Evolution of Tax Progressivity in the U.S.: New Estimates and Welfare Implications*

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Extended Abstract

This paper focuses on the dynamics of the federal income tax system in the United States since the 1960s. Using tax-revenue data, we first document that the progressivity of the income tax has substantially increased since the mid-1980s, and that this increase was entirely due to the expansion of tax-credits while changes in the tax-rates schedule had minor effects. As such, tax-credits have become a central element of the federal income tax system.

Motivated by this finding, we then analyze the optimal tax-credits and tax-rates schedule (tax curvature) in a quantitative model with heterogeneous agents. The model includes key features of U.S. tax system, namely: transfers, in-work tax-credits, and progressive tax rates, modeled as a log-linear tax function. The model also incorporates unemployment risk and a labor supply decision at both the intensive and the extensive margin. Taking into account both margins of adjustment on the labor market is essential to understand whether redistribution should be achieved through progressive tax-rates schedule, or rather through tax-credits. Indeed, the tax curvature mostly alters labor decisions on the intensive margin, while tax-credits are quantitatively more important for labor participation decisions.

Preliminary results suggest that tax-credits are a powerful tool to generate redistribution towards low-income households, while mitigating the efficiency costs on top-income earners. As a consequence, the recent changes in the structure of the federal income tax scheme have potentially generated large welfare gains, that we plan to quantify more precisely. Finally, we also intend to compare how the optimal choice of current tax instruments – i.e.: transfers, in-work tax-credits and the tax curvature – compare with the current U.S. tax code.

*The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Board or the Federal Reserve System. Preliminary and incomplete, comments are very welcome. Corresponding author: axelle.ferriere@eui.eu.
Preliminary Draft

1 Introduction

This paper documents the dynamics of the federal income tax system in the United States since the 1960s. We provide a statistical description of the evolution of tax progressivity and income inequality in the U.S. for the period 1960-2008, using tax-revenue data. We show that the progressivity of the income tax has substantially increased since the mid-1980s, and that this increase was entirely due to the expansion of tax-credits while changes in the tax-rates schedule had minor effects. As such, tax-credits have become a central element of the federal income tax system. Motivated by this finding, we then analyze the implications of tax-credits on the optimal efficiency-redistribution trade-off. In particular, what are the welfare gains from using tax-credits in addition to the standard tax code on personal income? How should the tax-rates schedule evolve when the government also uses tax-credits? What are the implications in terms of labor decisions, both on the intensive and on the extensive margin?

The empirical motivation of this paper is twofold. First, we provide an analysis of the evolution of the U.S. federal tax system, with particular emphasis on changes in tax progressivity and the key components underlying these changes. Second, we contribute to the literature using heterogeneous households models by providing estimates over time of the distribution of taxes, a key ingredient of these models. Our data source for income and taxes comes from IRS public files, which are part of the TAXSIM program at the NBER.\(^1\) The sample is annual for 1960-2008, and has approximately 100,000 observations per year. We first report results regarding distribution of pre-tax income across taxpayers: in line with the literature, we find an increasing concentration of income over the past fifty years, with the income share of the top-10% tax-filers rising from about 30% in the 60s to a peak of 45% in 2006.\(^2\) Then, we turn to the distribution of taxes. First, we report significant changes over time in the fraction of taxes paid by each deciles, both regarding the capital and the labor income taxes. Second, we estimate the distribution of taxes using the well-known log-linear tax function. We find that progressivity has been increasing over the past fifty years, with brief exceptions during the early 1980s and 2000s. Interestingly, we show that the increase in tax progressivity in the last thirty years is mostly driven by tax credits: excluding those, we find that tax progressivity has remained roughly flat since 1990. In addition, the log-linear tax function fits very well the before-credit tax function, but the fit decreases over time regarding the after-credit tax function.

These empirical findings motivate our normative analysis: what is the optimal level of tax progressivity in the presence of tax-credits? To answer this question, we analyze the optimal tax-credits and tax-rates schedule (tax curvature) in a quantitative model with heterogeneous agents.

\(^1\)See http://users.nber.org/~taxsim/
\(^2\)See Piketty and Saez (2003) and citations therein.
The model includes key features of U.S. tax system, namely: transfers, in-work tax-credits, and progressive tax rates, modeled as a log-linear tax function as suggested by our empirical analysis. The model also incorporates unemployment risk and a labor supply decision at both the intensive and the extensive margin. This environment generates realistic levels of labor elasticities along the income distribution, on both margins: elasticities are small and flat with respect to the intensive margin, while they are large for low-income workers and strongly decreasing with income regarding the extensive margin. Taking into account both margins of adjustment on the labor market is essential to understand whether redistribution should be achieved through progressive tax-rates schedule, or rather through transfers and/or tax-credits. Indeed, the tax curvature mostly alters labor decisions on the intensive margin, while tax-credits are quantitatively more important for labor participation decisions.

Preliminary results suggest that tax-credits are a powerful tool to generate redistribution towards low-income households, while mitigating the efficiency costs on top-income earners. As a consequence, the recent changes in the structure of the federal income tax scheme have potentially generated large welfare gains, that we plan to quantify more precisely. Finally, we also intend to compare how the optimal choice of current tax instruments – i.e.: transfers, in-work tax-credits and the tax curvature – compare with the current U.S. tax code.

Our empirical work complements earlier contributions of Gouveia and Strauss (1994), and Guner, Kaygusuz, and Ventura (2014) more recently, who provide tax estimates for given years. Similarly, we estimate tax functions typically used in the literature, which can be used by other research. Importantly, we offer a systematic dynamic analysis from 1960 to 2008; as such, we discuss changes in tax progressivity measures over time, which are of crucial importance when evaluating heterogeneous households models; see Ferriere and Navarro (2015) and Guvenen et al. (2014) for recent examples.

The rest of the paper is organized as follow. Section 2 presents our first empirical results. Section 3 describes the model used to conduct our quantitative analysis. Section ?? summarize our findings, while Section 6 concludes.

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3See Feenberg and Poterba (2000) for a discussion of the evolution of U.S. federal taxes for high income households. For a discussion of taxes in European countries, see Guvenen, Kuruscu, and Ozkan (2014) and references therein.
2 Empirical Findings

We provide a statistical description of the evolution of tax progressivity and income inequality in the U.S. for the period 1960-2008, using tax revenue data. We document two facts:

1. A large and steady increase of tax progressivity over our sample, with brief exceptions during the early 1980’s and early 2000’s.

2. The increasing importance of tax credits, in particular since the mid-eighties. And in particular:
   - Tax credits can explain a large part of the measured increase in tax progressivity;
   - The fit of the HSV parametric estimation is significantly better for the before-credit tax function than for the after-credit one.

2.1 Data

Our data source for income and taxes comes from IRS public files, which are part of the TAXSIM program at the NBER.\(^4\) The sample is annual for 1960-2008, and has approximately 100,000 observations per year.\(^5\) Importantly, the data is not top coded which makes it particularly useful to analyze tax distributions at the very top.\(^6\) Unfortunately, we do not have identification data and can only construct repeated cross-sections over time but not a panel. For the same reason, an observation in our sample is a tax filling 1040 form, which could be a joint or a single filling.\(^7\) Finally, and most importantly, we observe a relatively large change in propensity to file of low taxpayers, which increases the volatility of the lowest-income households include in TAXSIM over the years.

Our measure of total income corresponds to Adjusted Gross Income (AGI) ignoring losses and adding capital gain deductions.\(^8\) Regarding taxes, we observe the dollar amount that a taxpayer owes in federal taxes; and from 1979 onwards we also observe state level taxes.\(^9\) Let \(y_{it}\) be the income of household \(i\) in year \(t\), and \(T_{it}^f\) and \(T_{it}^s\) be the amount paid in federal and state taxes respectively. We compute federal tax rates as \(\tau_{it}^f = T_{it}^f / y_{it}\), and total total tax rates as \(\tau_{it} = \left( T_{it}^f + T_{it}^s \right) / y_{it} \).

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\(^4\)See [http://users.nber.org/~taxsim/](http://users.nber.org/~taxsim/)
\(^5\)The minimum and maximum number of observations are 59,037 for year 1986 and 171,751 for year 1979, respectively.
\(^6\)CITE Daniel’s paper.
\(^7\)SOMETHING MORE HERE?
\(^8\)ADD MORE DETAILS HERE.
\(^9\)We also have social security taxes, to be added.
2.2 Inequality: Description

Income inequality has increased over the last 50 years, with a steady increase of the highest income decile participation on total households’ income. Figure 1 documents this well-known fact by plotting mean income for several income groups (top panel) and each groups’ income relative share (bottom panel).

[CITE Piketty & Saez and Feenberg & Poterba. Briefly discuss about the top 1%.

2.3 Taxes: Description

The U.S. Federal tax system, as well as the State one, has always been progressive with higher tax rates for higher income deciles. Figure 2 plots average federal tax rates (left panel) for several income groups. [add social security] Interestingly, as we discuss in more detailed below, differences in tax rates across income groups varied substantially over time. For instance, the average tax rate for lowest 50% of income earners has been negative since the early 1990’s. In addition, state taxes increase the average tax rates of the top deciles, while roughly do not affect the lower deciles, increasing the overall progressivity of the whole tax system. [Figure for state taxes tba].

Since the early 1990’s, tax credits have been a crucial component of the progressivity of the tax system. While tax credits barely affect tax rates at the top, it significantly declines them at the bottom of the distribution. This is shown in Figure 2, which plots what tax rates would in the absence of credits (right panel).

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10 Each group is computed by income using the weights provided by TAXSIM. See Appendix ?? for computational details.
2.4 Tax Progressivity: Estimates

We provide estimates of the tax progressivity based on a simple parametric tax function: the loglinear case. We exploit the cross-sectional dimension of our data to provide year by year estimates of these tax functions. Consequently, these estimations provide a simple framework to describe how the tax system has evolved over time. We also discuss the fit of these different functions, and where they fail to match data.

Interestingly, most of these functions provide clean measures of progressivity as a combination of its parameters. Thus, estimating these tax functions over time provides historical measures of changes in tax progressivity.

**The Loglinear Specification.** The parametric tax function we estimate comes from Heathcote, Storesletten, and Violante (2014) (HSV henceforth), and is given by

$$\tau(y) = 1 - \lambda y^{-\gamma}$$

where $y$ is the income level, and $\tau(\cdot)$ is the tax rate.\(^{11}\) The function is fully described by two parameters, with $\gamma$ measuring the progressivity of the tax schedule, and $\lambda$ reflecting the tax level. In particular, when $\gamma = 0$ the tax function implies an affine tax: $\tau(y) = 1 - \lambda$; while $\gamma = 1$ implies complete redistribution: after-tax income $(1 - \tau(y)) y = \lambda$ for any pre-tax income $y$. The second parameter, $\lambda$, measures the level of the taxation scheme: one can think of $1 - \lambda$ as a quantitatively-close measure of the average tax rate.\(^{12}\)

\(^{11}\)This tax function is also called constant rate of progressivity.

\(^{12}\)When $\gamma = 0$, $1 - \lambda$ is exactly the tax rate.
Figure 3: Non-linear tax as a function of two parameters ($\lambda, \gamma$).

Notes: Plots for the tax function $\tau(y) = 1 - \lambda y^{-\gamma}$, for different values ($\lambda, \gamma$). The parameter $\gamma$ measures progressivity, while $1 - \lambda$ measures the level of the tax function.

More generally, $\gamma$ is the elasticity of one minus the tax rate with respect to income

$$\frac{\partial (1 - \tau(y))}{\partial y} \frac{y}{1 - \tau(y)} = -\gamma$$

Thus, an increase in $1 - \lambda$ captures an increase in the level of the taxation scheme (it shifts the entire tax function up), while a higher $\gamma$ implies that rate increases faster with income, and thus the system is more progressive: it turns the entire tax function counter-clockwise. Figure 3 shows how the tax function changes for different values of $\gamma$ and $\lambda$.

Results. Figure 4 shows the results of the estimation of equation 1, using Federal taxes only. The left panel reports estimates of $\gamma$, using two different measures of after-tax income: before and after credit. The right panel reports $R^2$ in both cases.

We find a large and steady increase of tax progressivity over our sample, with brief exceptions during the early 1980’s and early 2000’s. Note that, excluding tax credits, tax progressivity remains roughly stable since the early 1990s: the increase in tax progressivity in the past thirty years has been mostly driven by tax credits.

Interestingly, the fit, when using the after-credits after-tax income rather than accounting for tax credits explicitly, tends to decrease as tax credits become increasingly significant. That is, the tax system is more tightly estimated under this parametric assumption with tax credits:

$$\log(y^{bc}) = \log(y^{at} - TC(y)) = (1 - \gamma) \log y$$
where $TC$ describes tax credits; or, rewriting:

$$y_{after-tax} = \lambda y_{pre-tax}^{1-\gamma} + TC(y)$$

Thus, the HSV specification is more relevant for before-credit after-tax income, modelling credits explicitly. The difference seems important: the $R^2$ falls below 40% in the latter case, while remaining around 60% in the former one. We will use this latter specification in the next Section.

Finally, as a side remark, note that since 1979, we can also compute tax progressivity for state taxes. We do so in Appendix: including state taxes increase the progressivity of the whole tax system, but the dynamics of tax progressivity are essentially driven by federal taxes.

## 3 Model

We then use a canonical heterogeneous households model (Aiyagari, 1994) to compare the optimal tax progressivity to the current U.S. tax system.

We want to focus on two elements:

1. Tax credits, as we have shown that they have become significantly important over the past thirty years;

2. An extensive margin for labor decisions. That second element is motivated by two facts: first, we show that the empirical distribution of labor supply elasticities is better captured by a model where households make extensive labor supply choice only. Second, tax credits are said to have a possibly larger effect on labor market entry and exit.

We first present some results under an intensive margin assumption only. We then focus on a model with an extensive margin only. Finally, we propose a quantitative analysis with both the intensive and the extensive margin at play.
3.1 Equilibrium

Time is discrete and indexed by $t = 0, 1, 2, \ldots$. The economy is populated by a continuum of households, a representative firm, and a government. The firm has access to a constant return to scale technology in labor and capital given by $Y = K^{1-\alpha}L^\alpha$, where $K$, $L$ and $Y$ stand for capital, labor, and output, respectively. Both factor inputs are supplied by households. We assume constant total factor productivity.

**Households:** Households have preferences over sequences of consumption and hours worked given as follows:

$$E_o \sum_{t=0}^{\infty} \beta^t \left[ \frac{c_t^{1-\sigma}}{1-\sigma} - B \frac{h_t^{1+\varphi}}{1+\varphi} - \kappa 1_{h_t>0} \right]$$

where $c_t$ and $h_t$ stand for consumption and hours worked in period $t$. Households have access to a one period risk-free bond, subject to a borrowing limit $a$. Their idiosyncratic labor productivity $x$ follows a Markov process with transition probabilities $\pi_x(x', x)$.

Let $V(a, x)$ be the value function of a worker with level of assets $a$ and idiosyncratic productivity $x$. Then,

$$V(a, x) = \max_{c, a', h} \left\{ \frac{c^{1-\sigma}}{1-\sigma} - B \frac{h^{1+\varphi}}{1+\varphi} - \kappa 1_{h>0} + \beta E_{x'} [V(a', x') | x] \right\}$$

subject to

$$c + a' \leq w x h + (1+r) a - \tau(w x h, r a)$$

$$a' \geq a$$

$$h \in H$$

where $w$ stands for wages, $r$ for the interest rate and $a$ is an exogenous borrowing limit. Notice that labor supply is constrained to be in the set $H$, which we use to incorporate different restrictions on the extensive/intensive labor supply decisions. In the case of the *divisible labor supply* model, the set takes the form of $H = [0, h_{\text{max}}]$, where $h_{\text{max}}$ is the maximum number of hours a household can work in a period, and $\kappa = 0$. In the case of *indivisible labor supply* model, the set takes the form of $H = \{0, \bar{h}\}$, so that households can only choose whether to work $\bar{h}$ hours or not to work at all.\(^{13}\) In the general case with *both intensive and extensive margin*, $H = [0, h_{\text{max}}]$ and $\kappa > 0$.

Finally, note that households face a distortionary tax $\tau(w x h, r a)$, which depends on labor income $w x h$ and capital earnings $r a$ separately. We use the function $\tau(\cdot)$ to accommodate different progressive tax schemes and analyze the optimal tax progressivity choice.

\(^{13}\)With indivisible labor, it is redundant to have two parameters $B$ and $\varphi$. We keep this structure to ease the comparison with an environment with divisible labor in a later section.
Every period, households face the problem in (3) and make optimal labor, consumption and saving decisions accordingly. Let \( h(a, x), c(a, x) \) and \( a'(a, x) \) denote his optimal policies.

**Firms:** Every period, the firm chooses labor and capital demand in order to maximize current profits,

\[
\Pi = \max_{K,L} \left\{ K^{1-\alpha} L^\alpha - wL - (r + \delta)K \right\}
\]

(4)

where \( \delta \) is the depreciation rate of capital. Optimality conditions for the firm are standard: marginal productivities are equalized to the cost of each factor.

**Government:** The government’s budget constraint is given by:

\[
G + (1 + r)D = D + \int \tau(wxh, ra) d\mu(a, x)
\]

(5)

where \( D \) is government’s debt and \( \mu(a, x) \) is the measure of households with state \( (a, x) \) in the economy. Notice that government spending \( G \), as well as the fiscal policies \( \tau(\cdot) \) and \( D \), are kept constant. At the end of the section, we will analyze the welfare effect of different tax functions \( \tau(\cdot) \).

**Equilibrium:** Let \( A \) be the space for assets and \( X \) the space for productivities. Define the state space \( S = A \times X \) and \( B \) the Borel \( \sigma \)–algebra induced by \( S \). A formal definition of the competitive equilibrium for this economy is provided below.

**Definition 1** A **recursive competitive equilibrium** for this economy is given by: value function \( V(a, x) \) and policies \( \{h(a, x), c(a, x), a'(a, x)\} \) for the household; policies for the firm \( \{L, K\} \); government decisions \( \{G, B, \tau\} \); a measure \( \mu \) over \( B \); and prices \( \{r, w\} \) such that, given prices and government decisions: (i) Household’s policies solve his problem and achieve value \( V(a, x) \), (ii) Firm’s policies solve his static problem, (iii) Government’s budget constraint is satisfied, (iv) Capital market clears: \( K + D = \int_B a'(a, x) d\mu(a, x) \), (v) Labor market clears: \( L = \int_B xh(a, x) d\mu(a, x) \), (vi) Goods market clears: \( Y = \int_B c(a, x) d\mu(a, x) + \delta K + G \), (vii) The measure \( \mu \) is consistent with household’s policies: \( \mu(B) = \int_B Q((a, x), B) d\mu(a, x) \) where \( Q \) is a transition function between any two periods defined by: \( Q((a, x), B) = \mathbb{I}_{\{a'(a, x) \in B\}} \sum_{x' \in B} \pi_x(x', x) \).

**3.2 Calibration**

Some of the model’s parameters are standard and we calibrate them to values typically used in the literature. A period in the model is a quarter. We set the exponent of labor in the production function to \( \alpha = 0.64 \), the depreciation rate of capital to \( \delta = 0.025 \). Similarly, we set households’ coefficient of risk-aversion to \( \sigma = 2 \) and the Frisch-elasticity of labor
supply to $\varphi = 2.5$\textsuperscript{14} We follow Chang and Kim (2007) and set the idiosyncratic labor productivity $x$ shock to follow an AR(1) process in logs: $\log(x') = \rho_x \log(x) + \varepsilon_x'$, where $\varepsilon_x \sim \mathcal{N}(0, \sigma_x)$. Using PSID data on wages from 1979 to 1992, they estimate $\sigma_x = 0.287$ and $\rho_x = 0.989$. To obtain the transition probability function $\pi_x(x', x)$, we use the Tauchen (1986) method. The borrowing limit is set to $\underline{a} = -2$, which is approximately equal to a wage payment and delivers a reasonable distribution of wealth (add Table below). We set capital taxes to $\tau_K = 0.35$, following Chen, Imrohoroglu, and Imrohoroglu (2007).

Then, we assume that the tax system is loglinear (excluding tax credits): $\tau(wxh, ra) = wxh + ra - \lambda(wxh + ra)^{1-\gamma}$. We need to take a stand on a benchmark value for the tax progressivity $\gamma$. Heathcote et al. (2014) find a value of $\gamma = 0.15$ by using PSID data on labor income for the years 2001 to 2005; while ? find a value of $\gamma = 0.065$ using IRS data on total income for the year 2000. We set $\gamma = 0.1$, an intermediate value between these two estimates and close to our estimates in Section 2.4. The value of $\lambda$ is computed so that the government’s budget constraint is met in equilibrium.

The remaining parameters are calibrated within the model to match several moments. In particular, we jointly calibrate preference parameters $\beta$ and $B$, and policy parameters $G$ and $D$ to match an interest rate of 0.01, a government spending over output ratio of 0.15, a government debt-to-output ratio of 2.4, and an employment rate of 60 percent in the model with indivisible labor, which is the average of the Current Population Survey (CPS) from 1964 to 2003.\textsuperscript{15} We conduct a similar exercise in the divisible labor model, where we calibrate $B$ such that aggregate output is equal to the one in the indivisible labor steady-state, to avoid possible size effects. Table [ADD TABLE] summarizes the parameter values.

\textsuperscript{14} Notice that the parameter $\varphi$ is only relevant for the divisible labor supply model. See discussion below.

\textsuperscript{15} We target an average 60% participation rate as observed in the CPS. As a robustness check, we compare the distribution of participation in our model with PSID data for the 1984 survey. The average participation rate in PSID is 65%, which is close to our target.


4 Tax function

We study a tax function of the following structure. Assume a household with labor income \( y_\ell \) and capital income \( y_k \). Let \( y \equiv y_\ell + y_k; \bar{y} \) the average total income; and \( \bar{y}_\ell \) the average labor income in the economy. There are three components to the tax function:

1. First, the total income is taxed using a loglinear tax function:

\[
T(y) = y \left( 1 - \lambda \left( \frac{y}{\bar{y}} \right)^{-\gamma} \right)
\]

2. Then, there is a work-credit \( \tau \), that phases-in at rate \( r_i \) at labor income \( \omega_i \bar{y}_\ell \), plateaus, and phases-out at rate \( r_o \) at labor income \( \omega_o \bar{y}_\ell \), conditional on \( y_k < y_k^* \):

\[
T_\tau(y_\ell) = \tau \left[ \exp \left( - \left( \frac{y}{\bar{y}_\ell} + 1 - \omega_i \right)^{-r_i} \right) \right] \left[ 1 - \exp \left( - \left( \frac{y}{\bar{y}_\ell} + 1 - \omega_o \right)^{-r_o} \right) \right]
\]

3. Finally, there is a transfer \( \mu \), which phases-out at rate \( r_\mu \) at income-threshold \( \omega_\mu \bar{y} \):

\[
T_\mu(y) = \mu \left[ 1 - \exp \left( - \left( \frac{y}{\bar{y}} + 1 - \omega_\mu \right)^{-r_\mu} \right) \right]
\]

This leaves us with the following parameter to optimize on: \( (\gamma, y_k^*, \tau, r_i, \omega_i, r_o, \omega_o, \mu, \omega_\mu, r_\mu) \), and \( \lambda \) will be pinned down by the government’s budget constraint. Note that we have left unemployment (and unemployment benefits) out of the picture so far.

5 Divisible labor

We start with a benchmark with \( \gamma = 0.1 \), as in the US. For transfers, we use in the benchmark: \( \mu = 0.1, r_\mu = 20, \omega_\mu = 0.1 \). In words, transfers are about 10% of mean income, and they are received for households with income below 10%, with a quick phase-out, as, roughly, in the data. Finally, for in-work credit, the benchmark features: \( \tau = 0.1, \omega_i = 0.05, \omega_o = 0.6, r_i = 20, r_o = 7 \); in-work credit are at most 10% of mean labor income, with a quick phasing-in for households with at least 5% of mean labor income, and a slow period of phasing-out for households receiving until 60% of mean labor income, as seen in the data.\(^{16}\)

\[^{16}\text{Of course, we need more precision here, and we should calibrate using this tax function.}\]

\[^{17}\text{I should also plot the tax functions in more details...}\]
Figure 5: Optimal tax progressivity without tax credits and transfers

Notes: Welfare as a function of tax progressivity $\gamma$, assuming no credits and transfers ($\mu = \tau = 0$).

5.1 Without transfers and tax credits

Assume that $\tau = \mu = 0$. Then the optimal $\gamma$ is close to the one measured above: $\gamma^* = 0.07$. See Figure 5.

5.2 Adding transfers only

From the optimal tax system without tax and transfers, we first show that distributing transfers is welfare-improving. We fix $\gamma$ to its optimal level $\gamma^*$ when $\mu = \tau = 0$. A positive $\mu$ increases welfare, as can be seen in Figure 6.

The optimal combination of progressivity and transfers is $(\gamma^t, \mu^t, \omega^t) = (0.04, 0.08, 0.1750)$. That is, if the government can use transfers, it prefers to use positive transfers (about 8% of mean income) to the poorest 17.5% households; and a less progressive income tax schedule.

There is a trade-off between redistribution through $\gamma$ and redistribution through $\mu$, as shown in Figure 7, panel (a): the larger the $\mu$, the smaller the optimal $\gamma$; similarly, there is a trade-off between the optimal amount of transfers to distribute, and the fraction of households receiving it: the larger the $\omega_\mu$, the smaller the $\mu$ (see Figure 7, panel b).

5.3 Adding tax credits only

From the optimal tax system without tax and transfers, we first show that using in-work credit is welfare-improving. We fix $\gamma$ to its optimal level $\gamma^*$ when $\mu = \tau = 0$. A positive $\tau$ increases welfare, as can be seen in Figure 8. The optimal combination of progressivity and in-work credit is $(\gamma^c, \tau^c, \omega^c, \omega^o) = (0.04, 0.12^*, 0, 0.1)$, where $\tau^c$ is binding above. That is, if the government can use
Figure 6: Positive transfers increase welfare

Notes: Welfare as a function of the level of transfers $\mu$. Transfers $\mu$ are expressed in percentage of mean income. We set $\gamma = \gamma^\star$, its optimal value without transfers and credits; $\omega_\mu = 0.1$ and $r_\mu = 20$, their benchmark values; and $\tau = 0$.

Figure 7: Optimal progressivity and transfers: main trade-off

Notes: Panel (a): Welfare as a function of tax progressivity $\gamma$ and transfers $\mu$, when $\omega_\mu = \omega_\mu^\star$; Panel (b): Welfare as a function of transfers $\mu$ and number of households receiving transfers $\omega_\mu$, when $\gamma = \gamma^t$. Both panels assume zero credit ($\tau = 0$).
in-work credit, it prefers to use it (12% of mean labor income, binding) to all poorest households; and a less progressive income tax schedule.

There is a trade-off between redistribution through $\gamma$ and redistribution through $\tau$, as shown in Figure 9, panel (a); similarly, there is a trade-off between the optimal amount of credit to distribute, and the fraction of households receiving it: the larger the $\omega_o$, the smaller the $\tau$ (see Figure 9, panel b). Unambiguously, welfare is decreasing in $\omega_i$ though.

Finally, note that the welfare gains are much larger using credits than transfers. We investigate how credits and transfers interact in the next paragraph.

5.4 All together..

The optimal $\{\gamma, \mu, \omega_\mu, \tau, \omega_i, \omega_o\}$ is... TO RUN!

5.5 Watch out

We assume $y_k = \infty$ for now... And we did not play with $r_i$, $r_o$, $r_\mu$. 

Notes: Welfare as a function of the level of in-work credit $\tau$. Credit $\tau$ are expressed in percentage of mean labor income. We set $\gamma = \gamma^*$, its optimal value without transfers and credits; $\omega_i = 0.05$, $\omega_o = 0.6$, $r_i = 20$, and $r_o = 7$, their benchmark values; and $\mu = 0$. 

Figure 8: In-work credit increases welfare
For now, assume that $r_i = r_o = r_\mu = 30$, that is, everything phases-in and -out quite quickly. Assume that $y_k^*$ is equal to say 5% of total capital income. We will optimize on 6 parameters: $(\gamma, \tau, \omega_i, \omega_o, \mu, y_\mu)$, and $\lambda$ from the budget constraint.

**Build the code** Before optimizing on the 6 parameters, let us make sure that the code works for this tax function, for a given set of parameters. Assume that $\gamma = 0.1$, for work-credit $\tau = 0.2$, phasing-in at $\omega_i = 0.1$, phases-out at $\omega_o = 0.5$, and transfers are $\mu = 0.1$, phasing-out at $\omega_\mu = 0.05$. The household’s budget constraint is as follows:

- If $y_k < y_k^*$, the total taxes paid is: $T(y) - T_\tau(y_\ell) - T_\mu(y)$.
- If $y_k > y_k^*$, the total taxes paid is: $T(y) - T_\mu(y)$.

Compute first-order conditions for labor in both cases, and check if the first-order conditions are smooth and optimal labor is found. **IF NOT**, we will have to adjust the algorithm as follows: optimize on $c$, compute $h$ from first-order conditions (I think this should be in close-form) and $a_{np}$ from the budget constraint.

Once the code works, we will run it on the following parameters: $\gamma = [0; 0.05; 0.1]$, $\tau = [0; 0.1; 0.2]$, $\mu = [0; 0.1; 0.2]$, $\omega_i = [0; 0.05; 0.1]$, $\omega_o = [0.2; 0.3; 0.4]$, and $\omega_\mu = [0.05; 0.1; 0.15]$. (Of course, when $\tau = 0$, we don’t need to run for optimal $\omega_o$ and $\omega_i$, and when $\mu = 0$ we don’t need to run for optimal phasing-out $\omega_\mu$.)
5.6 What next

The divisible + indivisible model, and then unemployment.
6 Conclusion

References


