연세대학교 상경대학

경제연구소

Economic Research Institute

Yonsei Universit

서울시 서대문구 연세로 50

50 Yonsei-ro, Seodaemun-gu, Seoul, Korea

TEL: (+82-2) 2123-4065 FAX: (+82-2) 364-9149

E-mail: yeri4065@yonsei.ac.kr

http://yeri.yonsei.ac.kr/new

Designing Optimal Progressive Taxation with Hours Constraints

Kitae Cho

Yonsei University

Eunseong Ma

Yonsei University

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Kitae Cho†
Yonsei University

Eunseong Ma‡
Yonsei University

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Abstract

This paper investigates the effects of hours constraints on optimal progressive tax structures. To this end, we present a heterogeneous-agent model with a nonlinear progressive tax system. As a form of hours constraints, we introduce a wage penalty for those working below 40 hours per week, generating a realistic distribution of work hours predominantly concentrated at 40 hours. Our findings indicate that optimal tax progressivity should be significantly higher than the current level. Poor households benefit from the reform, while the rich experience welfare losses, primarily due to productive households being unable to adjust their labor supply under hours constraints. The optimal tax reform reduces overall inequality, albeit at the cost of decreased economic activity. Uncovering the Pareto weights in the social welfare functions, under the current tax system, the weight assigned to the richest households is approximately twice the average.

Keywords: hours constraints, optimal tax progressivity, labor supply elasticity, redistribution
JEL Codes: E21, H21, H23, J22

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†School of Economics, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea. Email: whrlxo9031@gmail.com.

‡Contact Author. School of Economics, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea. Email: masilver@yonsei.ac.kr.

1 Introduction

Determining a socially optimal tax schedule is complicated due to the well-known trade-off between equity and efficiency. For optimal tax reforms, policymakers must balance the aim of fair distribution against potential negative impacts on economic performance, primarily due to reduced labor supply from productive households.[1] *Hours constraints* are critical in this context, as they directly influence household labor supply decisions, which in turn affect economic efficiency. In practice, hours constraints are prevalent in labor markets. Notably, a substantial number of U.S. households are subject to the typical 40-hour work week (Bick, Blandin and Rogerson, 2022; Lachowska et al., 2023). Yet the specific impact of hours constraints on optimal taxation has not been thoroughly explored in the literature. This paper aims to address this gap.

In this study, we explore how hours constraints influence optimal progressive tax structures through labor supply channels. We develop a standard heterogeneous-agent model equipped with a nonlinear progressive tax system and hours constraints. The asset market is incomplete, as in Aiyagari (1994), which, coupled with borrowing constraints, generates rich heterogeneity across households and leads to heterogeneous responses to tax reforms. Following Heathcote, Storesletten and Violante (2017), we use a log-linear tax function to represent the U.S. progressive tax system. To capture hours constraints, we introduce a wage penalty for households working fewer than 40 hours per week, thereby generating a realistic distribution of work hours that predominantly concentrates at 40 hours.[2] In this setup, productive households adhering to around 40 hours of work become less responsive in more progressive tax regimes, which has important implications for optimal taxation.

We calibrate the model to reflect the current U.S. economy. The benchmark model demonstrates appropriate heterogeneity for analyzing hours constraints within an optimal progressive tax framework. It reasonably reproduces the distribution of earnings, tax rates, and work hours. Particularly, it successfully replicates the proportion of workers who work around 40 hours per week across earnings quintiles, which significantly influences the optimal progressive tax schedule. We adopt a Ramsey approach, considering once-and-for-all changes to the fiscal instruments and including the transitions

[1] While higher tax progressivity discourages labor supply for the rich, which decreases efficiency, greater tax progressivity reduces consumption dispersion, providing better insurance to the poor, which increases welfare.

[2] This wage penalty function is based on empirical findings from Bick, Blandin and Rogerson (2022) and Labanca and Pozzoli (2023).

to the new steady state in our welfare computations.

Key findings are summarized as follows. The tax system under the optimal reform is significantly more redistributive than the current system in the U.S. The optimal level of tax progressivity is found to be 0.18, significantly higher than the current level, 0.08. Under the optimal tax plan, the aggregate welfare gain is 0.4% in consumption-equivalent terms. These welfare gains occur because a more progressive tax system can provide a safety net against income volatility (better insurance) and reduce income inequality through wealth transfers (redistribution). Although the optimal tax system enhances overall welfare, it leads to a decline in economic activity. Regarding the disaggregate effects, all measures of inequality decrease under the optimal tax reform. Importantly, the impact of the optimal tax reform on household welfare is markedly heterogeneous; generally, low-productivity households benefit, whereas high-productivity households face welfare losses. This disparity in welfare effects is mainly due to greater differences in tax rates between high- and low-income groups under the optimal tax plan.

Another key finding is that hours constraints are found to be essential for achieving significantly greater optimal progressivity than currently observed. We explore changes in work hours across different productivity levels, which directly ties to the "equity-efficiency" trade-off. Our findings suggest that hours constraints crucially affect labor supply decisions of productive households. Specifically, many constrained households belong to the upper earnings bracket, and their labor supply is relatively inelastic to increases in tax rates due to the wage penalty. To illustrate this, we consider a counterfactual economy without these frictions and find that the optimal tax progressivity drops to 0.1, much lower than in the benchmark model. This is because without wage penalties, the government cannot impose higher tax rates on productive households as they would substantially reduce their labor supply without incurring costs. We interpret the results through the lens of labor supply elasticity (a critical factor in designing optimal tax systems), finding notable heterogeneity in labor supply elasticity across households: productive households have a lower elasticity of around 0.5, compared to 0.8 for less productive households. In the absence of hours constraints, labor supply elasticities for all households are uniform, causing efficiency issues for productive households and resulting in a lower optimal level of progressivity.

We rationalize the current tax system by calculating the Pareto weights—the weights in the social welfare function that would rationalize the existing level of tax progressivity.[3] Our findings reveal that these weights increase with the level of consumption, disproportionately favoring the wealthy. Specifically, in the current tax system, the weight assigned to the richest individuals is approximately double the average weight.

Related Literature

Our quantitative framework aligns with several studies focused on optimal tax progressivity within incomplete-market models. An early contribution by Conesa and Krueger (2006) computes the optimal progressivity of the income tax code within a dynamic general equilibrium model. A seminal paper by Heathcote, Storesletten and Violante (2017) develops the tax and transfer function, which successfully describes the progressive tax system. Other papers in the literature have found that optimal tax structures can depend on different model features. Significant contributions include studies on the importance of human capital accumulation (Krueger and Ludwig, 2016; Badel, Huggett and Luo, 2020), joint transfer-tax policy (Boar and Midrigan, 2022; Guner, Kaygusuz and Ventura, 2023; Ferriere et al., 2023), entrepreneurs (Brüggemann, 2021), top earners (Piketty, Saez and Stantcheva, 2014; Guner, Lopez-Daneri and Ventura, 2016; Kindermann and Krueger, 2022). In this context, our study introduces hours constraints as another avenue for determining optimal progressive tax structures.[4]

Our work is closely related to the existing literature on hours constraints. Previous research has established the prevalence of hours constraints. A seminal contribution by Altonji and Paxson (1988) finds that changes in hours worked are significantly larger for job movers compared to job stayers. Chetty et al. (2011) provide evidence that kinks that apply to a larger group of workers generate larger labor supply elasticities. Labanca and Pozzoli (2022) recently demonstrated that workers in firms with less variability in hours are less responsive to changes in tax rates.[5]

There has been relatively little theoretical discussion regarding hours constraints. Chetty et al.

[3] Chang, Chang and Kim (2018) identify the Pareto weights in the social welfare functions of various countries that justify their current redistribution policies.

[4] Other recent research exploring different dimensions includes negative income tax programs (Lopez-Daneri, 2016), family structure and taxes (Borella, De Nardi and Yang, 2022; Boar and Midrigan, 2022; Borella et al., 2023), capial income taxes (Kina, Slavik and Yazici, 2024), Laffer curves (Holter, Krueger and Stepanchuk, 2019), Pareto weights (Chang, Chang and Kim, 2018), and universal basic income (Conesa, Li and Li, 2023).

[5] Another notable example of hours constraints is the 40-hour work week: Bick, Blandin and Rogerson (2022) and Lachowska et al. (2023) document that usual work hours in the U.S. are concentrated at 40 hours.

(2011) develop a model where firms post job offers with specific hours requirements and workers incur search costs to find jobs. Yurdagul (2017) introduces a model that introduces inflexibility for salaried workers, which arises as a general equilibrium effect due to complementarities between workers' hours. In particular, Bick, Blandin and Rogerson (2022) develop a model of labor supply where earnings are nonlinear in hours, with the extent of nonlinearity varying across the hours distribution.[6] These studies highlight the critical role of hours constraints in explaining key features observed in labor markets. We expand the discussion to the optimal taxation literature, offering a new perspective on how these constraints can shape the design of optimal tax policies.

Road Map The remainder of the paper is structured as follows. Section 2 presents the quantitative model. Section 3 details the model calibration and fits. Section 4 discusses the optimal tax plan for the economy. Section 5 explores related issues in determining optimal tax progressivity. Section 6 concludes the paper.

2 The Model

We develop a heterogeneous-agent model to explore the implications of hours constraints on optimal tax progressivity. The model economy integrates two primary features. Firstly, it includes a nonlinear progressive tax system, as in Heathcote, Storesletten and Violante (2017). Secondly, it incorporates a wage penalty imposed on households working fewer than 40 hours per week (Bick, Blandin and Rogerson, 2022; Ma, 2024), thereby generating a realistic hour distribution with a notable spike at 40 hours. The economy within the model consists of three building blocks: households, firms, and the government.

2.1 Households

The economy is populated by a continuum of infinitely-lived heterogeneous households. At the beginning of each period, households are characterized by their assets, a, and labor productivity, x. Assets yield a real rate of return, r. We assume that the productivity follows a Markov chain with transition

[6] In a similar context, Ma (2024) introduces labor supply adjustments along both extensive and intensive margins and examines the role of these adjustments in conjunction with the 40-hour work week constraint, analyzing their macro and micro elasticity and the welfare effects of business cycles.

probabilities $\pi_x(x|x')$.[7] It is assumed that asset markets are incomplete as in Aiyagari (1994): households cannot fully insure against idiosyncratic productivity shocks. The dynamic decision problem of the household in the economy is given by:

$$V(a,x) = \max_{c,a',h} \left\{ \frac{c^{1-\sigma}}{1-\sigma} - \chi \frac{h^{1+1/\gamma}}{1+1/\gamma} + \beta \mathbb{E}[V(a',x')|x] \right\},$$

subject to

$$c + a' = y - T(y) + (1+r)a,$$

$$y = wxP(h),$$

$$a' \geq \underline{a},$$

where c and h represent consumption and hours worked, respectively. Four parameters govern the preference: σ is risk aversion parameter, χ determines the disutility of labor, γ is the curvature parameter for hours worked, and β is the subjective time discount factor. Households also face a borrowing limit, $\underline{a} \leq 0$. We assume that household earnings, y, are subject to progressive taxation. Specifically, progressive taxation is represented by the function:

$$T(y) = \max \left\{0, y - \lambda(y/\bar{y})^{1-\tau}\right\},$$

where $\bar{y}$ denotes the cross-sectional average earnings. The term, max$\{0, \bullet\}$, ensures non-negative taxes, excluding consideration of transfer systems. The tax system is defined by two parameters: τ governing tax progressivity and λ controlling the scale of taxation. This tax structure is commonly employed in the literature (Heathcote, Storesletten and Violante, 2017; Chang, Chang and Kim, 2018; Ferriere et al., 2023).

In each period, every household is allocated one unit of time, which can be divided between hours worked and leisure. When a household with a labor productivity of x allocates h units of time to work,

[7] We denote a variable with a prime symbol to represent its value in the subsequent period.

the resulting earnings, y, are $wxP(h)$, where w represents the real wage rate for one unit of efficient labor, and $P(\cdot)$ is the mapping from hours worked into labor services. To account for the constraints on hours faced by households, we introduce a friction mechanism that can create a spike at a specific threshold in the distribution of hours worked—typically the 40-hour work week. Consequently, we assume that households encounter a wage penalty function, denoted as $P(\cdot)$, where they incur costs for working fewer hours than a certain threshold, $\bar{h}$. Specifically, $P(\cdot)$ takes the following form:

$$P(h) = h - \phi \max(\bar{h} - h, 0),$$

where ϕ represents a wage penalty parameter. This functional form induces bunch of households working $\bar{h}$ hours. Moreover, this function leads to a significant portion of households working precisely 40 hours across the earnings distribution, consistent with empirical findings from Bick, Blandin and Rogerson (2022) and Labanca and Pozzoli (2023). We believe that this form of hours constraint is highly relevant for optimal progressive taxation. For instance, under more progressive tax reforms, households working 40 hours or slightly above become less sensitive to decreases in after-tax wages. If a substantial portion of these constrained households are located towards the upper end of the earnings distribution, the hours constraint would significantly impact the optimal taxation scheme.

2.2 Firm

The representative firm produces according to the Cobb-Douglas production function. It demands labor L and capital K input.

$$F(K, L) = K^{\alpha} L^{1-\alpha},$$

where α is the capital income share.

2.3 Government

The government runs the progressive tax system and balances the budget every period:

$$G = \int T(y(a, x)) d\mu,$$

where G is the government spending, μ is the measure of the households with the state (a, x) in the economy.

2.4 Definition of the Equilibrium

A stationary equilibrium of the economy consists of the value function $V(a, x)$; a set of the decision rules for the consumption;work hours, and savings $\{c(a, x), h(a, x), a'(a, x)\}$; a set of prices $\{w, r\}$; the aggregate capital and labor $\{K, L\}$; and the invariant distribution of households, μ, such that:

1. Given the prices w and r, households solve the decision problem above and achieve $V(a, x)$.

2. Given the prices w and r, the representative firm maximizes profits:

$$w = (1 - \alpha)(K/L)^{\alpha},$$

$$r = \alpha(K/L)^{\alpha-1} - \delta.$$

3. The goods market clears:

$$\int \{c(a, x) + a'(a, x)\} \, d\mu + G = F(K, L) + (1 - \delta)K,$$

   where δ is the depreciation rate of the capital.

4. The factor markets clear:

$$L = \int \Big\{xP(h(a, x))\Big\} d\mu,$$

$$K = \int a d\mu$$

5. The government balances the budget:

$$G = \int T(y(a, x)) d\mu.$$

6. Individual and the aggregate behaviors are consistent: for all $A^0 \subset \mathcal{A}$, and $X^0 \subset \mathcal{X}$,

$$\mu(A^0, X^0) = \int_{A^0, X^0} \Big\{ \int_{\mathcal{A}, \mathcal{X}} \mathbf{1}_{\mathbf{a}'=\mathbf{a}'(\mathbf{a},\mathbf{x})} d\pi_x(x'|x) d\mu \Big\} da' dx'.$$

3 Calibration and Model Fits

3.1 Calibration

We match the model to the US economy in 2019. For some of the preference parameters, we use the values that are widely used in the literature. We calibrate other parameters to match the targeted moments. The time period in the model is a year. Table 1 presents a summary of the parameter values used in the benchmark model.

Preference and Borrowing Constraint The risk aversion parameter, σ, is set to be 1. We calibrate the time discount factor, β, to match the annual interest rate of 4 percent. The value for the curvature parameter, γ, is set to 1. With this value, the resulting micro elasticity derived from this choice falls within the range of empirically estimated values.[8] We set χ to match the average work hours in the economy to 0.24, reflecting 40 hours per week (40 hours / 168 hours). The borrowing limit, $\underline{a}$, is set to 0.

Labor Productivity Process and Production Technology We calibrate parameters regarding labor productivity process as follows. We assume that x follows the AR(1) process in logs: $\log x' = \rho_x \log x + \epsilon_x$, where $\epsilon_x \sim N(0, \sigma_x^2)$. We discretize the shock process using the method in Tauchen (1986) and obtain transition probability matrix with 21 grids. Regarding the persistence parameter, we set $\rho_x = 0.95$, which is within the estimates found in the literature.[9] The standard deviation of individual productivity shocks, σ_x, is is chosen to ensure σ_x to ensure that the steady-state earnings Gini coefficient aligns with the data. For the production side, we set capital income share, α, to $1/3$ and a depreciation rate, δ, to 0.1.

Hours Constraints and Progressive Tax System Regarding parameters related to hours constraints and the progressive tax system, we utilize labor income, labor income tax, and weekly work hours observed in the CPS 2019.[10] We use the functional form $P(\cdot)$ to match hours distribution with

[8] In our model, the compensated labor supply elasticity differs from γ due to the hours constraints. As demonstrated later in this paper, the elasticity is lower than γ.

[9] Specifically, the estimate in Floden and Linde (2001) is 0.92 while that in French (2005) is around 0.98.

[10] We use the usual weekly hours worked in the last year as variable for the weekly work hours. We select employed individuals who report the positive weekly work hours as a sample. We select households with the head's age between 25

Table 1: Parameters for the Calibration

Parameter	Value	Description	Target or Reference
		Households	
β	0.9535	Time discount factor	Annual interest rate
ρ_x	0.95	Persistence of x shocks	See text
σ_x	0.201	Standard deviation of x shocks	Earnings Gini
$\bar{h}$	0.24	Working hours threshold	40 hours per week
ϕ	0.6	Wage penalty	Concentration at 40 hours
$\underline{a}$	0	Borrowing limit	See text
γ	1	Curvature parameter	See text
χ	13.4	Disutility from working	Average hours worked
σ	1	Relative risk aversion	Standard value
		Firms	
α	1/3	Capital income share	Standard value
δ	0.1	Capital depreciation rate	Standard value
		Government	
τ	0.08	Tax progressivity	See text
λ	0.363	Tax level	Government spending to GDP

the spike at 40 hours per week. Accordingly, we choose $\bar{h}$ be 0.24, and ϕ is set to 0.6 to align with the 45 percent of households working 40 hours per week.

In the model, the government operates the progressive tax system with parameters τ and λ. We estimate tax progressivity, τ, by regressing after-tax earnings on before-tax earnings. In the data, earnings are defined as the sum of wage and salary income along with other compensation received by workers. Taxes on earnings include federal and state income taxes, excluding any public transfers, as we do not account for negative taxes in our model economy. The resulting estimate for tax progressivity is 0.08, close to the value found in Ferriere et al. (2023). The remaining parameter, λ, determining the level of tax, is set to match the ratio of the government spending to the output (15 percent).

and 60, total labor income exceeding \$5000, total labor income taxes smaller than total labor income before credits, total annual work hours between 260 and 4160, and fewer than three employed household members.

Table 2: Characteristics of Earnings Distribution

	Earnings Quintile				
	1st	2nd	3rd	4th	5th
Data					
Share of earnings	5.40	10.41	15.35	22.79	46.05
Average tax rates	12.84	15.87	18.77	21.04	28.05
Benchmark Model					
Share of earnings	5.28	11.58	16.38	21.37	45.39
Average tax rates	12.38	16.79	19.51	21.95	26.48

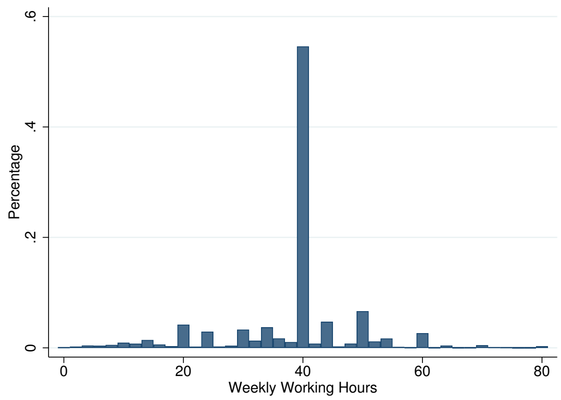
Note: Characteristics of earnings distribution. Statistics for earnings and tax rates are from the CPS 2019.

3.2 Model Fits

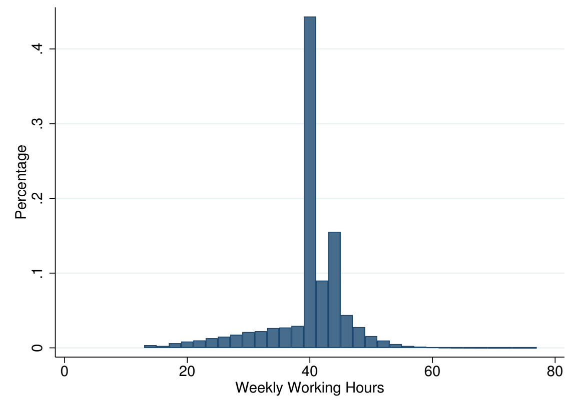
As we explore the implications of hours constraints in an optimal progressive tax structure, it is essential to assess whether the model economy produces reasonable heterogeneity among individual households. Specifically, evaluating the model fit of the earnings distribution and the distribution of hours worked is crucial steps toward achieving the objectives of this study.

Distributions of Earnings and Tax Rates In Table 2, we compare earnings shares and tax rates across earnings quintiles in the data with those generated by the model. Ensuring the model reasonably reflects the earnings distribution found in the data holds significance in two key aspects. Firstly, the tax system's design by the government is intricately tied to earnings. Second, the degree of inequality determines how the government shapes the tax progressivity. The data illustrates significant disparities in earnings among households. Notably, while the bottom 20% of households contribute 5% to total earnings, the top 20% contribute roughly half. The earnings Gini coefficient, standing at 0.41, highlights this inequality. Remarkably, the model successfully mirrors the observed earnings distribution, with the top 20% earners representing 45% of total earnings, similar to the data. Conversely, the bottom 20% retain only 5% of total earnings. The Gini coefficient in the model aligns at 0.41, consistent with the data.

As shown in Table 2, the US government operates a progressive labor tax policy: higher-income households face higher labor tax rates. While the bottom 20% households face a 13% tax rate, the top 20% face an average rate of 28%. Tax rates incrementally rise across earning quintiles. Despite employing only a straightforward log-linear tax function with two parameters, the benchmark model



Data



Benchmark Model

Figure 1: Distribution of Working Hours

Note: The distribution of individual weekly hours worked in the data (the CPS 2019) and the benchmark model.

effectively reproduces the progressive tax structure evident in the data. Medium-earning households in the model face approximately a 19% tax rate, closely resembling values in the data. Tax rates for the bottom 20% and top 20% are 12% and 22%, respectively.

Distributions of Hours and Constrained Households It is imperative to assess whether the benchmark model effectively replicates the empirical distribution of hours worked, particularly emphasizing a conspicuous concentration at the 40-hour threshold. Given the primary focus of this paper on delineating how hours constraints influence optimal progressive reforms, replicating realistic distribution of hours is paramount. The left panel of Figure 1 shows the distribution of individual weekly hours worked.[11] As documented by Bick, Blandin and Rogerson (2022), a discernible cluster of households adheres to a 40-hour work week regimen, with approximately 50% of employees conforming to this standard. Notably, the model successfully reproduces this concentration at 40 hours, as evidenced by the right panel of Figure 1, wherein roughly half of the households in the model similarly adhere to a 40-hour work week, thus aligning closely with empirical observations.

Moreover, the model effectively captures the hours distribution at a detailed level. Figure 2 compares the distribution of individual weekly hours worked in the CPS 2019 data and the benchmark model across earnings quintiles. The figure highlights that the model accurately mirrors the overall hours distributions within each earnings quintile. Notably, the proportion of households working

[11]We use the variable UHRWORKLY in ASEC CPS for the work hours. This variable contains the hours worked per week which individual worked during a previous year.

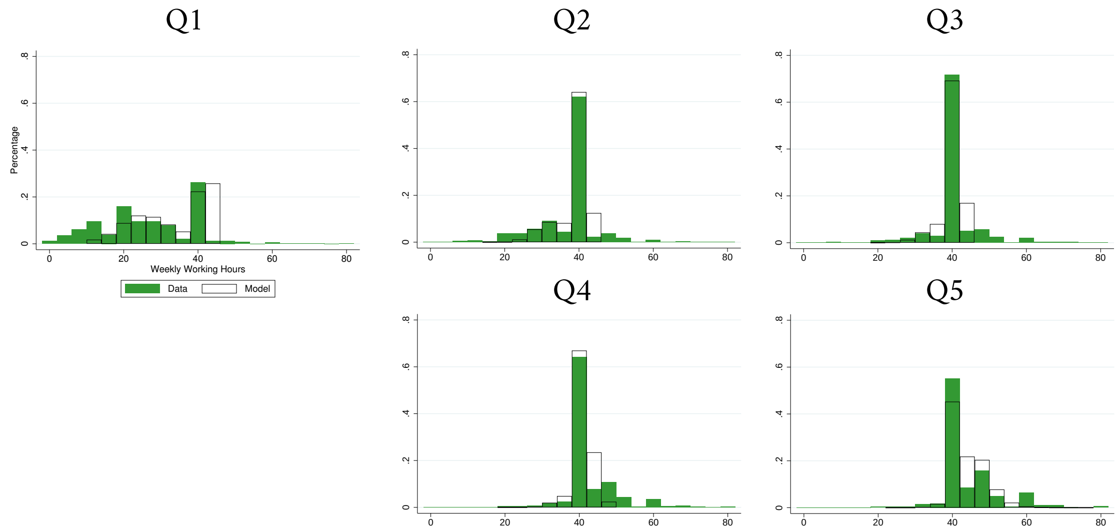


Figure 2: Hours Distribution by Earnings Quintiles

Note: The distribution of individual weekly hours worked in the data (the CPS 2019) and the benchmark model by earnings quintiles. Colored bins represent the data, while white bins represent the model. The x-axis represents hours worked per week; the y-axis shows the fractions.

around 40 hours per week is consistently reflected across all earnings groups. This finding underscores the success of our benchmark model in reasonably reproducing the empirical distribution of hours worked, particularly the prominent concentration at the 40-hour threshold, even at a granular level.

The impact of hours constraints on optimal progressive reforms is significantly contingent upon which demographic group is primarily affected by these constraints, as constrained households typically do not adjust their hours in response to changes in after-tax wages. In this context, the extent to which high-income earners are constrained by such friction notably influences the level of optimal tax progressivity. The greater the prevalence of these constraints among high-income earners, the less the government prioritizes concerns about efficiency losses—such as reduced labor supply—resulting from higher tax rates. Consequently, reasonably replicating the distribution of these households across the earnings distribution is crucial.

Figure 3 illustrates the fraction of workers who work 40 hours per week by earnings quintile. In the data, the highest portion of households working 40 hours per week is observed in the third quintile: 71% of households are binding to the the 40-hour work week. Additionally, a notable number of households in lower quintiles adhere to the 40-hour workweek. Importantly, significant proportions of households in the fourth and fifth quintiles also work 40 hours per week, with 63% and 54%, respectively. The model effectively replicates similar patterns across the earnings distribution. Like

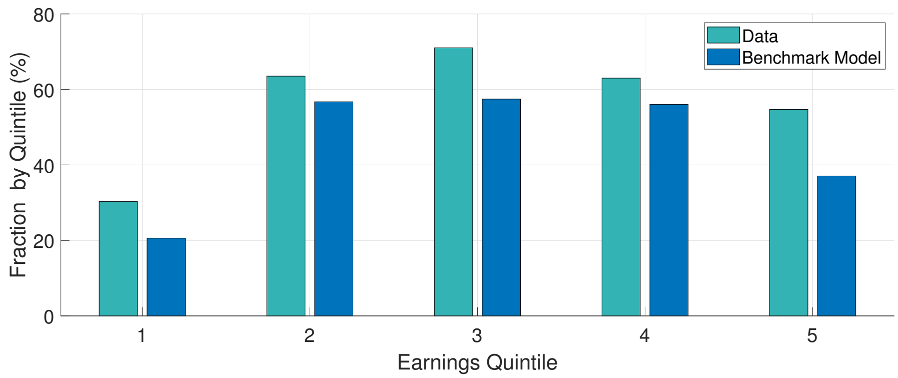


Figure 3: Fraction of Households Working 40 Hours

Note: Fraction of households working around 40 hours by earnings quintiles in the data (the CPS 2019) and the benchmark model.

the data, the ratios across quintiles form an inverted U-shape. Mirroring the data, 55% in the second quintile and 20% in the first quintile work around 40 hours per week. The model yields an accurate representation of the proportion of households working 40 hours in the upper earnings quintiles. Over half of households in the fourth quintile are constrained, while 35% of those in the fifth quintile adhere to the standard work schedule.

Based on the findings presented in this subsection, we argue that the benchmark model exhibits reasonable heterogeneity suitable for analyzing the implications of hours constraints within an optimal progressive tax framework. Specifically, as mentioned earlier, the benchmark economy adequately reproduces the degree to which high-income earners are affected by hours constraints, which can significantly influence the optimal progressive tax schedule.

4 Optimal Tax Plan

4.1 Finding Optimal Tax Progressivity

In the economic framework, the government's tax plan is characterized by the two-parameter tax system. We assume that the government aims to reform tax progressivity by selecting a new level that maximizes social welfare. This approach considers the transition path from the current status quo to a new steady state in the calculation of social welfare. We employ the utilitarian social welfare criterion, which weights each household's welfare equally. Therefore, the social welfare, SW, under

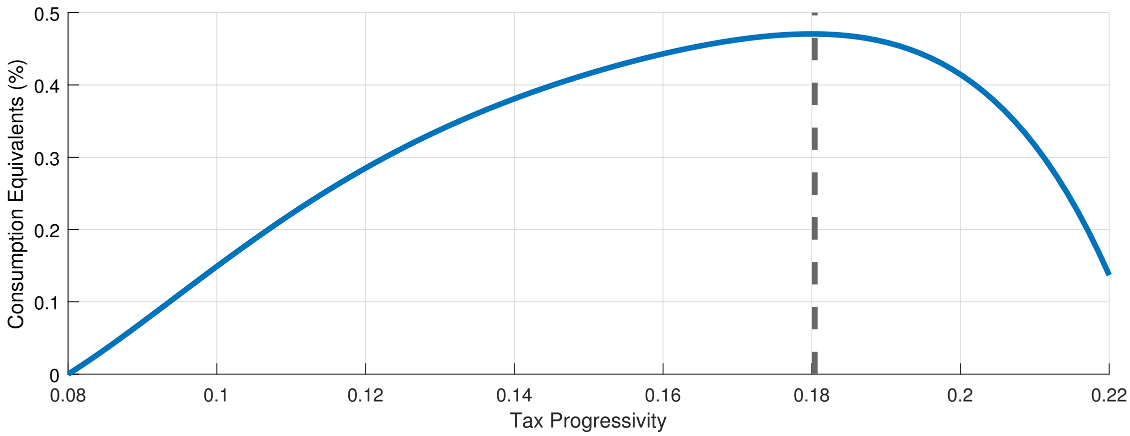


Figure 4: Optimal Tax Progressivity

Note: The social welfare gain in consumption-equivalent terms with levels of tax progressivity.

the new tax progressivity plan, τ^*, is defined as follows:

$$SW \equiv \int V(a,x;\tau^*)\mu_0(a,x),$$

where μ_0 represents the measure at the status quo, and $V(a,x;\tau^*)$ is the value function a household with assets a and productivity x. The value function integrates the utilities from the status quo to the new steady state, defined by:

$$V(a,x;\tau^*) = u(c_0,h_0;\tau_0) + \mathbb{E}_0 \sum_{t=1}^{T} \beta^t u(c_t,h_t;\tau^*),$$

where T is an integer sufficiently large that the economy converges to the new steady state. It is also important to understand the timing assumptions of the tax reform. At $t = 0$, the government implements the tax policy at the current progressivity, τ_0. The reform from τ_0 to τ^* occurs at $t = 1$, and households at $t = 0$ anticipate this reform in their future planning. Hence, the decision rules denoted with subscript zero reflect the decisions that households make in anticipation of the tax reform. The government will continue to apply the tax policy with the progressivity, τ^*, from $t = 1$ onward until the economy reaches the new steady state.[12] During each period of the transition, the level parameter, λ, is set to balance the government's budget.

Figure 4 shows the social welfare across different levels of tax progressivity. We find that the

[12]The quantitative results are minimally affected when considering the value function during the period in which the policy is implemented.

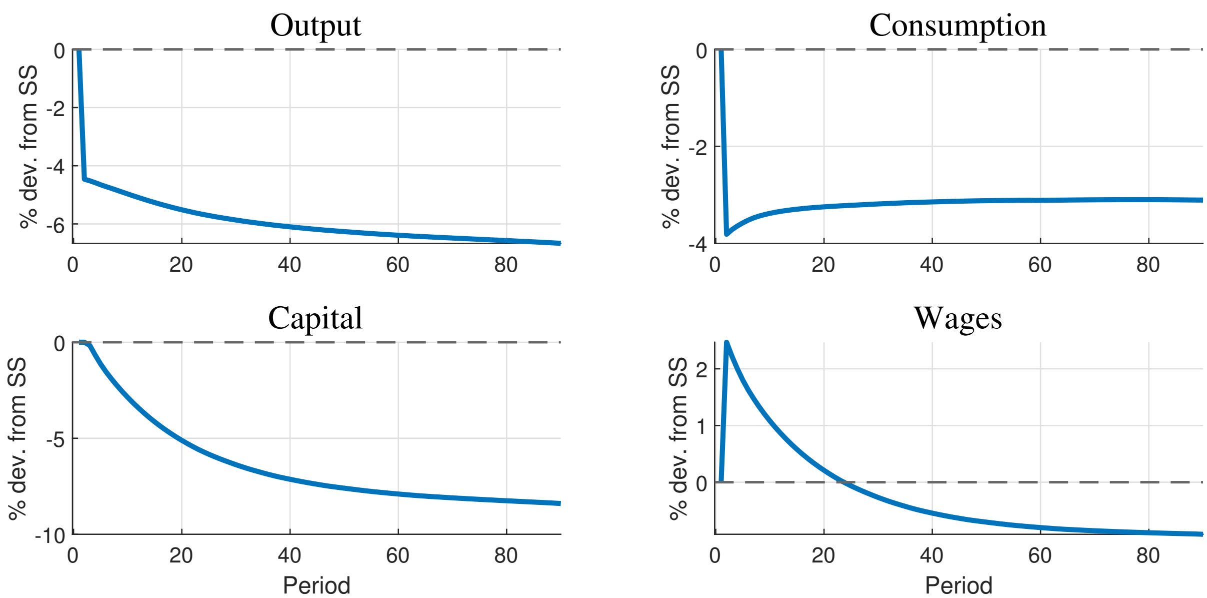


Figure 5: Transition Path: Aggregate Variables

Note: The transition paths of output, consumption, capital, and wages.

optimal tax progressivity is 0.18, much higher than that in the status quo, 0.08. This implies that the optimal tax system in our quantitative model is significantly more redistributive than the current one. Under the optimal tax plan, aggregate welfare gain is 0.4% in consumption equivalent terms. These welfare gains arise because a more progressive tax system provides a safety net against income volatility (better insurance) and reduces income inequality through resource transfers (redistribution). We will discuss this issue in detail in the following subsection.

It is important to examine how key aggregate variables evolve along the transition path, given that the government considers this path from the status quo to the new steady state when formulating the optimal tax policy. Figure 5 illustrates the transition paths of output, consumption, capital, and wages. Notably, despite the optimal tax system being welfare-enhancing, it results in a decline in economic activity. Both output and consumption fall due to higher taxes. As a result, output falls due to the reductions in both capital and effective labor. It is important to note that in the short term, wages increase, because the capital-labor ratio initially rises as capital adjustments lag.[13]

[13]The interest rate decreases as firms operate using a Cobb-Douglas production function.

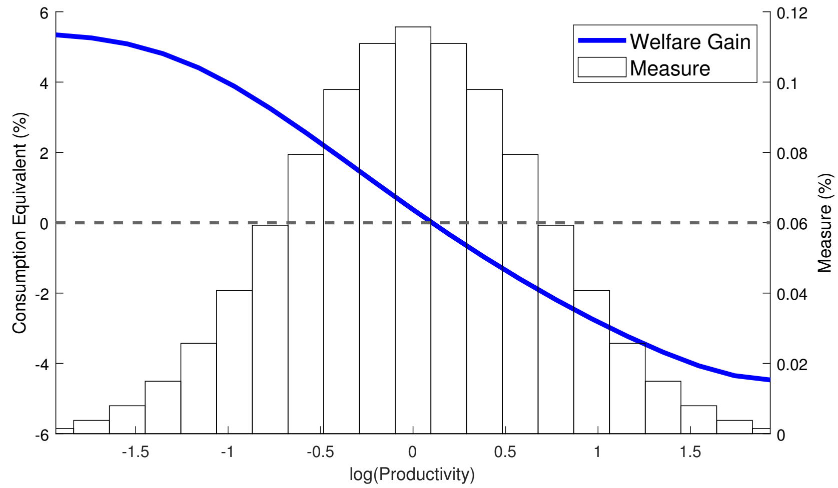


Figure 6: Welfare Gains in Consumption Equivalent Terms

Note: Welfare gains across the households with different levels of productivity. The x-axis is the logged productivity level of the households at the status quo.

4.2 Who are Losers and Winners?

We next discuss the heterogeneous welfare effects of the optimal tax schedule. Figure 6 and Table 3 display the welfare gains across the productivity distribution. The effects of the optimal tax reform on household welfare are significantly heterogeneous. Generally, the optimal policy benefits low-productivity households, whereas high-productivity households experience a welfare loss. Specifically, the average welfare gain for households in the first quintile is about 5%, indicating that these households would be willing to sacrifice as much as 5% of their lifetime consumption for the tax reform. In contrast, the most productive households (in the fifth quintile) would be willing to forgo about 4% of their lifetime consumption to maintain the current tax system. Overall, 63% of households benefit from the reform. This implies that a one-person-one-vote democratic system would likely adopt the policy, given that the median voter stands to benefit from the reform.

The heterogeneous welfare effects of the optimal tax schedule are mainly attributable to the greater disparity in tax rates between high-income and low-income groups. Panel (A) of Table 4 presents the average tax rates by productivity quintiles both in the status quo and under the optimal tax policy. It is clear that the poor benefit from the tax reform as their imposed tax rates significantly decrease. For example, earnings tax rates for households at the bottom of the productivity distribution decrease from 13.55% in the status quo to 3.87% under the optimal tax policy. Households in the second and third quintiles also experience decreases in tax rates. Conversely, due to the increased tax rates,

Table 3: Welfare Distribution across Productivity Quintiles

	Productivity Quintile					All
	1st	2nd	3rd	4th	5th	
Welfare Gains (%)	4.70	2.64	0.08	-2.20	-3.92	0.46

Note: The welfare gains in consumption-equivalent terms across the productivity distribution.

households with high productivity experience welfare losses.[14] For example, the average tax rate for the fifth productivity quintile under the optimal tax plan is 34%, around 7 percentage points higher than that in the status quo.

It is also meaningful to examine how consumption and hours worked are impacted by the tax reform, as these two factors are critical components of household welfare. Not surprisingly, the different tax rates induced by the reform lead to varied effects on households' consumption and labor supply. Panels (B) and (C) of Table 4 display consumption and work hours by productivity quintile. Most households experience a decrease in consumption due to reduced after-tax wages. Interestingly, households with the lowest productivity see an increase in consumption, benefiting from significant tax rate reductions. These varied responses in consumption help explain the heterogeneous welfare effects of the optimal tax schedule discussed earlier.

Understanding the changes in hours worked is particularly crucial, as this directly relates to the "equity-efficiency" trade-off—a fundamental issue in tax policy design. Interestingly, except for those in the first quintile, hours worked decrease across all households, with the extent of the decrease growing with productivity. High-income households reduce their labor supply as a response to increased tax rates. For instance, the average work hours for the most productive households (fifth quintile) decrease by about 6%. This shift can be attributed to the interaction between general equilibrium effects and tax rate changes, particularly how the decrease in wages due to general equilibrium effects further diminishes the incentive to work.[15] This wage reduction, stemming from general equilibrium effects, causes households in the second and third quintiles to reduce their work hours, despite lower tax rates under the optimal tax policy. However, the most significant reductions in tax rates for the least productive households outweigh the impact of decreased wages, leading to an increase in their

[14] Since the current and optimal tax systems are assumed to generate the same tax revenues (or government spending), any decrease in tax rates for the poor necessarily results in increased tax rates for the rich.

[15] The tax reform shifts resources from high-income to low-income groups and leads to a reduction in the capital stock, as low-income groups tend to consume more for the same amount of resources. Since prices are determined by the capital-labor ratio, wages decrease post-reform.

Table 4: The Effects of Optimal Tax Schedule: Benchmark

	Productivity Quintile				
	1st	2nd	3rd	4th	5th
(A) Average Tax Rates					
Calibration (%)	13.55	17.17	19.89	22.55	26.92
Optimal (%)	3.87	11.78	18.37	24.53	33.80
Difference (%p)	-9.68	-5.39	-1.52	1.98	6.88
(B) Consumption					
Calibration	0.25	0.37	0.48	0.62	0.89
Optimal	0.26	0.36	0.46	0.57	0.77
Difference (%)	0.88	-2.43	-5.08	-8.21	-12.90
(C) Hours					
Calibration	0.224	0.232	0.240	0.250	0.268
Optimal	0.225	0.227	0.233	0.240	0.252
Difference (%)	0.60	-1.80	-2.88	-3.92	-5.90
(D) After-tax Earnings Shares					
Calibration (%)	7.81	12.29	19.84	23.04	37.01
Optimal (%)	9.36	13.66	20.80	22.85	33.33
Difference (%p)	1.55	1.37	0.96	-0.20	-3.68

Note: The effects of the optimal tax schedule in the benchmark model. The average tax rates, consumption, hours, and after-tax earnings shares by productivity quintiles both in the status quo and under the optimal tax policy.

average hours worked after the reform.

Finally, the tax reform improves earnings inequality. Panel (D) of Table 4 displays after-tax earnings shares in both the status quo and the new steady state, segmented by productivity quintiles.[16] The after-tax earnings shares of the lower quintiles increase, while those of the higher quintiles decrease. Specifically, the share of the first quintile in the calibration economy rises from 7.8% to 9.4%, while that of the fifth quintile decreases from 37.0% to 33.3%. The reduction in inequality is further highlighted by the significant decrease in the Gini coefficient, which drops from 0.39 in the status quo to 0.33 under the optimal reform. Figure 5 depicts the transition paths of Gini coefficients for before and after-tax earnings, consumption, and wealth. As expected, all inequality measures decline in the long run.[17] Notably, the after-tax earnings Gini drops more significantly compared to the before-tax

[16] In this analysis, we consider after-tax earnings because they are more relevant for household welfare. We also conduct the same analysis for before-tax earnings, finding that inequality improves in this case as well. Refer to Table A.2 in the appendix for more details.

[17] In the short term, the wealth Gini increases due to a decline in the interest rate.

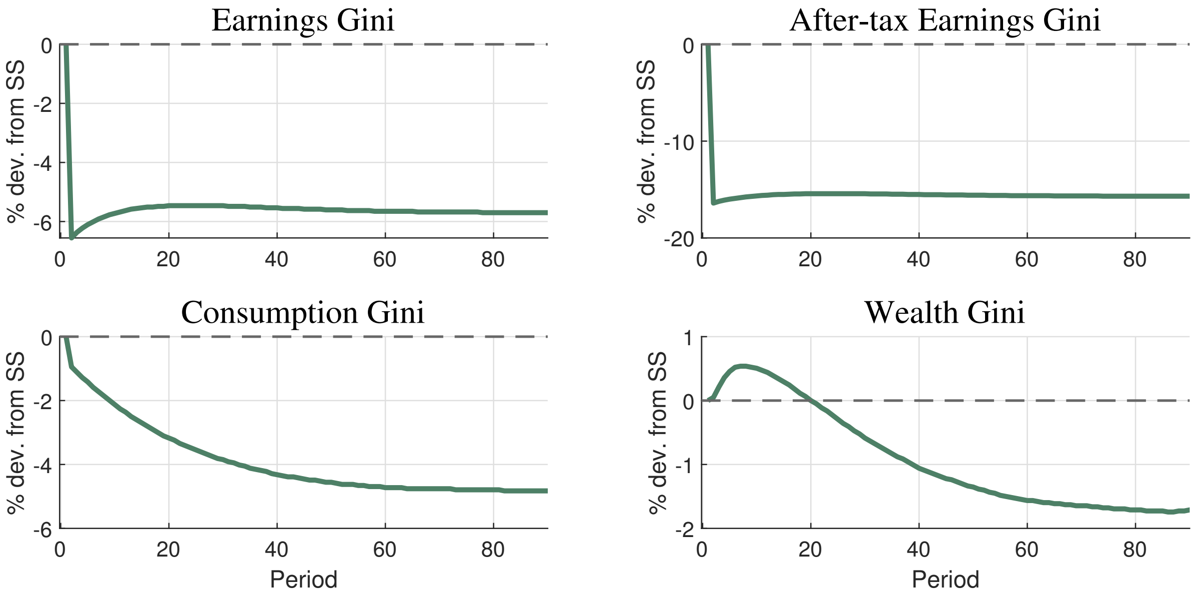


Figure 7: Transition Path: Gini Coefficients
Note: The transition paths of Gini coefficients for before and after-tax earnings, consumption, and wealth.

earnings Gini due to the increased progressivity of the tax system.

4.3 Role of Hours Constraints

Hours constraints are pivotal for achieving significantly greater optimal progressivity than currently observed. This is because a substantial number of constrained households fall towards the higher end of the earnings distribution. Importantly, the labor supply of these households is relatively inelastic to raises in tax rates due to a wage penalty. This subsection investigates how hours constraints critically shape the design of an optimal taxation system and examines their impact on labor supply decisions. It highlights the importance of analyzing how these constraints vary across different productivity levels to effectively design tax policies.

4.3.1 Hours Distribution

Our analysis begins with the impact of tax reform on labor supply, illustrated in Figure 8, which compares the hours distribution in the status quo to that under the optimal policy. We observe a decrease in the proportion of households working between 40 to 60 hours, as higher tax rates diminish their labor supply incentives. Notably, the proportion of households working around 40 hours increases by about 20 percentage points. This is both because those already working 40 hours continue to do

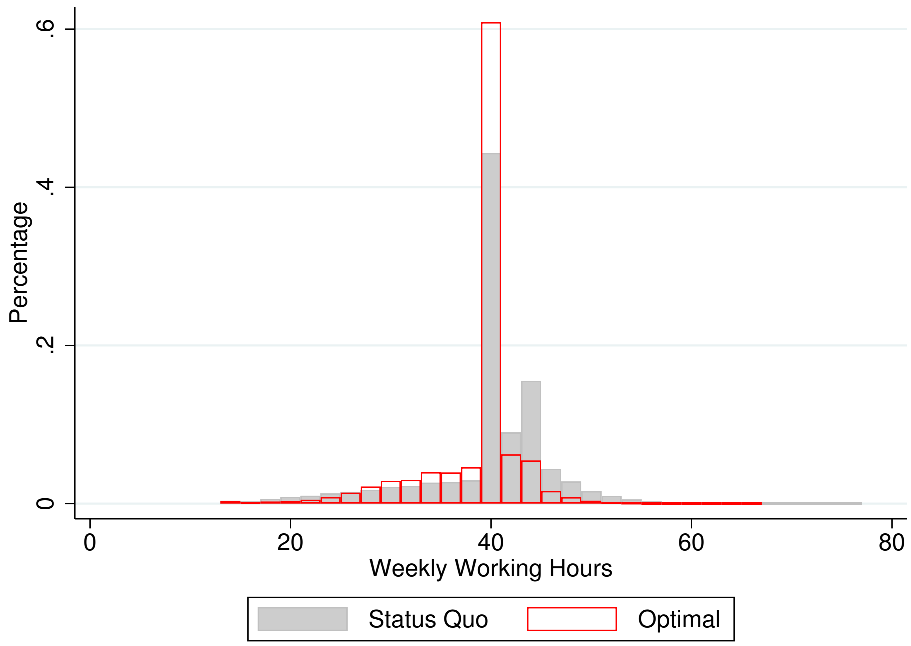


Figure 8: Distribution of Working Hours
Note: The hours worked distribution in the status quo and under the optimal policy.

so and because households previously working overtime reduce their hours in response to the reform. The wage penalty, which enforces the 40-hour work week schedule, is a key factor driving this change. Despite the disincentive created by higher taxes, these households must maintain a 40-hour work week to avoid wage penalties.

An important question is how hours constraints affect households differently. As demonstrated earlier, optimal tax progressivity is higher in the benchmark economy, since households incur a wage penalty, leading to a concentrated distribution of work hours around 40 per week. We argue that the labor supply limitations imposed by hours constraints on high-income households are the primary drivers of this increased optimal tax progressivity. For illustrative purposes, Figure 9 compares the hours distribution for the second and fourth quintiles both in the status quo and under the optimal policy. We choose these two quintiles because the proportion of households working 40 hours is similar to that in the status quo.[18]

The right panel of Figure 9 shows the hours distribution for households in the fourth quintile. Initially, about 60% work between 40 and 44 hours, and roughly 30% work over 44 hours. After the reform, almost no households work more than 48 hours due to higher tax rates and reduced wages.

[18] For the full distribution across all quintiles, see Figure A.1 in the appendix.

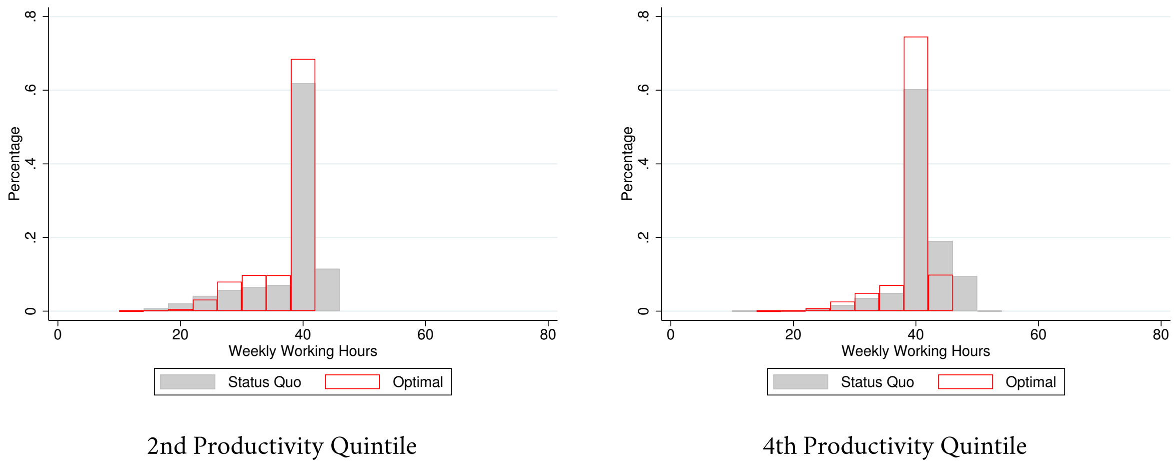


Figure 9: Distribution of Hours

Note: The distribution of hours worked by households in the second and fourth productivity quintiles, comparing the status quo with the scenario under the optimal policy

The proportion of households working exactly 40 hours increases by 16 percentage points, and those working less than 40 hours increase. As shown in the left panel of Figure 9, the pattern is different for households in the second quintile, where around 60% already work between 40 and 44 hours; the fraction rises by only 6 percentage points post-reform.

Higher concentrations of productive households working around 40 hours after the reform suggest their inability to adjust work hours. In the absence of a wage penalty, households could reduce their labor supply below 40 hours without incurring any costs. However, with hours constraints in effect, they are unable to decrease their hours as they might in an economy free from these penalties, because their hourly wages drop if they work less than 40 hours. The opportunity costs for more productive households are significant, as they must forfeit a substantial portion of their wages. As a result, the wage penalty compels households to maintain a 40-hour work week.

4.3.2 Counterfactual Analysis: What if $\phi = 0$?

Another way to examine the role of hours constraints is by considering an economy without a wage penalty. For this purpose, we recalibrate the model to eliminate the wage penalty ($\phi = 0$), targeting the same moments as the benchmark model except for the faction of households working 40 hours. This counterfactual model is referred to as the No-Hours-Constraint (NHC) economy. Table 5 displays the average tax rates, consumption, hours, and after-tax earnings shares by productivity quintiles both in the status quo and under the optimal tax policy in the NHC economy, corresponding to Table 4. The

Table 5: The Effects of Optimal Tax Schedule ($\phi = 0$)

	Productivity Quintile				
	1st	2nd	3rd	4th	5th
(A) Average Tax Rates					
Calibration (%)	13.09	16.63	19.44	22.27	26.91
Optimal (%)	9.01	14.46	18.73	22.93	29.64
Difference (%p)	-4.08	-2.17	-0.71	0.67	2.73
(B) Consumption					
Calibration	0.26	0.39	0.50	0.64	0.94
Optimal	0.26	0.38	0.48	0.62	0.88
Difference (%)	-0.02	-1.73	-2.47	-3.79	-5.66
(C) Hours					
Calibration	0.219	0.223	0.236	0.254	0.286
Optimal	0.216	0.220	0.232	0.248	0.277
Difference (%)	-1.48	-1.47	-1.75	-2.23	-2.94
(D) After-tax Earnings Shares					
Calibration (%)	7.82	11.88	19.26	22.84	38.20
Optimal (%)	8.32	12.39	19.69	22.83	36.77
Difference (%p)	0.50	0.51	0.43	-0.01	-1.43

Note: The effects of the optimal tax schedule in the NHC economy. The average tax rates, consumption, hours, and after-tax earnings shares by productivity quintiles both in the status quo and under the optimal tax policy.

NHC economy is comparable to the benchmark model in terms of heterogeneity across households, both quantitatively and qualitatively. In particular, the distributions of average tax rates and after-tax earnings before the tax reform are quite similar across the two economies.

In the NHC economy, we find that the optimal tax progressivity is 0.1, much lower than that in the benchmark model. Without a wage penalty, the government cannot impose higher tax rates on productive households, as they would significantly reduce their labor supply without incurring costs. Consequently, post-reform changes in tax rates are minimal in the NHC economy. Specifically, the average tax rate for the first productivity quintile drops by 4.1 percent points, a much smaller reduction compared to a 10 percentage point decrease in the benchmark economy. Similarly, top-quintile households face a less substantial increase in tax rates, with the average tax rate for households in the fifth quintile rising by 2.7 percent points, as opposed to 6.9 percent points in the benchmark.

We find that welfare gains are significantly smaller in the NHC economy compared to the benchmark, with an average gain of 0.07% in consumption equivalent terms. Although the distributional welfare effects mirror those in the benchmark—where low-income households benefit from the reform and high-income households incur losses—, the proportion of households benefiting in the NHC economy is 41% lower than in the benchmark model. The smaller welfare gains in the NHC economy stem primarily from i) decreased consumption for the lowest productivity households, whereas it increases in the benchmark model; and ii) smaller reductions in consumption for productive households than in the benchmark model.

What notably differentiates the NHC economy from the benchmark is the response of work hours among households. In the benchmark model, there is substantial heterogeneity in hours changes, as hours constraints significantly impact labor supply decisions, varying by productivity levels. However, in the absence of such constraints, the response of work hours differs little across the productivity distribution. This further underscores the significant role of hours constraints in shaping optimal tax policy. Lastly, while the tax reform in the NHC economy does improve after-tax earnings inequality, the improvement is less pronounced compared to the benchmark economy, as expected.

4.3.3 Interpretation through Lens of Labor Supply Elasticity

The relationship between labor supply elasticity and optimal tax reforms is crucial for understanding how tax policies affect economic behavior, especially in terms of how individuals adjust their work hours in response to tax changes. In principle, a highly elastic labor supply means that increases in tax rates can significantly deter work, as individuals might substantially reduce their labor supply in reaction to lower after-tax wages.

In this context, it is essential to analyze hours constraints through the lens of labor supply elasticity for designing tax systems that achieve both equity and efficiency. We argue that the inability of households working 40 hours or more to adjust their labor supply leads to higher optimal tax progressivity, consistent with Chetty et al. (2011). As noted, wage penalties create hours constraints that restrict the flexibility of productive households to alter their labor supply. This suggests a low elasticity in this group. The reduced elasticity among highly productive households alleviates concerns over economic inefficiency and enables the government to increase tax progressivity. This allows for a greater redistribution of resources to lower-income groups, thus improving overall social welfare.

Building on this discussion, we calculate the labor supply elasticities to substantiate our argument. We determine the implied compensated labor supply elasticity by taking into account the endogenous

Table 6: Implied Labor Supply Elasticity across Productivity Quintiles

	Productivity Quintile					All
	1st	2nd	3rd	4th	5th	
Benchmark	0.75	0.54	0.48	0.47	0.53	0.60
NHC Economy	0.97	1.00	1.00	1.00	1.00	0.99

Note: Implied labor supply elasticity across productivity quintiles in the benchmark and NHC models.

decisions of households regarding hours and consumption during the transition path. We define the implied elasticity, $\widetilde{\gamma}$, as follows:

$$\widetilde{\gamma} = \frac{\hat{h}}{\hat{w}_d - \hat{c}},$$

where $\hat{z} = \frac{z_T - z_0}{z_0}$ with $z = \{h, w_d, c\}$. After-tax wages, w_d, are defined as follows:

$$w_d = \begin{cases} \lambda(1-\tau)\left(\frac{wxh}{\bar{y}}\right)^{-\tau}\frac{wx}{\bar{y}} & h \geq \bar{h} \\ \lambda(1-\tau)\left(\frac{wxP(h)}{\bar{y}}\right)^{-\tau}\frac{wx(1+\phi)}{\bar{y}} & h < \bar{h}. \end{cases}$$

Note that the implied elasticity $\widetilde{\gamma}$ varies depending on whether the 40-hour work week constraints are (potentially) binding. Furthermore, in the presence of the wage penalty, $\widetilde{\gamma}$ differs from the curvature parameter γ, due to households binding to 40 hours. Table 6 presents the implied labor supply elasticities by productivity quintiles. The average elasticity is 0.60, but there is notable heterogeneity across households. Specifically, households in the middle of the productivity distribution—particularly the third and fourth quintiles—exhibit the lowest elasticities, around 0.5. This is largely due to the high number of constrained households in these groups. Many households are working exactly 40 hours and are less responsive to shocks as they adhere to this work week due to wage penalties for working fewer than 40 hours (see Figure A.1 in Appendix). Low elasticity is also observed in the fifth quintile but is slightly higher than in the third and fourth quintiles due to a substantial number of households working overtime. Conversely, households with lower productivity typically provide less than 40 hours of labor on average in the status quo, as already illustrated in Panel (C) of Table 4; their labor supply is less restricted by optimal tax reforms. This is because their opportunity cost of reducing hours is relatively small.

Unsurprisingly, the labor supply elasticities for all households in the NHC economy are approximately 1, the same as the curvature parameter value.[19] This suggests that the hours constraints induced by the wage penalty are the primary sources of the heterogeneous elasticity observed in the benchmark model. Notably, the uniform and higher elasticity in the NHC economy explains the different level of optimal progressivity compared to the benchmark model. The increased elasticity among productive households in the NHC economy raises concerns over efficiency loss when establishing optimal taxation, entailing a lower optimal tax progressivity in the NHC economy than in the benchmark model, as previously noted.

5 Discussions

5.1 Role of Heterogeneous Labor Supply Elasticity

A potential challenge in comparing results between the benchmark model and the NHC economy arises due to their differing average micro elasticities: the micro elasticity for the former is 0.6, while for the latter, it is approximately one. Consequently, it is informative to consider an economy that has the same micro elasticity as the benchmark model to better understand the role of heterogeneous elasticity of labor supply. Therefore, we consider another counterfactual economy where γ =0.6 but $\phi = 0$. We refer to the economy with Small elasticity and No-Hours-Constraint (SNHC). It is important to note that while the benchmark and this counterfactual economy share the same level of micro elasticity, the main difference lies in the elasticity distribution. In the benchmark model, elasticity varies depending on productivity—it is higher for more productive households. In contrast, the counterfactual economy exhibits homogeneous elasticity.

Table 7 illustrates the welfare gains, changes in consumption, and variations in work hours across productivity quintiles, all expressed as percentage changes from the status quo. This table offers several interesting points for discussion when compared with the benchmark economy. Firstly, the aggregate welfare gain in the SNHC economy is larger, with a 0.54% increase in consumption equivalent terms, compared to 0.46% in the benchmark model, primarily because households can now adjust their labor supply without penalties. Secondly, the welfare effects of eliminating hours constraints are more uneven in the SNHC economy compared to the benchmark case. For instance, households

[19] The elasticity of households at the bottom of the productivity distribution is slightly less than 1, as some of them are bound by borrowing constraints.

Table 7: The Effects of Optimal Tax Schedule ($\phi = 0$, γ =0.6)

	Productivity Quintile					All
	1st	2nd	3rd	4th	5th	
Welfare Gains (%)	3.99	2.20	0.24	-1.49	-2.88	0.54
Consumption (%)	0.03	-2.37	-4.01	-6.03	-9.45	-4.37
Hours (%)	-0.35	-2.12	-2.76	-3.37	-4.21	-2.42

Note: The effects of the optimal tax schedule in the economy where $\phi = 0$ and $\gamma = 0.6$. The welfare gains, changes in consumption, and variations in work hours. All figures are presented as percentage changes from the status quo.

at the bottom of the productivity distribution experience a 3.99% welfare gain in the SNHC economy, compared to 4.37% in the benchmark economy. In contrast, the top quintile sees a welfare loss of 2.88% in the SNHC economy, which is smaller than the 3.92% loss in the benchmark model. This suggests that many productive households are constrained by hours restrictions in the benchmark model. Thirdly, the smaller tax progressivity in the SNHC economy leads to a larger negative impact on consumption for poorer households but a smaller negative impact on consumption for the rich. Relatedly, the first quintile shows a negative response in work hours in the SNHC economy, but a positive response in the benchmark model. This indicates that for the least productive households, the impact of decreased wages outweighs the reductions in tax rates in the SNHC economy.

We can also interpret the results in terms of labor supply elasticity. Compared to the benchmark model, productive households in the SNHC economy exhibit higher elasticity, resulting in a lower welfare loss under the optimal tax reform. We next decompose the level and heterogeneity effects of labor supply elasticity induced by hours constraints. In the comparison between the NHC and SNHC economies, the primary difference stems from different levels of elasticity: the elasticity is 1 for the former and 0.6 for the latter. When contrasting the SNHC with the benchmark model, the discrepancy arises from heterogeneous elasticity. Quantitatively, the total effect is 0.08, comparing 0.18 in the benchmark model to 0.10 in the NHC economy. The level effect on optimal progressivity is 0.06 ($= 0.16 - 0.10$), and the heterogeneity effect is 0.02 ($= 0.18 - 0.16$).

5.2 Rationalizing the Current Tax System

We have shown that the optimal tax progressivity is significantly higher than the current level. The important question here is as to what justifies the current tax system. We address this by computing the so-called Pareto weights, which are the weights in the social welfare function that would justify

Table 8: Pareto Weights

Consumption quintile					Implied ξ
1st	2nd	3rd	4th	5th	
0.37	0.64	0.89	1.19	1.90	0.97

Note: Average Pareto weights by consumption quintile.

the current tax progressivity. Following Chang, Chang and Kim (2018), we assume that the Pareto weight $\omega(a, x; \tau_0)$ exhibits the following parametric form for any given τ:

$$\omega(a, x; \tau_0) \equiv \frac{c_0(a, x)^{\xi} \mu_0(a, x)}{\int c_0(a, x)^{\xi} d\mu_0(a, x)}.$$

When ξ is positive (negative), it can be interpreted as a political system where larger weights are assigned to the rich (the poor).[20] The value of ξ that rationalizes the current tax progressivity, τ_0, as the social optimum can be determined by solving the following problem:

$$\tau_0 = \arg\max_{\tau} \int V(a, x; \tau) d\omega(a, x; \tau_0).$$

Table 8 shows the Pareto weights for five consumption quintile groups. We find that with $\xi = 0.97$, the current U.S. tax progressivity of $\tau_0 = 0.08$ can be justified as socially optimal. This implies that the Pareto weight increases with level of consumption, with larger weights to the rich. Specifically, the average Pareto weight is 0.37 for the 1st quintile and 1.9 for the 5th quintile, indicating that in the current tax system, the weight on the richest is approximately twice the average.

5.3 Sensitivity Analysis

5.3.1 Borrowing

The demand for social insurance varies with the extent to which the financial market can provide private insurance against future uncertainty. In our benchmark model, households are not allowed to borrow at all ($\underline{a} = 0$), which is a restrictive assumption. However, in reality, most households have some access to financial markets or can borrow from family and friends. To determine whether our results are sensitive to the borrowing limit, we relax this constraint in our benchmark calibration,

[20]The case with $\xi = 0$ corresponds to the equal-weight utilitarian, while the case here $\xi \to \infty$ implies the Rawlsian tax system.

which is based on the U.S. economy.

Following Kaplan, Moll and Violante (2018), we set the exogenous borrowing constraint to one-fourth of the average annual earnings in the model ($\underline{a} = -0.1$). This adjustment results in 15 percent of households being in debt when borrowing is allowed, with the wealth Gini increasing to 0.63 from 0.60 in the benchmark model without borrowing. This increase indicates greater wealth inequality when borrowing is permitted. This reduces demand for social insurance, as households can use borrowing as a form of private insurance to buffer against adverse shocks.

As a result, the optimal progressivity of the tax system is affected. Specifically, we find that the optimal progressivity is 0.163, which is smaller than the 0.18 observed in the benchmark model without borrowing. This reduction highlights how the availability of borrowing options can lessen the need for highly progressive taxation by providing households with an alternative means of managing financial risks and uncertainties. Thus, the ability to borrow plays a crucial role in shaping the optimal design of progressive tax structures

5.3.2 Transfers

In the benchmark economy, we do not consider any public transfers to households. However, in practice, households, particularly the poor, receive government transfers that significantly affect their labor supply decisions. Therefore, we now introduce a transfer system into the benchmark economy to explore its impact on optimal tax structures. In this analysis, although we introduce a transfer system in the steady state, we only design an optimal tax system without reforming the existing transfer system. This allows us to evaluate how accounting for the transfer structure affects optimal progressive tax policy.[21] Following Yum (2018) and Jang, Sunakawa and Yum (2023), we assume that households receive transfers, TR, according to their earnings, y:

$$TR(y) = \kappa(1 + y/\bar{y})^{-\eta},$$

where κ governs the level of transfers, and η determines the degree of progressivity of the transfer

[21] Refer to previous literature that investigates optimal tax-transfer systems in the context of incomplete asset markets models, such as Boar and Midrigan (2022), Ferriere et al. (2023), and Guner, Kaygusuz and Ventura (2023). For example, Ferriere et al. (2023) study the optimal joint design of targeted transfers and progressive income taxes and find that transfers should be larger than they currently are and should be financed with moderate income tax progressivity.

Table 9: Transfer Rates (%) by Earnings Quintile

	Earnings Quintile					All
	1st	2nd	3rd	4th	5th	
Data	21.52	5.74	2.78	1.96	1.01	6.60
Model with Transfer	21.19	6.11	2.79	1.23	0.29	6.32

Note: Transfer rates (transfer/earnings) by earnings quintile. Statistics for earnings and transfer rates are from the CPS 2019.

system. We choose κ and η to replicate the measured transfer system observed in the U.S.[22] Table 9 compares the transfer rates across income quintiles from the data with those generated by the model. The transfer system we consider closely matches the observed distribution of transfer rates. Specifically, the model reasonably replicates the transfer rate of approximately 22 percent for the first quintile and approximately 1 percent for the richest households.

Our findings indicate that our main result remains robust even when incorporating a progressive transfer system. The optimal level of progressivity is 0.152, significantly higher than the current level, although slightly lower than in the benchmark case without a transfer system. The results are intuitive: in the presence of a progressive transfer system, the poor receive relatively more public insurance, leading the government to apply a lower level of tax progressivity than in the benchmark case. In other words, less insurance is necessary for poor households in an economy with progressive transfers. Consequently, tax rates under the optimal tax reform for households in the lower quintiles do not decrease as much as they do in the model without a transfer system (see Table A.4 in the Appendix).[23]

5.3.3 Income Risk

The size of income risk may play a critical role in determining the optimal fiscal plan. To investigate this, we alter the degree of income risk among households. Specifically, we decrease σ_x, the standard deviation of idiosyncratic productivity shocks, by 10 percent in the benchmark calibration. As the size of uninsurable idiosyncratic productivity shocks decreases, households find it easier to smooth their consumption. Consequently, with a decrease in the degree of heterogeneity, the need for public bonds for poorer households is reduced. In the model with smaller heterogeneity, the earnings Gini is 0.37, compared to 0.40 in the benchmark model.

[22] Specifically, we choose η to match the transfer-to-income ratio for the poorest, while κ is selected to match the average ratio. See Table A.1 in Appendix for calibration.

[23] For detailed information about how hours, consumption, and after-tax earnings shares are affected by the optimal reform in the model with transfers, see Table A.4 in the Appendix.

This reduction in heterogeneity leads to a shift in the optimal tax structure. The optimal level of progressivity in this scenario is 0.143, still significantly higher than current levels, though lower than in the benchmark case without any transfer system. With smaller heterogeneity, the precautionary saving motives among poorer households diminish, prompting the government to apply a lower level of tax progressivity than in the benchmark case. Accordingly, less insurance is necessary for poor households when heterogeneity is reduced.

As a result, tax rates under the optimal tax reform for households in the lower quintiles do not decrease as much as they do in the model without a transfer system. This highlights that, despite a lower degree of heterogeneity reducing the need for precautionary savings, a significant level of progressivity is still required to provide adequate support for households with limited means to insure against economic risks. This nuanced understanding of how heterogeneity influences tax policy underscores the importance of tailoring tax structures to the specific economic contexts faced by households.

6 Conclusion

This paper examines the influence of hours constraints on households' labor supply decisions and its implications for designing optimal progressive tax structures. We present a heterogeneous-agent model featuring a nonlinear progressive tax system and a wage penalty for households working fewer than 40 hours per week, creating a realistic concentration of work hours around 40 hours.

We find that optimal tax progressivity should be set higher than the current level. The impact of tax reform on household welfare varies significantly; typically, low-productivity households benefit, whereas high-productivity households experience welfare losses due to their inability to adjust work hours flexibly. Hours constraints are a crucial consideration for achieving much higher optimal progressivity than is currently observed. Many constrained households are in the upper earnings bracket, and their labor supply demonstrates relative inelasticity to increases in tax rates due to the wage penalty. Our analysis, conducted through the lens of labor supply elasticity—a critical factor in tax system design—reveals substantial heterogeneity. Specifically, households with higher productivity exhibit a lower elasticity than others.

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Appendix

A Computational Procedures

A.1 Steady-state Equilibrium

In the steady-state, the measure of households, $\mu(a,x)$, and the factor prices are time-invariant. We find a time-invariant distribution μ using the algorithm by Rios-Rull (1997). We compute the households' value functions and the decisions rules, and the time-invariant measure of the households. We take the following steps:

1. We choose the number of grid for the risk-free asset, a, and the idiosyncratic labor productivity, x. We set $N_a = 151$ and $N_x = 21$ where N denotes the number of grid for each variable. The range of asset is $[0, 300]$. To better incorporate the saving decisions of households near the borrowing constraint, we assign more points to the lower range of the asset. Hence, the grid of the asset is not equally spaced.

2. We choose the values for $\beta, \chi, \sigma_x, \phi, \tau$, and λ. Productivity x is equally distributed on the range $[-3\sigma_x/\sqrt{1-\rho_x^2}]$. As shown in the paper, we construct the transition probability matrix $\pi(x'|x)$ of the idiosyncratic labor productivity as suggested in Tauchen (1986).

3. Given the values of parameters, we find the value functions for each state (a,x). We also obtain the decision rules: savings $a'(a,x)$ and hours worked $h(a,x)$. The computation steps are as follow:

   (a) Value functions $V_0(a_i, x_j)$ are initialized for all $i = 1, 2, \cdots, N_a$ and $j = 1, 2, \cdots, N_x$.

   (b) We obtain the new value functions $V_1(a_i, x_j)$ for all $i = 1, 2, \cdots, N_a$ and $j = 1, 2, \cdots, N_x$ as follows:

$$V_1(a_i, x_j) = \max\Big\{u\Big(c(a_i, x_j), h(a_i, x_j)\Big) + \beta\sum_{j'=1}^{N_x} V_0(a', x_{j'})\pi(x_{j'}|x_j)\Big\}.$$

(c) If the absolute difference between V_0 and V_1 is small enough for all grid points, we then obtain the converged value functions. Otherwise, let $V_0 = V_1$ and go back to (b).

4. After obtaining the value functions and the decision rules, we compute the time-invariant distribution $\mu(a_i, x_j)$ as follows:

   (a) Measures for each state $\mu_0(a_i, x_j)$ are initialized.

   (b) We update the measure by following a law of motion:

$$\mu_1(a_{i'}, x_{j'}) = \sum_{i=1}^{N_a} \sum_{j=1}^{N_x} \mathbf{1}_{a_{i'}=a'(a_i,x_j)} \mu_0(a_i, x_j) \pi_x(x_{j'}|x_j).$$

   (c) If the absolute difference between μ_0 and μ_1 is small enough for all grid points, we then obtain the time-invariant distribution. Otherwise, let $\mu_0 = \mu_1$ and go back to (b).

5. We now can obtain the annual interest rate, average hours worked, the government spending, and other variables with households' decision rules and the measure of each state. If the variables of interest are close to the targeted values, we have found the steady-state. If not, we choose the new parameters and redo the above steps.

A.2 Optimal Tax Reform

The government incorporates the transition path from the status quo to the new steady state when it determines the optimal tax progressivity. We describe the steps below.

1. We obtain the initial steady state under the current tax progressivity, τ_0.

2. We choose the new tax progressivity, τ^{new}.

   (a) We obtain the new steady state under the new tax progressivity, τ^{new}.

   (b) We assume that the economy arrives at the new steady state at time T. We set the T to 100. The unit of time is a year.

   (c) We initialize the capital-labor ratio $\{K_t/E_t\}_{t=2}^{T-1}$ and obtain the associated factor prices $\{r_t, w_t\}_{t=2}^{T-1}$.

(d) We also initialize the tax parameter $\{\lambda_t\}_{t=2}^{T-1}$.

(e) As we know the value functions at time T (we compute them in step (a)), we can obtain the value functions and the decision rules in the transition path from $t = T-1$ to 1.

(f) We compute the measures $\{\mu_t\}_{t=2}^{T}$ with the measures at the initial steady state and the decision rules in the transition path.

(g) We obtain the aggregate variables in the transition path with the decision rules and the distribution measures. If the tax revenue is close to the assumed one in each transition period, we obtain the converged λ_t. Otherwise, we assume the new $\{\lambda_t\}_{t=2}^{T-1}$ and go back to (d).

(h) We compare the assumed paths of capital and the effective labor with the updated ones. If the absolute difference between them in each period is close enough, we obtain the converged transition path. Otherwise, we assume new capital-labor ratio and go back to (c).

3. We choose the tax progressivity that achieves the highest social welfare. As noted in the paper, we assume a utilitarian government.

B Welfare Gain in Consumption Equivalent Terms

The government achieves higher social welfare after the reform. We now investigate the distributional welfare effects of this reform across the households. We compute the welfare gain of each state variable in consumption equivalent terms. Consumption equivalent is the additional consumption given to the household in the status quo, and it makes household indifferent between the status quo and the sum of discounted utilities in the transition path. We compute the consumption equivalent of state (a, x) as follows. First, we define the value function in the status quo $V_0(a, x)$ as

$$V_0(a, x) = \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \left\{ \log(c_t^0(a, x)) - \chi \frac{h_t^0(a, x)^{1+1/\gamma}}{1 + 1/\gamma} \right\},$$

where $c_t^0(a, x)$ and $h_t^0(a, x)$ are the decision rules of the households with state (a, x) at time t. We then define the value function $V^*(a, x)$ which is the sum of the discounted utilities in the transition path of household whose state in the status quo is (a, x) as

$$V^*(a,x) = \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \Big\{ \log\Big(c_t^*(a,x)\Big) - \chi \frac{h_t^*(a,x)^{1+1/\gamma}}{1+1/\gamma} \Big\},$$

where $c_t^*(a,x)$ and $h_t^*(a,x)$ are the decision rules of the households at period t in the transition path with the initial state (a,x) . Finally, we compute the consumption equivalent $\omega(a,x)$ that satisfies the below equation:

$$\sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \Big\{ \log\Big(c_t^0(a,x)(1+\omega(a,x))\Big) - \chi \frac{h_t^0(a,x)^{1+1/\gamma}}{1+1/\gamma} \Big\} = \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \Big\{ \log\Big(c_t^*(a,x)\Big) - \chi \frac{h_t^*(a,x)^{1+1/\gamma}}{1+1/\gamma} \Big\},$$

The LHS of the equation is the sum of the discounted utilities in the status quo where the additional consumption is added. The RHS of the equation is $V^*(a,x)$. Finally, we obtain $\omega(a,x)$ as

$$\omega(a,x) = \exp\Big((1-\beta)\Big(V^*(a,x) - V_0(a,x)\Big)\Big) - 1.$$

C CPS Data

We use the Annual Social and Economics Supplement (ASEC) of the CPS for 2019 for labor income, labor income taxes, and hours worked. The ASEC collects the economic characteristics of 65,000 households every March. We use the data provided by the Integrated Public Use Microdata Series (IPUMS).

We first construct labor income and labor income taxes at the individual level as follows. Labor income includes wage and salary income (INCWAGE), unemployment benefits (INCUNEMP), and worker's compensation (INCWKCOM). We exclude business income as we only consider employees in the paper. Labor income taxes include federal and state income tax before credits (FEDTAX and STATETAX), total Social Security retirement payroll deductions (FICA), and federal retirement payroll deductions (FEDRETIR). Note that federal income tax before credits includes child tax credit (CTCCRD), which is a nonrefundable credit. We then select individuals who were employed in the previous year and aggregate earnings and taxes at the household level. Finally, we restrict the sample to households where (1) age of the head is between 25 and 60, (2) household total labor income is higher than $5,000, (3) household total before-credit labor income taxes are smaller than household

Table A.1: Parameters for Other Models

	β	χ	λ	σ_x	κ	η
Benchmark Model	0.9535	13.4	0.363	0.201	n.a.	n.a.
$\phi = 0, \gamma = 1$	0.9524	11.15	0.378	0.201	n.a.	n.a.
$\phi = 0, \gamma = 0.6$	0.9536	28.7	0.3715	0.2028	n.a.	n.a.
Model with Transfer	0.9545	11.92	0.349	0.191	0.0395	2.3

total labor income, (4) household total annual working hours are between 260 and 4160, and (5) the number of employed household members is less than three. We use UHRSWORKLY for the hours worked. This variable contains the working hours per week in the previous year. We compute hours worked at the individual level using the same household sample mentioned above.

D Recalibration Strategy for the Counterfactual Models

In the paper, we recalibrate the model to investigate the role of the wage penalty and the heterogeneity of the labor supply elasticity in optimal tax progressivity. We introduce the recalibration strategy in this section. The parameters used for the recalibration are β, χ λ, and σ_z. We set the status quo tax progressivity to 0.08 for all counterfactual models, the same value as in the benchmark model. We match the following moments in the status quo: (1) the Gini coefficient of before-tax earnings, (2) average working hours, (3) average tax rates by before-tax earning quintile, (4) annual interest rate, and (5) the ratio of government spending and the output. Table A.1 shows the values of the parameters for the benchmark and the counterfactual models.

E Other Tables and Figures

Table A.2: Earning Shares

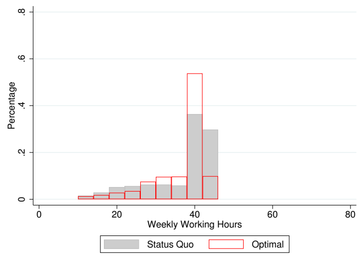
	Quintile					Gini
	1st	2nd	3rd	4th	5th	
Calibration (%)	7.00	11.50	19.19	23.06	39.25	0.42
Optimal (%)	7.41	11.79	19.40	23.05	38.34	0.40

Note: Earning shares under the benchmark calibration and under the optimal plan.

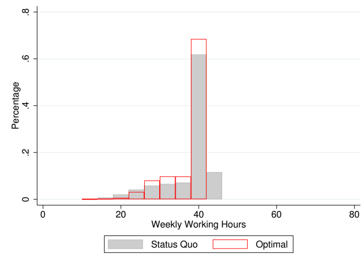
Table A.3: The Effects of Optimal Tax Schedule ($\phi = 0$, $\gamma =$0.6)

	Quintile				
	1st	2nd	3rd	4th	5th
(A) Average Tax Rates					
Calibration (%)	13.41	17.08	19.83	22.54	26.94
Optimal (%)	5.53	12.83	18.44	23.80	32.03
Difference (%p)	-7.87	-4.25	-1.39	1.25	5.09
(B) Consumption					
Calibration	0.26	0.38	0.49	0.63	0.91
Optimal	0.26	0.38	0.47	0.59	0.83
Difference (%)	0.03	-2.37	-4.01	-6.03	-9.45
(C) Hours					
Calibration	0.22	0.23	0.24	0.25	0.27
Optimal	0.22	0.22	0.23	0.24	0.26
Difference (%)	-0.35	-2.12	-2.76	-3.37	-4.21
(D) After-tax Earnings Shares					
Calibration (%)	7.99	12.27	19.69	22.93	37.12
Optimal (%)	9.04	13.21	20.38	22.81	34.56
Difference (%p)	1.06	0.94	0.69	-0.13	-2.56

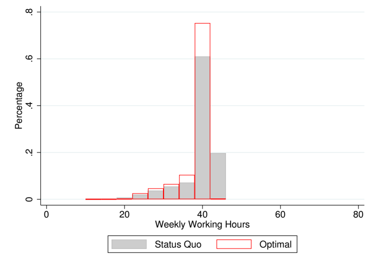
Note: The effects of the optimal tax schedule in the NHC economy with $\gamma = 0.6$. The average tax rates, consumption, hours, and after-tax earnings shares by productivity quintiles both in the status quo and under the optimal tax policy.



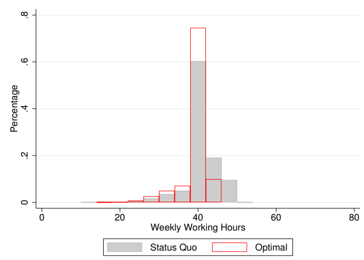
(A) Productivity Q1



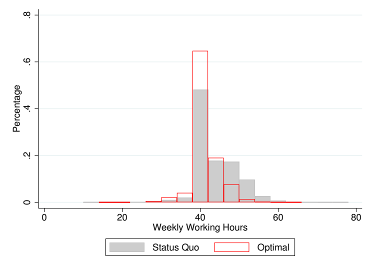
(B) Productivity Q2



(C) Productivity Q3



(D) Productivity Q4



(E) Productivity Q5

Figure A.1: Distribution of Working Hours

Table A.4: The Effects of Optimal Tax Schedule: Model with Transfer

	Productivity Quintile				
	1st	2nd	3rd	4th	5th
(A) Average Tax Rates					
Calibration (%)	16.53	20.09	22.72	25.26	29.37
Optimal (%)	12.64	18.18	22.17	25.94	31.85
Difference (%p)	-3.89	-1.91	-0.55	0.68	2.49
(B) Consumption					
Calibration	0.270	0.381	0.479	0.600	0.835
Optimal	0.270	0.377	0.473	0.588	0.809
Difference (%)	0.01	-0.95	-1.38	-2.03	-3.08
(C) Hours					
Calibration	0.212	0.230	0.243	0.256	0.279
Optimal	0.211	0.228	0.240	0.252	0.272
Difference (%)	-0.28	-0.87	-1.25	-1.74	-2.52
(D) After-tax Earnings Shares					
Calibration (%)	8.92	12.82	20.00	22.69	35.57
Optimal (%)	9.47	13.32	20.37	22.62	34.21
Difference (%p)	0.56	0.50	0.37	-0.07	-1.36

Note: The effects of the optimal tax schedule in the model with transfers. The average tax rates, consumption, hours, and after-tax earnings shares by productivity quintiles both in the status quo and under the optimal tax policy.