The Macroeconomic Effects of Income Taxes on Labor Markets

Aicha Kharazi*

University of Exeter

Francesco Ravazzolo†

Free University of Bolzano-Bozen

Claudia Udroiu‡

Free University of Bolzano-Bozen

October 3, 2023

Abstract

We analyse the inequalities arising from the 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, the paper provides 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 income tax is positive.

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

JEL Codes: E24, J20, H24, H31

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

†Francesco Ravazzolo: francesco.ravazzolo@unibz.it

‡Claudia Udroiu: claudia.udroiu@student.unibz.it

1 Introduction

In 2012 the wealth share of the top 0.1% of the United States population 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 labour 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. Nevertheless, Piketty and Saez (2007) 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 labour income taxes has become a key topic in public debate. In 2020 in the US, for example, a worker faced an average labour 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 labour 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 labour 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 labour supply to income taxation. We first 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. We then provide micro evidence based on 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 labour 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 labour productivity and employment. A seminal work by Mirrlees (1971) shows that taxing labour 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 labour supply. In a related work, Gabrovski and Guo (2022) examine how progressive taxation under nominal wage rigidity cause labour supply curve to shift. Golosov et al. (2013) assess the optimal policy mix that involves redistribution of labour income inequality using a labour 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 labour 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 labour income taxes on labour 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 focus on estimating the Frisch elasticity, that is the elasticity of labour 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 elasticities 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 labour 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 labour 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 labour 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 labour supply. His findings suggest that labour supply elasticity increases with age and is larger for married women. Diamond and Saez (2011) analyse 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 labour supply. The authors build a model and provide an aggregation theory using micro evidence to study implications of aggregate labour supply.

Additionally, our work is linked to literature about heterogeneity of agent behaviour 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) analysed 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 transmission, 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 behaviour of a more computably challenging Heterogeneous Agents New Keynesian model (HANK), 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 heterogeneous effects of income taxation on labour supply.

The rest of the paper is structured as follows. Section 3 describes the theoretical framework. In section 4 the quantitative analysis, including the calibration, the model results and the micro-data evidence are presented and section 5 concludes.

3 Theoretical framework

We develop a model that consists of two type of households: wealthy and hand-to-mouth households. The model framework includes a 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 and the government spending shock are given by:

$$\tau_t = \kappa_\tau \tau_{t-1} + \epsilon_t$$

$$g_t = \kappa_g g_{t-1} + \epsilon_t$$

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 chooses the level of debt d_{t+1}. To capture the feedback effects of the 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 the debt burden.

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

If the government's financing needs s_t is positive, this will guarantee an increase in government debt d_{t+1}. This 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 (savers): There is a continuum of households indexed by $j \in [0, 1]$ with the following utility function:

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

where $\beta \geq 0$ is the discount factor and σ is the coefficient of relative risk aversion. The saver's budget constraint is given by

$$c_{j,t}^w + a_{j,t} = (1 - \tau_{j,t}) e_{j,t}^w$$

The variable $c_{j,t}^w$ denotes consumption, $h_{j,t}^w$ represents labour and $\phi_{j,t}^w$ denotes a labour supply shock. Total taxable income is defined as

$$e_{j,t}^w = \omega_{j,t}^w h_{j,t}^w + (1 + r_{t-1}) a_{j,t-1} + \Pi_t^w$$

Given our budget constraint specification, we refer to $\omega_{j,t}^w$ as the hourly wage rate. The household is subject to a an income tax $\tau_{j,t}$ that is time varying and takes the form $\tau_{j,t} = 1/\left(1 + e^{-\zeta_{j,t}}\right)$. We assume that the saver household's type w accumulates assets $a_{j,t}$ over time and receives lump-sum transfers from the government Π_t^w. The household optimality conditions with respect to consumption $c_{j,t}^w$, asset accumulation $a_{j,t}$, and hours worked $h_{j,t}^w$ are given by:

$$\begin{aligned}
\lambda_{j,t} &= (c_{j,t}^w)^{-\sigma} \\
\phi_{j,t}^w (h_{j,t}^w)^{\eta} &= \lambda_{j,t} (1 - \tau_{j,t}) \omega_{j,t}^w \\
\lambda_{j,t} &= \beta E_t \lambda_{j,t+1} (1 - \tau_{j,t})(1 + r_t).
\end{aligned}$$

Hand-to-mouth households (spenders) Rule-of-thumb households derive utility from consumption $c^s_{j,t}$ and disutility from hours worked $h^s_{j,t}$ having the same utility function as for savers:

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

Similarly to the savers' case, β represents the discount factor, σ denotes the risk aversion parameter, and $\phi^s_{j,t}$ is a household preference shifter for labour. The spenders' budget constraint is given by

$$c^s_{j,t} = (1 - \tau_{j,t}) e^s_{j,t}$$

and the taxable income is defined as:

$$e^s_{j,t} = \omega^s_{j,t} h^s_{j,t} + \Pi^s_t$$

The specification of the hand-to-mouth household's budget constraint states that labour income $\omega^s_{j,t} h^s_{j,t}$ and dividends Π^s_t received are the only source of income. The household consumes $c^s_{j,t}$ and faces an income tax $\tau_{j,t}$. The optimality conditions with respect to consumption $c^s_{j,t}$ and hours worked $h^s_{j,t}$ are as follows:

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

Capital producers We follow Greenwood et al. (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 represents 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, Tobin (1969)) and r^k_t is the capital rental rate.

Firms and Market Clearing Condition There is a continuum of final good firms that combine capital k_t and two types of labour h^s_t and h^w_t to produce y_t through the following production function:

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

where $\alpha \in (0.1)$ is the Cobb Douglas parameter, and the exogenous variable A_t denotes a productivity shock. We assume that $\ln(A_t)$ follows an AR(1) process such that:

$$\ln(A_t) = \rho^A \ln(A_{t-1}) + \epsilon_t^A \tag{1}$$

Finally, the goods market equilibrium condition 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 $\{d_t\}$; (ii) Wealthy households choose $\{c_t^w,\, l_t^w,\, a_t\}$ in order to maximize their utility subject to the budget constraint; (ii) hand-to-mouth households choose $\{c_t^s\ l_t^s\}$ in order to maximize their utility subject to the budget constraint; (iii) Producers choose how much labour and capital input to use for production $\{l_t^w,\, l_t^s\ k_t\}$ in order to minimize their production cost. The first order conditions yields the two market prices at the equilibrium $\{\omega_t^w,\, \omega_t^s\}$. (iv) Equilibrium requires that the market for assets clears with $a_t = a_{t-1}(1 + r_{t-1})$.

The model is driven by three exogenous shocks: a tax shock τ_t, a government spending shock, g_t and a technology shock A_t.[1]

Solution method We use perturbation techniques as in Schmitt-Grohé and Uribe (2004) to solve our dynamic general equilibrium model, specifically a second-order approximation. This numerical approximation techniques of the policy function emerges as a convenient approach to compute the approximation in the neighbourhood of particular non-stochastic steady state that can deliver a reasonably accurate solution. However, we also provide results for a first-order approximation solution and discuss the differnce between the two. The

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

equilibrium conditions can be expressed by the 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 specification, variables l_t^s, l_t^w, and k_t belong to the vector y_t. x_t denotes the vector of predetermined variables A_t, g_t, and τ_t.

4 Quantitative analysis

4.1 Calibration

Firstly, we set a target of debt-to-gross domestic product ratio of 90 percent, which is consistent with the observed US data[2]. This ratio varied between 80 and 120 percent during the period 2009 - 2022. We parametrize the government spending to be equal to 20 percent, and total investment to 10 percent of GDP, which are both in line with the US macro data in our sample. 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 labour supplied by wealthy households η^w at 1.05, and for the curvature on the disutility of labour supplied by hand-to-mouth households η^s at 1.20. The weight on the disutility of labour for the two type of households ϕ^w and ϕ^s are assumed to be equal to 1. The discount factor is set at a standard value 0.97 for the two agents, which can pin down the value of interest rate in steady state r through $\frac{1}{\beta} - 1 = 3\%$. Additionally, the depreciation rate on capital equals 0.025, that is a standard value in literature.

Third, the steady state income tax rate τ is set at the value of 0.30, which is close to the top bracket of income tax rate that, in the US, ranges from 10 percent to 37 percent. The share of wealthy household consumption is assumed to be 60 percent of total consumption. This is consistent with Kaplan et al. (2018) and Bilbiie (2020). The risk aversion parameter

[2] Federal Reserve Bank of St. Louis (FRED) data available at: `https://fred.stlouisfed.org/series/GFDEGDQ188S`

for wealthy household and hand to mouth households equal 1, as in Kopiec (2022).

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

Finally, the Cobb Douglas parameter α is set a the value of 0.4 as in Christiano et al. (2014). 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). The labour elasticity of substitution parameter between the wealthy and the hand-to-mouth household is assumed to be 0.9.

Table 1: Calibrated parameters

Parameter	Description	Value
β	Discount rate	0.97
κ	Share of wealthy household consumption to total consumption	0.6
η_w	Curvature on the disutility of labour supplied by wealthy households	1.05
η_s	Curvature on the disutility of labour supplied by hand-to-mouth households	1.20
ϕ^w	Weight on the disutility of labour for wealthy households	1
ϕ^s	Weight on the disutility of labour for the hand-to-mouth households	1
τ	Income tax rate	0.30
σ^w	Risk aversion parameter for wealthy households	1
σ^s	Risk aversion parameter for hand-to-mouth households	1
ω^w_{ss}	Average hourly earnings for wealthy households	0.22
ω^s_{ss}	Average hourly earnings for hand-to-mouth households	0.14
δ	Depreciation rate on capital	0.025
α	Cobb Douglas parameter	0.4
θ	Labour elasticity of substitution parameter between wealth and hand-to-mouth households	0.9
κ^g	Persistence parameter of government spending shock	0.9
ρ^A	Coefficient on lagged productivity shock	0.95
σ^A	Standard deviation of the productivity shock	0.52

4.2 Effects of income tax changes: model

Responses of hours worked to the tax shock We investigate the impact of an increase in tax on hours worked implied by our model, which is solved using both a first-order and a second-order approximation. The results, as depicted in figure 1, are contrasting, as in the first case the response of labour supply is positive, and in the second case the impact is negative. As we will show in the next section, evidence from CPS data are in line with the impact on labour supply obtained in our model using the first order approximation. However, we focus now on the second-order approximation method, as this method accounts for non-linearities that may play an important role in the model.

A one positive standard deviation tax shock leads to a decrease in hours worked by wealthy households. The same is true for the response of hand-to-mouth households, who experience a drop in hours worked after an increase in tax. The tax shock experiment indicates that the labour supply drop is larger for wealthy households than hand-to-mouth households. This result suggests that conditional on household economic behaviour, a tax rise can generate heterogeneity in households labour response to tax shock. However, these are preliminary results obtained with the current calibration, where the two households have different labour supply elasticities. Nevertheless, in section 4.3 we are going to show micro-data evidence supporting this heterogeneous result.

An increase in the income tax rate serves as an incentive for households to reduce their work efforts. This finding aligns with previous results obtained by Born et al. (2013). The authors demonstrate that a decrease in labour taxes leads to an increase in hours worked within a dynamic general equilibrium framework. Specifically, when taxes are increased, households experience a decrease in their after-tax income, resulting in a reduction in labour services provided. This decline in labour supply induces firms to substitute labour with capital. Similarly, Zubairy (2014) emphasized that a reduction in labour taxes can lead to a substantial increase in labour supply, while the outcome of a capital tax cut may differ, initially causing a decline in hours worked followed by a subsequent rise.

Counterfactuals We now consider two experiments. In the first experiment the tax rate τ_t is significantly higher and equals 30 percent, while in the second experiment the tax rate is equal to 10 percent. We use our model to simulate and compare the time series of labour supply of the two agents under a high and a low tax environment, as depicted in figure 2. The effects of a low and a high tax environment show that hours worked fluctuations are either

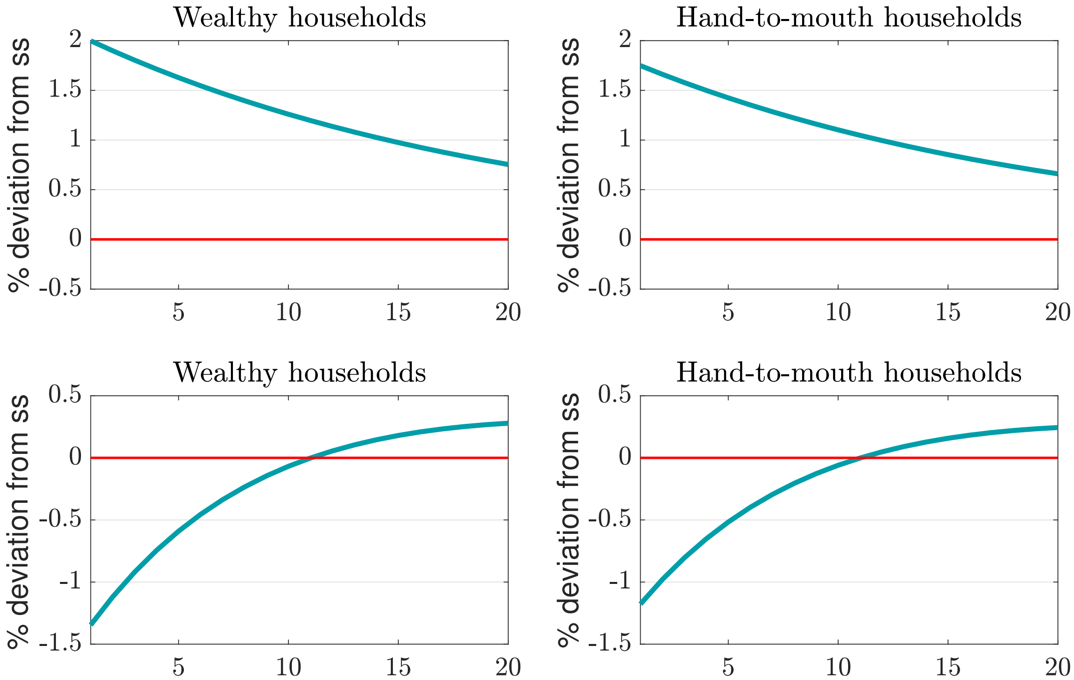


Figure 1: Tax shock - labour response

Note: 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.

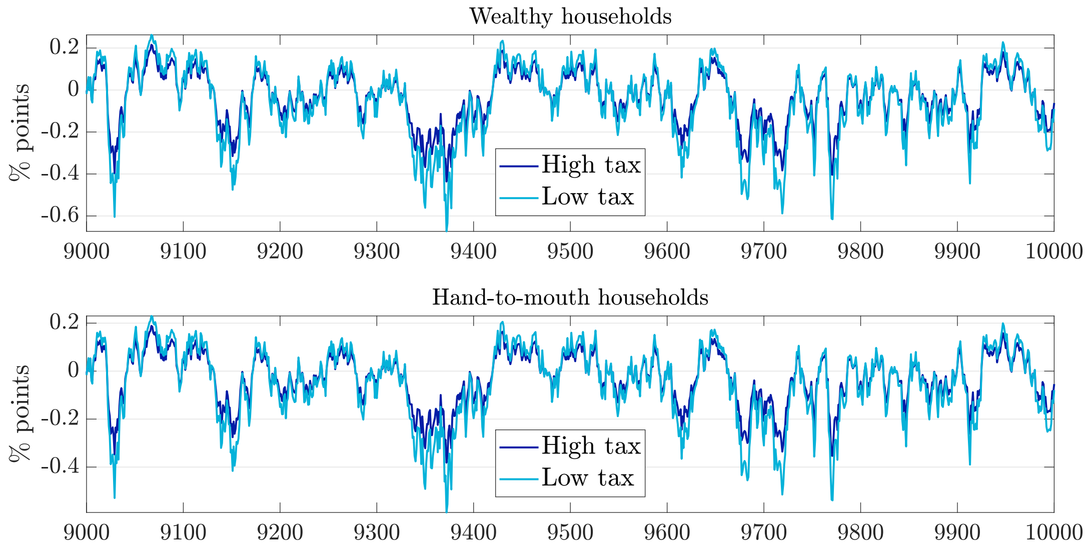
amplified or dampened. The low tax environment leads to an amplification of hours worked by both hand-to-mouth and wealthy households. The change in the tax rate does develop into an amplification of the labour supply, but does not exhibit a change in the pattern of labour supply fluctuations for the two households.

4.3 Income tax and hours worked: micro-data evidence

We use cross sectional data from the US Current Population Survey. This annual data allows us to observe the income tax after credit at the individual level and the level of taxable income. The sample period we use spans from 2009 to 2022. We first construct a measure of average tax rate as follows:

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

Figure 2: Counterfactuals



Note: Model simulation under high and low taxation environments

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 credit represents the total amount paid on taxes. Subsequently, we use these two observations to calculate the individual-specific average tax rate. Additionally, we construct a measure for hours worked:

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

where we multiply the hours worked per week by 52, as our focus lies on the total annual hours worked.

Figure 3 reports the distribution of weekly hours worked in the US between 2009 and 2022. Notably, 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 between 7.5 and 8. It is also evident from the figure that there is an upper limit for log hours worked, that is 8.5.

Salient observations from figure 4 point out to the differences in the way high and low-income individuals are taxed. On average, the tax rate for wealthy individuals is roughly 5%.

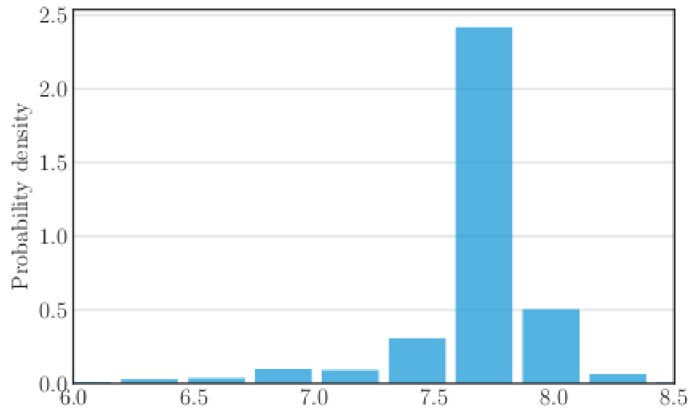


Figure 3: Log hours worked

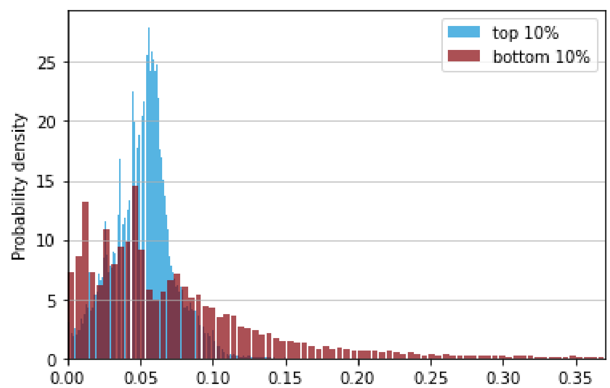


Figure 4: Tax rate top 10% vs bottom 10%

Note: The two figures show data from the Current Population Survey between 2009 and 2022.

On the other hand, the tax rate for the bottom 10% of the income distribution varies widely. Upon examination of the right side of the figure, it becomes clear that wealthy individuals are subject to a lower tax burden in relation to their income when compared to individuals with low incomes. 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 reports the average hourly earnings and the average annual hours worked during the reference period 2009-2022. Panel A presents the tax rates for different income quantiles. Data show that tax rates slightly increased between 2009 and 2022, rising from 6.5 percent to 8.1 percent for the bottom 10 % of income earners. On the contrary, the top 10 % of the income distribution experienced a modest increase in the tax rate, going from an average of 5

Table 2: Average tax rate and average annual hours worked, 2009 - 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

Note: Data source: Current Population Survey (2009-2022)

% in 2009 to an average rate of 5.3 % in 2022. There has been a similar increase from 5 percent to 5.6 % for the bottom 50 percent, and from 4.8 % to 5.2 % for the top 50 percent. The data show that income taxes imposed a greater burden on low-income households compared to high-income households during this period of time.

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 did not change much and show negligible fluctuations. Although not reported here, average total hours worked exhibit a large decline during the COVID-19 recession.

Estimation of the labour supply elasticity to the income tax To get a better understanding of the influence of the tax wedge on hours worked, we particularly focus on the household labour supply optimal decisions $\phi^w_{j,t}(h^w_{j,t})^\eta = \lambda_{j,t}(1-\tau_{j,t})\omega^w_{j,t}$ and $\phi^s_{j,t}(h^s_{j,t})^\eta = \lambda_{j,t}(1-\tau_{j,t})\omega^s_{j,t}$. These two optimality conditions describe the channel through which labour supply interacts with the income tax.

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 $\alpha^{\tau} = \frac{cov(\log h_{j,t}, \log \tau_{j,t})}{var(\log \tau_{j,t})} = 1/\eta$ is the labour supply elasticity with respect to the tax rate. 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. α_j and α_t denote the household and time fixed effects, respectively. We use the Current Population Survey data to estimate this elasticity over the sample period 2009 to 2022.

Empirically, we find a positive elasticity of labour supply to tax. The results are shown in table 3. The point estimate is positive and statistically different from zero (the estimate of α^{τ} equals roughly 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 the COVID-19 recession. Additional results are reported in Appendix tables B.2 and B.3. It is worth mentioning 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.

Next, we quantitatively analyse the heterogeneous effects of tax shock across income distribution. Table 4 reveals that high income households are more responsive to tax shocks than low-income households. Column 1 records a positive and statistically significant point estimate of roughly 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. Robustness checks are reported in the Appendix B. 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 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

Table 3: Tax rate and hours worked: OLS results

	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

Note: The table reports ordinary least squares regression results (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 source: Current Population Survey (2009-2022).*

shock is an interesting result, although the effect seems quantitatively small.

This analysis presents two contrasting perspectives on how the tax wedge impacts labour supply. It is indeed perplexing that an increase in taxes can lead to an increase in hours worked, as observed in the CPS micro data. Households tend to compensate for the reduction in wages by increasing their work efforts and enhancing their labour productivity. In a related study, Kleven and Schultz (2014) estimates that the elasticity of labour income with respect to tax reforms in Denmark is relatively modest, ranging between 0.05 and 0.10 for wage earners and self-employed individuals, respectively.

On the other hand, our theoretical model suggests that a tax increase could potentially result in a decrease in hours worked. This conclusion is supported by the cross-country analysis conducted by Prescott (2004), who examines the role of taxes and identifies several factors that could explain a decline in labour supply.

Table 4: Tax rate and hours worked: income distribution

	Dependent Variable: Log Hours Worked			
	Top 10	Top 50	Bottom 10	Bottom 50
	(1)	(2)	(3)	(4)
Constant	7.7079***	7.7269***	7.4594***	7.5976***
	(0.0053)	(0.0073)	(0.0089)	(0.0063)
Log average tax rate	0.0239***	0.0248***	0.0015	0.0054***
	(0.0018)	(0.0025)	(0.0028)	(0.0020)
No. Observations:	191996	106688	21246	106688
R-squared:	0.002	0.002	0.000	0.000
F-statistic:	402.6	175.5	0.2992	16.73
Covariance Type:	Clustered	Clustered	Clustered	Clustered

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

5 Conclusion

This paper examines the effects of taxation on the labour 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. With the calibration utilised in this analysis, the magnitude of the shock varies between wealthy and hand-to-mouth households. The model suggests that accounting for heterogeneity in household's economic behaviour can generate differential impacts on labour 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 labour elasticity with respect to income tax is positive. The elasticities at the top and bottom of the income distribution are also positive, although we find a weaker elasticity for low-income households.

Appendices

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 $a_{j,t}$, and hours worked $h^w_{j,t}$, $h^s_{j,t}$ are derived as follows:

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

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

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

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

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

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 labour demand from the producer's optimization problem are:

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

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

$$
\max_{k_t, i_t} \quad E_t[r_t^k k_t - i_t]
$$

The first order condition with respect to capital and investment are:

$$
\frac{\partial \mathcal{L}_{j,t}}{\partial k_t} : \qquad \lambda_t - E_t \beta \lambda_{t+1}(1-\delta) = r_t^k \tag{2}
$$

$$
\frac{\partial \mathcal{L}_{j,t}}{\partial i_t} : \qquad q_t = \lambda_t \tag{3}
$$

Combining the asset optimal choice $\lambda_{j,t} = \beta E_t \lambda_{j,t+1}(1-\tau_{j,t})(1+r_t)$ and equation 2, we obtain:

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

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

The government budget constraint is represented by:

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

The government fiscal rule is:

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

The market clearing condition is:

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

The model equilibrium is computed as follows:

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

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

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

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

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

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

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

Appendix B Data details and additional results

Table B.1: 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

Data source: Current Population Survey (2009 - 2022)

Table B.2: Tax rate and hours worked from 2010 to 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

Note: This table reports the ordinary least squares regression results (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 B.3: Tax rate and hours worked: robustness analysis

	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
Effects:	Entity	Entity, Time	Time	Entity	Entity, Time	Time	Entity	Entity, Time	Time	Entity	Entity, Time	Time

Note: This table reports the ordinary least squares regression results. 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)*

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.

Greenwood, J., Hercowitz, Z., and Krusell, P. (1997). Long-run implications of investment-specific technological change. *The American economic review*, pages 342–362.

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

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.

Piketty, T. and Saez, E. (2007). How progressive is the us federal tax system? a historical and international perspective. *Journal of Economic perspectives*, 21(1):3–24.

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.

Schmitt-Grohé, S. and Uribe, M. (2004). Solving dynamic general equilibrium models using a second-order approximation to the policy function. *Journal of economic dynamics and control*, 28(4):755–775.

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

Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of money, credit and banking*, 1(1):15–29.

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.