}}{\partial h^w_{t}}: \qquad \phi^w_{j,t}(h^w_{j,t})^{\eta} = \lambda_{j,t}(1-\tau_{j,t})\omega^w_{j,t} \tag{A.2}$$

$$\frac{\partial \mathcal{L}^w_{j,t}}{\partial a_{j,t}}: \qquad \lambda_{j,t} = \beta E_t \lambda_{j,t+1}(1-\tau_{j,t})(1+r_t) \tag{A.3}$$

$$\frac{\partial \mathcal{L}^s_{j,t}}{\partial c^s_{j,t}}: \qquad \lambda_{j,t} = (c^s_{j,t})^{-\sigma} \tag{A.4}$$

$$\frac{\partial \mathcal{L}^s_{j,t}}{\partial h^s_{j,t}}: \qquad \phi^s_{j,t}(h^s_{j,t})^{\eta} = \lambda_{j,t}(1-\tau_{j,t})\omega^s_{j,t} \tag{A.5}$$

This can also be simplified to:

$$\phi^w_{j,t}(h^w_{j,t})^{\eta} = \lambda_{j,t}(1-\tau_{j,t})\omega^w_{j,t},$$
$$\phi^s_{j,t}(h^s_{j,t})^{\eta} = \lambda_{j,t}(1-\tau_{j,t})\omega^s_{j,t}$$

Firms optimality conditions: Optimal capital and labor demand from the producer's optimization problem is

$$\omega_t^s = (1-\alpha)\,(k_t)^{\alpha} A_t (h_t^s)^{\frac{1}{\theta}-1}\left((h_t^w)^{\frac{1}{\theta}} + (h_t^s)^{\frac{1}{\theta}}\right)^{(1-\alpha)\theta-1}$$
$$\omega_t^w = (1-\alpha)\,(k_t)^{\alpha} A_t (h_t^w)^{\frac{1}{\theta}-1}\left((h_t^w)^{\frac{1}{\theta}} + (h_t^s)^{\frac{1}{\theta}}\right)^{(1-\alpha)\theta-1}$$
$$r_t^k = \alpha\left((h_t^s)^{\frac{1}{\theta}} + (h_t^w)^{\frac{1}{\theta}}\right)^{(1-\alpha)\theta} A_t (k_t)^{\alpha-1}$$

The Euler equation is given by

$$\frac{\omega_t^s}{\omega_t^w} = \frac{(h_t^s)^{\frac{1}{\theta}-1}}{(h_t^w)^{\frac{1}{\theta}-1}}$$

Capital Producers optimality conditions: We assume that capital producers provide capital to firms that evolves according to

$$k_t = (1-\delta)k_{t-1} + i_t$$

The objective of the capital producer is to choose k_t and i_t that maximizes the expected profits

$$\text{maximize} \quad E_t[r_t^k k_t - i_t]$$

The first order condition with respect to capital and investment is

$$\begin{aligned}
\frac{\partial \mathcal{L}_{j,t}}{\partial k_t} : &\qquad \lambda_t - E_t\beta\lambda_{t+1}(1-\delta) = r_t^k \\
\frac{\partial \mathcal{L}_{j,t}}{\partial i_t} : &\qquad q_t = \lambda_t
\end{aligned}$$

Use asset optimal choice $\lambda_{j,t} = \beta E_t \lambda_{j,t+1}(1-\tau_{j,t})(1+r_t)$ and the first order condition with respect to capital, we obtain:

$$\begin{aligned}
\beta E_t \lambda_{j,t+1}(1-\tau_{j,t})(1+r_t) &= r_t^k + E_t\beta\lambda_{t+1}(1-\delta) \\
r_t^k &= \beta E_t \lambda_{j,t+1}(1-\tau_{j,t})(1+r_t) - E_t\beta\lambda_{t+1}(1-\delta) \\
r_t^k &= \beta E_t \lambda_{j,t+1}((1-\tau_{j,t})(1+r_t) - (1-\delta))
\end{aligned}$$

Government debt:

$$d_{t+1} = s_t + (1 + r_t)d_t$$

Government fiscal rule

$$s_t = g_t - \tau_t(\omega_t^w h_t^w + (1 + r_{t-1})a_{t-1} + \Pi_t^w) - \tau_t(\omega_t^s h_t^s + \Pi_t^s)$$

Market clearing condition

$$y_t = c_t^w + c_t^s + i_t + g_t.$$

Reducing the model 1)

using the FOC wrt to labor $\phi_{j,t}^w (h_{j,t}^w)^\eta = \lambda_{j,t}(1 - \tau_{j,t})\omega_{j,t}^w$ and $\phi_{j,t}^s (h_{j,t}^s)^\eta = \lambda_{j,t}(1 - \tau_{j,t})\omega_{j,t}^s$.
and the FOC wrt to consumption $\lambda_{j,t} = (c_{j,t}^w)^{-\sigma}$ and $\lambda_{j,t} = (c_{j,t}^s)^{-\sigma}$.
we write the equations as follow: $\frac{\phi_{j,t}^w (h_{j,t}^w)^\eta}{(1-\tau_{j,t})\omega_{j,t}^w} = (c_{j,t}^w)^{-\sigma}$ and $\frac{\phi_{j,t}^s (h_{j,t}^s)^\eta}{(1-\tau_{j,t})\omega_{j,t}^s} = (c_{j,t}^s)^{-\sigma}$.
$\left(\frac{\phi_{j,t}^w (h_{j,t}^w)^\eta}{(1-\tau_{j,t})\omega_{j,t}^w}\right)^{\frac{1}{-\sigma}} = c_{j,t}^w$ and $\left(\frac{\phi_{j,t}^s (h_{j,t}^s)^\eta}{(1-\tau_{j,t})\omega_{j,t}^s}\right)^{\frac{1}{-\sigma}} = c_{j,t}^s$.
we substitute $c_{j,t}^s$ and $c_{j,t}^s$ in the resource constraint

$$y_t = \left(\frac{\phi_{j,t}^w (h_{j,t}^w)^\eta}{(1 - \tau_{j,t})\omega_{j,t}^w}\right)^{\frac{1}{-\sigma}} + \left(\frac{\phi_{j,t}^s (h_{j,t}^s)^\eta}{(1 - \tau_{j,t})\omega_{j,t}^s}\right)^{\frac{1}{-\sigma}} + i_t + g_t.$$

2) we use the optimality condition

$\lambda_{j,t} = \beta E_t \lambda_{j,t+1}(1 - \tau_{j,t})(1 + r_t)$

and the FOC wrt labor

$\phi_{j,t}^w (h_{j,t}^w)^\eta = \lambda_{j,t}(1 - \tau_{j,t})\omega_{j,t}^w$

and the FOC wrt labor $\phi_{j,t}^s (h_{j,t}^s)^\eta = \lambda_{j,t}(1 - \tau_{j,t})\omega_{j,t}^s$

We rewrite these two conditions as follow
$\frac{\phi_{j,t}^w (h_{j,t}^w)^\eta}{(1-\tau_{j,t})\omega_{j,t}^w} = \beta \frac{\phi_{j,t+1}^w (h_{j,t+1}^w)^\eta}{(1-\tau_{j,t+1})\omega_{j,t+1}^w}(1 - \tau_{j,t})(1 + r_t)$
$\frac{\phi_{j,t}^s (h_{j,t}^s)^\eta}{(1-\tau_{j,t})\omega_{j,t}^s} = \beta \frac{\phi_{j,t+1}^s (h_{j,t+1}^s)^\eta}{(1-\tau_{j,t+1})\omega_{j,t+1}^s}(1 - \tau_{j,t})(1 + r_t)$
We obtain the following expression

Model Equilibrium

$$log(A_{t-1}) = \rho^A(log(A_{t-1}))$$

$$log(g_t) = (1 - kg_d)(log(g_{t-1}))$$

$$log(\tau_t) = rho^\tau(log(\tau_{t-1}))$$

$$\left(\frac{(1-\tau)\omega_t^w}{\phi(h_t^w)^\eta}\right)^{\frac{1}{\sigma}} + \left(\frac{(1-\tau)\omega_t^s}{\phi(h_t^s)^\eta}\right)^{\frac{1}{\sigma}} - (1-\delta)k_t + k_{t+1} + g_t = (k_t)^\alpha A_t \left((h_t^s)^{\frac{1}{\theta}} + (h_t^w)^{\frac{1}{\theta}}\right)^{(1-\alpha)\theta}$$

$$\frac{\phi(h_t^w)^\eta}{(1-\tau)\omega_t^w} = \frac{\beta\phi(h_t^w)^\eta}{(1-\tau)\omega_t^w}(1-\tau)(1+R)$$

$$\frac{\phi(h_t^s)^\eta}{(1-\tau)\omega_t^s} = \frac{\beta\phi(h_t^s)^\eta}{(1-\tau)\omega_t^s}(1-\tau)(1+R)$$

$$r_t^k = \alpha A_t(K_t)^{(\alpha-1)}((h_t^w)^{(1/\theta)} + (h_t^s)^{(1/\theta)})^{((1-\alpha)\theta)}$$

$$r_t^k = \frac{(\phi^s(h_{t+1}^s)^{(\eta)})}{((1-\tau_{t+1})((1-\alpha)(h_{t+1}^s)^{(1/\theta-1)}A_t(K_{t+1})^{(\alpha)}((h_{t+1}^w)^{(1/\theta)} + (h_{t+1}^s)^{(1/\theta)})^{((1-\alpha)\theta-1)}))}(1+r_t)(1-\tau_t) - (1-\delta)$$

Appendix B Data details

Table 5: Current Population Survey - Variables

Variable	Description
YEAR	Survey year
SERIAL	Household serial number
CPSID	CPSID, household record
ASECFLAG	Flag for ASEC
CPSIDP	CPSID, person record
UHRSWORKT	Hours usually worked per week at all jobs
STATAXAC	State income tax liability, after all credits
TAXINC	Taxable income amount

Notes: Data sources: Current Population Survey (2009-2022).

Appendix C Additional Results

Table 6: Results of Ordinary Least Squares Estimation of the Relationship Between Tax Rate and Hours Worked 2010-2019

	Dependent Variable: Log Hours Worked			
	(1)	(2)	(3)	(4)
constant	7.6625***	7.6627***	7.6661***	7.6660***
	(0.0092)	(0.0096)	(0.0051)	(0.0049)
Log average tax rate	0.0147***	0.0148***	0.0159***	0.0158***
	(0.0031)	(0.0031)	(0.0017)	(0.0017)
Covariance Type:	Clustered	Clustered	Clustered	Clustered
Household Fixed Effects:	Yes	Yes	No	No
Year Fixed Effects:	No	Yes	Yes	No
F-statistic:	129.7	130.6	236.9	236.4
No. Observations:	231994	231994	231994	231994

Notes: This table reports the ordinary least squares regression; (1) with time and household fixed effects, (2) with time fixed effects, (3) with household fixed effects, (4) with no fixed effects. Statistical significance (Std. error in parentheses): 0.1*, 0.05**, 0.01***. Standard errors are clustered at household and year level. Data sources: Current Population Survey (2010-2019).

Table 7: Results of Ordinary Least Squares Estimation of the Relationship Between Tax Rate and Hours Worked

	Dependent Variable: Log Hours Worked											
	Top 10 Income			Top 50 Income			Bottom 10 Income			Bottom 50 Income		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
constant	7.7055***	7.7054***	7.7074***	7.7215***	7.7211***	7.7263***	7.4519***	7.4526***	7.4609***	7.5914***	7.5918***	7.5975***
	(0.0099)	(0.0098)	(0.0052)	(0.0139)	(0.0139)	(0.0072)	(0.0111)	(0.0109)	(0.0088)	(0.0101)	(0.0099)	(0.0062)
log average tax rate	0.0231***	0.0231***	0.0237***	0.0230***	0.0229***	0.0246***	-0.0010	-0.0008	0.0020	0.0034	0.0036	0.0054***
	(0.0032)	(0.0032)	(0.0018)	(0.0046)	(0.0046)	(0.0025)	(0.0035)	(0.0035)	(0.0027)	(0.0031)	(0.0031)	(0.0020)
No. Observations:	191996	191996	191996	106688	106688	106688	21246	21246	21246	106688	106688	106688
R-squared:	0.002	0.002	0.002	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000
F-statistic:	241.3	240.0	397.2	87.37	86.11	172.1	0.08449	0.05051	0.5261	4.391	4.668	16.42
Eeffects:	Entity	Entity, Time	Time	Entity	Entity, Time	Time	Entity	Entity, Time	Time	Entity	Entity, Time	Time

Notes: This table reports the ordinary least squares regression. Statistical significance (Std. error in parentheses): 0.1*, 0.05**, 0.01***. Standard errors are clustered at household and year level. Data sources: Current Population Survey (2010-2019).