

Discussion Paper Series

IZA DP No. 18810

July 2026

Progressing Towards Efficiency: The Role for Labor Tax Progression in Reforming Social Security

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Progressing Towards Efficiency: The Role for Labor Tax Progression in Reforming Social Security^{*}

Abstract

This paper studies the role for progressive labor income taxation in the context of social security reform. We propose a novel reform that replaces redistributive pensions with a contribution-based system while simultaneously increasing the progressivity of labor income taxation to preserve social insurance. Using a stylized model, we show that the benefit of such reform is derived from the Frisch elasticity of labor supply. For sufficiently high values, the reform can be fiscally neutral and Pareto-improving. We then evaluate the reform in a full general equilibrium model calibrated to the U.S. economy. Quantitative results on the efficiency-insurance trade-offs are in line with our theoretical predictions. In the steady-state, for plausible values of the Frisch elasticity, the fiscal space generated by increased labor supply is sufficient to compensate through lump-sum transfers the loss of pension-based insurance. These results carry over to transition dynamics: the reform yields a Pareto improvement along the transition path. Our findings highlight the potential for tax-based redistribution to replace pension-based insurance.

JEL classification

C68, E62, H55, J26

Keywords

social security reform, labor income tax, redistribution, insurance, welfare effects

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^{*} The authors are grateful to Alan Auerbach, Roel Beetsma, Monika Buetler, Lukasz Drozd, Borys Grochulski, Hans Fehr, Tim Kehoe, Fabian Kindermann, Jaromir Nosal, Franck Portier, Jose Victor Rios Rull, Ward Romp, Kent Smetters, Jacek Suda and Carlos E. Zarazaga for fruitful discussions and useful comments. Comments from two anonymous referees and the editor Evi Pappa greatly improved the paper. We have also greatly benefited from feedback received at SNDE (2014, 2019), Netspar International Pension Workshop (2017, 2019), ICMAIF (2017), XXII Workshop on Dynamic Macroeconomics in Vigo (2017), EEA (2019), T3M (2021), and CEF (2023). We thank Lukasz Krzempek for excellent research assistance. Support from National Science Centre (grant 2016/22/E/HS4/00129) is gratefully acknowledged. All errors are ours.

1 Introduction and motivation

We study the role of progressive labor income taxation as a complementary tool in social security reform. Demographic aging is exerting growing fiscal pressure on public pension systems worldwide. As life expectancy increases, traditional pay-as-you-go (PAYG) social security schemes face increasingly unsustainable financial burdens. Multiple studies propose reforms to address the fiscal side of the problem. However, these reforms typically necessitate the loss of insurance embedded in social security.¹

We propose a novel approach to social security reform that reassigns the redistributive role of the system while improving both fiscal sustainability and economic efficiency. The reform replaces the redistributive pension system with a defined contribution (DC) structure and shifts redistribution to the tax system. This separation between the provision of pensions and redistribution allows the economy to retain equity objectives while reducing distortions in labor supply. By reallocating redistribution away from pensions and toward taxation, the reform strengthens incentives without abandoning social insurance goals.²

To build intuition, we begin with a stylized model that makes this mechanism explicit. In the baseline, the social security system is fully redistributive, providing equal benefits to all retirees regardless of prior contributions, while the labor income tax is progressive. We consider a reform that ties pension benefits to individual contributions, thereby eliminating redistribution within the pension system. To preserve overall progressivity and maintain social insurance, we increase the progressivity of the labor income tax. This change is fiscally feasible because linking benefits to contributions reduces labor supply distortions, leading to higher labor supply and increased tax revenue. The resulting additional revenue is redistributed via lump-sum transfers, completing the shift of redistribution from pensions to taxation.

Our stylized model shows that the ability of the reform to deliver welfare gains hinges on the strength of labor supply response, as captured by the Frisch elasticity. When the elasticity is sufficiently high, the fiscally neutral reform becomes Pareto-improving, with all individuals better off. Crucially, at these elasticity levels, the existing redistributive pension system is no longer Pareto efficient. This highlights the potential for more efficient and incentive-compatible

¹See, among others, Fehr (2000), Diamond (2004), Braun and Joines (2015), Diamond et al. (2016), McGrattan and Prescott (2017). Reforms proposed in the literature usually involve linking pensions with individual contributions, which improves efficiency at the expense of insurance loss (Davidoff et al. 2005, Nishiyama and Smetters 2007, Fehr et al. 2008). Welfare gains arise predominantly through a reduction in distortions generated by social security contributions because there is a direct link between contemporaneous labor supply and future pension benefits. Welfare losses stem from the loss of insurance from redistribution inherent in the progressive design of current U.S. social security (see also Heer 2015).

²The literature typically distinguishes between two types of social security reform. The first privatizes or eliminates public pensions, requiring individuals to rely on private savings (e.g., Nishiyama and Smetters 2007, McGrattan and Prescott 2017). The second introduces a defined contribution system, where contributions are retained, but benefits depend on accumulated contributions that earn returns, typically tied to wage growth (e.g., Bütler 2000, Poterba et al. 2007, Attanasio et al. 2007, Börsch-Supan et al. 2014). Our paper contributes to this second strand by replacing the current redistributive system—similar to the U.S. Social Security program—with a defined contribution scheme, holding the contribution rate constant.

redistribution.

Simulations from the full general equilibrium model calibrated to the U.S. economy confirm key insights from the stylized framework. Our model features overlapping generations of heterogeneous agents who face idiosyncratic labor productivity shocks and make decisions about consumption, savings, and labor supply. This framework allows us to assess whether the reform is welfare-improving and to quantify the associated gains. It includes a government sector that runs a pay-as-you-go (PAYG) social security system and collects consumption, capital, and progressive labor income taxes to finance public expenditures and service debt. In the baseline, pension benefits are redistributive and provide partial insurance against income shocks. In the reform scenario, benefits are tied directly to individual contributions, eliminating redistribution within social security. We introduce fiscally neutral lump-sum transfers to compensate for the loss of income insurance.

Comparative statics between two steady-states reveal that the reform reduces labor market distortions, raises labor supply, and increases fiscal revenue. Under plausible values of the Frisch elasticity, redistributing this additional revenue through lump-sum transfers can offset the loss of insurance. The welfare effects remain positive under population aging and partial internalization, suggesting that the mechanism is robust to plausible demographic and behavioral variation.

We also analyze the reform along the transition from redistributive social security to the new regime. We introduce the reform gradually. Retirees and workers already in the system continue with the baseline pension formula—retaining insurance but not benefiting from reduced labor market distortions. Although their labor supply changes little, they experience welfare gains due to higher pension indexation and increased returns on savings. Labor market entrants are subject to the reformed system. They benefit from reduced labor market distortions and receive lump-sum transfers through enhanced tax-based redistribution. Although they lose insurance previously provided by social security, their overall welfare nevertheless increases.

In summary, our contribution to the literature is threefold.

1. We propose complementing social security reform with a more progressive labor income tax system. Tax-based redistribution can partially compensate for the loss of insurance traditionally provided by social security.
2. We show that the Frisch elasticity of labor supply is central to the welfare calculus of the reform.
3. Using a large-scale model calibrated to the U.S. economy, we analyze a reform that links pensions to contributions, reducing labor market distortions at the cost of lower insurance. For plausible calibrations of the Frisch elasticity, the reform yields a Pareto improvement when combined with greater labor tax progressivity.

Relating to the literature, we study how, in the absence of income insurance markets, linking

pensions to contributions affects the levels of insurance and how tax policy can substitute for redistribution. Our work is most closely related to Hosseini and Shourideh (2019), who study social security reform in the absence of annuity markets and show that supporting private savings among low-wealth households—combined with eliminating social security while maintaining the existing tax system—can generate welfare gains. While their framework features heterogeneity, it does not include idiosyncratic labor income shocks. By contrast, our model incorporates such risk and incomplete insurance. More broadly, our paper relates to the literature on taxation and redistribution, including Werning (2007).

Beyond this contribution, our work connects to several strands of the literature.³ First, our analysis builds on research on income risk, insurance, and redistribution (Heathcote et al. 2008, Huggett and Parra 2010, Golosov et al. 2013, 2016, Heathcote et al. 2017). Second, we contribute to the literature on U.S. social security reform (Nishiyama and Smetters 2007, McGrattan and Prescott 2017, Hosseini and Shourideh 2019). Third, we expand the government toolkit to progressive labor income taxation when balancing distortions in labor supply decisions. Most existing work in this area assumes linear labor taxation (see, e.g., Andolfatto and Gervais 2008, İmrohoroglu and Kitao 2009, Kitao 2014, Vogel et al. 2017).⁴

Conesa and Krueger (1999) and McGrattan and Prescott (2017) show that replacing redistributive social security with voluntary savings can improve welfare. In contrast, our setup retains mandatory public social security—operating on a pay-as-you-go basis—and still delivers welfare gains. Nishiyama and Smetters (2007) and others emphasize the importance of insurance provided by redistributive pension benefits across heterogeneous earnings histories in determining the welfare effects of reform. While we follow earlier work in eliminating redistribution within pensions, our novel contribution is to simultaneously increase labor income tax progressivity (in the spirit of Benabou 2002, Guner et al. 2014), thereby partially restoring the insurance function.

Our results extend the findings of Heathcote et al. (2008) and İmrohoroglu and Kitao (2009), who examine how labor supply responds to social security design and tax progressivity. We show that the welfare implications hinge on the extent of distortions in labor supply decisions (see also Huggett and Parra 2010, Berger et al. 2019, Boar and Midrigan 2020). Our findings are in line with recent work of Ábrahám et al. (2025), who study optimal redistribution across multiple policy tools. In their model, shifting redistribution from pensions to progressive taxation can improve welfare—consistent with our result that tax progressivity can offset insurance losses from social security reform.

³Some earlier studies of social security reform, e.g., Nishiyama and Smetters (2007), McGrattan and Prescott (2017), Chen et al. (2016) incorporate progressive income taxation. However, to the best of our knowledge, none explores *changes* in progressivity as a complementary policy tool alongside social security reform. Progressive taxation has long been shown to provide insurance against idiosyncratic income shocks (Varian 1980, Golosov et al. 2013, Heathcote et al. 2017). Indeed, as (Findeisen and Sachs 2017) shows, in life-cycle models with idiosyncratic risk, optimal labor taxation is generally not linear.

⁴There is a large literature on systemic social security reform in overlapping generations (OLG) models; see Lindbeck and Persson (2003), Fehr (2009), and Fehr (2016) for reviews.

Our paper is structured as follows. Section 2 develops a stylized framework to illustrate the role of tax progressivity in social security reform. Section 3 presents the quantitative model, and Section 4 describes its calibration. Comparative statics across steady-states are discussed in Section 5. Section 6 examines the reform along the transition path. The final section concludes by summarizing the main contributions and outlining the policy implications of the study.

2 Stylized model

We develop a parsimonious overlapping-generations model with heterogeneous households and an insurance motive. The economy features a pay-as-you-go (PAYG) social security system and a progressive labor income tax. We analyze two distinct types of social security systems. The first, which we label *Beveridgean*, is redistributive: benefits are equal for all individuals, while contributions are proportional to income. The second, referred to as *Bismarckian*, ties pension benefits to individual contributions, thereby transmitting income heterogeneity into pension heterogeneity.

To isolate the effects of each design, we compare their implications against a benchmark lump-sum pension system, which is neutral in terms of redistribution and does not generate distortions on the margins. The framework also includes progressive income taxation, allowing us to examine how tax and transfer systems interact.

The purpose of this section is to build core economic intuitions and identify the key trade-offs associated with social security reform. These insights serve as a foundation for the subsequent analysis in a large-scale computable general equilibrium model. All algebraic details and proofs are relegated to Appendix A.

2.1 Model setup

Environment. We consider a partial equilibrium OLG economy. Each generation lives for two periods, supplies labor when young, and retires when old. There are two types of individuals: high-productivity and low-productivity, each of measure one. These are denoted by $\theta \in \{\theta_L, \theta_H\}$, with corresponding type-specific productivity levels $\omega_\theta \in \{\omega_L, \omega_H\}$, where $\omega_L < \omega_H$.

The real interest rate r and the real wage w_t are exogenous. Wages grow at a constant rate γ , and we impose $\gamma = r$ to align the implicit return in the PAYG system with the growth rate of the wage bill.

Government. The government runs a balanced budget. Public spending is financed by a labor income tax with linear marginal rate τ_ℓ and lump-sum transfers μ_t , which jointly generate a progressive tax-transfer system. The exact budget constraint is provided in Appendix A.

Social security. The economy features a PAYG social security system with a total contribution rate $\tau < 1$ that is kept constant across all pension designs. We consider:

- **Beveridgean system.** Contributions are proportional to labor income at rate $\tau^{BEV} = \tau$, but benefits are uniform across retirees: $b_{2,t+1}(\theta_H) = b_{2,t+1}(\theta_L)$. The system is therefore redistributive.
- **Bismarckian system.** Contributions are proportional to income at rate $\tau^{BIS} = \tau$, and each retiree's benefit is proportional to her own past contributions. The system transmits earnings heterogeneity one-for-one into pension heterogeneity and is actuarially fair at the individual level.

In addition, as benchmark we use **lump-sum system**, whereby each young agent pays the same lump-sum contribution and receives the same lump-sum benefit in old age (i.e. neither contributions, nor benefits depend on income).

All three systems are PAYG and balanced in each period. Formal benefit formulas are given in Appendix A. In what follows, we present a unified framework that nests all three systems. For example, consider equation (1). If we analyze the Bismarckian system (denoted as BIS) $\tau^{BEV} = 0$. Thus, for each policy experiment, we set the parameter configuration such that only the system under consideration is active, while the others are effectively switched off.

Households. A young household of type θ chooses labor $\ell_{1,t}(\theta)$, consumption $c_{1,t}(\theta)$ and savings $a_{1,t+1}(\theta)$, taking as given r , w_t , taxes, transfers and the pension system. In old age, the household consumes out of savings and pension benefits $b_{2,t+1}(\theta)$.

To encompass all three pension systems within a unified framework, we write the budget constraints in their general form. The two period budget constraints can be written as

$$c_{1,t}(\theta) + a_{1,t+1}(\theta) = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})w_t\omega_\theta\ell_{1,t}(\theta) + \mu_t - T_t^{LS}, \quad (1)$$

$$c_{2,t+1}(\theta) = (1 + r)a_{1,t+1}(\theta) + b_{2,t+1}(\theta), \quad (2)$$

where T_t^{LS} denotes the lump-sum contribution under the lump-sum system (and is set to zero otherwise).

Combining the two constraints yields the lifetime budget constraint

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})w_t\omega_\theta\ell_{1,t}(\theta) + \mu_t - T_t^{LS} + \frac{b_{2,t+1}(\theta)}{1 + r}. \quad (3)$$

For each policy experiment, the relevant parameters are chosen such that only the pension system under consideration is active, while the others are set to zero.

Preferences and welfare. To keep the trade-offs in the stylized model transparent, we adopt GHH preferences (Greenwood et al. 1988). This class of preferences delivers a tractable analytical link between labor supply elasticity and the labor tax wedge. In the quantitative model, this assumption is relaxed. The utility function for a household of type θ takes the form:

$$U_t(\theta) = \frac{1}{1-\sigma} \left(c_{1,t}(\theta) - \frac{\phi}{1+1/\eta} (1+\gamma)^t \ell_{1,t}(\theta)^{1+1/\eta} \right)^{1-\sigma} + \delta \frac{1}{1-\sigma} (c_{2,t+1}(\theta))^{1-\sigma}, \quad (4)$$

where σ is the coefficient of relative risk aversion, ϕ governs the disutility of labor, and η is the Frisch elasticity of labor supply. We set $\delta^{-1} = 1 + r$.

As a welfare metric, we use expected welfare under the veil of ignorance—that is, before the realization of productivity type. Since both productivity types occur with equal probability, ex ante welfare is given by

$$U_t = \frac{1}{2} U_t(\theta_L) + \frac{1}{2} U_t(\theta_H).$$

From this perspective, households value insurance against productivity risk, but such insurance may entail efficiency losses through labor market distortions. The rest of the analysis explores this trade-off.

2.2 Model solution

We briefly summarize the equilibrium conditions that are central for our arguments; all derivations are provided in subsection A.2 of Appendix A. The expressions below are written for the unified framework and simplify once the parameter configuration corresponding to a given pension system is imposed.

Labor wedge. We define the labor wedge as the gap between the marginal rate of substitution between leisure and consumption and the individual wage $w_t \omega_\theta$. Pension contributions affect this wedge only to the extent that they are not offset by future benefits. Formally, the first-order condition for labor can be written as

$$MRS_{(\ell_1, c_1)}(\theta) = (1 - \tau_\ell - (1 - v^{BEV})\tau^{BEV} - (1 - v^{BIS})\tau^{BIS}) w_t \omega_\theta, \quad (5)$$

where $(1 - v^k)$ denotes the share of current contributions in system $k \in \{BEV, BIS\}$ that the household does not recover in present value and therefore effectively acts a tax.

With a balanced PAYG system and $\gamma = r$, we obtain $v^{BEV} = 0$ and $v^{BIS} = 1$. Thus, the labor wedge becomes:

$$\vartheta^{BEV} = \tau_\ell + \tau^{BEV}, \quad \vartheta^{BIS} = \tau_\ell, \quad \vartheta^{LS} = \tau_\ell.$$

This implies that in the Beveridgean system pension contributions function like an additional

labor tax, whereas in the Bismarckian system they are fully internalized and therefore non-distortionary. Accordingly, the Bismarckian and lump-sum systems do not distort labor supply beyond the standard labor income tax, while the Beveridgean system introduces an additional wedge equal to the contribution rate.

Labor supply. Solving the household problem yields a simple expression for labor supply, which is constant over time and depends only on the effective tax wedge:

$$\ell_1(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV}) \omega_\theta \right]^\eta. \quad (6)$$

This expression encompasses all three pension systems. Since only the Beveridgean system generates an additional distortionary wedge, the contribution rate τ^{BEV} appears explicitly in the formula. Under the Bismarckian system, contributions are fully internalized and therefore do not affect the effective labor wedge; under the lump-sum system, contributions are non-distortionary by construction. Hence, in both cases the effective wedge reduces to the labor income tax τ_ℓ . Consequently, for a given labor income tax, labor supply is strictly lower under the Beveridgean system than under the Bismarckian or lump-sum systems.

Lifetime budget constraint and redistribution. Using the explicit benefit formulas (see Appendix A) and the assumption $r = \gamma$, we can rewrite the lifetime budget constraint as

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = (1 - \tau_\ell - \tau^{BEV}) w_t \omega_\theta \ell_{1,t}(\theta) + \mu_t + \frac{\tau^{BEV} w_t}{2} \sum_{\theta' \in \{\theta_L, \theta_H\}} \omega_{\theta'} \ell_{1,t+1}(\theta'). \quad (7)$$

As in the case of the labor wedge, this expression nests all three systems and simplifies depending on which pension system is active. For the lump-sum and Bismarckian systems, the present value of contributions equals the present value of pension benefits at the individual level, so these terms cancel out from the lifetime budget constraint. When the corresponding contribution rates are set to zero, the remaining pension terms vanish mechanically. In the Beveridgean system they do not cancel, which generates intragenerational redistribution: high-productivity types pay more than they receive, while low-productivity types receive a net transfer.

2.3 Pension systems: comparison

We now characterize how the three systems affect individual decisions. Formal propositions and proofs are given in subsection A.4 of Appendix A.

Lump-sum system. Because contributions and benefits are independent of individual earnings, they simply shift resources over the life cycle without changing relative prices or redistributing

across types. Labor supply, consumption, and savings are identical to the no-social-security benchmark.

Bismarckian system. In the Bismarckian system, each household's pension is proportional to its own contributions. The system is actuarially fair at the individual level and does not redistribute income across types. Since contributions are fully internalized, the labor wedge is the same as in an economy without social security, and individual decisions (c_1, c_2, ℓ_1) are unchanged relative to the no-social-security case.

Beveridgean system. The Beveridgean system combines a contribution proportional to earnings with a flat benefit. It therefore redistributes from high- to low-productivity agents and, at the same time, increases the labor wedge by τ^{BEV} . In equilibrium, both types face a distorted labor supply decision, so labor supply is lower than under the Bismarckian or lump-sum systems. Low-productivity households work less but receive more in present value than they contribute, whereas high-productivity households work less and receive less in present value than they contribute. In effect, a Beveridgean pension contribution operates like an additional labor income tax with a lump-sum transfer.

2.4 Beveridgean-to-Bismarckian Reform: Steady-State Analysis

We now consider a reform that replaces the Beveridgean system with a Bismarckian one while keeping the PAYG structure and the contribution rate τ unchanged. The reform is paired with a fiscal adjustment that increases the progressivity of the labor tax. As a result, redistribution within the pension system is eliminated and the labor wedge is reduced. The resulting increase in labor supply raises tax revenue, which we assume is returned to households through higher lump-sum transfers⁵. In this way, redistribution is shifted from the pension system to the tax system.

The reform affects households through three channels:

Efficiency effect: A lower labor wedge raises labor supply and increases the present value of lifetime income for both types. This mechanism is a well-established finding in the literature on social security reform (Feldstein 1976, Nishiyama and Smetters 2007, Huggett and Parra 2010). When social security contributions do not linked to future benefits—as in the Beveridgean system—they operate like a tax on labor, distorting labor supply decisions. By contrast, when

⁵In the stylized model, transfers are directed to working-age households. In the steady state, however, the precise timing of transfers is not essential for the mechanism, since each cohort receives them at some point during its lifetime. Directing transfers to workers is convenient because it increases lifetime resources one-for-one when evaluated from the beginning of life, whereas transfers received in retirement are discounted by the interest rate. However, in the computational model we relax this assumption, and transfers are distributed to all individuals affected by the reform.

current contributions are tied to future benefits at fair actuarial value—like in the Bismarckian system—then they merely shift income from the present to the future, without distorting incentive. Thus, replacing the Beveridgean system with a Bismarckian one reduces the labor wedge.

Pension redistribution effect: Eliminating flat benefits reduces the net transfer to low-productivity agents and increases the net return to high-productivity agents. Under the Beveridgean system, pensions are not tied to individual contributions, creating implicit redistribution from high- to low-productivity households. In contrast, the Bismarckian system links pensions directly to past earnings, removing this redistribution. Consequently, this component of the reform benefits high-productivity households while reducing welfare for low-productivity ones.

Tax redistribution effect: Higher labor supply boosts tax revenue. Both low- and high-productivity households work more, but because the percentage increase in labor supply is the same for both types, the absolute increase is larger for high-productivity households. They therefore contribute more additional tax revenue in absolute terms. When the extra revenue is redistributed uniformly through lump-sum transfers, the tax system effectively shifts resources from high- to low-productivity households.

The relative strength of these forces depends primarily on the Frisch elasticity η and on the marginal tax rate τ_ℓ . A higher Frisch elasticity amplifies the efficiency effect and the tax-based redistribution: labor responds more strongly to the lower wedge, generating more additional revenue that can be redistributed. A higher τ_ℓ strengthens the redistribution channel for a given change in labor.

The following proposition summarizes the steady-state implications of the reform; its proof is given in subsection A.5 of Appendix A.

Proposition 1 (Steady-state welfare effects of reform) *Starting from a steady-state with a Beveridgean pension system, consider a reform that switches to a Bismarckian system while keeping the contribution rate τ fixed and rebating the additional tax revenue through lump-sum transfers. Then, in the new steady-state with the Bismarckian pension system, relative to the old one:*

- *For each $\tau_\ell \in (0, 1)$ there exists a threshold value for the Frisch elasticity $\underline{\eta}(\tau_\ell) > 0$ such that, for all $\eta \geq \underline{\eta}(\tau_\ell)$, the reform raises ex ante (utilitarian) welfare under the veil of ignorance $W = \sum_{\theta \in \{\theta_L, \theta_H\}} U(\theta)$.*
- *For each $\tau_\ell \in (0, 1)$ there exists a higher threshold value for the Frisch elasticity $\bar{\eta}(\tau_\ell) > \underline{\eta}(\tau_\ell)$ such that, for all $\eta \geq \bar{\eta}(\tau_\ell)$, the reform constitutes a Pareto improvement: both low- and high-productivity households are better off.*

- Both thresholds $\underline{\eta}(\tau_\ell)$ and $\bar{\eta}(\tau_\ell)$ are decreasing in τ_ℓ : a more progressive tax system makes it easier to offset the lost redistribution within pensions.

Intuitively, when labor supply is sufficiently elastic and the tax system is sufficiently progressive, the efficiency gains from reducing the labor wedge generate enough additional tax revenue for tax-based redistribution to fully compensate low-productivity households for the loss of pension-based redistribution.

2.5 Transition path

In this section, we study the welfare implications of the reform along the transition path, distinguishing between the initial old generation and the initial young as well as all future generations.

It is well known that social security reform may generate transition costs, particularly when switching from a PAYG system to a fully funded one or eliminating the system altogether. In such cases, transition costs arise because pensions for the elderly continue to be paid while contributions are diverted elsewhere, creating a temporary deficit that must be addressed. In contrast, the proposed reform modifies the pension formula while preserving the PAYG structure. Consequently, it does not generate additional transition costs.

The following proposition characterizes how the reform affects the welfare of the initial old generation and of the initial young and all future generations along the transition path.

Proposition 2 (Welfare effects along the transition path) *Suppose the economy is in the steady-state of the Beveridgean pension system in period t . Consider an unexpected reform such that:*

1. *for all generations born in period t and thereafter, the pension system switches from the Beveridgean to the Bismarckian formula while keeping the contribution rate fixed; and*
2. *the resulting fiscal adjustment is implemented through lump-sum transfers within the labor income tax system.*

Then:

- *both low- and high-productivity households of the initial old generation (born in period $t - 1$) experience a welfare gain;*
- *for the initial young and all future generations, the welfare effects of the reform are identical to those characterized in the steady-state comparison in Proposition 1.*

This proposition characterizes how the welfare effects of the reform unfold across cohorts along the transition path. A formal proof is provided in subsection A.6 of Appendix A; here we present the underlying economic intuition.

For the initial young generation and all future generations, the adjustment coincides with that between two steady-states. Wages and interest rates remain unchanged, while the labor wedge immediately adjusts to its post-reform level. Labor supply therefore jumps to its new steady-state level, generating efficiency gains and additional tax revenue. Redistribution through the tax system mirrors exactly the steady-state comparison. Moreover, because pension benefits depend on aggregate labor income and wage growth, and labor supply adjusts instantaneously, the pension redistribution effect also coincides with that in the steady-state. As a result, the welfare effects for these cohorts are identical to those implied by the steady-state analysis.

For the initial old generation (born in period $t-1$), the reform is implemented after retirement. As a consequence, there are no efficiency effects and no changes in redistribution through the tax system. Their welfare is affected only through the pension system. The increase in labor supply of the young expands the contribution base of the PAYG pension system, which translates into higher pension benefits for current retirees relative to the pre-reform steady-state. The initial old therefore benefit unambiguously from the reform.

Taken together, this proposition implies that the reform generates efficiency gains through higher labor supply, benefits current retirees through higher pension payments, and affects the welfare of the initial young and all future generations in the same way as in the new steady-state.

In the transition analysis, lump-sum transfers are directed to working-age households because these are the cohorts directly affected by the reform. The initial old generation is not subject to the reform and already benefits from it through higher pension benefits generated by the increase in labor supply of the young. Consequently, there is no need to compensate them through additional transfers. Redistribution is therefore targeted at cohorts whose labor supply and pension contributions are directly altered by the reform, which naturally corresponds to households entering the labor market during and after the reform date.

An immediate implication of Proposition 2 concerns the efficiency of the Beveridgean system.

Corollary 1 (Pareto inefficiency of the Beveridgean pension system) *Suppose the economy is in a steady-state under the Beveridgean pension system. Then, for each $\tau_\ell \in (0, 1)$ there exists a threshold value of the Frisch elasticity $\bar{\eta}(\tau_\ell) > 0$ such that, for all $\eta \geq \bar{\eta}(\tau_\ell)$, the steady-state allocation under the Beveridgean system is Pareto inefficient. Moreover, the threshold $\bar{\eta}(\tau_\ell)$ is decreasing in τ_ℓ .*

Corollary 1 establishes that the steady-state allocation under the Beveridgean pension system is Pareto inefficient. The inefficiency arises because the pension system is used to introduce redistribution by delinking benefits from individual contributions, which turns pension contributions into a distortionary tax on labor. Eliminating redistribution from the pension system therefore expands the tax base by increasing labor supply. Whether this expansion is sufficient to generate a Pareto improvement depends on the responsiveness of labor supply, captured by the Frisch elasticity, and on the size of the tax system, measured by the labor tax rate τ_ℓ . When

labor supply is sufficiently elastic and the tax system is sufficiently large, the resulting increase in tax revenue allows redistribution to be implemented through the tax and transfer system in a way that makes all households better off. The existence of such a feasible Pareto improvement implies that the Beveridgean allocation is inefficient.

This result is related to efficiency tests developed in the optimal taxation literature (Werning 2007, Hosseini and Shourideh 2019), which characterize when a given tax and transfer system is Pareto efficient. In these frameworks, the feasibility of Pareto-improving reforms depends on the responsiveness of labor supply, as captured by the Frisch elasticity.

2.6 Implications for the quantitative model

This stylized model is designed to clarify the key economic mechanisms underlying pension reform. By abstracting from many institutional and general equilibrium features, it allows us to build intuition for how pension design affects labor supply incentives, redistribution, and welfare. At the same time, the analysis makes clear that the ultimate welfare consequences of the reform depend on the quantitative strength of these mechanisms rather than on their qualitative direction alone.

To assess their quantitative relevance, the subsequent sections develop a large-scale general equilibrium model calibrated to the U.S. economy. While this model is considerably more realistic, the main forces shaping the welfare effects of the reform remain the same. In particular, the quantitative analysis continues to be driven by efficiency effects arising from labor supply responses, redistribution implemented through the tax system, and redistribution embedded in pension benefits. The richer framework allows these channels to interact with life-cycle dynamics and general equilibrium adjustments, providing a disciplined evaluation of their importance in an economy that more closely resembles that of the United States.

3 General equilibrium model

We develop a general equilibrium overlapping generations (OLG) model with idiosyncratic income shocks, giving rise to *ex post* heterogeneity within cohorts. In the baseline scenario, the economy features a U.S.-style social security system with redistributive elements. In the reform scenario, this system is replaced by a defined contribution scheme that ties pension benefits directly to individuals' past social security contributions.

Population dynamics Households live for $j = 1, 2, \dots, J$ periods, where j denotes age and each period corresponds to five years. Individuals enter the model at age 20 ($j = 1$), abstracting from labor market entry timing and educational decisions. The size of the cohort aged j in period t is denoted by $N_{j,t}$. Consumers face age- and time-specific survival probabilities $\pi_{j,t}$,

which represent the conditional probability of surviving one period for an individual of age j in period t . Households can work up to the retirement age $\bar{J}$. Those who reach age $J = 16$ (i.e., 95 years old) die with certainty.

Productivity heterogeneity Each individual's effective labor productivity at age j and time t is given by $\omega_{j,t} = e_{j,t}\epsilon_{j,t}$, where $e_{j,t}$ is a deterministic age-efficiency profile and $\epsilon_{j,t}$ is a persistent idiosyncratic earnings shock. The shock follows a first-order autoregressive process:

$$\ln(\epsilon_{j,t}) = \varrho \ln(\epsilon_{j-1,t-1}) + \varepsilon_{j,t}, \quad \varepsilon_{j,t} \sim \mathcal{N}(0, \sigma^2), \quad (8)$$

with persistence parameter ϱ .⁶ Initial heterogeneity is introduced through the distribution of idiosyncratic shocks at model entry, with variance σ_0^2 .

Budget constraint Households below retirement age ($j < \bar{J}$) earn gross labor income $\omega_{j,t}w_t\ell_{j,t}$, where w_t is the marginal productivity of labor and $\ell_{j,t}$ is individual labor supply. Labor income is subject to a social security contribution at rate τ and a progressive labor income tax denoted by $\mathcal{T}(\tilde{y}_{j,t})$, where pre-tax taxable income is given by $\tilde{y}_{j,t} = (1 - \tau)\tilde{w}_t\omega_{j,t}\ell_{j,t}$ and $\tilde{w}_t = w_t/z_t$ adjusts wages for technological progress z_t (defined below).

We follow Benabou (2002) and specify the tax schedule as:

$$\mathcal{T}(\tilde{y}_{j,t}) = \tilde{y}_{j,t} - (1 - \tau_\ell)\tilde{y}_{j,t}^{1-\lambda},$$

where $1 - \lambda$ is the elasticity of post-tax to pre-tax income, and τ_ℓ governs the average tax rate. Note that social security contributions are excluded from the income tax base.

In addition to labor income, households earn capital income $(1 - \tau_k)r_t a_{j,t}$, where τ_k is the capital income tax, r_t is the interest rate, and $a_{j,t}$ denotes asset holdings. Retirees receive pension benefits $b_{j,t}$, which are exempt from taxation. Since survival probabilities are less than one, each period generates unintended bequests $\Gamma_{j,t}$, which are redistributed equally within the cohort.

Households consume $c_{j,t}$ (subject to a consumption tax $\tau_{c,t}$), and save by accumulating assets $a_{j+1,t+1}$. Asset markets are incomplete: only a single risk-free asset is available. Households also receive a lump-sum transfer μ_t (described below). The period budget constraint is:

$$a_{j+1,t+1} + (1 + \tau_{c,t})c_{j,t} = z_t\tilde{y}_{j,t} - z_t\mathcal{T}(\tilde{y}_{j,t}) + b_{j,t} + (1 + (1 - \tau_k)r_t)a_{j,t} + \mu_t + \Gamma_{j,t}, \quad (9)$$

subject to the non-negativity constraint $a_{j+1,t+1} \geq 0$.

⁶Following standard practice in the literature (Nishiyama and Smetters 2007, Heathcote et al. 2008, Huggett and Parra 2010, Golosov et al. 2016, Heathcote et al. 2017), we approximate this process with a first-order Markov chain defined by the transition matrix $\Pi(\ln(\epsilon_{j,t})|\ln(\epsilon_{j-1,t-1}))$

Baseline social security In the baseline scenario, we replicate the key features of the U.S. Social Security system. It operates as a pay-as-you-go, defined-benefit scheme in which pension benefits are determined jointly by an individual's benefit drawing rights—based on their Average Indexed Monthly Earnings (AIME)—and the effective replacement rate. The AIME determines the earnings base, while the replacement rate determines what fraction of those earnings is paid as a pension. The system is explicitly redistributive: low earners receive a replacement rate of 90%, while high earners receive only 15%.

The value of pension benefits at the statutory retirement age $\bar{J}$ in period t , denoted $b_{\bar{J},t}^B$, depends on the replacement rate $\rho_{\bar{J},t}$, the benefit drawing rights $f_{\bar{J},t}^B$ —defined as the ratio of an individual's average lifetime earnings to the economy-wide average—and the average wage in the economy $\overline{\omega w_t \ell_t}$. To ensure that total pension expenditures match the observed 5% of GDP, we introduce a scaling factor ρ_m . This adjustment allows us to align statutory rules with effective expenditure, just as we calibrate contribution rates using effective rather than statutory values. After retirement, pension benefits are indexed to payroll growth, where the payroll growth rate is given by $r_{\ell,t} = \frac{w_t L_t}{w_{t-1} L_{t-1}} - 1$, with L_t denoting aggregate labor supply. The resulting pension benefit formulas are:

$$b_{j,t}^B = \rho_m \cdot \rho_{\bar{J},t} \cdot f_{j,t}^B \cdot \overline{\omega w_t \ell_t} \quad \text{and} \quad b_{j,t}^B = (1 + r_{\ell,t}) b_{j-1,t-1} \quad \forall j > \bar{J}, \quad (10)$$

Next, we specify how drawing rights and replacement rates are computed. In the *status quo* social security system, the drawing rights $f_{j+1,t+1}^B$ evolve recursively according to:

$$f_{j+1,t+1}^B = F^B(f_{j,t}^B, \omega_{j,t} w_t \ell_{j,t}) \equiv \frac{1}{j} \left((j-1) \cdot f_{j,t}^B + \frac{\min\{\omega_{j,t} w_t \ell_{j,t}, \text{cap}_t\}}{\overline{\omega w_t \ell_t}} \right), \quad (11)$$

where cap_t denotes the contribution ceiling under the Old-Age, Survivors, and Disability Insurance (OASDI) system. In this formulation, only earnings below the cap contribute to the drawing rights, and these earnings are expressed as a share of the economy-wide average. The ratio is then averaged across the individual's working life.⁷

The effective replacement rate $\rho_{\bar{J},t}$, applied at the retirement age $\bar{J}$, is determined by a piecewise formula reflecting the progressive structure of U.S. Social Security benefits. We define it as:

$$\rho_{\bar{J},t} = \begin{cases} 0.9 & \text{for } f_{\bar{J},t}^B \leq F_{1,t} \\ \frac{0.9F_{1,t} + 0.32(f_{\bar{J},t}^B - F_{1,t})}{f_{\bar{J},t}^B} & \text{for } F_{1,t} \leq f_{\bar{J},t}^B \leq F_{2,t} \\ \frac{0.9F_{1,t} + 0.32(F_{2,t} - F_{1,t}) + 0.15 \cdot (f_{\bar{J},t}^B - F_{2,t})}{f_{\bar{J},t}^B} & \text{for } F_{2,t} \leq f_{\bar{J},t}^B \end{cases} \quad (12)$$

⁷In our model, contributions above the cap do not generate any additional benefit rights—the replacement rate for earnings above the cap is effectively zero. In the data, approximately 6% of individuals reach the OASDI earnings cap. In our model, this corresponds to about 3% of the population and 2% of total earnings. See: <https://www.ssa.gov/policy/docs/population-profiles/tax-max-earners.html>.

where $F_{1,t}$ and $F_{2,t}$ denote the bend points, expressed as fractions of average earnings. This functional form replicates the progressive benefit formula in U.S. Social Security, as described in McGrattan and Prescott (2017).

Reformed social security In the reform scenario, the existing social security system is replaced with a defined contribution scheme, while remaining pay-as-you-go in nature.

At retirement, pension benefits $b_{j,t}^R$ are based on individual entitlements $f_{j,t}^R$ accumulated over the working life through social security contributions. These accumulated entitlements are annuitized by dividing by the conditional life expectancy at retirement age $LE_{t,\bar{j}}$. After retirement, pensions are indexed to the rate of payroll growth $r_{\ell,t}$, so that pension payments evolve according to:

$$b_{j,t}^R = f_{j,t}^R / LE_{t,\bar{j}} \quad \text{and} \quad \forall_{j > \bar{j}} \quad b_{j,t}^R = (1 + r_{\ell,t}) b_{j-1,t-1}^R, \quad (13)$$

where the conditional life expectancy is $LE_{t,\bar{j}} = 1 + \sum_{s=0}^{J-\bar{j}-1} (\prod_{i=1}^s \pi_{\bar{j}+i,t+i})$.

Entitlements evolve over working period by accumulating current contributions and indexing past entitlements to payroll growth adjusted for mortality. Specifically:

$$f_{j+1,t+1}^R = \frac{(1 + r_{\ell,t})}{\pi_{j,t}} f_{j,t}^R + \frac{(1 + r_{\ell,t})}{\pi_{j,t}} \tau \omega_{j,t} w_t \ell_{j,t}, \quad (14)$$

This direct mapping between contributions and future benefits increases labor supply incentives by linking current effort to retirement income. For a formal derivation of the associated implicit tax on labor, see Appendix B.2 and Butler (2002).

Consumer problem The state of an individual household of age j at time t is given by $s_{j,t} = (a_{j,t}, f_{j,t}, \epsilon_{j,t}) \in \Omega$, where $a_{j,t}$ denotes asset holdings, $f_{j,t}$ denotes pension entitlements, and $\epsilon_{j,t}$ captures individual idiosyncratic productivity shock realization. Newborn households enter the economy with no assets: $a_{1,t} = 0$.

At each state $s_{j,t}$, the household chooses consumption and labor supply to maximize expected lifetime utility. Future utility is discounted using the time discount factor δ and conditional survival probabilities $\pi_{j,t}$. The household's optimization problem can be formulated recursively as follows:

$$V_{j,t}(s_{j,t}) = \max_{(c_{j,t}, \ell_{j,t}, a_{j+1,t+1})} u(c_{j,t}, \ell_{j,t}) + \delta \pi_{j,t} \mathbf{E}(V_{j,t+1}(s_{j+1,t+1}) \mid s_{j,t}), \quad (15)$$

subject to the budget constraint in equation (9), the relevant pension formula—either equation (10) in the baseline scenario or equation (13) under the reform—and the productivity process in equation (8). Total time endowment is normalized to one. The instantaneous utility from

consumption and leisure is:

$$u(c_{j,t}, \ell_{j,t}) = \frac{1}{1-\sigma} c_{j,t}^{1-\sigma} - \frac{\phi}{1+\frac{1}{\eta}} \ell_{j,t}^{1+\frac{1}{\eta}}. \quad (16)$$

where σ denotes the inverse of the intertemporal elasticity of substitution and η is the Frisch elasticity of labor supply.

Production The economy produces final output using capital K_t and labor L_t via a standard Cobb-Douglas production function $Y_t = K_t^\alpha (z_t L_t)^{1-\alpha}$ with labor-augmenting technological progress. The growth rate of technology is denoted by $\gamma_{t+1} = z_{t+1}/z_t$, and capital depreciates at the rate d . Firms operate in perfectly competitive markets and choose capital and labor inputs to maximize profits. This leads to the following equilibrium conditions for the rental rate of capital and the real wage:

$$r_t = \alpha K_t^{\alpha-1} (z_t L_t)^{1-\alpha} - d \quad \text{and} \quad w_t = (1-\alpha) K_t^\alpha z_t^{1-\alpha} L_t^{-\alpha}. \quad (17)$$

Government Tax revenue T_t is used to finance government consumption G_t , cover subsidy to social security $\mathcal{S}_t$ in case of shortfall, service interest payments on public debt $r_t D_t$, and fund lump-sum transfers μ_t . The government budget constraint is:

$$G_t + \mathcal{S}_t + r_t D_t + \sum_{j=1}^J N_{j,t} \mu_t = T_t + \Delta D_{t+1}, \quad (18)$$

where $\Delta D_{t+1} = D_{t+1} - D_t$ denotes the change in public debt. Tax revenue T_t is given by:

$$T_t = \sum_{j=1}^{\bar{J}-1} N_{j,t} \int_{\Omega} z_t \mathcal{T}(\tilde{y}_{j,t}(s_{j,t})) d\mathbb{P}_{j,t} + \tau_{k,t} r_t A_t + \tau_{c,t} C_t, \quad (19)$$

where, C_t and A_t denote aggregate consumption and aggregate assets, respectively. We assume that government consumption G_t is the same in both the baseline and reform scenarios. The individual state at age j and time t is denoted $s_{j,t} = (a_{j,t}, f_{j,t}, e_{j,t}) \in \Omega$ and the distribution of agents over the state space Ω is represented by probability measure $\mathbb{P}_{j,t}$.

The social security deficit, $\mathcal{S}_t$, which also represents the required subsidy to social security, is defined as the difference between the total pension benefit payments and the total contributions:

$$\mathcal{S}_t = \sum_{j=\bar{J}}^J N_{j,t} \int_{\Omega} b_{j,t}(s_{j,t}) d\mathbb{P}_{j,t} - \tau w_t \sum_{j=1}^{\bar{J}} N_{j,t} \int_{\Omega} \omega_{j,t}(s_{j,t}) \ell_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}. \quad (20)$$

Here $b_{j,t} = b_{j,t}^B$ in the baseline and $b_{j,t} = b_{j,t}^R$ in the reform. The superscript B and R denote variables in the baseline and the reform scenarios, respectively. Under the baseline, any deficit $\mathcal{S}_t$

is covered by general government revenues. In the reform, the system is designed to be balanced in steady-state, so $\mathcal{S}_t = 0$ by construction.

In the baseline, lump-sum transfers μ_t^B are set to zero. In the reform, we introduce additional progressivity via positive lump-sum transfers μ_t^R . Along the transition path, these transfers are directed only to cohorts affected by the reform, namely those entering the labor market from the reform date onward. This allocation reflects the fact that these cohorts are the ones whose pension formula changes and therefore the ones for whom tax-based redistribution is intended to compensate for the loss of redistribution within the pension system. Once a cohort becomes eligible for transfers, it continues to receive them throughout the remainder of its lifetime.

The transfers are determined endogenously to ensure fiscal neutrality, holding the level of government debt constant. Specifically, the lump-sum transfer in the reform is calculated as:

$$\mu_t^R = \frac{G_t + \mathcal{S}_t^R + r_t^R D_t - \Delta D_{t+1} - T_t^R}{N_t^\mu}. \quad (21)$$

where N_t^μ denotes the number of households eligible for lump-sum transfers in period t , i.e. the cohorts alive in period t affected by the reform.

In summary, the general government is modeled in consolidated form, and is given by the government budget constraint from equation (18), the tax revenue equation (19), and the PAYG social security condition. In the baseline economy, government expenditure balance the budget. In contrast, in the reformed economy, lump-sum transfers are endogenously determined to satisfy the fiscal constraint while keeping government expenditure and debt constant.

Measuring welfare effects We assess welfare effects of the reform using consumption equivalents, defined as the percentage change in lifetime consumption that would make an individual indifferent between the status quo and the reform steady-states.

Our main analysis focuses on aggregate welfare under the veil of ignorance—that is, before individual income shocks are realized. The derivation is presented in Appendix B.3. In complementary analyses, we also compute ex post welfare effects, evaluating outcomes across all realized income shock histories.

4 Calibration

The model is calibrated to reflect key features of the U.S. economy. Using microeconomic evidence and macroeconomic aggregates, we set reference values for preferences, life-cycle productivity profiles, tax rates, technology growth, etc. Survival probabilities $\pi_{j,t}$ and population growth are calibrated using United Nations World Population Prospects.⁸ Table 1 summarizes

⁸We use age-grouped survival and fertility rates in five-year intervals, consistent with the model's period length.

the calibrated parameter values used in the model.

Productivity heterogeneity. We follow Borella et al. (2018) in modeling individual labor productivity as the product of a deterministic age profile and a persistent idiosyncratic component. We obtain the estimates from Panel Study of Income Dynamics (PSID). Our model includes two dimensions of ex-ante heterogeneity. First, agents draw a persistent productivity shock upon entering the model at age $j = 1$, consistent with Guvenen et al. (2022). Second, productivity evolves along a deterministic life-cycle profile (which we obtain from the PSID data via decomposition of Deaton 1997, Deaton and Paxson 1998). These components are illustrated in Figure C1.

Once we adjust for the deterministic profile, we estimate the stochastic component specified as a first-order autoregressive AR(1) process with annual persistence $\bar{\varrho}_\epsilon = 0.973$ and innovation variance $\bar{\sigma}_\epsilon = 0.021$. Since each model period corresponds to five years, we convert these into model-consistent values using: $\varrho_\epsilon = \bar{\varrho}_\epsilon^5$ and $\sigma_\epsilon = \bar{\sigma}_\epsilon \frac{1 - \bar{\varrho}_\epsilon^{10}}{1 - \bar{\varrho}_\epsilon^2}$.

Preferences. We set the inverse of the intertemporal elasticity of substitution to $\sigma = 2$, in line with standard macroeconomic literature. The discount factor δ is calibrated to 0.994 to match a capital-to-GDP ratio of 2.9. Since agents face mortality risk, the effective discounting is lower.

To quantitatively explore the mechanisms highlighted in the stylized model, we consider a wide range of Frisch elasticities. For each value, we calibrate the disutility of labor parameter ϕ to target an average labor supply of 0.31. Specifically, we consider values of $\eta \in \{0.2, 0.4, 0.6, \dots, 2.8, 3\}$. Our baseline specification follows Chetty, Guren, Manoli and Weber (2011) and sets the Frisch elasticity at $\eta = 0.8$. All alternative calibrations are reported in Table C2 in the Appendix.⁹

Social security Given that the replacement rates ρ at each earnings level are defined by law, we introduce a scaling parameter ρ_m to ensure that pension expenditures match 5.0% of GDP. The effective contribution rate τ is calibrated to balance the social security budget, in line with observed data. We set the retirement age at 66, which corresponds to $\bar{J} = 10$ in our five-year-period model.¹⁰ Throughout, we model social security in net terms: neither contributions nor benefits are subject to taxation, in either the baseline or the reformed system.

Government We calibrate taxes following the approach of Mendoza et al. (1994). The capital income tax rate is set to 24.3% to match the 5.4% capital tax revenue-to-GDP ratio. The

⁹For some calibrations, δ exceeds 1, but due to mortality risk, effective discounting is below 1.

¹⁰OECD *Pensions At a Glance* reports that the United States is characterized by a uniquely high effective exit age: with current normal retirement age of 66.7, the effective exit age is 67.3 for men and 66.9 for women (despite the early eligibility age of 62).

Table 1: Calibrated parameters for the initial steady-state

Macroeconomic parameters		Calibration	Target	Value (source)	Model outcome
Preferences					
ϕ	disutility from work	8.41	average hours	31% BEA(NIPA)	31%
σ	risk preference	2	literature		
η	Frisch elasticity	0.8	literature ^(a)		
δ	discounting rate	0.994	K_t/Y_t ^(b)	2.9 OECD	2.9
Firm					
α	capital share	0.33			
d	1-year depreciation	0.06			
Government					
τ_c	consumption tax	0.044	$\tau_c C_t/Y_t$	2.8% OECD	2.8%
τ_k	capital tax	0.243	$\tau_k K_t/Y_t$	5.4% OECD	5.4%
ρ_m	benefits scaling factor	0.55	$\sum_{j=\bar{J}}^J N_{j,t} b_{j,t}/Y_t$	5.0% BEA(NIPA)	5.0%
τ	social security contr.	0.075	soc. sec. deficit as % GDP	0.00%	0.00%
τ_l	labor tax ^(c)	0.037	$\sum_{j=1}^{J-1} N_{j,t} \int_{\Omega} \mathcal{T}(y_{j,t}(s_{j,t})) d\mathbb{P}_{j,t}/Y_t$	9.2% OECD	9.2%
λ	labor tax progression	0.137	earnings distribution	Holter et al. (2019)	
Wage process					
$e_{j,t}$	age-specific profile			Borella et al. (2018)	
σ_0^2	initial variance			Borella et al. (2018)	
ϱ	shock persistence			Borella et al. (2018)	
σ^2	shock variance			Borella et al. (2018)	

Notes:

We use NIPA for 2011-2015 to obtain macroeconomic aggregates. We use OECD data for 2011-2015 to obtain five-year average share of tax revenues in GDP. We follow Mendoza et al. (1994) in classifying categories of tax revenues to tax types, see Table C1 in the Appendix for details.

^(a) Calibration for alternative values of the Frisch elasticity are provided in Table C2 in the Appendix

^(b) This implies an interest rate 5.3%. For reference, Nishiyama and Smetters (2007) calibrate to an interest rate of 6.3% for mid 2000s.

^(c) Effective tax rate for average income is equal to 13.5%, in line with 11.3% reported by Holter et al. (2019).

consumption tax rate is set at 4.4%, consistent with a 2.8% consumption tax revenue-to-GDP ratio. These ratios are based on OECD data (see Table C1).

Labor income tax parameters are set to match both micro and macro targets. Specifically, we follow Holter et al. (2019) and set $\lambda = 0.137$ and $\tau_l = 0.037$ to replicate the observed elasticity of post-tax to pre-tax income, and to match a 9.2% labor tax revenue-to-GDP ratio.

In the initial steady-state, the government debt-to-annual-GDP ratio is set at 100%, reflecting recent U.S. fiscal conditions.¹¹ In the reform scenario, government debt is held constant in per capita terms rather than as a share of GDP. The government budget is balanced by government consumption G , which settles at 14% of GDP—within the range implied by NIPA accounts.

Firms We set the output elasticity with respect to capital to 0.33, a standard value in the macroeconomic literature. The annual depreciation rate is set at 6%. The resulting investment-to-GDP ratio in the model is 22.1%, closely matching the average observed in NIPA data for the

¹¹This value is higher than in earlier studies, consistent with updated U.S. debt levels.

period 2011-2015.

Productivity growth The model assumes labor-augmenting technological progress, defined as $\gamma_{t+1} = z_{t+1}/z_t$. While there is ongoing debate about the long-term outlook for U.S. productivity growth (e.g., Fernald and Jones 2014, Gordon 2016), we follow standard practice and set the annual growth rate to 2%. Importantly, this growth rate is assumed to be identical across both the baseline and reform scenarios, as both systems are modeled as pay-as-you-go.

5 Results: Steady-state

We implement the reform as described in Section 3: we change the formula for pensions from redistributive to non-distortionary and we use increased labor income tax revenue to finance lump-sum transfers to all individuals in a fiscally neutral manner. We organize the discussion of the results as follows. First, we show the three effects identified in the stylized model—namely, the reduction in the labor wedge, the decline in pension-based redistribution, and the increase in tax-based redistribution—operating in the computational model. Second, we demonstrate that the reduction in the labor wedge leads to a non-negligible increase in labor supply. Third, we present the welfare consequences of the reform. Finally, we examine its macroeconomic and fiscal implications, emphasizing the critical role played by the strength of the labor supply response. Throughout this chapter, we focus on steady-state outcomes. In the next chapter, we extend the analysis to study the effects of the reform along the transition path.

5.1 Efficiency Effect: Labor Wedge

We operationalize distortions to labor supply decisions as labor wedges (Chari et al. 2007, Berger et al. 2019, Boar and Midrigan 2020). Consider the labor supply choice of households. With marginal labor income tax denoted as $\mathcal{T}'(y_{j,t}(s_{j,t}))$, the first-order condition is given by:

$$\phi \ell_{j,t}(s_{j,t})^{\frac{1}{\eta}} = \frac{c_{j,t}(s_{j,t})^{-\sigma}}{1 + \tau_c} [1 - (1 - \tau)\mathcal{T}'(y_{j,t}(s_{j,t})) - \tau(1 - v_{j,t})] w_t \omega_{j,t}(s_{j,t}), \quad (22)$$

where $v_{j,t}$ determines implicit marginal tax stemming from social security.¹² In the stylized model, the implicit tax associated with pension system contributions is defined and characterized by equations (A13) and (A16).

Notice that the implicit marginal tax due to social security may be negative in the reform scenario, due to the annuitization provided by the social security system. Indeed, under the reformed social security, $v_{j,t}$ may exceed one.

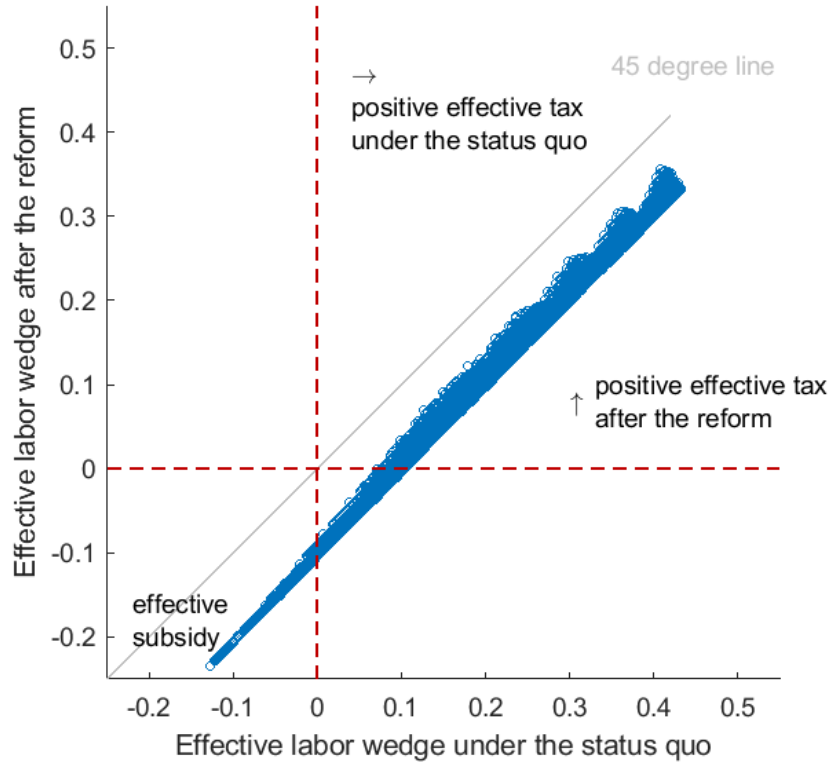
¹²For details on the implicit tax associated with social security, see Appendix B.2.

Following Cociuba and Ueberfeldt (2010), we measure labor wedges as the discrepancy between the household's marginal rate of substitution between labor and consumption and the wage. The labor wedge faced by household at age j at time t , characterized by the state $s_{j,t}$, is defined as:

$$\vartheta_{j,t}(s_{j,t}) = \frac{(1 - \tau)\mathcal{T}'(y_{j,t}(s_{j,t})) + \tau(1 - v_{j,t}) - 1}{1 + \tau_c} + 1. \quad (23)$$

This formula is the direct analog of equation (A18) from the stylized model.

Figure 1: Effective Labor Wedge Before and After the Reform



Notes: The figure portrays the values of the effective labor wedge $\vartheta_{j,t}(s_{j,t})$ across positive-probability combinations of states (a total of 2.34 million plotted state-age outcomes) under both the status quo and the reform. These values are computed using equation (23).

Figure 1 scatters the age- and state-specific labor wedges $\vartheta_{j,t}(s_{j,t})$, as defined by equation (23), before and after the reform. The points lie below the 45-degree line, indicating that across the entire state space, the labor wedge is lower after the reform.

Importantly, neither the parameters of the tax system nor the social security contributions are changed relative to the status quo. Yet, the decline in labor wedge is substantial and comprehensive. This reflects the efficiency gain from the social security reform. In the baseline system, agents perceive social security contributions as a tax, while after the reform, they view them as a source of future income.

Thus, even though the computational model does not yield an analytical expression for the

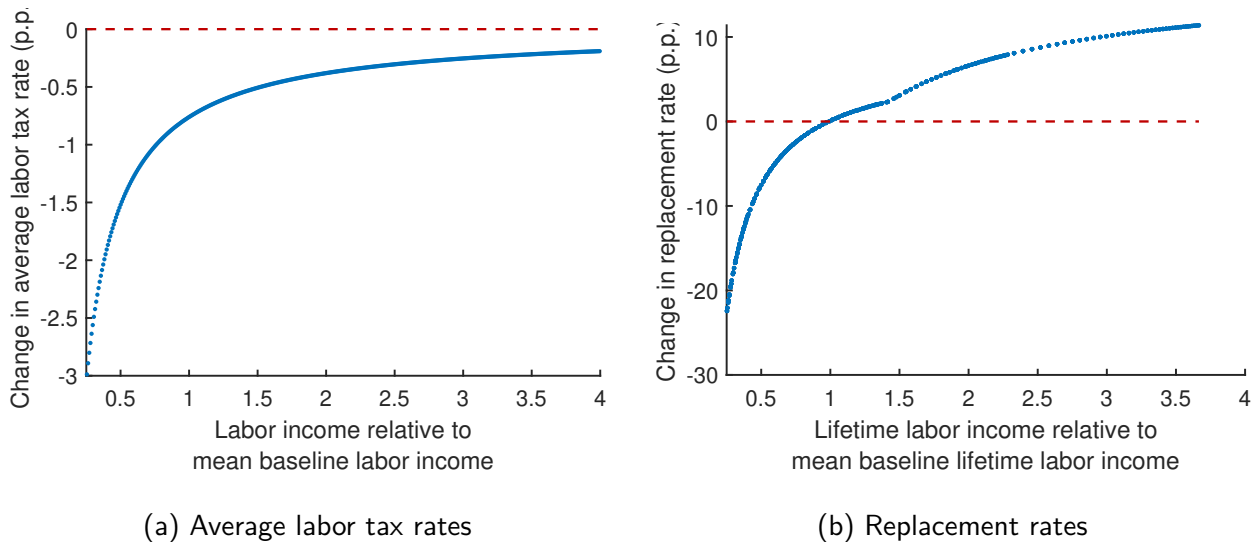
labor wedge as in the stylized model, Figure 1 confirms that the same positive efficiency effect emerges. The implications for labor supply are discussed in section 5.3.

5.2 Tax-Based and Pension-Based Redistribution

In the stylized model, we argued that the reform reduces redistribution within the pension system while enhancing redistribution through the tax system. Here, we verify whether this pattern holds in the more realistic computational model. To do so, we examine how average tax rates and replacement rates change as a result of the reform—in other words, we study the extent to which insurance is shifted from the social security system to the tax system.

Panel (a) of Figure 2 shows how the reform affects average labor taxation across the distribution of instantaneous income. The results indicate that the reform strengthens redistribution through the tax system: average tax rates decline more for lower-income individuals than for higher-income ones. Consequently, the tax system provides greater implicit insurance. Specifically, following the reform, average tax rates for low-income individuals decrease by up to 3 percentage points relative to the status quo, while for high-income individuals, the reduction is smaller but still positive at around 0.2 percentage points. Overall, the reform leads to a broad-based decline in average labor tax rates across the income distribution.

Figure 2: Changes in Average Labor Tax Rates and Replacement Rates



Notes: The left panel shows the change in the average labor tax rate between the reform and the status quo across percentiles of instantaneous labor income. Negative values indicate a reduction in taxation. The right panel shows the change in replacement rates between the two systems across percentiles of lifetime labor income at retirement age. Negative values indicate a decline in replacement rates. The replacement rate is defined as the ratio of Social Security pension benefits received at retirement to the retiree's average labor income. Levels are reported in Figure E1 in Appendix E.

Panel (b) of Figure 2 shows the change in replacement rates between the reform and the

status quo, across the distribution of average labor income at retirement under the status quo. Here, the replacement rate is defined as the ratio of pension benefits received at retirement to the average lifetime labor income of the retiree. The reform lowers replacement rates for low-income individuals—by about 22 percentage points—while raising them for individuals with above-average lifetime income—by about 11 percentage points. This shift reduces redistribution within the pension system.

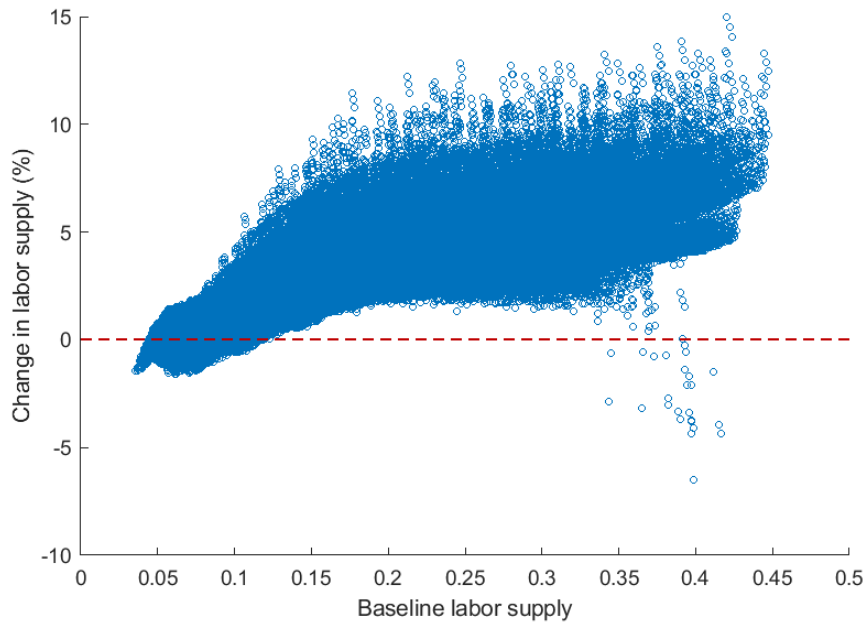
Taken together, these results confirm that in the large-scale computational model, the reform indeed shifts the burden of redistribution from the pension system to the tax system.

5.3 Labor supply

As we showed in the stylized model, the increase in labor supply is crucial for the success of the reform. In the stylized setting, we assumed GHH preferences, where there is no income effect, so labor supply depends directly on the labor wedge. In contrast, the computational model features a more general utility function, which features both a substitution effect and an income effect—the latter dampening the labor supply response to changes in net wages.

Figure 3 illustrates the labor supply response to the reform across realizations of productivity shocks, relative to the status quo. Consistent with the stylized model, labor supply increases for nearly all individuals.

Figure 3: Labor Supply Response to the Reform



Notes: The figure shows the percentage change in labor supply after the reform relative to the status quo. Each dot represents an individual in a given state, identified by the realization of idiosyncratic productivity shocks. A version of this figure that accounts for the probability measure $\mathbb{P}_{j,t}$ is available in Appendix E (see Figure E2).

Several economic forces drive this outcome. First, the reduction in the labor wedge generates a substitution effect that increases labor supply. Second, the decline in pensions for low-productivity agents induces a negative income effect, further encouraging work effort, while the increase in pensions for high-productivity agents generates a positive income effect, reducing their labor supply. Third, the lump-sum transfer induces a positive income effect across all individuals, tending to lower labor supply. Overall, the substitution effect dominates, explaining the widespread increase in labor supply observed after the reform.

The mean and standard deviation of labor supply changes across different productivity realizations are reported in Table 2, using the probability measure $\mathbb{P}_{j,t}$ to weight observations according to the distribution of the population.

Table 2: Average and standard deviation of labor supply response across productivity shock realizations

Productivity Shock	Mean Labor Supply Change	Std. Dev. of Change
ϵ^1	1.99	2.51
ϵ^2	3.31	1.45
ϵ^3	3.52	1.30
ϵ^4	3.38	1.14
ϵ^5	2.67	0.95

Notes: This table reports the mean and standard deviation of percentage changes in labor supply in response to a social security reform, conditional on five different realizations of idiosyncratic labor productivity shocks $\hat{H} = \{\epsilon^1, \epsilon^2, \epsilon^3, \epsilon^4, \epsilon^5\}$. Values are expressed in percent.

We find that labor supply increases by 3.52% on average at the median productivity realization, where the response is the strongest. The response remains elevated for realizations one level lower and higher than the median, at 3.31% and 3.38%, respectively. Labor supply rises by 2.67% for the highest shock realization and by 1.99% for the lowest shock realization. This pattern indicates that the distribution of responses exhibits a hump-shaped pattern, with the largest response occurring at the center of the productivity distribution. At the same time, highest-productivity individuals are more responsive to the reform than the lowest-productivity ones.¹³ Note that responses above median are typically on a higher base.

The standard deviations reported in Table 2 provide additional context on the variability of responses within each productivity group, ranging from 2.51 percentage points at the lowest productivity level to 0.95 at the highest. At the median productivity level, the standard deviation is 1.30 percentage points. Thus, responses are more heterogeneous for low income individuals and more homogeneous for high income individuals.

The reform partially addresses concerns raised in the literature regarding incentive alignment across the income distribution. For instance, Heathcote et al. (2008) argue that greater income dispersion can be socially desirable if high-productivity individuals increase labor supply while low-productivity individuals reduce it. Similarly, Huggett and Parra (2010) find that under the current

¹³All these differences between these means are statistically significant at conventional levels.

U.S. system, high-productivity individuals work too little and low-productivity individuals work too much relative to the social optimum. Our reform moves in this direction by eliciting stronger labor supply responses among higher-productivity workers, but it does not reduce labor supply at the bottom. Instead, it increases labor supply across the board, with stronger responses among high-productivity workers than among the lowest-productivity workers, although the largest response occurs near the middle of the productivity distribution.

5.4 Welfare

The results presented so far validate that the social security reform, accompanied by the lump-sum transfers, produces the effects emphasized in the stylized model. First, there is an efficiency effect stemming from the reduction of the labor wedge, which benefits all agents. Second, a pension redistribution effect that advantages high-income individuals while disadvantaging low-income individuals. Third, a tax system redistribution effect that works in the opposite direction. Overall, the net effect is primarily quantitative. For the preferred Frisch elasticity of 0.8, we find that the ex ante welfare gain (under the veil of ignorance), expressed in consumption equivalent and computed according to equation (B15), amounts to 0.30% of lifetime consumption. Thanks to the labor wedge reduction, the increase in tax revenues creates space for greater labor tax progression, which can substitute, at least partially, for the loss of insurance due to reduced redistribution in the social security system.

The intuitions developed in the stylized model in Section 2 suggest that labor supply elasticity plays a paramount role in determining both the sign and the magnitude of the response to the reform. To quantify this insight, we present in Figure 4 results for alternative calibrations of the Frisch elasticity. Calibrated parameters are reported in Table C2 in the Appendix. According to Chetty, Guren, Manoli and Weber (2011), values for aggregate hours elasticity ranging from 0.6 to 0.8 are consistent with macroeconomic data, although microeconomic studies suggest higher values. The vertical dashed line signifies our preferred calibration of 0.8.¹⁴ Our results show that, at this value, the reform delivers positive welfare gains. The results show that for higher values of the Frisch elasticity the welfare effects become larger.

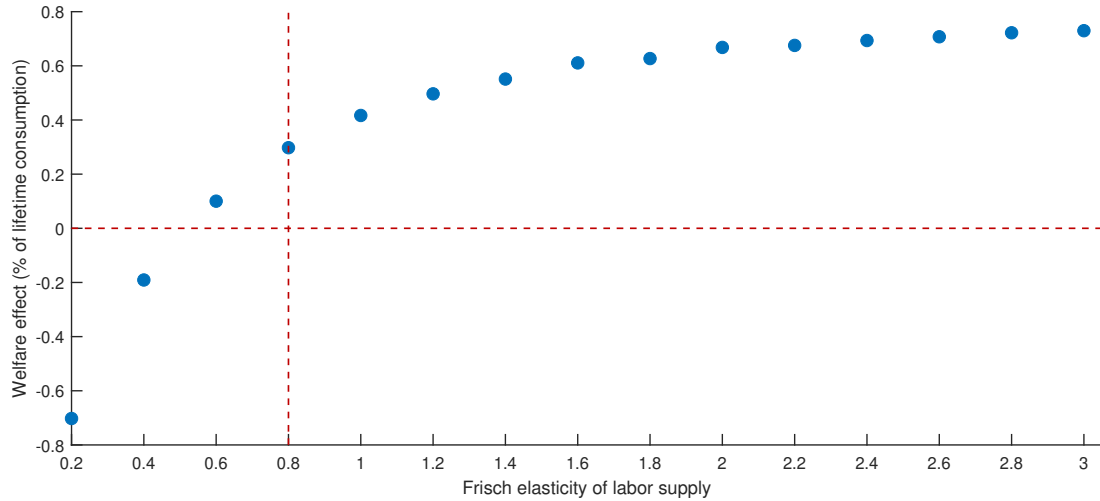
However, it is important to note that all of the analysis conducted in this section thus far is based on steady-state comparisons, which abstract from medium-term dynamics. Since welfare outcomes during the transition can differ substantially from long-run outcomes—particularly in the context of large reforms such as social security privatization—it is crucial to also assess the welfare effects along the transition path. Therefore, in the next chapter, we extend our analysis to include the transition dynamics.

Notably, our findings align with the conclusions of Ferriere et al. (2023), who show that, within an optimal fiscal policy framework, transfers should be substantially higher than their

¹⁴See Chetty, Guren, Manoli and Weber (2011), Chetty, Friedman, Olsen and Pistaferri (2011), Chetty (2012).

current levels in the United States and financed through a moderately progressive income tax system.

Figure 4: Welfare Effects Across Alternative Calibrations of the Frisch Elasticity



Notes: Each dot represents the welfare effect under the veil of ignorance for a given value of the Frisch elasticity; see equation (B15). The welfare effect is expressed as a consumption-equivalent change in lifetime consumption. Calibrated parameters are as reported in Table C2 in the Appendix. The vertical dashed line denotes our preferred calibration, based on consensus estimates of plausible Frisch elasticity values in the literature.

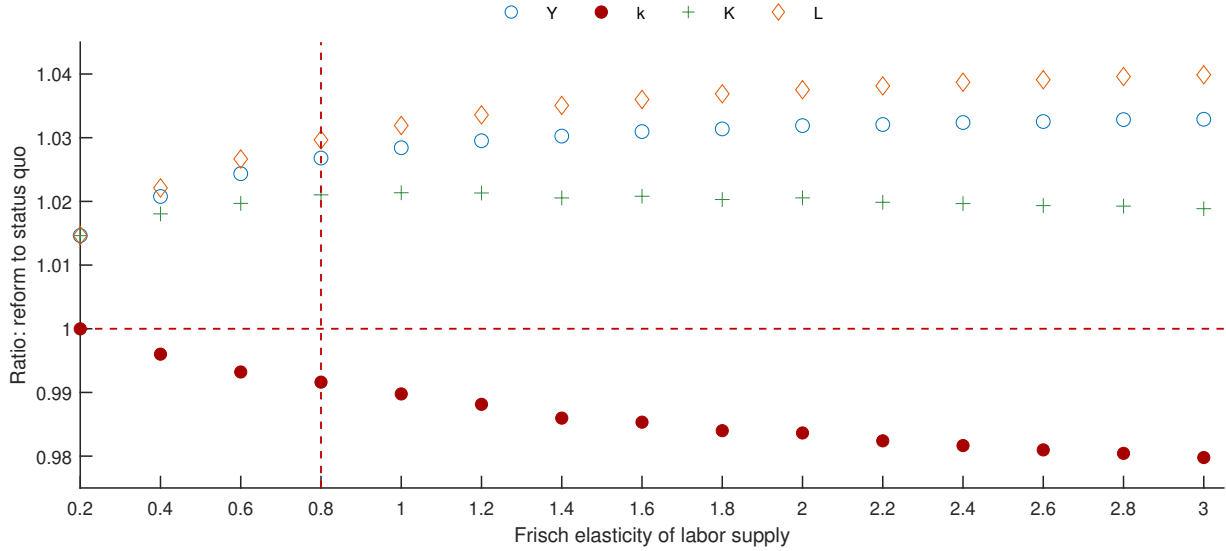
5.5 Macroeconomic and fiscal consequences

Figure 5 presents the macroeconomic adjustments across different Frisch elasticity calibrations, quantifying the intuitions discussed earlier. Labor supply increases by approximately 3% for plausible values of the Frisch elasticity in the range of 0.6 to 0.8, and approaches 4% for the highest elasticity values considered. Simultaneously, the increase in labor income combined with lump-sum transfers, boosts savings and thus capital accumulation. Moreover, the rise in labor supply increases the return to capital, further encouraging capital accumulation. Nevertheless, capital grows by less than labor supply, leading to a decline in the capital-labor ratio. The expansion of both capital and labor results in higher aggregate output.

These macroeconomic adjustments, in turn, facilitate fiscal adjustments, which are illustrated in Figure 6. The increase in labor supply generates higher labor tax revenues, which emerge as the primary source of additional fiscal capacity. The magnitude of this increase is substantial: for our preferred Frisch elasticity of 0.8, labor tax revenues rise by approximately 0.44% of baseline output. To put this figure in context, total labor tax revenues account for approximately 9.2% of GDP in the baseline. Other tax revenues also increase, as greater capital accumulation and higher consumption expand their respective tax bases, thereby creating additional fiscal space for higher lump-sum transfers to all individuals. The only fiscal adjustment that reduces available

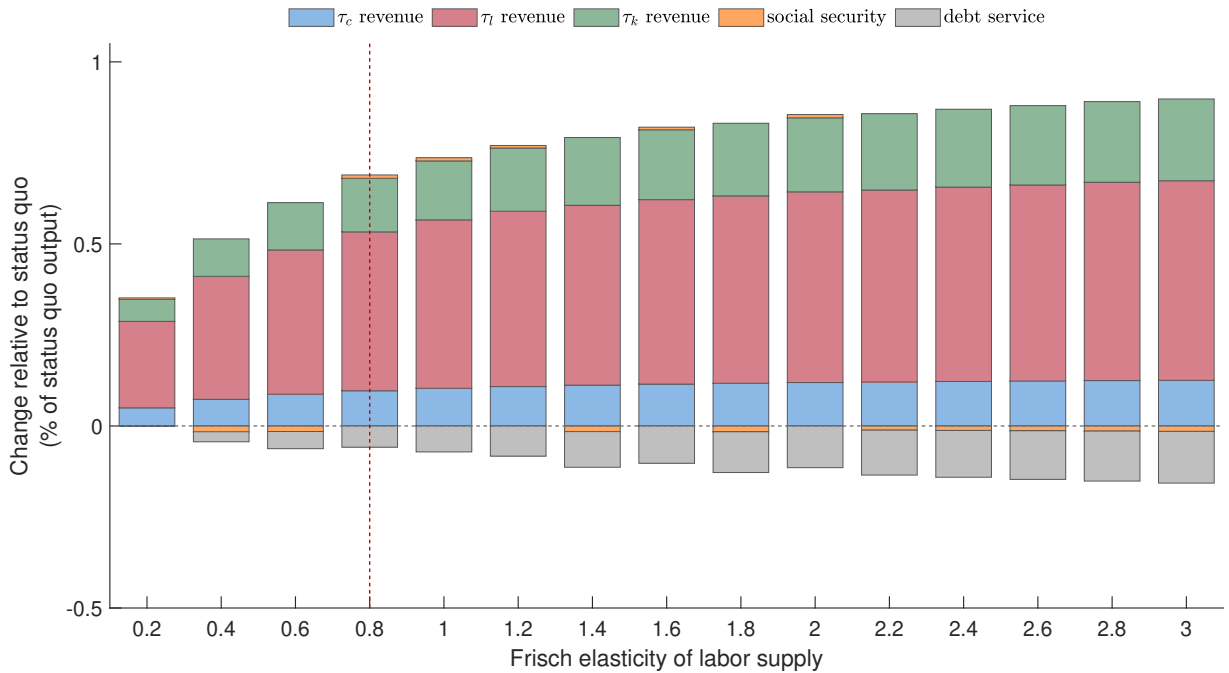
fiscal space stems from debt: debt servicing costs rise because the higher return to capital, resulting from the lower capital-labor ratio, increases the interest rate.

Figure 5: Macroeconomic Adjustments Across Alternative Calibrations of the Frisch Elasticity



Notes: The figure displays the ratios of selected macroeconomic variables—aggregate output (Y), capital per effective unit of labor (k), aggregate capital (K), and effective aggregate labor (L)—between the reform and the status quo scenarios, across different values of the Frisch elasticity. Values above one indicate that the variable is higher under the reform. The vertical dashed line denotes the preferred calibration.

Figure 6: Fiscal Position Changes Across Alternative Calibrations of the Frisch Elasticity



Notes: The figure shows changes in fiscal revenues and expenditures between the reform and status quo scenarios across values of the Frisch elasticity. Positive values increase fiscal space, whereas negative values reduce it. Changes are expressed as a percentage of status quo aggregate output. The vertical dashed line denotes the preferred calibration.

The analysis above highlights two main findings. First, redistribution through the tax system can effectively substitute for the redistribution currently provided by U.S. social security. Second, the extent to which this compensation occurs depends crucially on the labor supply response. For plausible values of the Frisch elasticity, the welfare implications of reforming social security in the United States are positive, provided that the additional tax revenue is used to enhance redistribution through labor taxation.

5.6 Distributions

For illustrative purposes, Figure 7 depicts the distribution of the ex post welfare effects between the two steady-states. We compute welfare outcomes across all shock realizations by evaluating welfare at each point in the $s_{j,t}$ state space and adjusting for the corresponding probability measure. The figure shows that, from an ex post perspective, approximately 90% of lifetime paths (weighted by the probability measure) experience a welfare gain.

Nonetheless, there are individuals for whom welfare losses persist, despite the provision of lump-sum transfers. For these individuals, the reduction in income resulting from the less redistributive pension system is too large to be offset by the lump-sum transfers and the associated efficiency gains. We interpret this finding as evidence that the optimal combination of social security reform and increased labor tax progression should be designed in a more targeted manner, specifically to protect vulnerable groups from welfare losses.

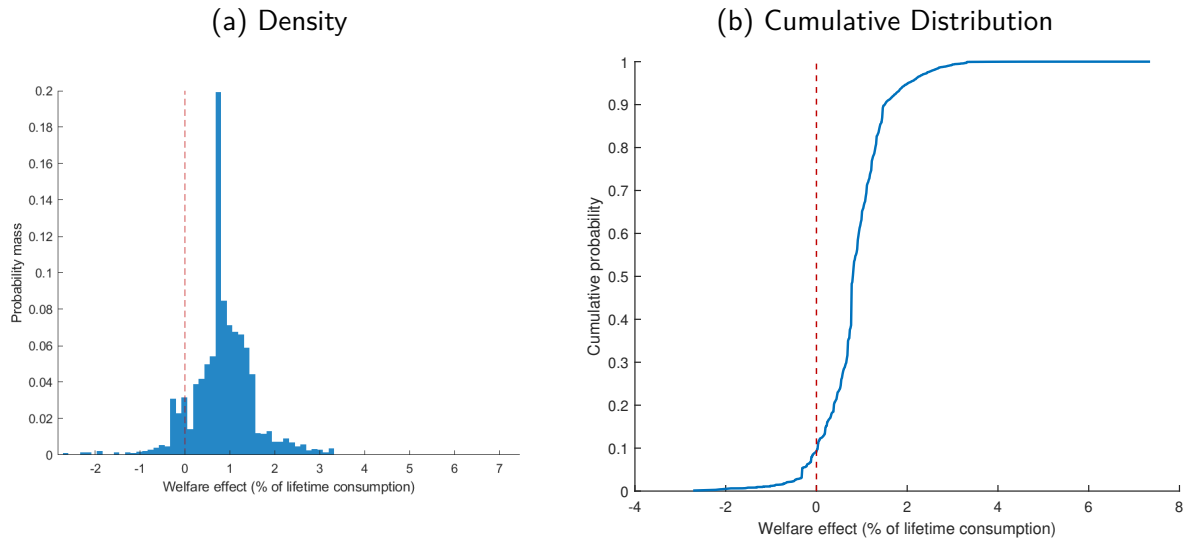
5.7 Sensitivity Analyses

To assess the robustness of our findings, we conducted a set of sensitivity analyses, reported in full in Appendix D. We focused on three key dimensions: demographic trends, the behavioral response of agents to the reform, and the fiscal closure used to redistribute the gains from the reform.

First, we examined how increased longevity, consistent with demographic projections for 2080, affects the results. We found that longer life expectancy amplifies the welfare gains from the reform. This is driven by higher capital accumulation and a smaller decline in the capital-labor ratio, which together boost labor supply and generate larger efficiency gains. Notably, even at lower values of the Frisch elasticity, the reform delivers positive welfare effects under the aging scenario.

Second, we investigated the degree to which individuals internalize the changes in social security contributions. Our baseline results assume full internalization, i.e., that individuals perceive pension contributions as deferred income rather than a tax. When we gradually relax this assumption, we find that the reform still produces welfare gains under partial internalization: with population aging, welfare gains emerge once about 60% of incentives are internalized, while under current demographics the corresponding threshold is roughly 80%. This finding implies

Figure 7: Distribution of Welfare Effects: Ex Post Evaluation



Notes: Welfare effects are expressed as consumption equivalents in percent of lifetime consumption. The figures portray the outcomes of 1.74 million positive-probability simulations used in the figure. For each potential realization of the lifetime path of shocks, we use the policy functions to generate the corresponding paths of consumption and labor supply under both the status quo and the reformed system. We then compute the welfare effect of the reform following equation (B15) for each simulated path. This procedure allows us to obtain the distribution of welfare effects across all simulations, weighted by the corresponding probability measure.

that moderate levels of economic awareness are sufficient for the reform to succeed in enhancing welfare. Taken together, these results suggest that the welfare improvements are robust to plausible variations in demographic structure, behavioral assumptions.

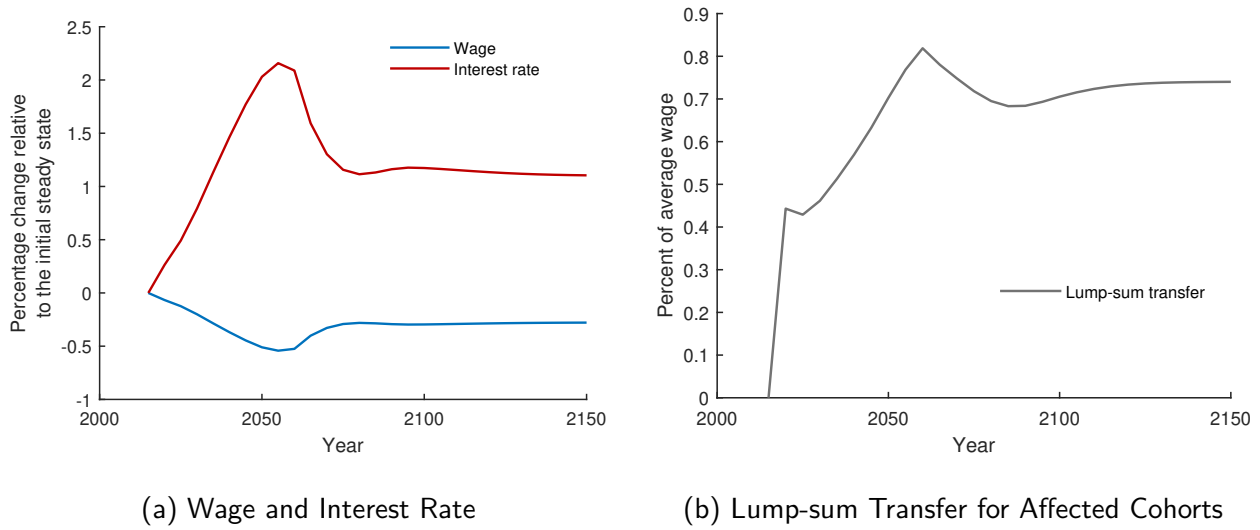
6 Results: Transition path

A large body of literature points out that the results from steady-state analyses of pension reform may differ from those accounting for the transition path. In our reform—which modifies the pension formula while maintaining the PAYG structure—our stylized model suggests that the transition dynamics do not differ substantially from the long-run steady-state outcomes.

However, our more realistic computational model departs from the stylized version in two key dimensions. First, it features a richer demographic structure: 16 overlapping cohorts are active in each period, with one period corresponding to five years. Second, the computational model operates in a general equilibrium framework, meaning that prices, including wages and interest rates, adjust over time.

In this framework, we assume that individuals already participating in the labor market at the time of the reform retain the original (baseline) pension formula, while only those entering the labor market from 2020 onward are subject to the new, reformed formula. Although this allocation rule is admittedly somewhat arbitrary, it serves to highlight the trade-offs that emerge

Figure 8: Macroeconomic Prices and Lump-Sum Transfers on the Transition Path



Notes: Panel (a) reports changes in wages and interest rates relative to the initial steady state. Panel (b) reports lump-sum transfers received by cohorts subject to the reformed pension formula, expressed as a percent of the average wage.

along the transition path in a clear and tractable manner. Similarly as in the stylized model, we assume that any additional tax revenues generated by the reform are redistributed in the form of lump-sum transfers, but only among the cohorts affected by the new pension rules—that is, those entering the labor market in 2020 or later.

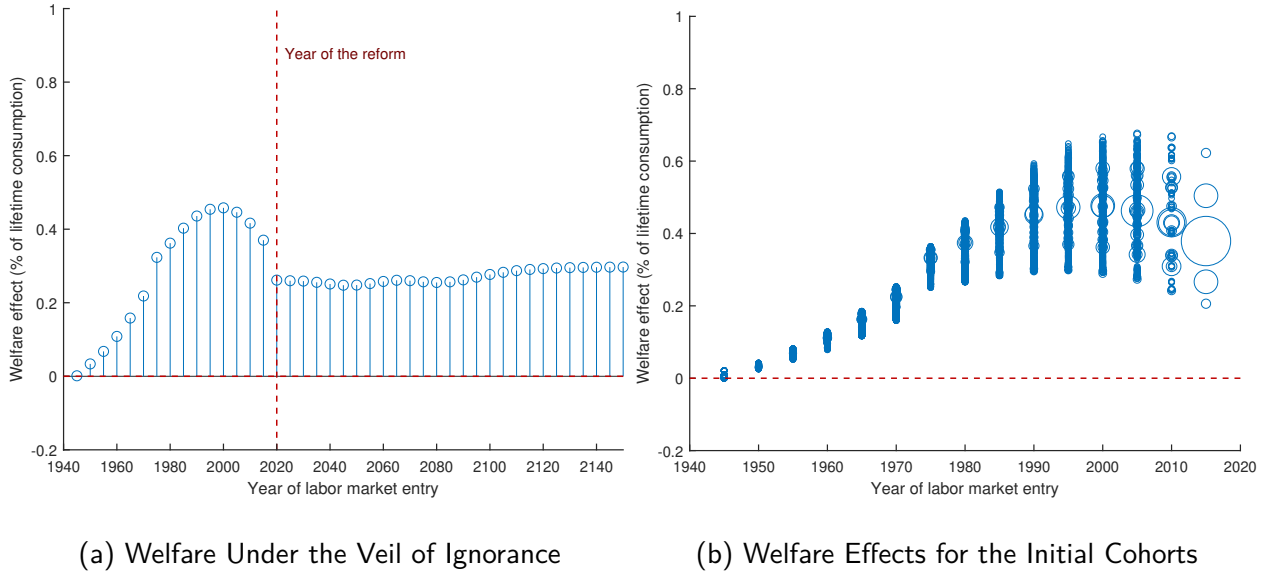
The general equilibrium adjustments in our model are as follows. Agents entering the labor market experience a decline in the labor wedge, which prompts them—and all future generations—to increase their labor supply. With reduced redistribution in the pension system and higher incomes resulting from increased labor supply, these individuals also increase their savings, leading to an overall rise in the capital stock (for further details, please refer to Figure F1a in Appendix F). However, the increase in the capital stock is delayed relative to the immediate rise in labor supply and is lower in magnitude.

As a result, capital per worker declines. Because capital adjusts more slowly than labor, this decline is more pronounced during the transition than in the final steady-state. This dynamic lowers wages and raises interest rates, as illustrated in Figure 8a. Additionally, the gradual increase in labor supply leads to higher labor tax revenue. Since lump-sum transfers are limited to individuals entering the labor market from 2020 onward—those subject to the new, reformed formula—these transfers increase immediately to levels comparable to those in the steady-state, as shown in Figure 8b. Consequently, the enhanced tax-based redistribution takes effect relatively quickly.

The timing and allocation of lump-sum transfers are important for interpreting the transition. In our reform experiment, transfers are directed to cohorts affected by the new pension rules, that

is, those entering the labor market from 2020 onward. This reflects the logic of the reform: tax-based redistribution is used to compensate the cohorts that lose part of the insurance previously embedded in the pension system. By contrast, older cohorts remain under the baseline pension formula and benefit from the reform through higher pension indexation and, in many cases, higher returns on savings, so there is no analogous need to compensate them through additional transfers.

Figure 9: Welfare Effects of the Reform Along the Transition Path



Notes: Welfare effects are expressed as consumption equivalents in percent of lifetime consumption. Panel (a): Each dot represents the welfare effect under the veil of ignorance for a given cohort. Panel (b): Each dot represents the welfare effect for a cohort defined by age, productivity shock, and accumulated assets at the time of the reform. The size of each dot corresponds to the relative size of that cohort.

Equipped with the analysis of the steady-state and the general equilibrium adjustments, we are ready to investigate the welfare effects of the pension system reform coupled with increased progressivity of the labor income tax system.

The welfare effects for different generations along the transition path are presented in Figure 9. Panel (a) illustrates the average welfare gain for individuals who are alive in the year of the reform (2020) as well as, under the veil of ignorance, for those entering the labor market during and after the reform. For individuals active at the time of the reform—whose income shocks have already been realized—we also examine the distribution of welfare outcomes within the cohort. Panel (b) displays this distribution of welfare effects, measured as consumption equivalents, across different individuals alive at the time of the reform.

We begin with the retired individuals at the moment of reform introduction. Although their pension formulas remain intact, they still experience welfare gains as a result of the reform.

First, their pensions are indexed to the growth rate of the aggregate wage bill. As the cohorts entering the labor market from the reform year onward increase their labor supply, the wage bill

risers slightly—leading to higher pension benefits for retirees. Second, as asset holders, retirees benefit from the increase in the interest rate brought about by the reform, which raises the return on their savings and thus enhances their lifetime wealth. Taken together, these two channels imply that all retired individuals benefit from the reform—this result is illustrated in Figure 9.

Next, we turn to individuals who are active in the labor market at the time of the reform. These workers continue to be covered by the baseline pension formula and therefore do not lose the redistribution embedded in the original system. In fact, they also benefit from slightly higher future pension indexation, resulting from the projected increase in the aggregate wage bill following the reform.

Additionally, these individuals—especially those closer to retirement—are net savers, so they benefit from higher interest rates. Although they experience a wage reduction, this negative effect is limited to the working period, whereas the positive impact of higher interest rates applies both during employment and in retirement. Overall, as illustrated in Figure 9, working-age individuals at the time of the reform benefit, with the gains being larger for middle-aged workers. This shows that the positive effects of higher pensions and increased interest rates outweigh the adverse impact of lower wages.

Finally, we turn to future generations—those entering the labor market in the year of the reform (2020) and thereafter. These cohorts are the first to be subject to the modified pension formula, which implies a loss of part of the insurance previously provided by the pension system—an effect that adversely impacts their welfare. At the same time, they benefit immediately from a reduced labor wedge, which boosts their labor supply, and they receive lump-sum transfers as part of enhanced tax-based redistribution.

Taken together, the balance of the three main forces—for plausible calibrations of the Frisch elasticity—proves to be positive. The key determinants of the reform’s impact in the steady-state—reduced pension insurance, improved labor incentives, and tax-based redistribution—remain largely unchanged along the transition path for these cohorts. Additionally, a temporary transition-specific effect arises: these individuals enter the labor market without prior savings and thus face slightly lower wages—the primary price variable affecting them. Nevertheless, this transitory wage effect has only a minimal impact on the overall positive welfare outcome.

Summarizing, the pension reform yields overall welfare gains for all cohorts, driven by different mechanisms. Retirees benefit from higher pension indexation linked to a growing wage bill and from increased interest rates that enhance the value of their savings. Workers active at the time of the reform retain the original, more redistributive pension formula while also gaining from improved pension indexation and higher returns on savings, which more than offset the negative impact of lower wages. Future generations, although facing reduced pension insurance, experience stronger labor supply incentives and receive lump-sum transfers as part of enhanced tax-based redistribution. For plausible values of the Frisch elasticity, these combined effects result in net welfare improvements. These results mirror the findings from the stylized model, providing

additional effects arising from general equilibrium. In this respect, our analysis complements the framework of Hosseini and Shourideh (2019), which studies efficiency gains arising from incomplete annuity markets, whereas our mechanism operates through incomplete insurance against idiosyncratic labor income risk.

7 Conclusions

In this paper, we revisit the welfare implications of social security reform in an environment with idiosyncratic income risk. While the existing U.S. social security provides partial insurance through a redistributive benefit formula, it also distorts labor supply. The standard trade-off in the literature has been that reducing these distortions improves efficiency but comes at the cost of lower insurance. We propose to complement social security reform with increased progressivity of labor taxation. This reform addresses both concerns simultaneously: it links pension benefits to contributions (thus reducing labor market distortions) while restoring insurance (through increased progressivity of the labor income tax).

In a stylized model, we illustrate the mechanism at play: a reduction in the labor wedge increases labor supply and tax revenues, enabling lump-sum transfers that partially or fully offset the loss of pension-based redistribution. We then quantify this reform in a full overlapping generations model calibrated to the U.S. economy. Our simulations show that a fiscally neutral reform generates welfare gains under plausible calibrations of the Frisch elasticity. For our preferred value of 0.8, the reform yields a lifetime consumption equivalent gain of 0.30%. Welfare gains are larger if the labor supply responds more strongly to reduced distortions. Along the transition path, we find that the results align with the implications of the steady-state analysis: under plausible calibrations of the Frisch elasticity, all generations benefit, making the reform Pareto-improving. In general equilibrium, increased labor supply generates also benefits through relative prices of capital and labor.

Our results contribute to the literature on optimal taxation and pension reform by showing that, under realistic conditions, redistribution can be shifted from pensions to progressive taxation without sacrificing insurance or equity. We show that when the market for income risk is missing, partial insurance in labor tax progression is effectively more efficient than redistribution through social security. We thus offer a politically and economically viable reform blueprint that balances efficiency and redistribution in the face of aging populations and fiscal pressures.

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Online Appendix

Progressing Towards Efficiency: The Role of Labor Tax Progression in Reforming Social Security

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A Technical Derivations and Proofs for the Stylized Model

This appendix provides the algebraic details and proofs omitted from Section 2. We first restate key equilibrium conditions and then present formal proofs of the propositions and lemmas.

A.1 Model Details and Notation

Government budget constraint

We assume that the government must raise revenue $\mathcal{R}_t$ to finance an exogenously given level of government spending g_t , which grows at the constant rate γ . This revenue is collected via labor income taxes. Any revenue that exceeds government spending is redistributed as a lump-sum transfer μ_t . The government budget constraint is:

$$g_t + 2 \cdot \mu_t = \mathcal{R}_t \equiv \sum_{\theta \in \{\theta_H, \theta_L\}} \tau_\ell \omega_\theta w_t. \quad (\text{A1})$$

The government maintains a balanced budget. Allowing for public debt would not change the core insights of the model.

Social security formulas

The PAYG social security system is balanced in each period and features three alternative designs. We keep the overall contribution rate τ fixed across designs.

Lump-sum system. Each young agent pays a uniform contribution T_t^{LS} and receives an equal pension benefit in old age:

$$T_t^{LS} = T_t^{LS}(\theta_H) = T_t^{LS}(\theta_L) = \tau w_t \cdot \frac{1}{2} \sum_{\theta \in \{\theta_H, \theta_L\}} \omega_\theta \ell_{1,t}(\theta), \quad \tau^{BEV} = \tau^{BIS} = 0, \quad (\text{A2})$$

and

$$b_{2,t+1}^{LS}(\theta_H) = b_{2,t+1}^{LS}(\theta_L) = T_{t+1}^{LS}, \quad (\text{A3})$$

where contributions grow with in line with wage growth, $T_{t+1}^{LS} = (1 + \gamma)T_t^{LS}$.

Beveridgean system. Contributions are proportional to earnings at rate $\tau^{BEV} = \tau$ and pooled; all retirees receive the same benefit. Given that wages grow at the rate γ , $w_{t+1} = (1 + \gamma)w_t$, the pension benefits are given by:

$$b_{2,t+1}^{BEV}(\theta_H) = b_{2,t+1}^{BEV}(\theta_L) = \tau^{BEV} w_{t+1} \cdot \frac{1}{2} \sum_{\theta \in \{\theta_H, \theta_L\}} \omega_\theta \ell_{1,t+1}(\theta), \quad (\text{A4})$$

with $T_t^{LS} = \tau^{BIS} = 0$.

Bismarckian system. Contributions are proportional to earnings at rate $\tau^{BIS} = \tau$, and each retiree's benefit is proportional to her own past earnings:

$$b_{2,t+1}^{BIS}(\theta) = \tau^{BIS}(1 + \gamma)\omega_\theta w_t \ell_{1,t}(\theta), \quad b_{2,t+1}^{BIS}(\theta_H) > b_{2,t+1}^{BIS}(\theta_L), \quad (\text{A5})$$

with $T_t^{LS} = \tau^{BEV} = 0$. With $r = \gamma$, the implicit return on contributions equals wage growth.

Household budget constraints and preferences

For completeness, we restate the two-period budget constraints:

$$c_{1,t}(\theta) + a_{1,t+1}(\theta) = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t - T_t^{LS}, \quad (\text{A6})$$

$$c_{2,t+1}(\theta) = (1 + r)a_{1,t+1}(\theta) + b_{2,t+1}(\theta), \quad (\text{A7})$$

where

$$b_{2,t+1}(\theta) = b_{2,t+1}^{BEV} + b_{2,t+1}^{BIS}(\theta) + b_{2,t+1}^{LS}.$$

Combining (A6) and (A7) yields the lifetime budget constraint

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t - T_t^{LS} + \frac{b_{2,t+1}(\theta)}{1 + r}. \quad (\text{A8})$$

Preferences follow the GHH specification

$$U_t(\theta) = \frac{1}{1 - \sigma} \left(c_{1,t}(\theta) - \frac{\phi}{1 + \frac{1}{\eta}} (1 + \gamma)^t \ell_{1,t}(\theta)^{1 + \frac{1}{\eta}} \right)^{1 - \sigma} + \delta \frac{1}{1 - \sigma} \left(c_{2,t+1}(\theta) \right)^{1 - \sigma}, \quad (\text{A9})$$

with $\delta^{-1} = 1 + r$. Ex ante welfare under the veil of ignorance is

$$U_t = \sum_{\theta \in \{\theta_L, \theta_H\}} U_t(\theta). \quad (\text{A10})$$

A.2 Labor Wedge and Labor Supply: Derivation

To solve the model, it is convenient to use the marginal rate of substitution between labor and first-period consumption:

$$MRS_{(\ell_1, c_1)} \equiv - \frac{\partial U_t(c_{1,t}, \ell_{1,t}, c_{2,t}; \theta) / \partial \ell_{1,t}}{\partial U_t(c_{1,t}, \ell_{1,t}, c_{2,t}; \theta) / \partial c_{1,t}}. \quad (\text{A11})$$

Solving the household problem and using the budget constraints, the first-order condition for optimal labor supply can be written as

$$MRS_{(\ell_1, c_1)} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t + (v_{1,t}^{BEV} \cdot \tau^{BEV} + v_{1,t}^{BIS} \cdot \tau^{BIS})\omega_\theta w_t, \quad (A12)$$

The term $v_{1,t}$ denotes the share of current contributions that is returned in present value. It is defined as:

$$v_{1,t} = \frac{\frac{1}{1+r} \frac{\partial b_{2,t+1}(\theta)}{\partial \ell_{1,t}(\theta)}}{\tau \omega_\theta w_t}. \quad (A13)$$

Thus, $1 - v_{1,t}$ measures the fraction of the contribution rate that is not returned to the individual and therefore acts as a pure tax from the individual's perspective.

We define the labor wedge:

$$\vartheta_{1,t} \equiv 1 - (1 - \tau_\ell - (1 - v_{1,t}^{BEV})\tau^{BEV} - (1 - v_{1,t}^{BIS})\tau^{BIS}). \quad (A14)$$

If $v_{1,t} = 1$, contributions are fully internalized and do not add to the labor wedge. However, if $v_{1,t} < 1$, part of the contributions effectively acts as a tax, increasing the wedge.

Using the pension formulas (A4) and (A5), we obtain

$$\frac{\partial b_{2,t+1}^{BEV}(\theta)}{\partial \ell_{1,t}(\theta)} = 0 \quad \text{and} \quad \frac{\partial b_{2,t+1}^{BIS}(\theta)}{\partial \ell_{1,t}(\theta)} = \tau^{BIS}(1 + \gamma)\omega_\theta w_t. \quad (A15)$$

With $r = \gamma$ this implies

$$v_{1,t}^{BEV} = 0 \quad \text{and} \quad v_{1,t}^{BIS} = 1, \quad (A16)$$

so that

$$MRS_{(c_1, \ell_1)}(\theta) = (1 - \tau_\ell - \tau^{BEV})\omega_\theta w_t, \quad (A17)$$

and the wedges under Beveridgean and Bismarckian systems are

$$\vartheta_{1,t}^{BEV} = \tau_\ell + \tau^{BEV} \quad \text{and} \quad \vartheta_{1,t}^{BIS} = \tau_\ell. \quad (A18)$$

With GHH preferences, the first-order conditions yield labor supply

$$\ell_1(\theta) = \ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV})\omega_\theta \right]^\eta, \quad (A19)$$

which is the expression used in the main text. For the lump-sum and Bismarckian systems, $\tau^{BEV} = 0$.

A.3 Lifetime Budget Constraint and Redistribution

Substituting the pension formulas (A3)-(A5) into the lifetime budget constraint (A8), using $w_{t+1} = (1 + \gamma)w_t$ and $r = \gamma$, we obtain:

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t + \frac{\tau^{BEV} w_t}{2} \sum_{\theta' \in \{\theta_L, \theta_H\}} \omega_{\theta'} \ell_{1,t+1}(\theta'). \quad (\text{A20})$$

For the lump-sum and Bismarckian systems, i.e. $\tau^{BEV} = 0$, the present value of contributions equals the present value of benefits at the individual level, so those terms cancel out and (A20) collapses to the no-social-security case. Under Beveridge, the last term is non-zero and captures redistribution across types.

A.4 Pension Systems: Technical Details of the Comparison

Under the lump-sum system, contributions and benefits are fixed and cancel out, so labor supply and consumption choices are unchanged relative to the no-social-security benchmark.

Proposition 3 (Lump-Sum System Neutrality) *Lump-sum social security does not affect $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$ relative to the no-social-security case.*

Proof of Proposition 3: Under the lump-sum pension system, we have $\tau^{BEV} = \tau^{BIS} = 0$. Therefore, from equation (A19), labor supply is

$$\ell_1(\theta) = \ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell) \omega_\theta \right]^\eta, \quad (\text{A21})$$

for $\theta \in \{\theta_L, \theta_H\}$, which is identical to the no-social-security case.

From the government budget constraint (A1) it follows that μ_t remains unchanged relative to the no-social-security case. Given this, the rearranged lifetime budget constraint (A20) becomes

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = \omega_\theta w_t \ell_{1,t}(\theta) - \tau_\ell w_t \omega_\theta \ell_{1,t}(\theta) + \mu_t, \quad (\text{A22})$$

which is identical to the no-social-security case. Since neither the objective function nor the constraints are affected, the consumer's problem yields the same solution. Therefore, lump-sum social security does not impact $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$. ■

In the Bismarckian system, contributions and benefits move one-for-one with individual earnings. Since each household receives exactly what it pays in, there is no redistribution, and consumption-labor decisions remain unchanged. The system is therefore neutral.

Proposition 4 (Bismarckian System Neutrality) *Bismarckian social security does not affect $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$ relative to the no-social-security case.*

Proof of Proposition 4: Under the Bismarckian system, $\tau^{BEV} = 0$. Therefore, from equation (A19), labor supply is

$$\ell_1^{BIS}(\theta) = \ell_{1,t}^{BIS}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell) \omega_\theta \right]^\eta, \quad (\text{A23})$$

for $\theta \in \{\theta_L, \theta_H\}$, identical to the no-social-security case.

From the government budget constraint (A1), the transfer μ_t is also unchanged relative to the no-social-security case. Therefore, the household faces the same lifetime budget constraint as in (A22), the no-social-security benchmark, and the structure of the problem it solves is identical. Since both the household's objective function and its constraints are unchanged, the optimal choices of consumption in each period, savings, and labor supply coincide with those in the no-social-security case. Thus, the Bismarckian system is neutral. ■

Unlike the previous two systems, the Beveridgean design redistributes income: workers contribute in proportion to earnings but receive identical benefits. This redistribution from high- to low-income individuals comes at the cost of a higher labor wedge.

Proposition 5 (Beveridgean System Effects) *The Beveridgean social security reduces labor supply and redistributes from high-income to low-income individuals relative to both the no-social-security and lump-sum social security cases.*

Proof of Proposition 5: Under the Beveridgean system, contributions proportional to earnings introduce a wedge in the consumption-labor decision. From (A19), labor supply is

$$\ell_1^{BEV}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV}) \omega_\theta \right]^\eta, \quad (\text{A24})$$

so for $\tau^{BEV} > 0$ labor is strictly lower than in the lump-sum or Bismarckian cases.

Furthermore, the Beveridgean system redistributes from high-income to low-income individuals. From the lifetime budget constraint (A20), the net present value of pensions is

$$\begin{aligned} NPV_t^{Pen, BEV}(\theta_L) &= \tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)] > 0, \\ NPV_t^{Pen, BEV}(\theta_H) &= -NPV_t^{Pen, BEV}(\theta_L) < 0. \end{aligned} \quad (\text{A25})$$

Thus the Beveridgean system reduces labor supply and redistributes from high- to low-income agents. ■

A.5 Beveridgean-to-Bismarckian Reform: Technical Details of Steady-State Analysis

We begin by observing several important features of the model. First, regardless of the social security arrangement, high-productivity households (denoted with θ_H) supply more labor than low-productivity households (denoted by θ_L), as implied by (A19). Second, the ratio of labor

supply between high- and low-productivity households is constant across pension systems. It depends only on their relative productivity levels and the Frisch elasticity. Specifically, from equation (A19), labor supplies of the two types under any system with contribution rate τ^{BEV} satisfy:

$$\frac{\ell^{BEV}(\theta_H)}{\ell^{BEV}(\theta_L)} = \frac{\ell^{BIS}(\theta_H)}{\ell^{BIS}(\theta_L)} = \left(\frac{\omega_H}{\omega_L} \right)^\eta \equiv \varpi^\eta > 1. \quad (\text{A26})$$

Third, the percentage change in labor supply induced by the reform—from Beveridgean to Bismarckian pensions—is the same across types. Using (A19), this change is given by:

$$\frac{\Delta \ell(\theta)}{\ell^{BEV}(\theta)} \equiv \frac{\ell^{BIS}(\theta) - \ell^{BEV}(\theta)}{\ell^{BEV}(\theta)} = \left(\frac{1 - \tau_\ell}{1 - \tau_\ell - \tau^{BEV}} \right)^\eta - 1 \equiv \xi^\eta - 1. \quad (\text{A27})$$

Next, to examine the welfare effect of the reform, it is useful to focus on how the right-hand side of the lifetime budget constraint—given by equation (A20)—changes when the Beveridgean system is replaced with the Bismarckian one. This change can be decomposed into three distinct effects, reiterated here from the main text: (i) an **efficiency effect** stemming from reduced labor market distortion, (ii) a **reduction in redistribution through pensions**, (iii) an **increase in redistribution via tax system**.

To formalize this decomposition, we subtract the budget constraint under the Beveridgean system from the corresponding expression under the Bismarckian system. Rearranging terms allows us to isolate the three channels through which the reform impacts household income. For low-productivity individuals (the analysis for high-productivity individuals is analogous), the reform's effect is given by:

$$\begin{aligned} RHS_t^{BIS}(\theta_L) - RHS_t^{BEV}(\theta_L) &= \underbrace{\omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}_{\text{efficiency}} - \underbrace{\frac{1}{2} \tau w_t (\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L))}_{\text{redistribution via social security}} \\ &\quad + \underbrace{(\Delta \mu_t - \tau_\ell (1 - \tau)) \omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}_{\text{redistribution via labor taxes}}, \end{aligned} \quad (\text{A28})$$

where $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$.

This decomposition provides a transparent breakdown of how the reform alters household resources through efficiency gains, the removal of pension-based redistribution, and enhanced tax-based redistribution. In what follows, we show how each of these components maps into welfare changes.

To evaluate the welfare consequences of replacing the Beveridgean pension system with a Bismarckian one while increasing tax progressivity, we proceed in four steps:

- **Step 1: Efficiency Effect.** We begin by shutting down all redistributive channels to show that the pure efficiency effect—due to the reduction in the labor wedge—raises welfare. Specifically, we demonstrate that the allocation implied by the labor supply $\ell_1^{BIS}(\theta)$ under

the the budget constraint with no redistribution $RHS(\theta) = \omega_\theta w_t \ell_{1,t}(\theta)$ yields higher welfare than that implied by $\ell_1^{BEV}(\theta)$. This result is established in Lemma 1.

- Step 2 and 3: Redistribution Effects. We then consider the redistributive effects of the reform. The loss of pension-based redistribution is analyzed in Lemma 2, while the compensating increase in tax-based redistribution is assessed in Lemma 3.
- Step 4: Total Welfare Impact. Finally, we combine the insights from the previous steps to evaluate the overall welfare effect of the reform in Proposition 1.

Importantly, when evaluating redistribution, it suffices to consider the right-hand side of the budget constraint: if it rises exogenously, welfare increases; if it falls, welfare declines.

Efficiency effect. If we switch off all redistribution—either via social security or the tax system—the lifetime budget constraint simplifies to:

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = \omega_\theta w_t \ell_{1,t}(\theta) \quad (\text{A29})$$

Lemma 1 (Efficiency Effect) *Replacing Beveridgean social security with the Bismarckian one reduces the labor wedge from $\tau_\ell + \tau$ to τ_ℓ . Consequently, the optimal labor supply given by (A19) increases for both θ_H -type and θ_L -type households. Moreover, given the resulting labor supplies, the welfare defined as*

$$\max_{(c_{1,t}(\theta), c_{2,t+1}(\theta))} U_t(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta)) \quad (\text{A30})$$

$$\text{subject to } c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = \omega_\theta w_t \ell_{1,t}(\theta) \quad (\text{A31})$$

is higher under the Bismarckian labor wedge than under the Beveridgean one, for both types of households.

Proof of Lemma 1: The results on the labor wedge and labor supply follow from equations (A19). To isolate the welfare effects of reducing distortions, denote by $\tilde{\tau}$ the distortion to labor supply that is rebated to a household in the form of a lump-sum transfer

$$\tilde{\mu}_t(\theta) = \tilde{\tau} \omega_\theta w_t \ell_{1,t}(\theta). \quad (\text{A32})$$

Define the following indirect utility of $(\tilde{\tau}, \tilde{\mu}(\tilde{\tau}))$

$$\begin{aligned} \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta) &= \max_{(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))} U_t(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta)) \\ &\text{subject to } c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = (1 - \tilde{\tau}) \omega_\theta w_t \ell_{1,t}(\theta) + \tilde{\mu}_t(\theta) \end{aligned} \quad (\text{A33})$$

First note that for GHH preferences given by (4)

$$\ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tilde{\tau}) \omega_\theta \right]^\eta \quad (\text{A34})$$

In order to show that reduction of labor distortion improves welfare it is enough to show that the total derivative $\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} < 0$ for $\tilde{\tau} \in (0, 1)$. Note

$$\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} = \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tau} + \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\mu}_t} \frac{d\tilde{\mu}_t(\tilde{\tau})}{d\tilde{\tau}} \quad (\text{A35})$$

Using the envelope theorem, we obtain

$$\frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\tau}} = -\frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)} \omega_\theta w_t \ell_{1,t}(\theta); \text{ and } \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\mu}_t} = \frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)}$$

Substituting these into (A35) and using the expression from (A32), with $\frac{d\tilde{\mu}_t(\tilde{\tau})}{d\tilde{\tau}} = \omega_\theta w_t \ell_{1,t}(\theta) + \tilde{\tau} \omega_\theta w_t \frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}}$, we obtain

$$\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} = \frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)} \tilde{\tau} \omega_\theta w_t \frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}} < 0 \quad (\text{A36})$$

Since equation (A34) implies $\frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}} < 0$, the derivative is negative. Therefore, reducing the labor distortion improves welfare. Moreover, since $\tilde{\tau}^{BIS} = \tau_\ell < \tau_\ell + \tau$ welfare – as defined in (A30) – is higher under the wedge implied by the Bismarckian system than under one implied by the Beveridgean system for both types of households. ■

Thus, the efficiency effect of the social security reform—from Beveridgean to Bismarckian—reduces the labor wedge, raises the labor supply, and improves welfare of both high- and low-productivity households.

Pension-Based Redistribution. To quantify redistribution via pensions we define the net present value of pensions:

$$NPV_t^{Pen}(\theta) = \frac{b_{2,t+1}(\theta)}{1+r} - \tau w_t \omega_\theta \ell_{1,t}(\theta), \quad (\text{A37})$$

and the reform-induced change in the scope of redistribution

$$\Delta NPV_t^{Pen}(\theta) = NPV_t^{Pen, BIS}(\theta) - NPV_t^{Pen, BEV}(\theta). \quad (\text{A38})$$

It is convenient to express this change as a percentage of the low-type income under the *status quo* (i.e., under the Beveridgean system), which we formalize in the following lemma.

Lemma 2 (Pension-Based Redistribution) *Suppose that the economy is in steady-state with*

the Beveridgean pension system. Consider the following reform bundle:

1. the social security system is shifted from the Beveridgean to the Bismarckian formula; and
2. the resulting fiscal adjustment is implemented via lump-sum transfers within the tax system.

Then in the new steady-state with the Bismarckian pension system, this reform reduces redistribution via social security from θ_H -type to θ_L -type households. The resulting change in the net present value of pensions, expressed as a percentage of the low-type income the Beveridgean system, is given by

$$\frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = -\frac{1}{2} \tau (\varpi^{1+\eta} - 1) = -\frac{\Delta NPV_t^{Pen}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} < 0 \quad (A39)$$

where $\varpi = \omega_H / \omega_L > 1$.

Proof of Lemma 2: First, we can compute the scope of redistribution in the Beveridgean system. Substituting the Beveridgean pension formula from equation (A2) into equation (A37), we have

$$NPV_t^{Pen, BEV}(\theta) = \frac{\tau w_{t+1} \frac{1}{2} \sum_{\theta \in \{\theta_L, \theta_H\}} \omega_\theta \ell_1^{BEV}(\theta)}{1 + r} - \tau w_t \omega_\theta \ell_1^{BEV}(\theta).$$

Using $w_{t+1} = (1 + \gamma)w_t$, $r = \gamma$, and noting from equation (A19) that $\ell_1^{BEV}(\theta_H) > \ell_1^{BEV}(\theta_L)$, we obtain

$$\begin{aligned} NPV_t^{Pen, BEV}(\theta_L) &= \tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)] > 0 \\ NPV_t^{Pen, BEV}(\theta_H) &= -NPV_t^{Pen, BEV}(\theta_L) < 0 \end{aligned} \quad (A40)$$

This implies that the Beveridgean system redistributes from high-ability to low-ability workers. Next, under the Bismarckian social security the net present value of pension is

$$NPV_t^{Pen, BIS}(\theta_L) = NPV_t^{Pen, BIS}(\theta_H) = 0. \quad (A41)$$

Substituting from equations (A40) and (A41) into (A38) and dividing by $\omega_L w_t \ell_1^{BEV}(\theta_L)$ yields the change in the scope of redistribution:

$$\begin{aligned} \frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} &= -\frac{\tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)]}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = -\frac{1}{2} \tau (\varpi^{1+\eta} - 1) < 0 \quad (A42) \\ \frac{\Delta NPV_t^{Pen}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} &= -\frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau (\varpi^{1+\eta} - 1) > 0 \end{aligned}$$

The second equality follows from (A26) and inequality from $\varpi = \omega_H / \omega_L > 1$. Note that the term in the numerator corresponds to the pension redistribution effect from equation (A28). ■

Thus, the reform reduces the scope of redistribution through the pension system, transferring fewer resources from high- to low-productivity households.

Tax-Based Redistribution. Note that, according to equation (A19), labor supply distortions are lower under the Bismarckian system than under the Beveridgean one. Equation (A27) quantifies the percentage change in labor supply resulting from the pension system reform. The increase in labor supply, determined by the Frisch elasticity, is identical in percentage terms for both types of households—namely, $\zeta^\eta - 1$. Consequently, under a constant marginal tax rate, the corresponding increase in government revenue is proportional to the rise in labor supply.

$$\frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \frac{\tau_\ell w_t \omega_H (\Delta \ell(\theta_H)) + \tau_\ell w_t \omega_L (\Delta \ell(\theta_L))}{\tau_\ell w_t \omega_H \ell_t^{BEV}(\theta_H) + \tau_\ell w_t \omega_L \ell_t^{BEV}(\theta_L)} = \xi^\eta - 1 \quad (\text{A43})$$

Since $\xi > 1$, the derivative of equation (A43) with respect to η is given by $\xi^\eta \ln \xi > 0$ and is positive. In particular, we have:

$$\lim_{\eta \rightarrow 0} \frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \lim_{\eta \rightarrow 0} \xi^\eta - 1 = 0, \quad \lim_{\eta \rightarrow \infty} \frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \lim_{\eta \rightarrow \infty} \xi^\eta - 1 = \infty$$

Thus, as $\eta \rightarrow 0$, we have $(\xi^\eta - 1) \rightarrow 0$, and as $\eta \rightarrow \infty$, $(\xi^\eta - 1) \rightarrow \infty$. Since the function $\xi^\eta - 1$ is continuous in η , it can attain any value on the interval $[0, \infty]$. Consequently, the percentage change in government revenue resulting from the reform can vary continuously from 0 to ∞ , depending on the value of the Frisch elasticity.

To quantify this redistribution, we define the net present value (NPV^{Tax}) of the tax as the difference between the lump-sum transfer received and the labor taxes paid by agent of type θ :

$$NPV_t^{Tax}(\theta) = \mu_t - \tau_\ell \omega_\theta w_t \ell_1(\theta). \quad (\text{A44})$$

The change in the scope of tax system redistribution induced by the reform for an agent of type θ is then:

$$\Delta NPV_t^{Tax}(\theta) = \Delta \mu_t - \tau_\ell \omega_\theta w_t (\ell_1^{BIS}(\theta) - \ell_1^{BEV}(\theta)). \quad (\text{A45})$$

where $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$. It is convenient to express this change as a percentage of the low-type income under *status quo* which is the Beveridgean system, as we do in the following lemma.

Lemma 3 (Tax-Based Redistribution) *Suppose that the economy is in the steady-state with the Beveridgean pension system. Consider the following reform bundle:*

1. *the social security system is shifted from the Beveridgean to the Bismarckian formula; and*
2. *the resulting fiscal adjustment is implemented via lump-sum transfers within the tax system.*

Then in the new steady-state with the Bismarckian pension system, this reform increases redistribution via the tax system from θ_H -type to the θ_L -type households. This effect, expressed as a percentage of the low-type income under the Beveridgean system is given by

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) = - \frac{\Delta NPV_t^{Tax}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} > 0 \quad (A46)$$

where $\varpi = \omega_H/\omega_L > 1$. Moreover, the magnitude of this redistribution effect also increases with the Frisch elasticity η and the marginal tax rate τ_ℓ .

Proof of Lemma 3: We express the change in scope of redistribution for θ_L from equation (A45) as a percentage of the low-type income under the Beveridgean system, i.e., relative to $\omega_L w_t \ell_1^{BEV}(\theta_L)$:

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{\Delta \mu_t - \tau_\ell \omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}{\omega_L w_t \ell_1^{BEV}(\theta_L)}$$

Here $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$ and the numerator represents the tax redistribution effect as shown in equation (A28). Using:

$$\Delta \mu_t = \frac{1}{2} \tau_\ell \left(\sum_{\theta \in \{\theta_L, \theta_H\}} \omega_\theta w_t (\ell_1^{BIS}(\theta) - \ell_1^{BEV}(\theta)) \right) \quad (A47)$$

and substituting for ℓ_1 from (A19), we obtain the following formula that represents the net present value change in taxation for θ_L -type households

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) > 0 \quad (A48)$$

The sign of inequality follows from the fact that $\varpi = \omega_H/\omega_L > 1$. Moreover, the net tax change for θ_H -type households is equal in magnitude but opposite in sign.

Additionally, as shown in equation (A43), both $\xi^\eta - 1$ and $\varpi^{1+\eta}$ increase with the Frisch elasticity η . Hence, a larger η implies a greater tax redistribution effect. Finally, it follows from equation (A48) that the tax redistribution effect is also increasing in the marginal labor tax rate τ_ℓ . ■

Thus, the reform increases the extent of redistribution through the tax system, transferring more resources from high- to low-productivity households. The magnitude of this effect depends on both the Frisch elasticity and the marginal labor tax rate.

Total effect. Finally, we show that the reform bundle—which involves switching from the Beveridgean to the Bismarckian pension formula and redistributing the additional labor tax through lump-sum transfers—can improve welfare. In fact, under certain conditions, it is possible to

achieve both welfare improvement under the veil of ignorance as well as a Pareto welfare improvement, where both types of households experience a welfare gain. Proposition 1 establishes the conditions under which tax system redistribution can substitute for the pension-based redistribution to the extent that renders the reform ex ante and Pareto welfare improving.

Proof of Proposition 1: [Steady-state welfare effects of reform]

The proof combines the results of the previous lemmas. First, Lemma 1 demonstrates that replacing the Beveridgean social security system with the Bismarckian one reduces the effective labor wedge, which increases labor supply and raises welfare of both θ_L - and θ_H -type households. Second, Lemma 2 shows that eliminating redistribution in the social security reduces the welfare of θ_L -type households while improving that of θ_H -type households. Third, Lemma 3 establishes that redistributing additional tax revenue - generated by the efficiency effect - via lump-sum transfers favors θ_L -type households. In their case, the extra transfer exceeds the additional tax they pay, whereas the opposite holds for θ_H -type households.

It is evident that θ_H -type households always benefit, as the efficiency effect more than offsets the tax redistribution effect (see equation (A28)), and the pension redistribution effect is positive for them. However, a welfare gain is not ensured for θ_L -type households.

To determine when a Pareto improvement is possible, note that, since the efficiency effect is always positive, it suffices for the two redistribution effects for θ_L -type households to cancel out. Define $\tilde{\eta}$ such that the net redistribution effect for θ_L -type households is zero; that is, the sum of the pension and tax redistribution effects equals zero:

$$\frac{\Delta NPV^{Tax}(\theta_L)}{\omega_L w_t \ell_t^{BEV}(\theta_L)} + \frac{\Delta NPV^{Pen}(\theta_L)}{\omega_L w_t \ell_t^{BEV}(\theta_L)} = 0 \quad \Leftrightarrow \quad \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) = \frac{1}{2} \tau (\varpi^{1+\eta} - 1) \quad (A49)$$

This relationship is derived from equations (A39) and (A46). Notice that a positive $\tilde{\eta} > 0$ satisfying equation (A49) exists. To see this, observe that after canceling the common factor $\frac{1}{2}(\varpi^{1+\eta} - 1)$, the left-hand side becomes an increasing function of η , while the right-hand side is constant. Moreover, as η ranges from zero to infinity, the left-hand side takes on all values between zero and infinity, ensuring that there exists a unique $\tilde{\eta} > 0$ such that the net redistribution effect is exactly zero.

For $\eta = \tilde{\eta}$, the redistribution effects cancel out exactly, so the welfare gain for θ_L -type households comes solely from the positive efficiency effect. By continuity of the left-hand side of equation (A49) and of the utility function $U(\theta)$, there exists a threshold $\bar{\eta} < \tilde{\eta}$ at which welfare of θ_L -type households remains unchanged after the reform. Consequently, for all $\eta \geq \bar{\eta}$, the reform constitutes a Pareto improvement.

Regarding utilitarian social welfare, the continuity of both the left-hand side of equation (A49) and the utility function implies that for all η 's in a sufficiently small neighborhood below $\bar{\eta}$, any decline in $U(\theta_L)$ is small enough to be offset by an increase in $U(\theta_H)$. Hence, there

exists $\underline{\eta} < \bar{\eta}$ such that $\forall \eta \geq \underline{\eta}$ the reform improves the utilitarian social welfare function $W = \sum_{\theta \in \{\theta_L, \theta_H\}} U(\theta)$.

Regarding the final point. By substituting $\tau^{BEV} = \tau$ and the expression for ξ from equation (A27) into equation (A49), and applying using the implicit function theorem, we obtain

$$\frac{\partial \tilde{\eta}}{\partial \tau_\ell} = -\frac{\xi^{\tilde{\eta}} - 1 + \tau_\ell \tilde{\eta} \xi^{\tilde{\eta}-1} \frac{\tau}{(1-\tau_\ell-\tau)^2}}{\tau_\ell \xi^{\tilde{\eta}} \ln \xi} < 0. \quad (\text{A50})$$

By continuity of the left-hand side of equation (A49) and of the $U(\theta)$ function, both $\underline{\eta}(\tau_\ell)$ and $\bar{\eta}(\tau_\ell)$ are decreasing with τ_ℓ . ■

A.6 Transition Path: Technical Details

Proof of Proposition 2: [Welfare effects along the transition path]

For the initial old generation (born in period $t - 1$), the reform occurs after they have retired; thus, no efficiency effect arises. Moreover, since these retired households are not subject to labor income taxation, there is no change in redistribution through the tax system. However, because the labor supply of the initial young increases—as implied by equations (A19) and (A24)—the pension benefits of the initial old rise relative to the original steady-state, see formula (A2). As a result, their welfare improves.

For the initial young and all future generations, the adjustment mirrors that between two steady-states. First, since this is a partial equilibrium analysis, wages and interest rates remain unchanged. Second, the labor wedge immediately adjusts to its new steady-state level, so the efficiency effect is exactly as implied by the steady-state comparison. Third, the labor supply of young workers in the first period jumps to its new steady-state level—as given by formula (A23)—which is higher than in the previous steady-state, as given by formula (A24). Consequently, the redistribution effect via the tax system matches that implied by the steady-state comparison. Finally, since pensions are determined by labor supply and the exogenous wage growth rate, and because labor supply instantaneously adjusts to its new steady-state level, pensions also adjust accordingly. Thus, the pension redistribution effect is exactly as implied by the steady-state comparison.

Since all three effects—efficiency, tax redistribution, and pension redistribution—match those in the steady-state, the overall adjustment for the initial young and all future generations is identical to that between two steady-states. ■

B Technical Derivations from Computational Model

B.1 Equilibrium and Model Solving

We define equilibrium in our economy using the notion of a recursive equilibrium. Recall that the state of an agent of age j in period t is fully characterized by $s_{j,t} = (a_{j,t}, f_{j,t}, \epsilon_{j,t}) \in \Omega$. We denote the probability measure over the state space Ω for agents of age j at time t by $\mathbb{P}_{j,t}$. Below we define an equilibrium for the baseline system. Equilibrium for the reformed system is defined analogously.

Definition 1 (Recursive competitive equilibrium) *A recursive competitive equilibrium consists of a sequence of value functions $\{(V_{j,t}(s_{j,t}))_{j=1}^J\}_{t=0}^\infty$, policy functions $\{(c_{j,t}(s_{j,t}), \ell_{j,t}(s_{j,t}), a_{j+1,t+1}(s_{j,t}), f_{j+1,t+1}(s_{j,t}))_{j=1}^J\}_{t=0}^\infty$, prices $\{r_t, w_t\}_{t=0}^\infty$, government policies $\{\tau_c, \tau_k, \tau_l, \lambda, \mu_t, D_t\}_{t=0}^\infty$, social security parameters $\{\tau, S_t, \rho_m\}_{t=1}^\infty$, aggregate quantities $\{L_t, A_t, K_t, C_t, Y_t\}_{t=0}^\infty$, and a probability measure $\{\mathbb{P}_{j,t}\}_{t=0}^\infty$ such that:*

- **consumer problem:** for each j and t , the value functions $(V_{j,t}(s_{j,t}), V_{j+1,t+1}(s_{j+1,t+1}))$ and the policy functions $(c_{j,t}(s_{j,t}), \ell_{j,t}(s_{j,t}), a_{j+1,t+1}(s_{j,t}), f_{j+1,t+1}(s_{j,t}))$ solve the Bellman equation (15) given prices and government policies;
- **firm problem:** for each t , prices (r_t, w_t) are given by equations (17);
- **government sector:** the consolidated government budget constraint—including both general government operations and the PAYG social security system—is satisfied, i.e., equations (18) through (20) hold;
- **markets clear:**

$$\begin{aligned}
 \text{labor market: } L_t &= \sum_{j=1}^J N_{j,t} \int_{\Omega} \omega_{j,t}(s_{j,t}) \ell_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}; \\
 \text{capital market: } A_{t+1} &= \sum_{j=1}^J N_{j,t} \int_{\Omega} a_{j+1,t+1}(s_{j,t}) d\mathbb{P}_{j,t}, \\
 K_{t+1} &= A_{t+1} + D_{t+1}; \\
 \text{goods market: } C_t &= \sum_{j=1}^J N_{j,t} \int_{\Omega} c_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}, \\
 Y_t &= C_t + K_{t+1} - (1-d)K_t + G_t;
 \end{aligned}$$

- **probability measure:** for all t and for all j , the probability measure $\mathbb{P}_{j,t}$ is consistent with productivity processes and policy functions.

We solve the consumer problem using value function iterations. To reduce the dimensionality of the state space, we adopt the implicit tax approach following Butler (2002). We discretize

the state space $\hat{\Omega} = \hat{A} \times \hat{F} \times \hat{H}$, with grids $\hat{A} = \{a^1, \dots, a^{n_A}\}$, $\hat{F} = \{f^1, \dots, f^{n_F}\}$, and $\hat{H} = \{\epsilon^1, \dots, \epsilon^{n_H}\}$, where $n_A = 300$, $n_F = 15$, and $n_H = 5$.

We interpolate policy and value functions using piece-wise linear functions based on Powell's recursive algorithm. For each discrete state $\hat{s}_{j,t} \in \hat{\Omega}$, we compute optimal consumption and labor supply numerically with the Newton-Raphson method. This is necessary due to the nonlinearity of the labor income tax schedule.

Given an initial distribution $\hat{\mathbb{P}}_{1,t}$, a transition matrix $\Pi(\epsilon_{j,t}|\epsilon_{j-1,t-1})$, and policy functions $\{a_{j+1,t+1}(\hat{s}_{j,t}), f_{j+1,t+1}(\hat{s}_{j,t})\}_{j=1}^J\}_{t=1}^\infty$, we can iterate forward to obtain the distribution at all future ages and periods.

After computing distributions and policy functions, we aggregate consumption, labor supply, and savings using Gaussian quadrature. Once the individual decision problem is solved for a given set of prices and fiscal policies, we update the aggregate capital stock using the Gauss-Seidel method. We repeat the procedure until the difference in aggregate capital across iterations is below a tolerance of 10^{-12} in l_1 -norm.

B.2 Implicit Tax: Linking Pension Benefits to Contributions

In this section, we examine how the structure of the pension system—specifically, the degree to which pension benefits are linked to contributions—affects households' labor supply decisions. When contributions to the pension system are effectively rebated in the form of future benefits, individuals partially internalize these payments as forced savings rather than pure taxes. This reduces the labor-supply distortion relative to systems where contributions and benefits are weakly or not at all connected.

To capture this mechanism formally, we derive the first-order condition from the household's optimization problem and introduce the concept of the implicit tax rate. This implicit tax reflects the net cost of contributing to the pension system after accounting for the expected present value of future benefits. A higher degree of internalization corresponds to a lower implicit tax and thus smaller labor market distortions.

We begin by analyzing the reformed pension system, where the link between contributions and benefits is explicit. Then we contrast it with the status quo system, where the connection is weaker and more complex, leading households to treat contributions more like regular taxes.

Reformed Social Security We begin by defining the present value of future pensions of an agent of age j in period t , who will retire at age $\bar{J} > j$, $PV_{j,t}^b$. It is given by the following:

$$PV_{j,t}^b = PV_{\bar{J},t(j,t,\bar{J})}^b \left[\prod_{s=1}^{\bar{J}-j} \left(\frac{1 + r_{\ell,t+s}}{1 + (1 - \tau_{k,t+s})r_{t+s}} \right) \right] \quad (\text{B1})$$

where $t(j, t, \bar{J}) = t + \bar{J} - j$ is the retirement period for someone aged j in t , and $PV_{\bar{J}, t + \bar{J} - j}^b$ denotes the present value of future pensions at retirement:

$$PV_{\bar{J}, t(j, t, \bar{J})}^b = \sum_{\kappa=0}^{J-\bar{J}} \left[\prod_{s=1}^{\kappa} \frac{(1 + r_{\ell, t(j, t, \bar{J}) + s})}{(1 + (1 - \tau_{k, t(j, t, \bar{J}) + s})r_{t(j, t, \bar{J}) + s})} \right] b_{\bar{J} + \kappa, t(j, t, \bar{J}) + \kappa} \quad (B2)$$

To understand how the link between contributions and pension affects household decisions, we derive the following first-order condition characterizing consumption-labor choice:

$$\phi \ell_{j, t}(s_{j, t})^{\frac{1}{\eta}} = \frac{c_{j, t}(s_{j, t})^{-\sigma}}{1 + \tau_c} \left[(1 - (1 - \tau)\mathcal{T}'(y_{j, t}(s_{j, t})) - \tau)w_t\omega_{j, t}(s_{j, t}) + \frac{\partial PV_{j, t}^b}{\partial \ell_{j, t}} \right], \quad (B3)$$

To interpret this better, we define the implicit tax $v_{j, t}$, as the fraction of contributions that are effectively rebated via future pensions:

$$v_{j, t} = \frac{\frac{\partial PV_{j, t}^b}{\partial \ell_{j, t}}}{\tau w_t \omega_{j, t}(s_{j, t})} \quad (B4)$$

Substituting from (B4) to (B3) yields:

$$\phi \ell_{j, t}(s_{j, t})^{\frac{1}{\eta}} = \frac{c_{j, t}(s_{j, t})^{-\sigma}}{1 + \tau_c} [1 - (1 - \tau)\mathcal{T}'(y_{j, t}(s_{j, t})) - (1 - v_{j, t})\tau] w_t \omega_{j, t}(s_{j, t}) \quad (B5)$$

If $v_{j, t} = 1$, then contributions are fully internalized by individuals and do not distort their labor supply—i.e., contributions behave like forced savings. In contrast, if $v_{j, t} = 0$, then contributions act like a pure tax and fully distort labor supply. Interestingly, because the pension system annuitizes contributions, the effective return may exceed that of private savings, implying in the reformed system $v_{j, t}^R > 1$ is possible.

We compute $v_{j, t}$ from (B4) using the formula for pension benefits in the reformed system (13):

$$b_{\bar{J}, t}^R = f_{\bar{J}, t}^R / LE_{t, \bar{J}} \quad \text{and} \quad \forall j > \bar{J} \quad b_{j, t}^R = (1 + r_{\ell, t})b_{j-1, t-1}^R, \quad (B6)$$

where the conditional life expectancy is $LE_{t, \bar{J}} = 1 + \sum_{s=0}^{J-\bar{J}-1} (\prod_{i=1}^s \pi_{\bar{J}+i, t+i})$. We also need the formula for the evolution of entitlements given by (14)

$$f_{j+1, t+1}^R = (1 + r_{\ell, t})/\pi_{j, t} f_{j, t}^R + (1 + r_{\ell, t})/\pi_{j, t} \tau \omega_{j, t} w_t \ell_{j, t} \quad (B7)$$

From these formulas, we find:

$$v_{j, t}^R = v_{\bar{J}, t(j, t, \bar{J})}^R \left[\prod_{s=1}^{\bar{J}-j} \left(\frac{(1 + r_{\ell, t+s})}{(1 + (1 - \tau_{k, t+s})r_{t+s})\pi_{j+s, t+s}} \right) \right] \quad (B8)$$

where

$$v_{\bar{j},t(j,t,\bar{j})}^R = \left[\sum_{\kappa=0}^{J-\bar{j}} \prod_{s=1}^{\kappa} \frac{(1 + r_{\ell,t(j,t,\bar{j})+s})}{(1 + (1 - \tau_{k,t(j,t,\bar{j})+s})r_{t(j,t,\bar{j})+s})} \frac{1}{LE_{t(j,t,\bar{j}),\bar{j}}} \right]. \quad (\text{B9})$$

Baseline Social Security Under the status quo, the U.S. Social Security system operates as a pay-as-you-go, defined-benefit program with a progressive benefit formula. Pension benefits are based on a worker's Average Indexed Monthly Earnings (AIME), and the replacement rate applied to those earnings declines with income. Because the benefit formula is nonlinear and redistributive, the link between additional labor supply and future pension benefits is weak. In particular, an individual's marginal return from paying additional payroll taxes is small, especially relative to the contribution paid.

As a result, workers are typically modeled as not perceiving Social Security contributions as deferred compensation, but rather as a pure tax. That is, they do not internalize the future benefits when making labor-supply decisions. This approach is standard in the literature, as in Nishiyama and Smetters (2007) and McGrattan and Prescott (2017), where payroll contributions are treated as distortionary taxes that do not yield marginal returns to the individual.

Following this convention, we set the implicit tax rate in the baseline system to zero: $v_{j,t}^B = 0$. That is, contributions under the current system are fully distortionary from the household's perspective.

B.3 Measuring welfare effects

We express the welfare effects of the reform using a consumption equivalent variation, measured as a percentage change of lifetime consumption. To evaluate this, we separately account for the utility from consumption and the disutility from labor. Define the expected lifetime utility from consumption (under the veil of ignorance) as:

$$W_t^c = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{c(s_{j,t+j-1})^{1-\sigma}}{1-\sigma} \right] \quad (\text{B10})$$

where $c(s_{j,t})$ denotes the optimal consumption at age j and period t . Analogously, define the expected lifetime disutility from labor as:

$$W_t^\ell = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{\phi}{1 + \frac{1}{\eta}} \ell(s_{j,t+j-1})^{1+\frac{1}{\eta}} \right] \quad (\text{B11})$$

where $\ell(s_{j,t})$ denotes optimal labor supply.

To compute welfare changes in consumption equivalent terms, define:

$$W_t^c(\Lambda_t) = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{((1 + \Lambda_t)^c(s_{j,t+j-1}))^{1-\sigma}}{1 - \sigma} \right]. \quad (\text{B12})$$

From homotheticity, it follows that:

$$W_t^c(\Lambda_t) = (1 + \Lambda_t)^{1-\sigma} W_t^c. \quad (\text{B13})$$

Let B denote the baseline (status quo) and R the reformed system. The welfare gain from the reform, expressed as a consumption equivalent percentage of lifetime consumption Λ_t , is defined implicitly by:

$$W_t^{c,B}(\Lambda_t) - W_t^{\ell,B} = W_t^{c,R} - W_t^{\ell,R} \quad (\text{B14})$$

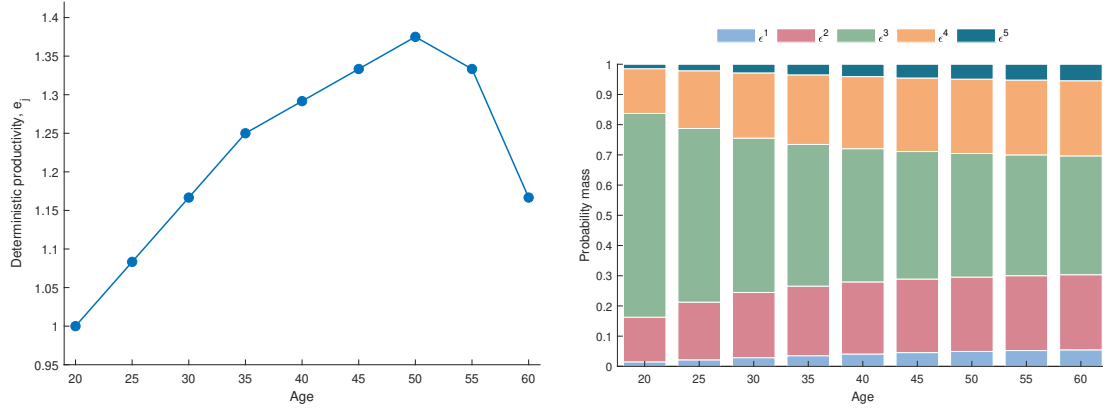
Solving for Λ_t , we obtain:

$$\Lambda_t = \left(\frac{W_t^{c,R} - (W_t^{\ell,R} - W_t^{\ell,B})}{W_t^{c,B}} \right)^{\frac{1}{1-\sigma}} - 1. \quad (\text{B15})$$

This expression gives the welfare effect as a consumption equivalent—that is the proportional increase in lifetime consumption in the baseline economy required to make an individual indifferent between the baseline and the reform scenarios.

C Model calibration

Figure C1: Labor Productivity



(a) Deterministic productivity component e_j by age (b) Distribution of idiosyncratic productivity shocks by age

Notes: Panel C1 reports the deterministic age component of labor productivity, e_j . Panel C2 reports the age-specific distribution over the five discretized realizations of the idiosyncratic productivity shock, ϵ^h , with $h = 1, \dots, 5$. The realizations are ordered from the lowest to the highest value: $\epsilon^1 = 0.28$, $\epsilon^2 = 0.53$, $\epsilon^3 = 1.00$, $\epsilon^4 = 1.87$, and $\epsilon^5 = 3.51$. Probability masses in Panel C2 sum to one within each age group.

Table C1: Tax Rates Calibration

Macroeconomic parameters	Calibration	OECD code	revenue as % of GDP
τ_l labor tax	0.037	1110	9.2%
τ_c consumption tax	0.044	5100, 5121	2.8%
τ_k capital tax	0.243	1120, 1200, 4100, 4400	5.4%

Notes: Tax rates are calibrated following Mendoza et al. (1994), based on five-year averages (2011-2015) of revenue-to-GDP ratios for labor, capital, and consumption taxes.

Table C2: Calibrated Parameters in the Initial Steady-State Across Different Frisch Elasticities

Parameter	values of η														
	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3.0
ϕ	694	36.91	13.88	8.41	6.25	5.10	4.41	4.01	3.67	3.41	3.21	3.09	2.94	2.87	2.77
δ	1.02	1.01	1.00	0.99	0.99	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.96	0.96	0.96
τ_l	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
τ_c	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
τ_k	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

Notes: ϕ denotes the disutility from work, δ the discount factor, τ_l the labor income tax, τ_c the consumption tax, and τ_k the capital income tax. The calibration targets remain constant across all alternative values of the Frisch elasticity. For each case, the risk aversion parameter is fixed at $\sigma = 2$, the annual depreciation rate at $d = 0.06$, the degree of labor tax progression at $\lambda = 0.137$, the social security contribution rate at $\tau = 0.075$, and the pension scaling factor at $\rho_m = 0.55$.

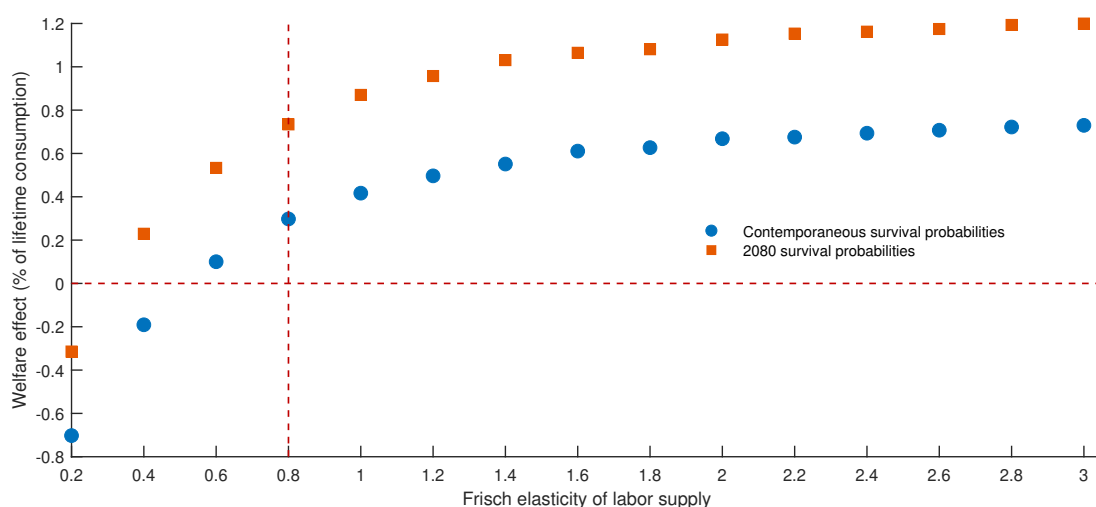
D Sensitivity Analyses to Steady-State Results

D.1 Population aging

Rising longevity across birth cohorts is a central motivation for reforming the U.S. Social Security system. The current system is both redistributive and defined-benefit in nature. However, sustaining this model under demographic pressure would require either a roughly 40% increase in contribution rates (Braun and Joines 2015, Vogel et al. 2017), or a rise in the federal deficit by about 2% of GDP by 2080 (Feldstein 2016). Prior research has shown that such adjustments would carry substantial welfare costs (e.g. Kotlikoff et al. 1999, Huggett and Ventura 1999, Genakoplos et al. 2000, Kitao 2014). In contrast, moving to a defined contribution structure renders the pension system fiscally neutral.¹⁵

This explains why welfare gains from our proposed reform are larger when longevity rises. Figure D1 replicates the analysis from Figure 4, but uses projected survival probabilities $\pi_{j,t}$ for the year 2080. To maintain consistency across systems, we also raise the retirement age $\bar{J}$ in both the baseline and the reform under the longevity scenario.

Figure D1: Welfare Effects Across Alternative Calibrations of the Frisch Elasticity: Population Aging



Notes: Each dot represents the welfare effect under the veil of ignorance for a given value of the Frisch elasticity. Welfare effects are expressed as consumption-equivalent changes in lifetime consumption. The current-demography series uses contemporaneous survival probabilities, while the aging-demography series uses survival probabilities from the 2080 UN forecast. In each case, the status quo and reform economies are computed under the same survival probabilities. Calibrated parameters are as reported in Table C2 in the Appendix. The vertical dashed line denotes our preferred calibration.

Longer lifespans also promote greater capital accumulation and modestly higher labor supply.

¹⁵Longer lifespans reduce per-period pension payments for future cohorts, making defined contribution systems more sustainable. This type of reform has been proposed for the U.S. (Feldstein 2005) and recommended internationally by institutions such as the World Bank and IMF. It has been implemented in many countries since the 1990s, including Sweden, Chile, Mexico, and much of Central and Eastern Europe (Holzmann 2013).

As shown in Figure D2, this reduces the post-reform decline in the capital-labor ratio $k = K/L$ compared to Figure 5. As a result, welfare gains emerge even for Frisch elasticities as low as 0.4. Compared to the baseline calibration, welfare losses at low elasticity values are smaller, and welfare gains at higher elasticity values are nearly twice as large.

These larger gains stem from improved efficiency. In the baseline, aggregate capital grows by less than labor in response to the reform, lowering capital per effective unit of labor, depressing wages, and dampening labor supply. Under longer lifespans, capital accumulation is stronger, mitigating wage declines and strengthening the labor supply response. Consequently, rising longevity amplifies efficiency gains and expands redistribution via progressive labor taxation. (See Figure D3 versus Figure 6.)

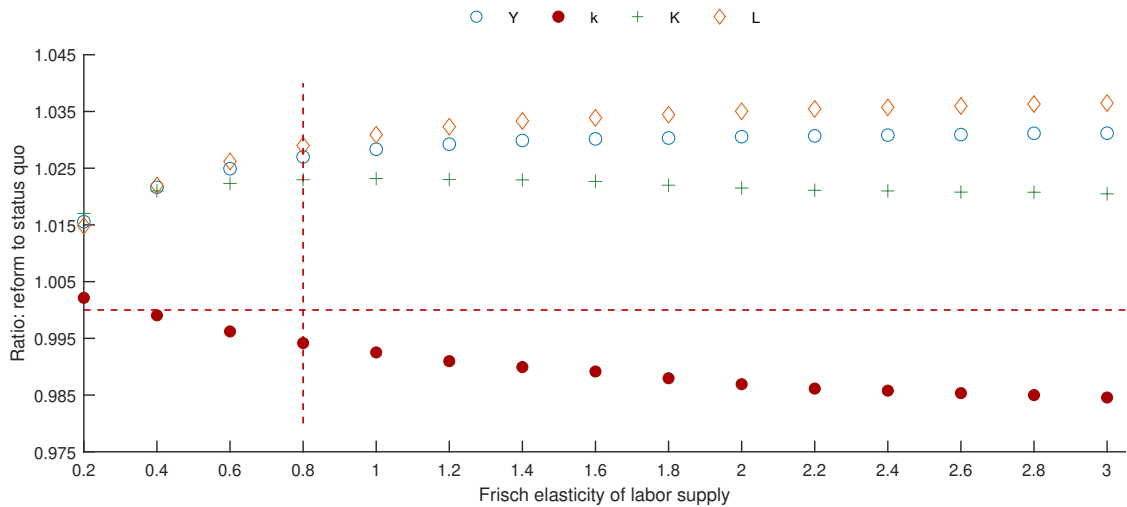
D.2 Drivers of labor supply response

Because our results hinge on the labor supply response to improved incentives, we assess how sensitive the welfare outcomes are to the strength of this response. In our setup, the reform substantially reduces the labor wedge by altering how social security contributions are perceived: what was previously treated as a pure tax is now understood as a deferred income stream. Given the magnitude of the contribution rate, the resulting increase in labor supply—ranging from approximately 1.5% to 4%—is internally consistent within the model framework.

Numerous studies review behavioral responses to tax reforms and provide bounds for plausible labor supply reactions. Evidence from Denmark by Chetty, Friedman, Olsen and Pistaferri (2011) suggests that individuals are more responsive to explicit changes in taxation—such as changes clearly reflected in paychecks—than to implicit or less visible changes. A similar pattern is found for Germany by Tazhitdinova (2020). However, most of this literature focuses on direct changes in labor income taxation, while reforms that alter the lifetime labor wedge—such as changes to pension formulas—are less frequently studied. One exception is Lachowska and Myck (2018), who find significant labor supply responses to relatively subtle adjustments in pension benefit calculation rules. Given this mixed evidence, we explore the sensitivity of our results to the extent to which individuals internalize the changes in social security incentives.

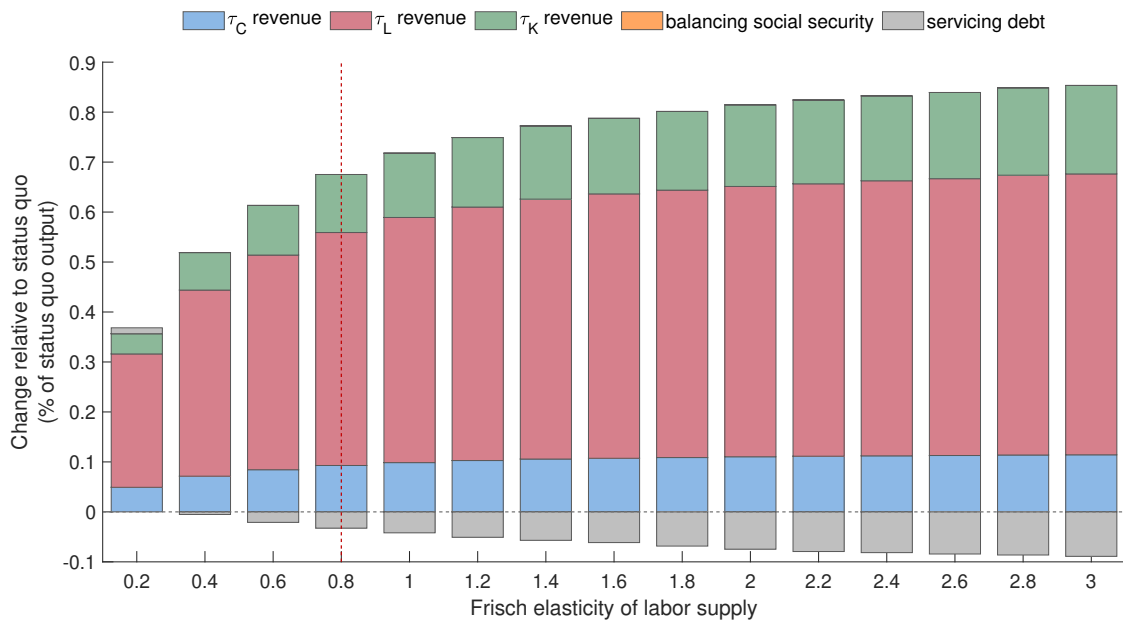
We conduct the following experiment: for each working-age group, a fraction of contributions is governed by equation (10), while the remaining share follows equation (13). Specifically, assuming a Frisch elasticity of 0.8, we vary the proportion of income subject to equation (13) from 0% to 100%, with the remainder governed by equation (10). This setup captures the extent to which individuals internalize changes in social security incentives, as discussed in Section B.2. The results, presented in Figure D4, show with aging population, even a 60% internalization of incentives is sufficient to generate aggregate welfare gains. By contrast, in a scenario with a current population, welfare improvements require individuals to internalize incentives on roughly 80% of their labor income. We conclude that the effectiveness of social security reform does

Figure D2: Macroeconomic Adjustments Across Alternative Calibrations of the Frisch Elasticity: Population Aging



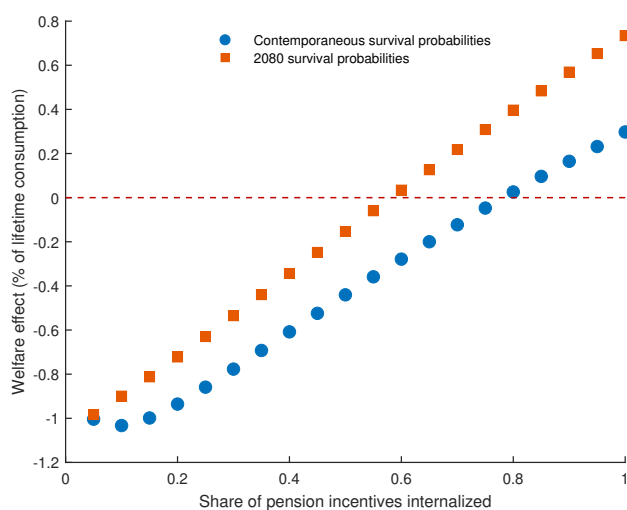
Notes: The figure displays the ratios of selected macroeconomic variables—aggregate output (Y), capital per effective unit of labor (k), aggregate capital (K), and effective aggregate labor (L)—between the reform and the status quo scenarios, across different values of the Frisch elasticity under the aging-demography calibration. Values above one indicate that the variable is higher under the reform. The vertical dashed line denotes the preferred calibration.

Figure D3: Fiscal Position Changes Across Alternative Calibrations of the Frisch Elasticity: Population Aging



Notes: The figure shows changes in fiscal revenues and expenditures between the reform and status quo scenarios across values of the Frisch elasticity under the aging-demography calibration. Positive values increase fiscal space, whereas negative values reduce it. Changes are expressed as a percentage of status quo aggregate output. The vertical dashed line denotes the preferred calibration.

Figure D4: Welfare Effects Under Partial Internalization of Social Security Reform

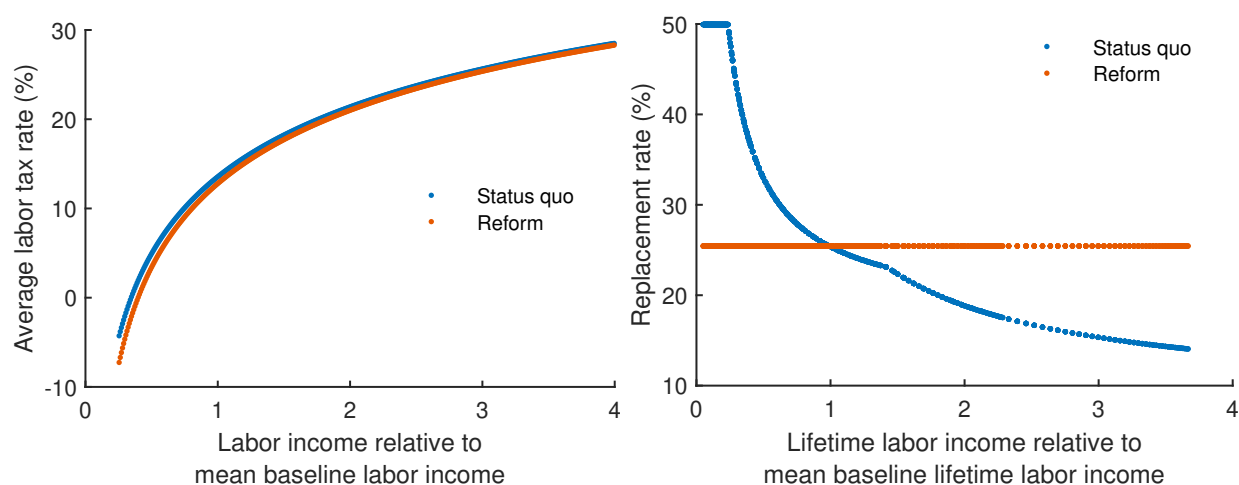


Notes: The figure reports welfare effects under the veil of ignorance for a Frisch elasticity of 0.8. The horizontal axis measures the share of pension incentives internalized by individuals. The rightmost point corresponds to full internalization and matches the welfare effect reported in the baseline analysis. Points to the left show outcomes under partial internalization, where only a fraction of individuals perceive the reduction in the implicit tax introduced by the reform. Welfare effects are expressed as consumption-equivalent changes in lifetime consumption.

not depend on full rationality—a reasonable degree of responsiveness to incentives is enough to deliver the intended efficiency gains.

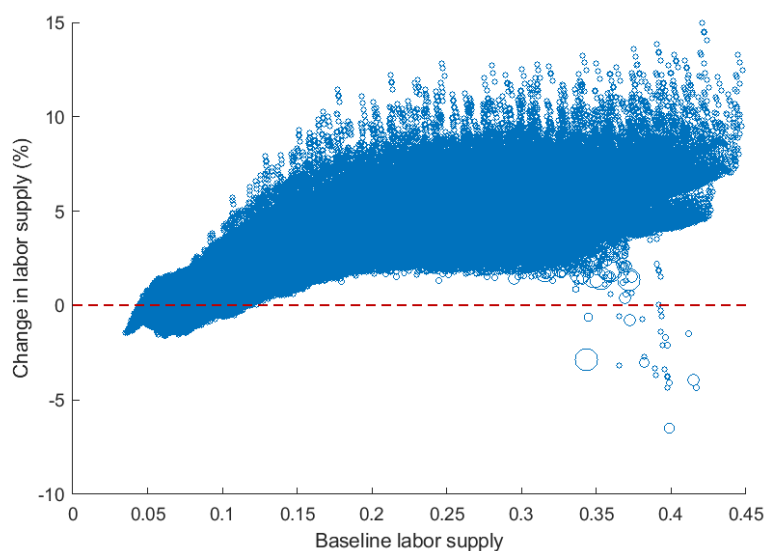
E Additional Results: Steady State

Figure E1: Average tax rate (left) and average replacement rate (right)



Notes: Level of the average tax rates along the income distribution in status quo in the left panel. Lifetime income at retirement is the total stream of pension benefits (adjusted for survival). Lifetime earned income is the total stream of earned income (the social security contribution base, likewise adjusted for survival). The ratio between the two streams signifies the replacement rate, here displayed along the income distribution in the status quo.

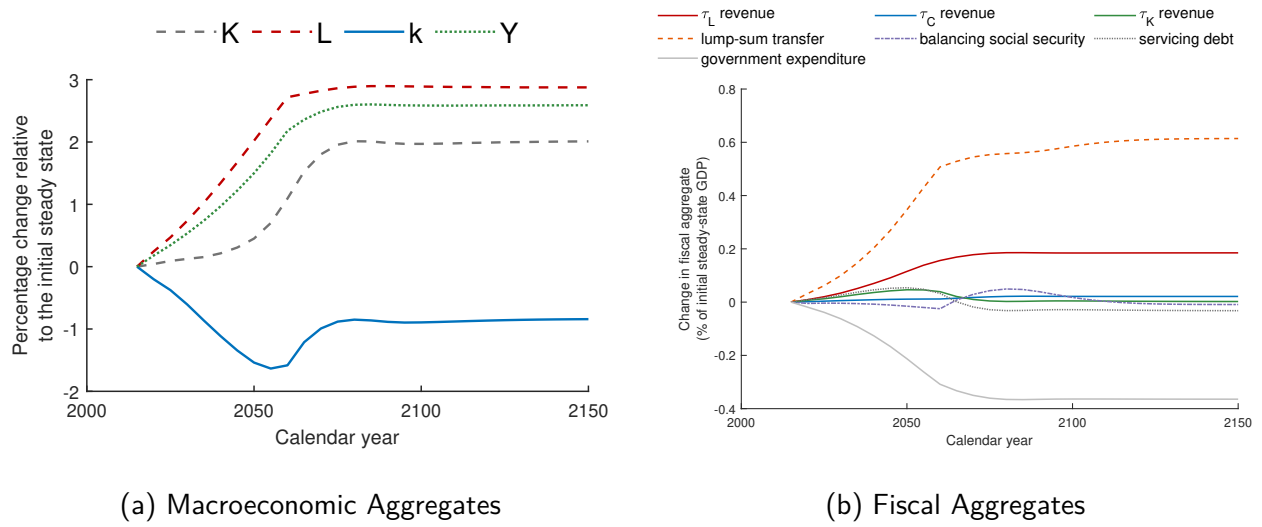
Figure E2: Labor Supply Response to the Reform: Probability-Weighted Shock Realizations



Notes: The figure scatters labor supply under the status quo against the percentage change in labor supply induced by the reform. Each dot corresponds to an individual with a given shock realization. The size of the dot is proportional to the probability of that shock realization.

F Additional Results: Transition Path

Figure F1: Macroeconomic and Fiscal Variables Along the Transition Path



1 Introduction and motivation

We study the role of progressive labor income taxation as a complementary tool in social security reform. Demographic aging is exerting growing fiscal pressure on public pension systems worldwide. As life expectancy increases, traditional pay-as-you-go (PAYG) social security schemes face increasingly unsustainable financial burdens. Multiple studies propose reforms to address the fiscal side of the problem. However, these reforms typically necessitate the loss of insurance embedded in social security.¹

We propose a novel approach to social security reform that reassigns the redistributive role of the system while improving both fiscal sustainability and economic efficiency. The reform replaces the redistributive pension system with a defined contribution (DC) structure and shifts redistribution to the tax system. This separation between the provision of pensions and redistribution allows the economy to retain equity objectives while reducing distortions in labor supply. By reallocating redistribution away from pensions and toward taxation, the reform strengthens incentives without abandoning social insurance goals.²

To build intuition, we begin with a stylized model that makes this mechanism explicit. In the baseline, the social security system is fully redistributive, providing equal benefits to all retirees regardless of prior contributions, while the labor income tax is progressive. We consider a reform that ties pension benefits to individual contributions, thereby eliminating redistribution within the pension system. To preserve overall progressivity and maintain social insurance, we increase the progressivity of the labor income tax. This change is fiscally feasible because linking benefits to contributions reduces labor supply distortions, leading to higher labor supply and increased tax revenue. The resulting additional revenue is redistributed via lump-sum transfers, completing the shift of redistribution from pensions to taxation.

Our stylized model shows that the ability of the reform to deliver welfare gains hinges on the strength of labor supply response, as captured by the Frisch elasticity. When the elasticity is sufficiently high, the fiscally neutral reform becomes Pareto-improving, with all individuals better off. Crucially, at these elasticity levels, the existing redistributive pension system is no longer Pareto efficient. This highlights the potential for more efficient and incentive-compatible

¹See, among others, Fehr (2000), Diamond (2004), Braun and Joines (2015), Diamond et al. (2016), McGrattan and Prescott (2017). Reforms proposed in the literature usually involve linking pensions with individual contributions, which improves efficiency at the expense of insurance loss (Davidoff et al. 2005, Nishiyama and Smetters 2007, Fehr et al. 2008). Welfare gains arise predominantly through a reduction in distortions generated by social security contributions because there is a direct link between contemporaneous labor supply and future pension benefits. Welfare losses stem from the loss of insurance from redistribution inherent in the progressive design of current U.S. social security (see also Heer 2015).

²The literature typically distinguishes between two types of social security reform. The first privatizes or eliminates public pensions, requiring individuals to rely on private savings (e.g., Nishiyama and Smetters 2007, McGrattan and Prescott 2017). The second introduces a defined contribution system, where contributions are retained, but benefits depend on accumulated contributions that earn returns, typically tied to wage growth (e.g., Bütler 2000, Poterba et al. 2007, Attanasio et al. 2007, Börsch-Supan et al. 2014). Our paper contributes to this second strand by replacing the current redistributive system—similar to the U.S. Social Security program—with a defined contribution scheme, holding the contribution rate constant.

redistribution.

Simulations from the full general equilibrium model calibrated to the U.S. economy confirm key insights from the stylized framework. Our model features overlapping generations of heterogeneous agents who face idiosyncratic labor productivity shocks and make decisions about consumption, savings, and labor supply. This framework allows us to assess whether the reform is welfare-improving and to quantify the associated gains. It includes a government sector that runs a pay-as-you-go (PAYG) social security system and collects consumption, capital, and progressive labor income taxes to finance public expenditures and service debt. In the baseline, pension benefits are redistributive and provide partial insurance against income shocks. In the reform scenario, benefits are tied directly to individual contributions, eliminating redistribution within social security. We introduce fiscally neutral lump-sum transfers to compensate for the loss of income insurance.

Comparative statics between two steady-states reveal that the reform reduces labor market distortions, raises labor supply, and increases fiscal revenue. Under plausible values of the Frisch elasticity, redistributing this additional revenue through lump-sum transfers can offset the loss of insurance. The welfare effects remain positive under population aging and partial internalization, suggesting that the mechanism is robust to plausible demographic and behavioral variation.

We also analyze the reform along the transition from redistributive social security to the new regime. We introduce the reform gradually. Retirees and workers already in the system continue with the baseline pension formula—retaining insurance but not benefiting from reduced labor market distortions. Although their labor supply changes little, they experience welfare gains due to higher pension indexation and increased returns on savings. Labor market entrants are subject to the reformed system. They benefit from reduced labor market distortions and receive lump-sum transfers through enhanced tax-based redistribution. Although they lose insurance previously provided by social security, their overall welfare nevertheless increases.

In summary, our contribution to the literature is threefold.

1. We propose complementing social security reform with a more progressive labor income tax system. Tax-based redistribution can partially compensate for the loss of insurance traditionally provided by social security.
2. We show that the Frisch elasticity of labor supply is central to the welfare calculus of the reform.
3. Using a large-scale model calibrated to the U.S. economy, we analyze a reform that links pensions to contributions, reducing labor market distortions at the cost of lower insurance. For plausible calibrations of the Frisch elasticity, the reform yields a Pareto improvement when combined with greater labor tax progressivity.

Relating to the literature, we study how, in the absence of income insurance markets, linking

pensions to contributions affects the levels of insurance and how tax policy can substitute for redistribution. Our work is most closely related to Hosseini and Shourideh (2019), who study social security reform in the absence of annuity markets and show that supporting private savings among low-wealth households—combined with eliminating social security while maintaining the existing tax system—can generate welfare gains. While their framework features heterogeneity, it does not include idiosyncratic labor income shocks. By contrast, our model incorporates such risk and incomplete insurance. More broadly, our paper relates to the literature on taxation and redistribution, including Werning (2007).

Beyond this contribution, our work connects to several strands of the literature.³ First, our analysis builds on research on income risk, insurance, and redistribution (Heathcote et al. 2008, Huggett and Parra 2010, Golosov et al. 2013, 2016, Heathcote et al. 2017). Second, we contribute to the literature on U.S. social security reform (Nishiyama and Smetters 2007, McGrattan and Prescott 2017, Hosseini and Shourideh 2019). Third, we expand the government toolkit to progressive labor income taxation when balancing distortions in labor supply decisions. Most existing work in this area assumes linear labor taxation (see, e.g., Andolfatto and Gervais 2008, İmrohoroglu and Kitao 2009, Kitao 2014, Vogel et al. 2017).⁴

Conesa and Krueger (1999) and McGrattan and Prescott (2017) show that replacing redistributive social security with voluntary savings can improve welfare. In contrast, our setup retains mandatory public social security—operating on a pay-as-you-go basis—and still delivers welfare gains. Nishiyama and Smetters (2007) and others emphasize the importance of insurance provided by redistributive pension benefits across heterogeneous earnings histories in determining the welfare effects of reform. While we follow earlier work in eliminating redistribution within pensions, our novel contribution is to simultaneously increase labor income tax progressivity (in the spirit of Benabou 2002, Guner et al. 2014), thereby partially restoring the insurance function.

Our results extend the findings of Heathcote et al. (2008) and İmrohoroglu and Kitao (2009), who examine how labor supply responds to social security design and tax progressivity. We show that the welfare implications hinge on the extent of distortions in labor supply decisions (see also Huggett and Parra 2010, Berger et al. 2019, Boar and Midrigan 2020). Our findings are in line with recent work of Ábrahám et al. (2025), who study optimal redistribution across multiple policy tools. In their model, shifting redistribution from pensions to progressive taxation can improve welfare—consistent with our result that tax progressivity can offset insurance losses from social security reform.

³Some earlier studies of social security reform, e.g., Nishiyama and Smetters (2007), McGrattan and Prescott (2017), Chen et al. (2016) incorporate progressive income taxation. However, to the best of our knowledge, none explores *changes* in progressivity as a complementary policy tool alongside social security reform. Progressive taxation has long been shown to provide insurance against idiosyncratic income shocks (Varian 1980, Golosov et al. 2013, Heathcote et al. 2017). Indeed, as (Findeisen and Sachs 2017) shows, in life-cycle models with idiosyncratic risk, optimal labor taxation is generally not linear.

⁴There is a large literature on systemic social security reform in overlapping generations (OLG) models; see Lindbeck and Persson (2003), Fehr (2009), and Fehr (2016) for reviews.

Our paper is structured as follows. Section 2 develops a stylized framework to illustrate the role of tax progressivity in social security reform. Section 3 presents the quantitative model, and Section 4 describes its calibration. Comparative statics across steady-states are discussed in Section 5. Section 6 examines the reform along the transition path. The final section concludes by summarizing the main contributions and outlining the policy implications of the study.

2 Stylized model

We develop a parsimonious overlapping-generations model with heterogeneous households and an insurance motive. The economy features a pay-as-you-go (PAYG) social security system and a progressive labor income tax. We analyze two distinct types of social security systems. The first, which we label *Beveridgean*, is redistributive: benefits are equal for all individuals, while contributions are proportional to income. The second, referred to as *Bismarckian*, ties pension benefits to individual contributions, thereby transmitting income heterogeneity into pension heterogeneity.

To isolate the effects of each design, we compare their implications against a benchmark lump-sum pension system, which is neutral in terms of redistribution and does not generate distortions on the margins. The framework also includes progressive income taxation, allowing us to examine how tax and transfer systems interact.

The purpose of this section is to build core economic intuitions and identify the key trade-offs associated with social security reform. These insights serve as a foundation for the subsequent analysis in a large-scale computable general equilibrium model. All algebraic details and proofs are relegated to Appendix A.

2.1 Model setup

Environment. We consider a partial equilibrium OLG economy. Each generation lives for two periods, supplies labor when young, and retires when old. There are two types of individuals: high-productivity and low-productivity, each of measure one. These are denoted by $\theta \in \{\theta_L, \theta_H\}$, with corresponding type-specific productivity levels $\omega_\theta \in \{\omega_L, \omega_H\}$, where $\omega_L < \omega_H$.

The real interest rate r and the real wage w_t are exogenous. Wages grow at a constant rate γ , and we impose $\gamma = r$ to align the implicit return in the PAYG system with the growth rate of the wage bill.

Government. The government runs a balanced budget. Public spending is financed by a labor income tax with linear marginal rate τ_ℓ and lump-sum transfers μ_t , which jointly generate a progressive tax-transfer system. The exact budget constraint is provided in Appendix A.

Social security. The economy features a PAYG social security system with a total contribution rate $\tau < 1$ that is kept constant across all pension designs. We consider:

- **Beveridgean system.** Contributions are proportional to labor income at rate $\tau^{BEV} = \tau$, but benefits are uniform across retirees: $b_{2,t+1}(\theta_H) = b_{2,t+1}(\theta_L)$. The system is therefore redistributive.
- **Bismarckian system.** Contributions are proportional to income at rate $\tau^{BIS} = \tau$, and each retiree's benefit is proportional to her own past contributions. The system transmits earnings heterogeneity one-for-one into pension heterogeneity and is actuarially fair at the individual level.

In addition, as benchmark we use **lump-sum system**, whereby each young agent pays the same lump-sum contribution and receives the same lump-sum benefit in old age (i.e. neither contributions, nor benefits depend on income).

All three systems are PAYG and balanced in each period. Formal benefit formulas are given in Appendix A. In what follows, we present a unified framework that nests all three systems. For example, consider equation (1). If we analyze the Bismarckian system (denoted as BIS) $\tau^{BEV} = 0$. Thus, for each policy experiment, we set the parameter configuration such that only the system under consideration is active, while the others are effectively switched off.

Households. A young household of type θ chooses labor $\ell_{1,t}(\theta)$, consumption $c_{1,t}(\theta)$ and savings $a_{1,t+1}(\theta)$, taking as given r , w_t , taxes, transfers and the pension system. In old age, the household consumes out of savings and pension benefits $b_{2,t+1}(\theta)$.

To encompass all three pension systems within a unified framework, we write the budget constraints in their general form. The two period budget constraints can be written as

$$c_{1,t}(\theta) + a_{1,t+1}(\theta) = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})w_t\omega_\theta\ell_{1,t}(\theta) + \mu_t - T_t^{LS}, \quad (1)$$

$$c_{2,t+1}(\theta) = (1 + r)a_{1,t+1}(\theta) + b_{2,t+1}(\theta), \quad (2)$$

where T_t^{LS} denotes the lump-sum contribution under the lump-sum system (and is set to zero otherwise).

Combining the two constraints yields the lifetime budget constraint

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})w_t\omega_\theta\ell_{1,t}(\theta) + \mu_t - T_t^{LS} + \frac{b_{2,t+1}(\theta)}{1 + r}. \quad (3)$$

For each policy experiment, the relevant parameters are chosen such that only the pension system under consideration is active, while the others are set to zero.

Preferences and welfare. To keep the trade-offs in the stylized model transparent, we adopt GHH preferences (Greenwood et al. 1988). This class of preferences delivers a tractable analytical link between labor supply elasticity and the labor tax wedge. In the quantitative model, this assumption is relaxed. The utility function for a household of type θ takes the form:

$$U_t(\theta) = \frac{1}{1-\sigma} \left(c_{1,t}(\theta) - \frac{\phi}{1+1/\eta} (1+\gamma)^t \ell_{1,t}(\theta)^{1+1/\eta} \right)^{1-\sigma} + \delta \frac{1}{1-\sigma} (c_{2,t+1}(\theta))^{1-\sigma}, \quad (4)$$

where σ is the coefficient of relative risk aversion, ϕ governs the disutility of labor, and η is the Frisch elasticity of labor supply. We set $\delta^{-1} = 1 + r$.

As a welfare metric, we use expected welfare under the veil of ignorance—that is, before the realization of productivity type. Since both productivity types occur with equal probability, ex ante welfare is given by

$$U_t = \frac{1}{2} U_t(\theta_L) + \frac{1}{2} U_t(\theta_H).$$

From this perspective, households value insurance against productivity risk, but such insurance may entail efficiency losses through labor market distortions. The rest of the analysis explores this trade-off.

2.2 Model solution

We briefly summarize the equilibrium conditions that are central for our arguments; all derivations are provided in subsection A.2 of Appendix A. The expressions below are written for the unified framework and simplify once the parameter configuration corresponding to a given pension system is imposed.

Labor wedge. We define the labor wedge as the gap between the marginal rate of substitution between leisure and consumption and the individual wage $w_t \omega_\theta$. Pension contributions affect this wedge only to the extent that they are not offset by future benefits. Formally, the first-order condition for labor can be written as

$$MRS_{(\ell_1, c_1)}(\theta) = (1 - \tau_\ell - (1 - v^{BEV})\tau^{BEV} - (1 - v^{BIS})\tau^{BIS}) w_t \omega_\theta, \quad (5)$$

where $(1 - v^k)$ denotes the share of current contributions in system $k \in \{BEV, BIS\}$ that the household does not recover in present value and therefore effectively acts as a tax.

With a balanced PAYG system and $\gamma = r$, we obtain $v^{BEV} = 0$ and $v^{BIS} = 1$. Thus, the labor wedge becomes:

$$\vartheta^{BEV} = \tau_\ell + \tau^{BEV}, \quad \vartheta^{BIS} = \tau_\ell, \quad \vartheta^{LS} = \tau_\ell.$$

This implies that in the Beveridgean system pension contributions function like an additional

labor tax, whereas in the Bismarckian system they are fully internalized and therefore non-distortionary. Accordingly, the Bismarckian and lump-sum systems do not distort labor supply beyond the standard labor income tax, while the Beveridgean system introduces an additional wedge equal to the contribution rate.

Labor supply. Solving the household problem yields a simple expression for labor supply, which is constant over time and depends only on the effective tax wedge:

$$\ell_1(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV}) \omega_\theta \right]^\eta. \quad (6)$$

This expression encompasses all three pension systems. Since only the Beveridgean system generates an additional distortionary wedge, the contribution rate τ^{BEV} appears explicitly in the formula. Under the Bismarckian system, contributions are fully internalized and therefore do not affect the effective labor wedge; under the lump-sum system, contributions are non-distortionary by construction. Hence, in both cases the effective wedge reduces to the labor income tax τ_ℓ . Consequently, for a given labor income tax, labor supply is strictly lower under the Beveridgean system than under the Bismarckian or lump-sum systems.

Lifetime budget constraint and redistribution. Using the explicit benefit formulas (see Appendix A) and the assumption $r = \gamma$, we can rewrite the lifetime budget constraint as

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = (1 - \tau_\ell - \tau^{BEV}) w_t \omega_\theta \ell_{1,t}(\theta) + \mu_t + \frac{\tau^{BEV} w_t}{2} \sum_{\theta' \in \{\theta_L, \theta_H\}} \omega_{\theta'} \ell_{1,t+1}(\theta'). \quad (7)$$

As in the case of the labor wedge, this expression nests all three systems and simplifies depending on which pension system is active. For the lump-sum and Bismarckian systems, the present value of contributions equals the present value of pension benefits at the individual level, so these terms cancel out from the lifetime budget constraint. When the corresponding contribution rates are set to zero, the remaining pension terms vanish mechanically. In the Beveridgean system they do not cancel, which generates intragenerational redistribution: high-productivity types pay more than they receive, while low-productivity types receive a net transfer.

2.3 Pension systems: comparison

We now characterize how the three systems affect individual decisions. Formal propositions and proofs are given in subsection A.4 of Appendix A.

Lump-sum system. Because contributions and benefits are independent of individual earnings, they simply shift resources over the life cycle without changing relative prices or redistributing

across types. Labor supply, consumption, and savings are identical to the no-social-security benchmark.

Bismarckian system. In the Bismarckian system, each household's pension is proportional to its own contributions. The system is actuarially fair at the individual level and does not redistribute income across types. Since contributions are fully internalized, the labor wedge is the same as in an economy without social security, and individual decisions (c_1, c_2, ℓ_1) are unchanged relative to the no-social-security case.

Beveridgean system. The Beveridgean system combines a contribution proportional to earnings with a flat benefit. It therefore redistributes from high- to low-productivity agents and, at the same time, increases the labor wedge by τ^{BEV} . In equilibrium, both types face a distorted labor supply decision, so labor supply is lower than under the Bismarckian or lump-sum systems. Low-productivity households work less but receive more in present value than they contribute, whereas high-productivity households work less and receive less in present value than they contribute. In effect, a Beveridgean pension contribution operates like an additional labor income tax with a lump-sum transfer.

2.4 Beveridgean-to-Bismarckian Reform: Steady-State Analysis

We now consider a reform that replaces the Beveridgean system with a Bismarckian one while keeping the PAYG structure and the contribution rate τ unchanged. The reform is paired with a fiscal adjustment that increases the progressivity of the labor tax. As a result, redistribution within the pension system is eliminated and the labor wedge is reduced. The resulting increase in labor supply raises tax revenue, which we assume is returned to households through higher lump-sum transfers⁵. In this way, redistribution is shifted from the pension system to the tax system.

The reform affects households through three channels:

Efficiency effect: A lower labor wedge raises labor supply and increases the present value of lifetime income for both types. This mechanism is a well-established finding in the literature on social security reform (Feldstein 1976, Nishiyama and Smetters 2007, Huggett and Parra 2010). When social security contributions do not linked to future benefits—as in the Beveridgean system—they operate like a tax on labor, distorting labor supply decisions. By contrast, when

⁵In the stylized model, transfers are directed to working-age households. In the steady state, however, the precise timing of transfers is not essential for the mechanism, since each cohort receives them at some point during its lifetime. Directing transfers to workers is convenient because it increases lifetime resources one-for-one when evaluated from the beginning of life, whereas transfers received in retirement are discounted by the interest rate. However, in the computational model we relax this assumption, and transfers are distributed to all individuals affected by the reform.

current contributions are tied to future benefits at fair actuarial value—like in the Bismarckian system—then they merely shift income from the present to the future, without distorting incentive. Thus, replacing the Beveridgean system with a Bismarckian one reduces the labor wedge.

Pension redistribution effect: Eliminating flat benefits reduces the net transfer to low-productivity agents and increases the net return to high-productivity agents. Under the Beveridgean system, pensions are not tied to individual contributions, creating implicit redistribution from high- to low-productivity households. In contrast, the Bismarckian system links pensions directly to past earnings, removing this redistribution. Consequently, this component of the reform benefits high-productivity households while reducing welfare for low-productivity ones.

Tax redistribution effect: Higher labor supply boosts tax revenue. Both low- and high-productivity households work more, but because the percentage increase in labor supply is the same for both types, the absolute increase is larger for high-productivity households. They therefore contribute more additional tax revenue in absolute terms. When the extra revenue is redistributed uniformly through lump-sum transfers, the tax system effectively shifts resources from high- to low-productivity households.

The relative strength of these forces depends primarily on the Frisch elasticity η and on the marginal tax rate τ_ℓ . A higher Frisch elasticity amplifies the efficiency effect and the tax-based redistribution: labor responds more strongly to the lower wedge, generating more additional revenue that can be redistributed. A higher τ_ℓ strengthens the redistribution channel for a given change in labor.

The following proposition summarizes the steady-state implications of the reform; its proof is given in subsection A.5 of Appendix A.

Proposition 1 (Steady-state welfare effects of reform) *Starting from a steady-state with a Beveridgean pension system, consider a reform that switches to a Bismarckian system while keeping the contribution rate τ fixed and rebating the additional tax revenue through lump-sum transfers. Then, in the new steady-state with the Bismarckian pension system, relative to the old one:*

- *For each $\tau_\ell \in (0, 1)$ there exists a threshold value for the Frisch elasticity $\underline{\eta}(\tau_\ell) > 0$ such that, for all $\eta \geq \underline{\eta}(\tau_\ell)$, the reform raises ex ante (utilitarian) welfare under the veil of ignorance $W = \sum_{\theta \in \{\theta_L, \theta_H\}} U(\theta)$.*
- *For each $\tau_\ell \in (0, 1)$ there exists a higher threshold value for the Frisch elasticity $\bar{\eta}(\tau_\ell) > \underline{\eta}(\tau_\ell)$ such that, for all $\eta \geq \bar{\eta}(\tau_\ell)$, the reform constitutes a Pareto improvement: both low- and high-productivity households are better off.*

- Both thresholds $\underline{\eta}(\tau_\ell)$ and $\bar{\eta}(\tau_\ell)$ are decreasing in τ_ℓ : a more progressive tax system makes it easier to offset the lost redistribution within pensions.

Intuitively, when labor supply is sufficiently elastic and the tax system is sufficiently progressive, the efficiency gains from reducing the labor wedge generate enough additional tax revenue for tax-based redistribution to fully compensate low-productivity households for the loss of pension-based redistribution.

2.5 Transition path

In this section, we study the welfare implications of the reform along the transition path, distinguishing between the initial old generation and the initial young as well as all future generations.

It is well known that social security reform may generate transition costs, particularly when switching from a PAYG system to a fully funded one or eliminating the system altogether. In such cases, transition costs arise because pensions for the elderly continue to be paid while contributions are diverted elsewhere, creating a temporary deficit that must be addressed. In contrast, the proposed reform modifies the pension formula while preserving the PAYG structure. Consequently, it does not generate additional transition costs.

The following proposition characterizes how the reform affects the welfare of the initial old generation and of the initial young and all future generations along the transition path.

Proposition 2 (Welfare effects along the transition path) *Suppose the economy is in the steady-state of the Beveridgean pension system in period t . Consider an unexpected reform such that:*

1. *for all generations born in period t and thereafter, the pension system switches from the Beveridgean to the Bismarckian formula while keeping the contribution rate fixed; and*
2. *the resulting fiscal adjustment is implemented through lump-sum transfers within the labor income tax system.*

Then:

- *both low- and high-productivity households of the initial old generation (born in period $t - 1$) experience a welfare gain;*
- *for the initial young and all future generations, the welfare effects of the reform are identical to those characterized in the steady-state comparison in Proposition 1.*

This proposition characterizes how the welfare effects of the reform unfold across cohorts along the transition path. A formal proof is provided in subsection A.6 of Appendix A; here we present the underlying economic intuition.

For the initial young generation and all future generations, the adjustment coincides with that between two steady-states. Wages and interest rates remain unchanged, while the labor wedge immediately adjusts to its post-reform level. Labor supply therefore jumps to its new steady-state level, generating efficiency gains and additional tax revenue. Redistribution through the tax system mirrors exactly the steady-state comparison. Moreover, because pension benefits depend on aggregate labor income and wage growth, and labor supply adjusts instantaneously, the pension redistribution effect also coincides with that in the steady-state. As a result, the welfare effects for these cohorts are identical to those implied by the steady-state analysis.

For the initial old generation (born in period $t-1$), the reform is implemented after retirement. As a consequence, there are no efficiency effects and no changes in redistribution through the tax system. Their welfare is affected only through the pension system. The increase in labor supply of the young expands the contribution base of the PAYG pension system, which translates into higher pension benefits for current retirees relative to the pre-reform steady-state. The initial old therefore benefit unambiguously from the reform.

Taken together, this proposition implies that the reform generates efficiency gains through higher labor supply, benefits current retirees through higher pension payments, and affects the welfare of the initial young and all future generations in the same way as in the new steady-state.

In the transition analysis, lump-sum transfers are directed to working-age households because these are the cohorts directly affected by the reform. The initial old generation is not subject to the reform and already benefits from it through higher pension benefits generated by the increase in labor supply of the young. Consequently, there is no need to compensate them through additional transfers. Redistribution is therefore targeted at cohorts whose labor supply and pension contributions are directly altered by the reform, which naturally corresponds to households entering the labor market during and after the reform date.

An immediate implication of Proposition 2 concerns the efficiency of the Beveridgean system.

Corollary 1 (Pareto inefficiency of the Beveridgean pension system) *Suppose the economy is in a steady-state under the Beveridgean pension system. Then, for each $\tau_\ell \in (0, 1)$ there exists a threshold value of the Frisch elasticity $\bar{\eta}(\tau_\ell) > 0$ such that, for all $\eta \geq \bar{\eta}(\tau_\ell)$, the steady-state allocation under the Beveridgean system is Pareto inefficient. Moreover, the threshold $\bar{\eta}(\tau_\ell)$ is decreasing in τ_ℓ .*

Corollary 1 establishes that the steady-state allocation under the Beveridgean pension system is Pareto inefficient. The inefficiency arises because the pension system is used to introduce redistribution by delinking benefits from individual contributions, which turns pension contributions into a distortionary tax on labor. Eliminating redistribution from the pension system therefore expands the tax base by increasing labor supply. Whether this expansion is sufficient to generate a Pareto improvement depends on the responsiveness of labor supply, captured by the Frisch elasticity, and on the size of the tax system, measured by the labor tax rate τ_ℓ . When

labor supply is sufficiently elastic and the tax system is sufficiently large, the resulting increase in tax revenue allows redistribution to be implemented through the tax and transfer system in a way that makes all households better off. The existence of such a feasible Pareto improvement implies that the Beveridgean allocation is inefficient.

This result is related to efficiency tests developed in the optimal taxation literature (Werning 2007, Hosseini and Shourideh 2019), which characterize when a given tax and transfer system is Pareto efficient. In these frameworks, the feasibility of Pareto-improving reforms depends on the responsiveness of labor supply, as captured by the Frisch elasticity.

2.6 Implications for the quantitative model

This stylized model is designed to clarify the key economic mechanisms underlying pension reform. By abstracting from many institutional and general equilibrium features, it allows us to build intuition for how pension design affects labor supply incentives, redistribution, and welfare. At the same time, the analysis makes clear that the ultimate welfare consequences of the reform depend on the quantitative strength of these mechanisms rather than on their qualitative direction alone.

To assess their quantitative relevance, the subsequent sections develop a large-scale general equilibrium model calibrated to the U.S. economy. While this model is considerably more realistic, the main forces shaping the welfare effects of the reform remain the same. In particular, the quantitative analysis continues to be driven by efficiency effects arising from labor supply responses, redistribution implemented through the tax system, and redistribution embedded in pension benefits. The richer framework allows these channels to interact with life-cycle dynamics and general equilibrium adjustments, providing a disciplined evaluation of their importance in an economy that more closely resembles that of the United States.

3 General equilibrium model

We develop a general equilibrium overlapping generations (OLG) model with idiosyncratic income shocks, giving rise to *ex post* heterogeneity within cohorts. In the baseline scenario, the economy features a U.S.-style social security system with redistributive elements. In the reform scenario, this system is replaced by a defined contribution scheme that ties pension benefits directly to individuals' past social security contributions.

Population dynamics Households live for $j = 1, 2, \dots, J$ periods, where j denotes age and each period corresponds to five years. Individuals enter the model at age 20 ($j = 1$), abstracting from labor market entry timing and educational decisions. The size of the cohort aged j in period t is denoted by $N_{j,t}$. Consumers face age- and time-specific survival probabilities $\pi_{j,t}$,

which represent the conditional probability of surviving one period for an individual of age j in period t . Households can work up to the retirement age $\bar{J}$. Those who reach age $J = 16$ (i.e., 95 years old) die with certainty.

Productivity heterogeneity Each individual's effective labor productivity at age j and time t is given by $\omega_{j,t} = e_{j,t}\epsilon_{j,t}$, where $e_{j,t}$ is a deterministic age-efficiency profile and $\epsilon_{j,t}$ is a persistent idiosyncratic earnings shock. The shock follows a first-order autoregressive process:

$$\ln(\epsilon_{j,t}) = \varrho \ln(\epsilon_{j-1,t-1}) + \varepsilon_{j,t}, \quad \varepsilon_{j,t} \sim \mathcal{N}(0, \sigma^2), \quad (8)$$

with persistence parameter ϱ .⁶ Initial heterogeneity is introduced through the distribution of idiosyncratic shocks at model entry, with variance σ_0^2 .

Budget constraint Households below retirement age ($j < \bar{J}$) earn gross labor income $\omega_{j,t}w_t\ell_{j,t}$, where w_t is the marginal productivity of labor and $\ell_{j,t}$ is individual labor supply. Labor income is subject to a social security contribution at rate τ and a progressive labor income tax denoted by $\mathcal{T}(\tilde{y}_{j,t})$, where pre-tax taxable income is given by $\tilde{y}_{j,t} = (1 - \tau)\tilde{w}_t\omega_{j,t}\ell_{j,t}$ and $\tilde{w}_t = w_t/z_t$ adjusts wages for technological progress z_t (defined below).

We follow Benabou (2002) and specify the tax schedule as:

$$\mathcal{T}(\tilde{y}_{j,t}) = \tilde{y}_{j,t} - (1 - \tau_\ell)\tilde{y}_{j,t}^{1-\lambda},$$

where $1 - \lambda$ is the elasticity of post-tax to pre-tax income, and τ_ℓ governs the average tax rate. Note that social security contributions are excluded from the income tax base.

In addition to labor income, households earn capital income $(1 - \tau_k)r_t a_{j,t}$, where τ_k is the capital income tax, r_t is the interest rate, and $a_{j,t}$ denotes asset holdings. Retirees receive pension benefits $b_{j,t}$, which are exempt from taxation. Since survival probabilities are less than one, each period generates unintended bequests $\Gamma_{j,t}$, which are redistributed equally within the cohort.

Households consume $c_{j,t}$ (subject to a consumption tax $\tau_{c,t}$), and save by accumulating assets $a_{j+1,t+1}$. Asset markets are incomplete: only a single risk-free asset is available. Households also receive a lump-sum transfer μ_t (described below). The period budget constraint is:

$$a_{j+1,t+1} + (1 + \tau_{c,t})c_{j,t} = z_t\tilde{y}_{j,t} - z_t\mathcal{T}(\tilde{y}_{j,t}) + b_{j,t} + (1 + (1 - \tau_k)r_t)a_{j,t} + \mu_t + \Gamma_{j,t}, \quad (9)$$

subject to the non-negativity constraint $a_{j+1,t+1} \geq 0$.

⁶Following standard practice in the literature (Nishiyama and Smetters 2007, Heathcote et al. 2008, Huggett and Parra 2010, Golosov et al. 2016, Heathcote et al. 2017), we approximate this process with a first-order Markov chain defined by the transition matrix $\Pi(\ln(\epsilon_{j,t}) | \ln(\epsilon_{j-1,t-1}))$

Baseline social security In the baseline scenario, we replicate the key features of the U.S. Social Security system. It operates as a pay-as-you-go, defined-benefit scheme in which pension benefits are determined jointly by an individual's benefit drawing rights—based on their Average Indexed Monthly Earnings (AIME)—and the effective replacement rate. The AIME determines the earnings base, while the replacement rate determines what fraction of those earnings is paid as a pension. The system is explicitly redistributive: low earners receive a replacement rate of 90%, while high earners receive only 15%.

The value of pension benefits at the statutory retirement age $\bar{J}$ in period t , denoted $b_{\bar{J},t}^B$, depends on the replacement rate $\rho_{\bar{J},t}$, the benefit drawing rights $f_{\bar{J},t}^B$ —defined as the ratio of an individual's average lifetime earnings to the economy-wide average—and the average wage in the economy $\overline{\omega w_t \ell_t}$. To ensure that total pension expenditures match the observed 5% of GDP, we introduce a scaling factor ρ_m . This adjustment allows us to align statutory rules with effective expenditure, just as we calibrate contribution rates using effective rather than statutory values. After retirement, pension benefits are indexed to payroll growth, where the payroll growth rate is given by $r_{\ell,t} = \frac{w_t L_t}{w_{t-1} L_{t-1}} - 1$, with L_t denoting aggregate labor supply. The resulting pension benefit formulas are:

$$b_{\bar{J},t}^B = \rho_m \cdot \rho_{\bar{J},t} \cdot f_{\bar{J},t}^B \cdot \overline{\omega w_t \ell_t} \quad \text{and} \quad b_{j,t}^B = (1 + r_{\ell,t}) b_{j-1,t-1} \quad \forall j > \bar{J}, \quad (10)$$

Next, we specify how drawing rights and replacement rates are computed. In the *status quo* social security system, the drawing rights $f_{j+1,t+1}^B$ evolve recursively according to:

$$f_{j+1,t+1}^B = F^B(f_{j,t}^B, \omega_{j,t} w_t \ell_{j,t}) \equiv \frac{1}{j} \left((j-1) \cdot f_{j,t}^B + \frac{\min\{\omega_{j,t} w_t \ell_{j,t}, \text{cap}_t\}}{\overline{\omega w_t \ell_t}} \right), \quad (11)$$

where cap_t denotes the contribution ceiling under the Old-Age, Survivors, and Disability Insurance (OASDI) system. In this formulation, only earnings below the cap contribute to the drawing rights, and these earnings are expressed as a share of the economy-wide average. The ratio is then averaged across the individual's working life.⁷

The effective replacement rate $\rho_{\bar{J},t}$, applied at the retirement age $\bar{J}$, is determined by a piecewise formula reflecting the progressive structure of U.S. Social Security benefits. We define it as:

$$\rho_{\bar{J},t} = \begin{cases} 0.9 & \text{for } f_{\bar{J},t}^B \leq F_{1,t} \\ \frac{0.9F_{1,t} + 0.32(f_{\bar{J},t}^B - F_{1,t})}{f_{\bar{J},t}^B} & \text{for } F_{1,t} \leq f_{\bar{J},t}^B \leq F_{2,t} \\ \frac{0.9F_{1,t} + 0.32(F_{2,t} - F_{1,t}) + 0.15 \cdot (f_{\bar{J},t}^B - F_{2,t})}{f_{\bar{J},t}^B} & \text{for } F_{2,t} \leq f_{\bar{J},t}^B \end{cases} \quad (12)$$

⁷In our model, contributions above the cap do not generate any additional benefit rights—the replacement rate for earnings above the cap is effectively zero. In the data, approximately 6% of individuals reach the OASDI earnings cap. In our model, this corresponds to about 3% of the population and 2% of total earnings. See: <https://www.ssa.gov/policy/docs/population-profiles/tax-max-earners.html>.

where $F_{1,t}$ and $F_{2,t}$ denote the bend points, expressed as fractions of average earnings. This functional form replicates the progressive benefit formula in U.S. Social Security, as described in McGrattan and Prescott (2017).

Reformed social security In the reform scenario, the existing social security system is replaced with a defined contribution scheme, while remaining pay-as-you-go in nature.

At retirement, pension benefits $b_{j,t}^R$ are based on individual entitlements $f_{j,t}^R$ accumulated over the working life through social security contributions. These accumulated entitlements are annuitized by dividing by the conditional life expectancy at retirement age $LE_{t,\bar{j}}$. After retirement, pensions are indexed to the rate of payroll growth $r_{\ell,t}$, so that pension payments evolve according to:

$$b_{j,t}^R = f_{j,t}^R / LE_{t,\bar{j}} \quad \text{and} \quad \forall_{j > \bar{j}} \quad b_{j,t}^R = (1 + r_{\ell,t}) b_{j-1,t-1}^R, \quad (13)$$

where the conditional life expectancy is $LE_{t,\bar{j}} = 1 + \sum_{s=0}^{J-\bar{j}-1} (\prod_{i=1}^s \pi_{\bar{j}+i,t+i})$.

Entitlements evolve over working period by accumulating current contributions and indexing past entitlements to payroll growth adjusted for mortality. Specifically:

$$f_{j+1,t+1}^R = \frac{(1 + r_{\ell,t})}{\pi_{j,t}} f_{j,t}^R + \frac{(1 + r_{\ell,t})}{\pi_{j,t}} \tau \omega_{j,t} w_t \ell_{j,t}, \quad (14)$$

This direct mapping between contributions and future benefits increases labor supply incentives by linking current effort to retirement income. For a formal derivation of the associated implicit tax on labor, see Appendix B.2 and Butler (2002).

Consumer problem The state of an individual household of age j at time t is given by $s_{j,t} = (a_{j,t}, f_{j,t}, \epsilon_{j,t}) \in \Omega$, where $a_{j,t}$ denotes asset holdings, $f_{j,t}$ denotes pension entitlements, and $\epsilon_{j,t}$ captures individual idiosyncratic productivity shock realization. Newborn households enter the economy with no assets: $a_{1,t} = 0$.

At each state $s_{j,t}$, the household chooses consumption and labor supply to maximize expected lifetime utility. Future utility is discounted using the time discount factor δ and conditional survival probabilities $\pi_{j,t}$. The household's optimization problem can be formulated recursively as follows:

$$V_{j,t}(s_{j,t}) = \max_{(c_{j,t}, \ell_{j,t}, a_{j+1,t+1})} u(c_{j,t}, \ell_{j,t}) + \delta \pi_{j,t} \mathbf{E}(V_{j,t+1}(s_{j+1,t+1}) \mid s_{j,t}), \quad (15)$$

subject to the budget constraint in equation (9), the relevant pension formula—either equation (10) in the baseline scenario or equation (13) under the reform—and the productivity process in equation (8). Total time endowment is normalized to one. The instantaneous utility from

consumption and leisure is:

$$u(c_{j,t}, \ell_{j,t}) = \frac{1}{1-\sigma} c_{j,t}^{1-\sigma} - \frac{\phi}{1+\frac{1}{\eta}} \ell_{j,t}^{1+\frac{1}{\eta}}. \quad (16)$$

where σ denotes the inverse of the intertemporal elasticity of substitution and η is the Frisch elasticity of labor supply.

Production The economy produces final output using capital K_t and labor L_t via a standard Cobb-Douglas production function $Y_t = K_t^\alpha (z_t L_t)^{1-\alpha}$ with labor-augmenting technological progress. The growth rate of technology is denoted by $\gamma_{t+1} = z_{t+1}/z_t$, and capital depreciates at the rate d . Firms operate in perfectly competitive markets and choose capital and labor inputs to maximize profits. This leads to the following equilibrium conditions for the rental rate of capital and the real wage:

$$r_t = \alpha K_t^{\alpha-1} (z_t L_t)^{1-\alpha} - d \quad \text{and} \quad w_t = (1-\alpha) K_t^\alpha z_t^{1-\alpha} L_t^{-\alpha}. \quad (17)$$

Government Tax revenue T_t is used to finance government consumption G_t , cover subsidy to social security $\mathcal{S}_t$ in case of shortfall, service interest payments on public debt $r_t D_t$, and fund lump-sum transfers μ_t . The government budget constraint is:

$$G_t + \mathcal{S}_t + r_t D_t + \sum_{j=1}^J N_{j,t} \mu_t = T_t + \Delta D_{t+1}, \quad (18)$$

where $\Delta D_{t+1} = D_{t+1} - D_t$ denotes the change in public debt. Tax revenue T_t is given by:

$$T_t = \sum_{j=1}^{\bar{J}-1} N_{j,t} \int_{\Omega} z_t \mathcal{T}(\tilde{y}_{j,t}(s_{j,t})) d\mathbb{P}_{j,t} + \tau_{k,t} r_t A_t + \tau_{c,t} C_t, \quad (19)$$

where, C_t and A_t denote aggregate consumption and aggregate assets, respectively. We assume that government consumption G_t is the same in both the baseline and reform scenarios. The individual state at age j and time t is denoted $s_{j,t} = (a_{j,t}, f_{j,t}, e_{j,t}) \in \Omega$ and the distribution of agents over the state space Ω is represented by probability measure $\mathbb{P}_{j,t}$.

The social security deficit, $\mathcal{S}_t$, which also represents the required subsidy to social security, is defined as the difference between the total pension benefit payments and the total contributions:

$$\mathcal{S}_t = \sum_{j=\bar{J}}^J N_{j,t} \int_{\Omega} b_{j,t}(s_{j,t}) d\mathbb{P}_{j,t} - \tau w_t \sum_{j=1}^{\bar{J}} N_{j,t} \int_{\Omega} \omega_{j,t}(s_{j,t}) \ell_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}. \quad (20)$$

Here $b_{j,t} = b_{j,t}^B$ in the baseline and $b_{j,t} = b_{j,t}^R$ in the reform. The superscript B and R denote variables in the baseline and the reform scenarios, respectively. Under the baseline, any deficit $\mathcal{S}_t$

is covered by general government revenues. In the reform, the system is designed to be balanced in steady-state, so $\mathcal{S}_t = 0$ by construction.

In the baseline, lump-sum transfers μ_t^B are set to zero. In the reform, we introduce additional progressivity via positive lump-sum transfers μ_t^R . Along the transition path, these transfers are directed only to cohorts affected by the reform, namely those entering the labor market from the reform date onward. This allocation reflects the fact that these cohorts are the ones whose pension formula changes and therefore the ones for whom tax-based redistribution is intended to compensate for the loss of redistribution within the pension system. Once a cohort becomes eligible for transfers, it continues to receive them throughout the remainder of its lifetime.

The transfers are determined endogenously to ensure fiscal neutrality, holding the level of government debt constant. Specifically, the lump-sum transfer in the reform is calculated as:

$$\mu_t^R = \frac{G_t + \mathcal{S}_t^R + r_t^R D_t - \Delta D_{t+1} - T_t^R}{N_t^\mu}. \quad (21)$$

where N_t^μ denotes the number of households eligible for lump-sum transfers in period t , i.e. the cohorts alive in period t affected by the reform.

In summary, the general government is modeled in consolidated form, and is given by the government budget constraint from equation (18), the tax revenue equation (19), and the PAYG social security condition. In the baseline economy, government expenditure balance the budget. In contrast, in the reformed economy, lump-sum transfers are endogenously determined to satisfy the fiscal constraint while keeping government expenditure and debt constant.

Measuring welfare effects We assess welfare effects of the reform using consumption equivalents, defined as the percentage change in lifetime consumption that would make an individual indifferent between the status quo and the reform steady-states.

Our main analysis focuses on aggregate welfare under the veil of ignorance—that is, before individual income shocks are realized. The derivation is presented in Appendix B.3. In complementary analyses, we also compute ex post welfare effects, evaluating outcomes across all realized income shock histories.

4 Calibration

The model is calibrated to reflect key features of the U.S. economy. Using microeconomic evidence and macroeconomic aggregates, we set reference values for preferences, life-cycle productivity profiles, tax rates, technology growth, etc. Survival probabilities $\pi_{j,t}$ and population growth are calibrated using United Nations World Population Prospects.⁸ Table 1 summarizes

⁸We use age-grouped survival and fertility rates in five-year intervals, consistent with the model's period length.

the calibrated parameter values used in the model.

Productivity heterogeneity. We follow Borella et al. (2018) in modeling individual labor productivity as the product of a deterministic age profile and a persistent idiosyncratic component. We obtain the estimates from Panel Study of Income Dynamics (PSID). Our model includes two dimensions of ex-ante heterogeneity. First, agents draw a persistent productivity shock upon entering the model at age $j = 1$, consistent with Guvenen et al. (2022). Second, productivity evolves along a deterministic life-cycle profile (which we obtain from the PSID data via decomposition of Deaton 1997, Deaton and Paxson 1998). These components are illustrated in Figure C1.

Once we adjust for the deterministic profile, we estimate the stochastic component specified as a first-order autoregressive AR(1) process with annual persistence $\bar{\varrho}_\epsilon = 0.973$ and innovation variance $\bar{\sigma}_\epsilon = 0.021$. Since each model period corresponds to five years, we convert these into model-consistent values using: $\varrho_\epsilon = \bar{\varrho}_\epsilon^5$ and $\sigma_\epsilon = \bar{\sigma}_\epsilon \frac{1 - \bar{\varrho}_\epsilon^{10}}{1 - \bar{\varrho}_\epsilon^2}$.

Preferences. We set the inverse of the intertemporal elasticity of substitution to $\sigma = 2$, in line with standard macroeconomic literature. The discount factor δ is calibrated to 0.994 to match a capital-to-GDP ratio of 2.9. Since agents face mortality risk, the effective discounting is lower.

To quantitatively explore the mechanisms highlighted in the stylized model, we consider a wide range of Frisch elasticities. For each value, we calibrate the disutility of labor parameter ϕ to target an average labor supply of 0.31. Specifically, we consider values of $\eta \in \{0.2, 0.4, 0.6, \dots, 2.8, 3\}$. Our baseline specification follows Chetty, Guren, Manoli and Weber (2011) and sets the Frisch elasticity at $\eta = 0.8$. All alternative calibrations are reported in Table C2 in the Appendix.⁹

Social security Given that the replacement rates ρ at each earnings level are defined by law, we introduce a scaling parameter ρ_m to ensure that pension expenditures match 5.0% of GDP. The effective contribution rate τ is calibrated to balance the social security budget, in line with observed data. We set the retirement age at 66, which corresponds to $\bar{J} = 10$ in our five-year-period model.¹⁰ Throughout, we model social security in net terms: neither contributions nor benefits are subject to taxation, in either the baseline or the reformed system.

Government We calibrate taxes following the approach of Mendoza et al. (1994). The capital income tax rate is set to 24.3% to match the 5.4% capital tax revenue-to-GDP ratio. The

⁹For some calibrations, δ exceeds 1, but due to mortality risk, effective discounting is below 1.

¹⁰OECD *Pensions At a Glance* reports that the United States is characterized by a uniquely high effective exit age: with current normal retirement age of 66.7, the effective exit age is 67.3 for men and 66.9 for women (despite the early eligibility age of 62).

Table 1: Calibrated parameters for the initial steady-state

Macroeconomic parameters		Calibration	Target	Value (source)	Model outcome
Preferences					
ϕ	disutility from work	8.41	average hours	31% BEA(NIPA)	31%
σ	risk preference	2	literature		
η	Frisch elasticity	0.8	literature ^(a)		
δ	discounting rate	0.994	K_t/Y_t ^(b)	2.9 OECD	2.9
Firm					
α	capital share	0.33			
d	1-year depreciation	0.06			
Government					
τ_c	consumption tax	0.044	$\tau_c C_t/Y_t$	2.8% OECD	2.8%
τ_k	capital tax	0.243	$\tau_k K_t/Y_t$	5.4% OECD	5.4%
ρ_m	benefits scaling factor	0.55	$\sum_{j=\bar{J}}^J N_{j,t} b_{j,t}/Y_t$	5.0% BEA(NIPA)	5.0%
τ	social security contr.	0.075	soc. sec. deficit as % GDP	0.00%	0.00%
τ_l	labor tax ^(c)	0.037	$\sum_{j=1}^{J-1} N_{j,t} \int_{\Omega} \mathcal{T}(y_{j,t}(s_{j,t})) d\mathbb{P}_{j,t}/Y_t$	9.2% OECD	9.2%
λ	labor tax progression	0.137	earnings distribution	Holter et al. (2019)	
Wage process					
$e_{j,t}$	age-specific profile			Borella et al. (2018)	
σ_0^2	initial variance			Borella et al. (2018)	
ϱ	shock persistence			Borella et al. (2018)	
σ^2	shock variance			Borella et al. (2018)	

Notes:

We use NIPA for 2011-2015 to obtain macroeconomic aggregates. We use OECD data for 2011-2015 to obtain five-year average share of tax revenues in GDP. We follow Mendoza et al. (1994) in classifying categories of tax revenues to tax types, see Table C1 in the Appendix for details.

^(a) Calibration for alternative values of the Frisch elasticity are provided in Table C2 in the Appendix

^(b) This implies an interest rate 5.3%. For reference, Nishiyama and Smetters (2007) calibrate to an interest rate of 6.3% for mid 2000s.

^(c) Effective tax rate for average income is equal to 13.5%, in line with 11.3% reported by Holter et al. (2019).

consumption tax rate is set at 4.4%, consistent with a 2.8% consumption tax revenue-to-GDP ratio. These ratios are based on OECD data (see Table C1).

Labor income tax parameters are set to match both micro and macro targets. Specifically, we follow Holter et al. (2019) and set $\lambda = 0.137$ and $\tau_l = 0.037$ to replicate the observed elasticity of post-tax to pre-tax income, and to match a 9.2% labor tax revenue-to-GDP ratio.

In the initial steady-state, the government debt-to-annual-GDP ratio is set at 100%, reflecting recent U.S. fiscal conditions.¹¹ In the reform scenario, government debt is held constant in per capita terms rather than as a share of GDP. The government budget is balanced by government consumption G , which settles at 14% of GDP—within the range implied by NIPA accounts.

Firms We set the output elasticity with respect to capital to 0.33, a standard value in the macroeconomic literature. The annual depreciation rate is set at 6%. The resulting investment-to-GDP ratio in the model is 22.1%, closely matching the average observed in NIPA data for the

¹¹This value is higher than in earlier studies, consistent with updated U.S. debt levels.

period 2011-2015.

Productivity growth The model assumes labor-augmenting technological progress, defined as $\gamma_{t+1} = z_{t+1}/z_t$. While there is ongoing debate about the long-term outlook for U.S. productivity growth (e.g., Fernald and Jones 2014, Gordon 2016), we follow standard practice and set the annual growth rate to 2%. Importantly, this growth rate is assumed to be identical across both the baseline and reform scenarios, as both systems are modeled as pay-as-you-go.

5 Results: Steady-state

We implement the reform as described in Section 3: we change the formula for pensions from redistributive to non-distortionary and we use increased labor income tax revenue to finance lump-sum transfers to all individuals in a fiscally neutral manner. We organize the discussion of the results as follows. First, we show the three effects identified in the stylized model—namely, the reduction in the labor wedge, the decline in pension-based redistribution, and the increase in tax-based redistribution—operating in the computational model. Second, we demonstrate that the reduction in the labor wedge leads to a non-negligible increase in labor supply. Third, we present the welfare consequences of the reform. Finally, we examine its macroeconomic and fiscal implications, emphasizing the critical role played by the strength of the labor supply response. Throughout this chapter, we focus on steady-state outcomes. In the next chapter, we extend the analysis to study the effects of the reform along the transition path.

5.1 Efficiency Effect: Labor Wedge

We operationalize distortions to labor supply decisions as labor wedges (Chari et al. 2007, Berger et al. 2019, Boar and Midrigan 2020). Consider the labor supply choice of households. With marginal labor income tax denoted as $\mathcal{T}'(y_{j,t}(s_{j,t}))$, the first-order condition is given by:

$$\phi \ell_{j,t}(s_{j,t})^{\frac{1}{\eta}} = \frac{c_{j,t}(s_{j,t})^{-\sigma}}{1 + \tau_c} [1 - (1 - \tau)\mathcal{T}'(y_{j,t}(s_{j,t})) - \tau(1 - v_{j,t})] w_t \omega_{j,t}(s_{j,t}), \quad (22)$$

where $v_{j,t}$ determines implicit marginal tax stemming from social security.¹² In the stylized model, the implicit tax associated with pension system contributions is defined and characterized by equations (A13) and (A16).

Notice that the implicit marginal tax due to social security may be negative in the reform scenario, due to the annuitization provided by the social security system. Indeed, under the reformed social security, $v_{j,t}$ may exceed one.

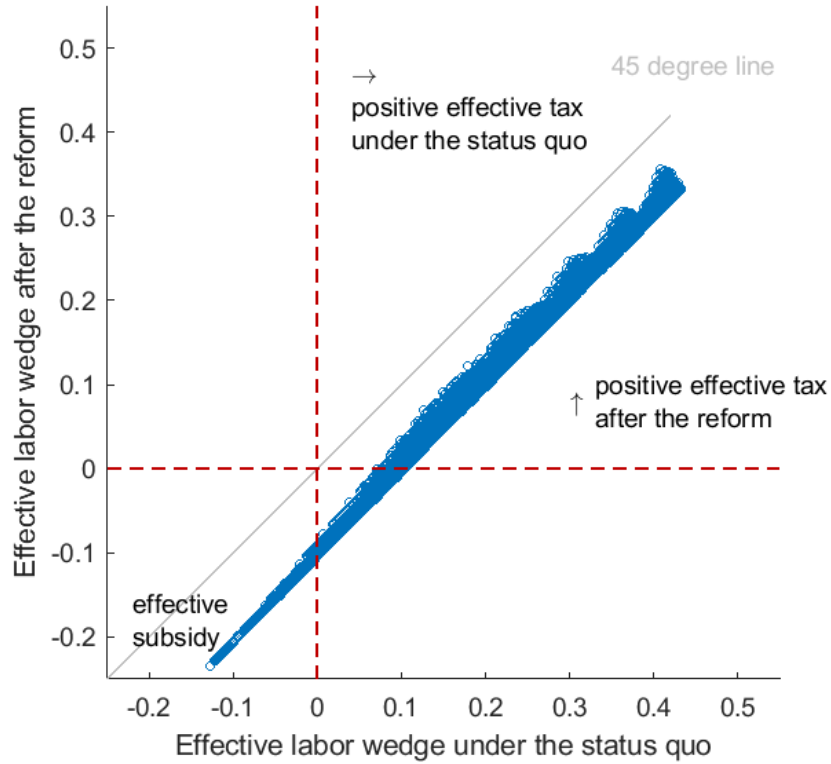
¹²For details on the implicit tax associated with social security, see Appendix B.2.

Following Cociuba and Ueberfeldt (2010), we measure labor wedges as the discrepancy between the household's marginal rate of substitution between labor and consumption and the wage. The labor wedge faced by household at age j at time t , characterized by the state $s_{j,t}$, is defined as:

$$\vartheta_{j,t}(s_{j,t}) = \frac{(1 - \tau)\mathcal{T}'(y_{j,t}(s_{j,t})) + \tau(1 - v_{j,t}) - 1}{1 + \tau_c} + 1. \quad (23)$$

This formula is the direct analog of equation (A18) from the stylized model.

Figure 1: Effective Labor Wedge Before and After the Reform



Notes: The figure portrays the values of the effective labor wedge $\vartheta_{j,t}(s_{j,t})$ across positive-probability combinations of states (a total of 2.34 million plotted state-age outcomes) under both the status quo and the reform. These values are computed using equation (23).

Figure 1 scatters the age- and state-specific labor wedges $\vartheta_{j,t}(s_{j,t})$, as defined by equation (23), before and after the reform. The points lie below the 45-degree line, indicating that across the entire state space, the labor wedge is lower after the reform.

Importantly, neither the parameters of the tax system nor the social security contributions are changed relative to the status quo. Yet, the decline in labor wedge is substantial and comprehensive. This reflects the efficiency gain from the social security reform. In the baseline system, agents perceive social security contributions as a tax, while after the reform, they view them as a source of future income.

Thus, even though the computational model does not yield an analytical expression for the

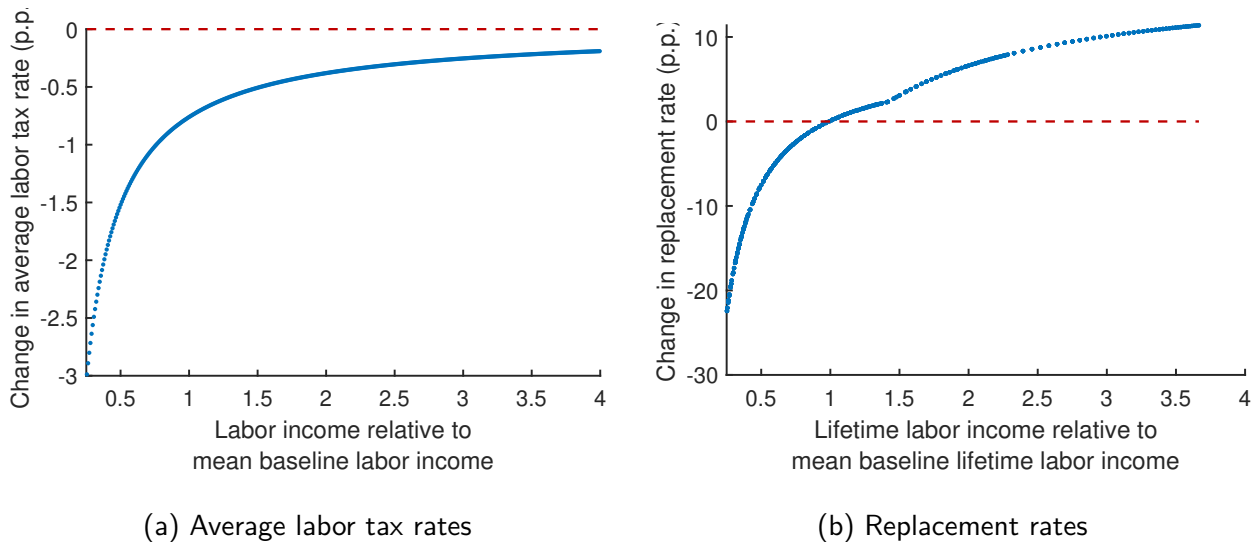
labor wedge as in the stylized model, Figure 1 confirms that the same positive efficiency effect emerges. The implications for labor supply are discussed in section 5.3.

5.2 Tax-Based and Pension-Based Redistribution

In the stylized model, we argued that the reform reduces redistribution within the pension system while enhancing redistribution through the tax system. Here, we verify whether this pattern holds in the more realistic computational model. To do so, we examine how average tax rates and replacement rates change as a result of the reform—in other words, we study the extent to which insurance is shifted from the social security system to the tax system.

Panel (a) of Figure 2 shows how the reform affects average labor taxation across the distribution of instantaneous income. The results indicate that the reform strengthens redistribution through the tax system: average tax rates decline more for lower-income individuals than for higher-income ones. Consequently, the tax system provides greater implicit insurance. Specifically, following the reform, average tax rates for low-income individuals decrease by up to 3 percentage points relative to the status quo, while for high-income individuals, the reduction is smaller but still positive at around 0.2 percentage points. Overall, the reform leads to a broad-based decline in average labor tax rates across the income distribution.

Figure 2: Changes in Average Labor Tax Rates and Replacement Rates



Notes: The left panel shows the change in the average labor tax rate between the reform and the status quo across percentiles of instantaneous labor income. Negative values indicate a reduction in taxation. The right panel shows the change in replacement rates between the two systems across percentiles of lifetime labor income at retirement age. Negative values indicate a decline in replacement rates. The replacement rate is defined as the ratio of Social Security pension benefits received at retirement to the retiree's average labor income. Levels are reported in Figure E1 in Appendix E.

Panel (b) of Figure 2 shows the change in replacement rates between the reform and the

status quo, across the distribution of average labor income at retirement under the status quo. Here, the replacement rate is defined as the ratio of pension benefits received at retirement to the average lifetime labor income of the retiree. The reform lowers replacement rates for low-income individuals—by about 22 percentage points—while raising them for individuals with above-average lifetime income—by about 11 percentage points. This shift reduces redistribution within the pension system.

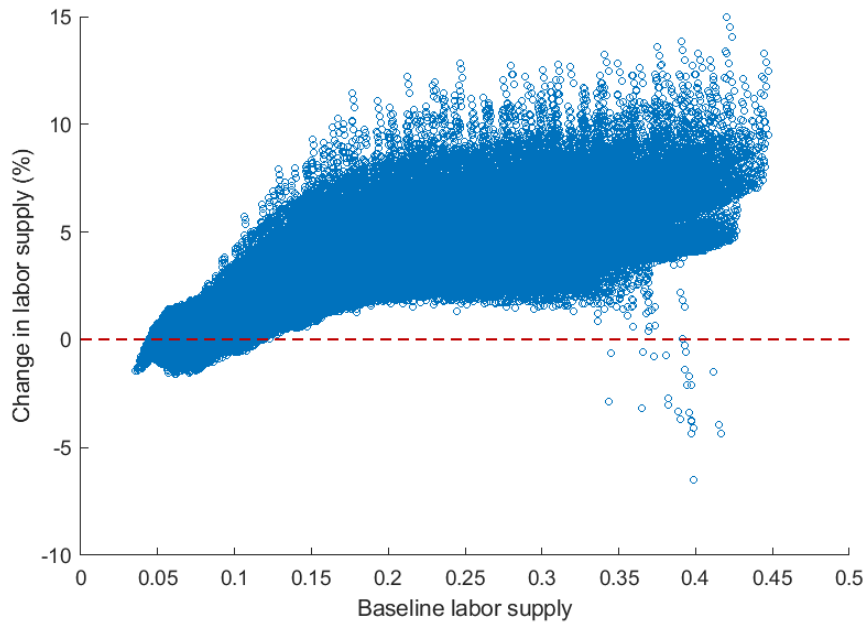
Taken together, these results confirm that in the large-scale computational model, the reform indeed shifts the burden of redistribution from the pension system to the tax system.

5.3 Labor supply

As we showed in the stylized model, the increase in labor supply is crucial for the success of the reform. In the stylized setting, we assumed GHH preferences, where there is no income effect, so labor supply depends directly on the labor wedge. In contrast, the computational model features a more general utility function, which features both a substitution effect and an income effect—the latter dampening the labor supply response to changes in net wages.

Figure 3 illustrates the labor supply response to the reform across realizations of productivity shocks, relative to the status quo. Consistent with the stylized model, labor supply increases for nearly all individuals.

Figure 3: Labor Supply Response to the Reform



Notes: The figure shows the percentage change in labor supply after the reform relative to the status quo. Each dot represents an individual in a given state, identified by the realization of idiosyncratic productivity shocks. A version of this figure that accounts for the probability measure $\mathbb{P}_{j,t}$ is available in Appendix E (see Figure E2).

Several economic forces drive this outcome. First, the reduction in the labor wedge generates a substitution effect that increases labor supply. Second, the decline in pensions for low-productivity agents induces a negative income effect, further encouraging work effort, while the increase in pensions for high-productivity agents generates a positive income effect, reducing their labor supply. Third, the lump-sum transfer induces a positive income effect across all individuals, tending to lower labor supply. Overall, the substitution effect dominates, explaining the widespread increase in labor supply observed after the reform.

The mean and standard deviation of labor supply changes across different productivity realizations are reported in Table 2, using the probability measure $\mathbb{P}_{j,t}$ to weight observations according to the distribution of the population.

Table 2: Average and standard deviation of labor supply response across productivity shock realizations

Productivity Shock	Mean Labor Supply Change	Std. Dev. of Change
ϵ^1	1.99	2.51
ϵ^2	3.31	1.45
ϵ^3	3.52	1.30
ϵ^4	3.38	1.14
ϵ^5	2.67	0.95

Notes: This table reports the mean and standard deviation of percentage changes in labor supply in response to a social security reform, conditional on five different realizations of idiosyncratic labor productivity shocks $\hat{H} = \{\epsilon^1, \epsilon^2, \epsilon^3, \epsilon^4, \epsilon^5\}$. Values are expressed in percent.

We find that labor supply increases by 3.52% on average at the median productivity realization, where the response is the strongest. The response remains elevated for realizations one level lower and higher than the median, at 3.31% and 3.38%, respectively. Labor supply rises by 2.67% for the highest shock realization and by 1.99% for the lowest shock realization. This pattern indicates that the distribution of responses exhibits a hump-shaped pattern, with the largest response occurring at the center of the productivity distribution. At the same time, highest-productivity individuals are more responsive to the reform than the lowest-productivity ones.¹³ Note that responses above median are typically on a higher base.

The standard deviations reported in Table 2 provide additional context on the variability of responses within each productivity group, ranging from 2.51 percentage points at the lowest productivity level to 0.95 at the highest. At the median productivity level, the standard deviation is 1.30 percentage points. Thus, responses are more heterogeneous for low income individuals and more homogeneous for high income individuals.

The reform partially addresses concerns raised in the literature regarding incentive alignment across the income distribution. For instance, Heathcote et al. (2008) argue that greater income dispersion can be socially desirable if high-productivity individuals increase labor supply while low-productivity individuals reduce it. Similarly, Huggett and Parra (2010) find that under the current

¹³All these differences between these means are statistically significant at conventional levels.

U.S. system, high-productivity individuals work too little and low-productivity individuals work too much relative to the social optimum. Our reform moves in this direction by eliciting stronger labor supply responses among higher-productivity workers, but it does not reduce labor supply at the bottom. Instead, it increases labor supply across the board, with stronger responses among high-productivity workers than among the lowest-productivity workers, although the largest response occurs near the middle of the productivity distribution.

5.4 Welfare

The results presented so far validate that the social security reform, accompanied by the lump-sum transfers, produces the effects emphasized in the stylized model. First, there is an efficiency effect stemming from the reduction of the labor wedge, which benefits all agents. Second, a pension redistribution effect that advantages high-income individuals while disadvantaging low-income individuals. Third, a tax system redistribution effect that works in the opposite direction. Overall, the net effect is primarily quantitative. For the preferred Frisch elasticity of 0.8, we find that the ex ante welfare gain (under the veil of ignorance), expressed in consumption equivalent and computed according to equation (B15), amounts to 0.30% of lifetime consumption. Thanks to the labor wedge reduction, the increase in tax revenues creates space for greater labor tax progression, which can substitute, at least partially, for the loss of insurance due to reduced redistribution in the social security system.

The intuitions developed in the stylized model in Section 2 suggest that labor supply elasticity plays a paramount role in determining both the sign and the magnitude of the response to the reform. To quantify this insight, we present in Figure 4 results for alternative calibrations of the Frisch elasticity. Calibrated parameters are reported in Table C2 in the Appendix. According to Chetty, Guren, Manoli and Weber (2011), values for aggregate hours elasticity ranging from 0.6 to 0.8 are consistent with macroeconomic data, although microeconomic studies suggest higher values. The vertical dashed line signifies our preferred calibration of 0.8.¹⁴ Our results show that, at this value, the reform delivers positive welfare gains. The results show that for higher values of the Frisch elasticity the welfare effects become larger.

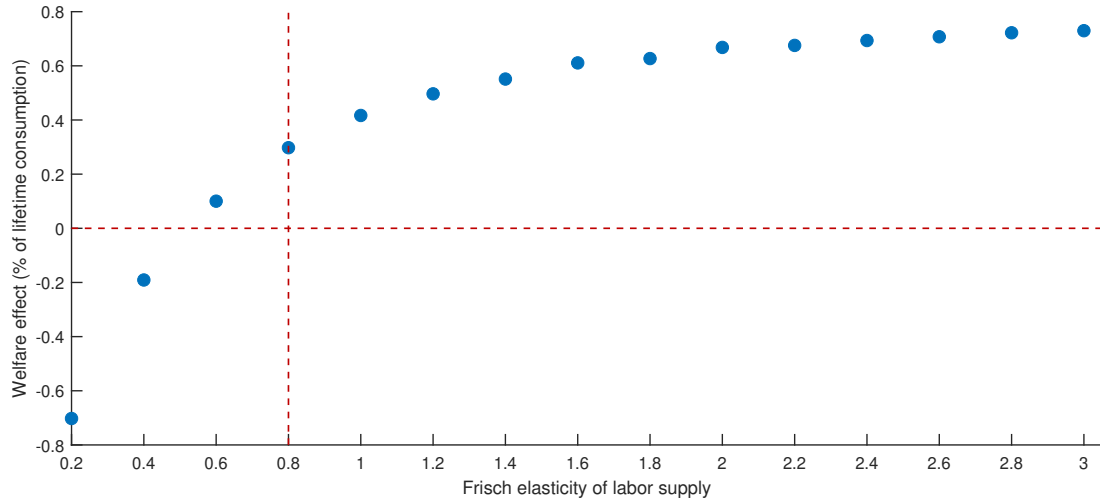
However, it is important to note that all of the analysis conducted in this section thus far is based on steady-state comparisons, which abstract from medium-term dynamics. Since welfare outcomes during the transition can differ substantially from long-run outcomes—particularly in the context of large reforms such as social security privatization—it is crucial to also assess the welfare effects along the transition path. Therefore, in the next chapter, we extend our analysis to include the transition dynamics.

Notably, our findings align with the conclusions of Ferriere et al. (2023), who show that, within an optimal fiscal policy framework, transfers should be substantially higher than their

¹⁴See Chetty, Guren, Manoli and Weber (2011), Chetty, Friedman, Olsen and Pistaferri (2011), Chetty (2012).

current levels in the United States and financed through a moderately progressive income tax system.

Figure 4: Welfare Effects Across Alternative Calibrations of the Frisch Elasticity



Notes: Each dot represents the welfare effect under the veil of ignorance for a given value of the Frisch elasticity; see equation (B15). The welfare effect is expressed as a consumption-equivalent change in lifetime consumption. Calibrated parameters are as reported in Table C2 in the Appendix. The vertical dashed line denotes our preferred calibration, based on consensus estimates of plausible Frisch elasticity values in the literature.

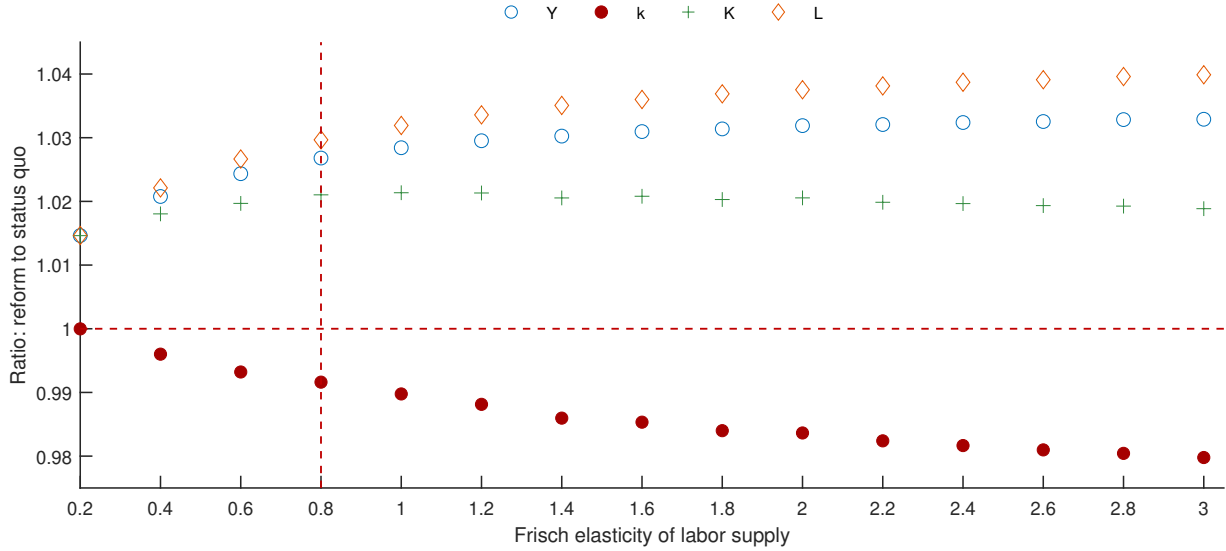
5.5 Macroeconomic and fiscal consequences

Figure 5 presents the macroeconomic adjustments across different Frisch elasticity calibrations, quantifying the intuitions discussed earlier. Labor supply increases by approximately 3% for plausible values of the Frisch elasticity in the range of 0.6 to 0.8, and approaches 4% for the highest elasticity values considered. Simultaneously, the increase in labor income combined with lump-sum transfers, boosts savings and thus capital accumulation. Moreover, the rise in labor supply increases the return to capital, further encouraging capital accumulation. Nevertheless, capital grows by less than labor supply, leading to a decline in the capital-labor ratio. The expansion of both capital and labor results in higher aggregate output.

These macroeconomic adjustments, in turn, facilitate fiscal adjustments, which are illustrated in Figure 6. The increase in labor supply generates higher labor tax revenues, which emerge as the primary source of additional fiscal capacity. The magnitude of this increase is substantial: for our preferred Frisch elasticity of 0.8, labor tax revenues rise by approximately 0.44% of baseline output. To put this figure in context, total labor tax revenues account for approximately 9.2% of GDP in the baseline. Other tax revenues also increase, as greater capital accumulation and higher consumption expand their respective tax bases, thereby creating additional fiscal space for higher lump-sum transfers to all individuals. The only fiscal adjustment that reduces available

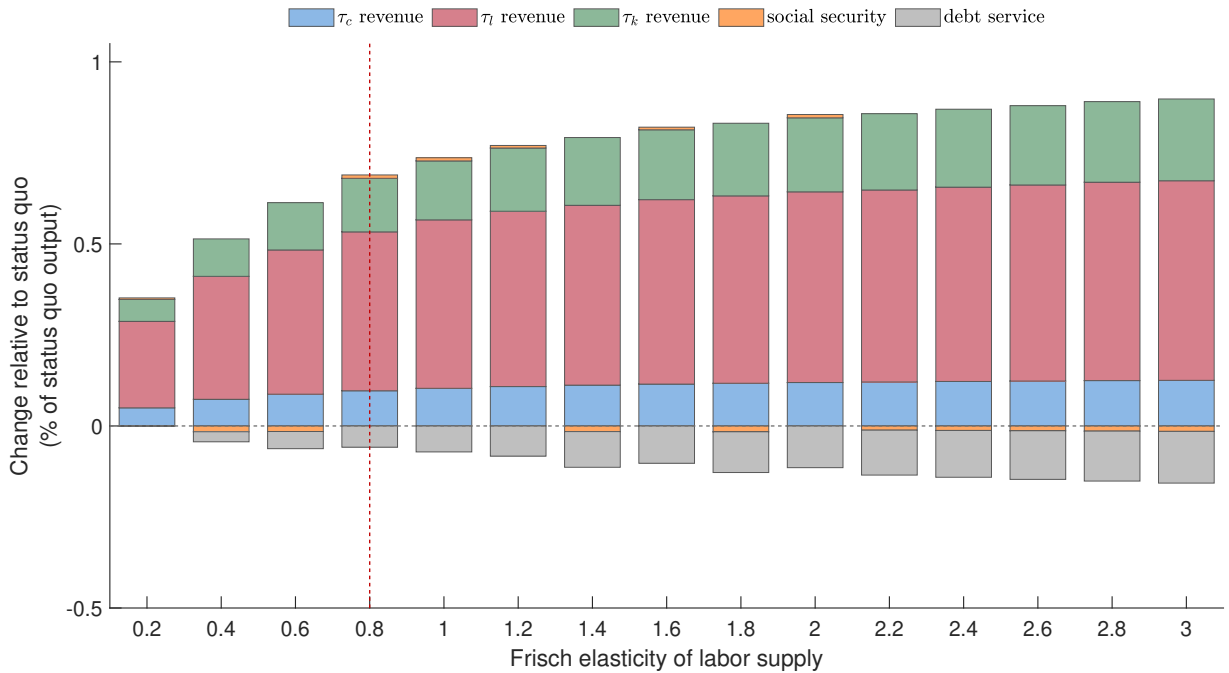
fiscal space stems from debt: debt servicing costs rise because the higher return to capital, resulting from the lower capital-labor ratio, increases the interest rate.

Figure 5: Macroeconomic Adjustments Across Alternative Calibrations of the Frisch Elasticity



Notes: The figure displays the ratios of selected macroeconomic variables—aggregate output (Y), capital per effective unit of labor (k), aggregate capital (K), and effective aggregate labor (L)—between the reform and the status quo scenarios, across different values of the Frisch elasticity. Values above one indicate that the variable is higher under the reform. The vertical dashed line denotes the preferred calibration.

Figure 6: Fiscal Position Changes Across Alternative Calibrations of the Frisch Elasticity



Notes: The figure shows changes in fiscal revenues and expenditures between the reform and status quo scenarios across values of the Frisch elasticity. Positive values increase fiscal space, whereas negative values reduce it. Changes are expressed as a percentage of status quo aggregate output. The vertical dashed line denotes the preferred calibration.

The analysis above highlights two main findings. First, redistribution through the tax system can effectively substitute for the redistribution currently provided by U.S. social security. Second, the extent to which this compensation occurs depends crucially on the labor supply response. For plausible values of the Frisch elasticity, the welfare implications of reforming social security in the United States are positive, provided that the additional tax revenue is used to enhance redistribution through labor taxation.

5.6 Distributions

For illustrative purposes, Figure 7 depicts the distribution of the ex post welfare effects between the two steady-states. We compute welfare outcomes across all shock realizations by evaluating welfare at each point in the $s_{j,t}$ state space and adjusting for the corresponding probability measure. The figure shows that, from an ex post perspective, approximately 90% of lifetime paths (weighted by the probability measure) experience a welfare gain.

Nonetheless, there are individuals for whom welfare losses persist, despite the provision of lump-sum transfers. For these individuals, the reduction in income resulting from the less redistributive pension system is too large to be offset by the lump-sum transfers and the associated efficiency gains. We interpret this finding as evidence that the optimal combination of social security reform and increased labor tax progression should be designed in a more targeted manner, specifically to protect vulnerable groups from welfare losses.

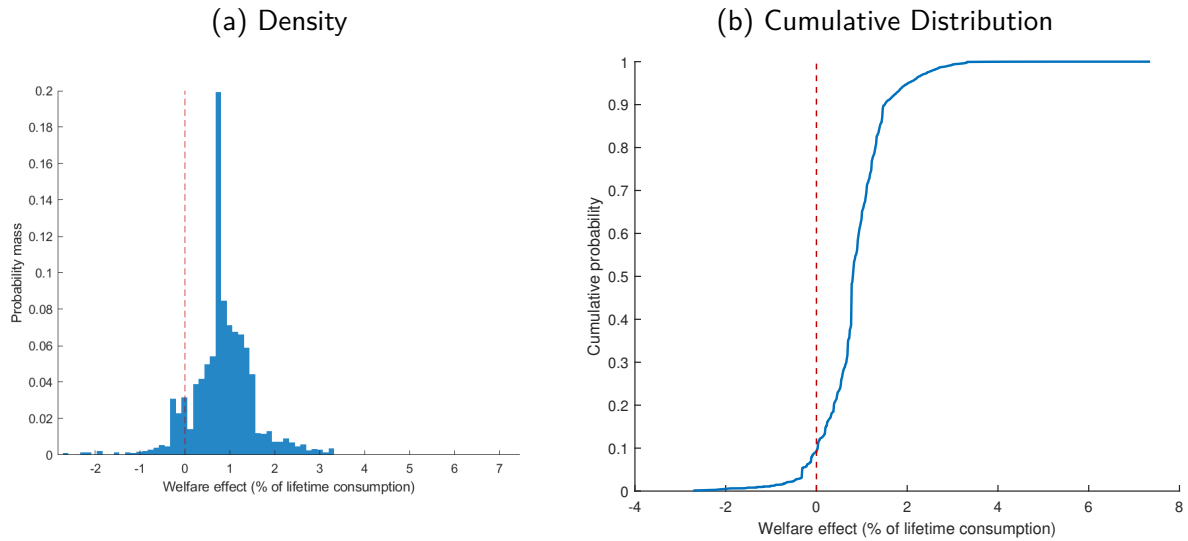
5.7 Sensitivity Analyses

To assess the robustness of our findings, we conducted a set of sensitivity analyses, reported in full in Appendix D. We focused on three key dimensions: demographic trends, the behavioral response of agents to the reform, and the fiscal closure used to redistribute the gains from the reform.

First, we examined how increased longevity, consistent with demographic projections for 2080, affects the results. We found that longer life expectancy amplifies the welfare gains from the reform. This is driven by higher capital accumulation and a smaller decline in the capital-labor ratio, which together boost labor supply and generate larger efficiency gains. Notably, even at lower values of the Frisch elasticity, the reform delivers positive welfare effects under the aging scenario.

Second, we investigated the degree to which individuals internalize the changes in social security contributions. Our baseline results assume full internalization, i.e., that individuals perceive pension contributions as deferred income rather than a tax. When we gradually relax this assumption, we find that the reform still produces welfare gains under partial internalization: with population aging, welfare gains emerge once about 60% of incentives are internalized, while under current demographics the corresponding threshold is roughly 80%. This finding implies

Figure 7: Distribution of Welfare Effects: Ex Post Evaluation



Notes: Welfare effects are expressed as consumption equivalents in percent of lifetime consumption. The figures portray the outcomes of 1.74 million positive-probability simulations used in the figure. For each potential realization of the lifetime path of shocks, we use the policy functions to generate the corresponding paths of consumption and labor supply under both the status quo and the reformed system. We then compute the welfare effect of the reform following equation (B15) for each simulated path. This procedure allows us to obtain the distribution of welfare effects across all simulations, weighted by the corresponding probability measure.

that moderate levels of economic awareness are sufficient for the reform to succeed in enhancing welfare. Taken together, these results suggest that the welfare improvements are robust to plausible variations in demographic structure, behavioral assumptions.

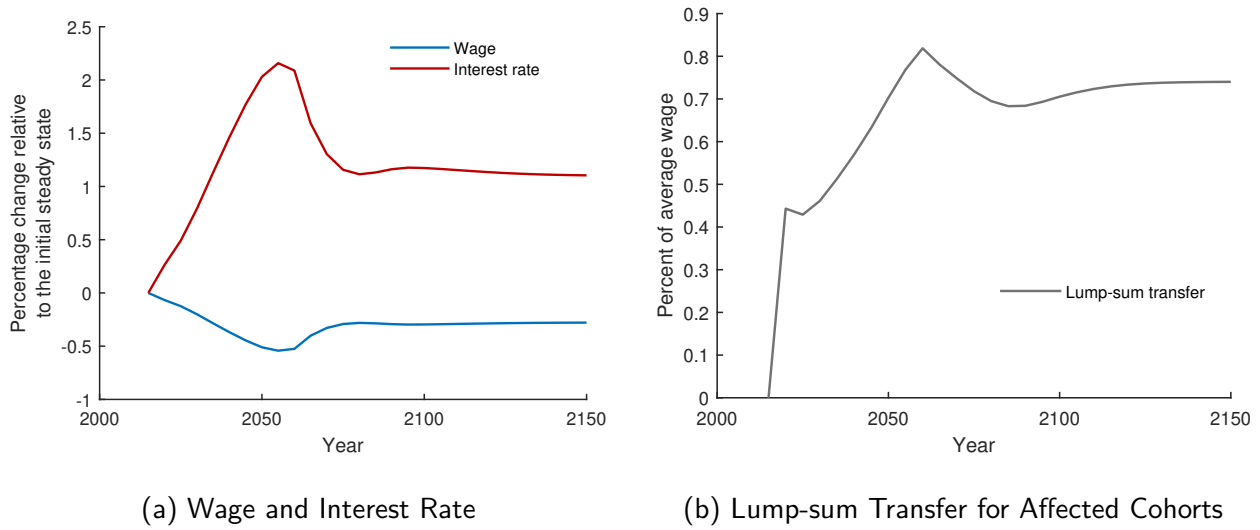
6 Results: Transition path

A large body of literature points out that the results from steady-state analyses of pension reform may differ from those accounting for the transition path. In our reform—which modifies the pension formula while maintaining the PAYG structure—our stylized model suggests that the transition dynamics do not differ substantially from the long-run steady-state outcomes.

However, our more realistic computational model departs from the stylized version in two key dimensions. First, it features a richer demographic structure: 16 overlapping cohorts are active in each period, with one period corresponding to five years. Second, the computational model operates in a general equilibrium framework, meaning that prices, including wages and interest rates, adjust over time.

In this framework, we assume that individuals already participating in the labor market at the time of the reform retain the original (baseline) pension formula, while only those entering the labor market from 2020 onward are subject to the new, reformed formula. Although this allocation rule is admittedly somewhat arbitrary, it serves to highlight the trade-offs that emerge

Figure 8: Macroeconomic Prices and Lump-Sum Transfers on the Transition Path



Notes: Panel (a) reports changes in wages and interest rates relative to the initial steady state. Panel (b) reports lump-sum transfers received by cohorts subject to the reformed pension formula, expressed as a percent of the average wage.

along the transition path in a clear and tractable manner. Similarly as in the stylized model, we assume that any additional tax revenues generated by the reform are redistributed in the form of lump-sum transfers, but only among the cohorts affected by the new pension rules—that is, those entering the labor market in 2020 or later.

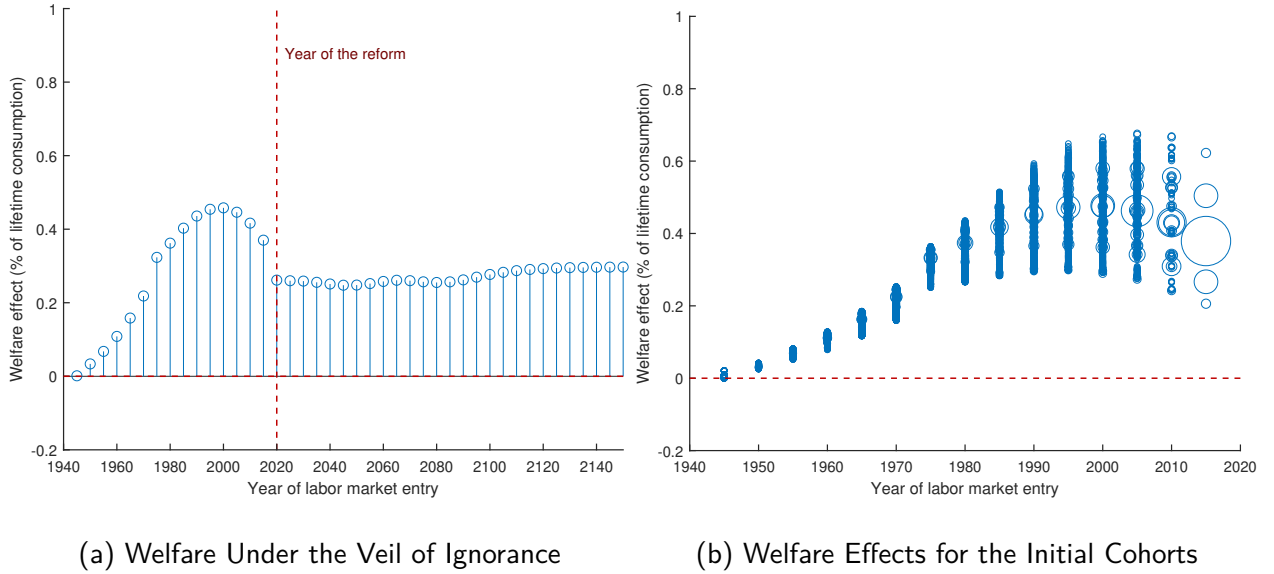
The general equilibrium adjustments in our model are as follows. Agents entering the labor market experience a decline in the labor wedge, which prompts them—and all future generations—to increase their labor supply. With reduced redistribution in the pension system and higher incomes resulting from increased labor supply, these individuals also increase their savings, leading to an overall rise in the capital stock (for further details, please refer to Figure F1a in Appendix F). However, the increase in the capital stock is delayed relative to the immediate rise in labor supply and is lower in magnitude.

As a result, capital per worker declines. Because capital adjusts more slowly than labor, this decline is more pronounced during the transition than in the final steady-state. This dynamic lowers wages and raises interest rates, as illustrated in Figure 8a. Additionally, the gradual increase in labor supply leads to higher labor tax revenue. Since lump-sum transfers are limited to individuals entering the labor market from 2020 onward—those subject to the new, reformed formula—these transfers increase immediately to levels comparable to those in the steady-state, as shown in Figure 8b. Consequently, the enhanced tax-based redistribution takes effect relatively quickly.

The timing and allocation of lump-sum transfers are important for interpreting the transition. In our reform experiment, transfers are directed to cohorts affected by the new pension rules, that

is, those entering the labor market from 2020 onward. This reflects the logic of the reform: tax-based redistribution is used to compensate the cohorts that lose part of the insurance previously embedded in the pension system. By contrast, older cohorts remain under the baseline pension formula and benefit from the reform through higher pension indexation and, in many cases, higher returns on savings, so there is no analogous need to compensate them through additional transfers.

Figure 9: Welfare Effects of the Reform Along the Transition Path



Notes: Welfare effects are expressed as consumption equivalents in percent of lifetime consumption. Panel (a): Each dot represents the welfare effect under the veil of ignorance for a given cohort. Panel (b): Each dot represents the welfare effect for a cohort defined by age, productivity shock, and accumulated assets at the time of the reform. The size of each dot corresponds to the relative size of that cohort.

Equipped with the analysis of the steady-state and the general equilibrium adjustments, we are ready to investigate the welfare effects of the pension system reform coupled with increased progressivity of the labor income tax system.

The welfare effects for different generations along the transition path are presented in Figure 9. Panel (a) illustrates the average welfare gain for individuals who are alive in the year of the reform (2020) as well as, under the veil of ignorance, for those entering the labor market during and after the reform. For individuals active at the time of the reform—whose income shocks have already been realized—we also examine the distribution of welfare outcomes within the cohort. Panel (b) displays this distribution of welfare effects, measured as consumption equivalents, across different individuals alive at the time of the reform.

We begin with the retired individuals at the moment of reform introduction. Although their pension formulas remain intact, they still experience welfare gains as a result of the reform.

First, their pensions are indexed to the growth rate of the aggregate wage bill. As the cohorts entering the labor market from the reform year onward increase their labor supply, the wage bill

risers slightly—leading to higher pension benefits for retirees. Second, as asset holders, retirees benefit from the increase in the interest rate brought about by the reform, which raises the return on their savings and thus enhances their lifetime wealth. Taken together, these two channels imply that all retired individuals benefit from the reform—this result is illustrated in Figure 9.

Next, we turn to individuals who are active in the labor market at the time of the reform. These workers continue to be covered by the baseline pension formula and therefore do not lose the redistribution embedded in the original system. In fact, they also benefit from slightly higher future pension indexation, resulting from the projected increase in the aggregate wage bill following the reform.

Additionally, these individuals—especially those closer to retirement—are net savers, so they benefit from higher interest rates. Although they experience a wage reduction, this negative effect is limited to the working period, whereas the positive impact of higher interest rates applies both during employment and in retirement. Overall, as illustrated in Figure 9, working-age individuals at the time of the reform benefit, with the gains being larger for middle-aged workers. This shows that the positive effects of higher pensions and increased interest rates outweigh the adverse impact of lower wages.

Finally, we turn to future generations—those entering the labor market in the year of the reform (2020) and thereafter. These cohorts are the first to be subject to the modified pension formula, which implies a loss of part of the insurance previously provided by the pension system—an effect that adversely impacts their welfare. At the same time, they benefit immediately from a reduced labor wedge, which boosts their labor supply, and they receive lump-sum transfers as part of enhanced tax-based redistribution.

Taken together, the balance of the three main forces—for plausible calibrations of the Frisch elasticity—proves to be positive. The key determinants of the reform’s impact in the steady-state—reduced pension insurance, improved labor incentives, and tax-based redistribution—remain largely unchanged along the transition path for these cohorts. Additionally, a temporary transition-specific effect arises: these individuals enter the labor market without prior savings and thus face slightly lower wages—the primary price variable affecting them. Nevertheless, this transitory wage effect has only a minimal impact on the overall positive welfare outcome.

Summarizing, the pension reform yields overall welfare gains for all cohorts, driven by different mechanisms. Retirees benefit from higher pension indexation linked to a growing wage bill and from increased interest rates that enhance the value of their savings. Workers active at the time of the reform retain the original, more redistributive pension formula while also gaining from improved pension indexation and higher returns on savings, which more than offset the negative impact of lower wages. Future generations, although facing reduced pension insurance, experience stronger labor supply incentives and receive lump-sum transfers as part of enhanced tax-based redistribution. For plausible values of the Frisch elasticity, these combined effects result in net welfare improvements. These results mirror the findings from the stylized model, providing

additional effects arising from general equilibrium. In this respect, our analysis complements the framework of Hosseini and Shourideh (2019), which studies efficiency gains arising from incomplete annuity markets, whereas our mechanism operates through incomplete insurance against idiosyncratic labor income risk.

7 Conclusions

In this paper, we revisit the welfare implications of social security reform in an environment with idiosyncratic income risk. While the existing U.S. social security provides partial insurance through a redistributive benefit formula, it also distorts labor supply. The standard trade-off in the literature has been that reducing these distortions improves efficiency but comes at the cost of lower insurance. We propose to complement social security reform with increased progressivity of labor taxation. This reform addresses both concerns simultaneously: it links pension benefits to contributions (thus reducing labor market distortions) while restoring insurance (through increased progressivity of the labor income tax).

In a stylized model, we illustrate the mechanism at play: a reduction in the labor wedge increases labor supply and tax revenues, enabling lump-sum transfers that partially or fully offset the loss of pension-based redistribution. We then quantify this reform in a full overlapping generations model calibrated to the U.S. economy. Our simulations show that a fiscally neutral reform generates welfare gains under plausible calibrations of the Frisch elasticity. For our preferred value of 0.8, the reform yields a lifetime consumption equivalent gain of 0.30%. Welfare gains are larger if the labor supply responds more strongly to reduced distortions. Along the transition path, we find that the results align with the implications of the steady-state analysis: under plausible calibrations of the Frisch elasticity, all generations benefit, making the reform Pareto-improving. In general equilibrium, increased labor supply generates also benefits through relative prices of capital and labor.

Our results contribute to the literature on optimal taxation and pension reform by showing that, under realistic conditions, redistribution can be shifted from pensions to progressive taxation without sacrificing insurance or equity. We show that when the market for income risk is missing, partial insurance in labor tax progression is effectively more efficient than redistribution through social security. We thus offer a politically and economically viable reform blueprint that balances efficiency and redistribution in the face of aging populations and fiscal pressures.

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Online Appendix

Progressing Towards Efficiency: The Role of Labor Tax Progression in Reforming Social Security

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A Technical Derivations and Proofs for the Stylized Model

This appendix provides the algebraic details and proofs omitted from Section 2. We first restate key equilibrium conditions and then present formal proofs of the propositions and lemmas.

A.1 Model Details and Notation

Government budget constraint

We assume that the government must raise revenue $\mathcal{R}_t$ to finance an exogenously given level of government spending g_t , which grows at the constant rate γ . This revenue is collected via labor income taxes. Any revenue that exceeds government spending is redistributed as a lump-sum transfer μ_t . The government budget constraint is:

$$g_t + 2 \cdot \mu_t = \mathcal{R}_t \equiv \sum_{\theta \in \{\theta_H, \theta_L\}} \tau_\ell \omega_\theta w_t. \quad (\text{A1})$$

The government maintains a balanced budget. Allowing for public debt would not change the core insights of the model.

Social security formulas

The PAYG social security system is balanced in each period and features three alternative designs. We keep the overall contribution rate τ fixed across designs.

Lump-sum system. Each young agent pays a uniform contribution T_t^{LS} and receives an equal pension benefit in old age:

$$T_t^{LS} = T_t^{LS}(\theta_H) = T_t^{LS}(\theta_L) = \tau w_t \cdot \frac{1}{2} \sum_{\theta \in \{\theta_H, \theta_L\}} \omega_\theta \ell_{1,t}(\theta), \quad \tau^{BEV} = \tau^{BIS} = 0, \quad (\text{A2})$$

and

$$b_{2,t+1}^{LS}(\theta_H) = b_{2,t+1}^{LS}(\theta_L) = T_{t+1}^{LS}, \quad (\text{A3})$$

where contributions grow with in line with wage growth, $T_{t+1}^{LS} = (1 + \gamma)T_t^{LS}$.

Beveridgean system. Contributions are proportional to earnings at rate $\tau^{BEV} = \tau$ and pooled; all retirees receive the same benefit. Given that wages grow at the rate γ , $w_{t+1} = (1 + \gamma)w_t$, the pension benefits are given by:

$$b_{2,t+1}^{BEV}(\theta_H) = b_{2,t+1}^{BEV}(\theta_L) = \tau^{BEV} w_{t+1} \cdot \frac{1}{2} \sum_{\theta \in \{\theta_H, \theta_L\}} \omega_\theta \ell_{1,t+1}(\theta), \quad (\text{A4})$$

with $T_t^{LS} = \tau^{BIS} = 0$.

Bismarckian system. Contributions are proportional to earnings at rate $\tau^{BIS} = \tau$, and each retiree's benefit is proportional to her own past earnings:

$$b_{2,t+1}^{BIS}(\theta) = \tau^{BIS}(1 + \gamma)\omega_\theta w_t \ell_{1,t}(\theta), \quad b_{2,t+1}^{BIS}(\theta_H) > b_{2,t+1}^{BIS}(\theta_L), \quad (\text{A5})$$

with $T_t^{LS} = \tau^{BEV} = 0$. With $r = \gamma$, the implicit return on contributions equals wage growth.

Household budget constraints and preferences

For completeness, we restate the two-period budget constraints:

$$c_{1,t}(\theta) + a_{1,t+1}(\theta) = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t - T_t^{LS}, \quad (\text{A6})$$

$$c_{2,t+1}(\theta) = (1 + r)a_{1,t+1}(\theta) + b_{2,t+1}(\theta), \quad (\text{A7})$$

where

$$b_{2,t+1}(\theta) = b_{2,t+1}^{BEV} + b_{2,t+1}^{BIS}(\theta) + b_{2,t+1}^{LS}.$$

Combining (A6) and (A7) yields the lifetime budget constraint

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t - T_t^{LS} + \frac{b_{2,t+1}(\theta)}{1 + r}. \quad (\text{A8})$$

Preferences follow the GHH specification

$$U_t(\theta) = \frac{1}{1 - \sigma} \left(c_{1,t}(\theta) - \frac{\phi}{1 + \frac{1}{\eta}} (1 + \gamma)^t \ell_{1,t}(\theta)^{1 + \frac{1}{\eta}} \right)^{1 - \sigma} + \delta \frac{1}{1 - \sigma} \left(c_{2,t+1}(\theta) \right)^{1 - \sigma}, \quad (\text{A9})$$

with $\delta^{-1} = 1 + r$. Ex ante welfare under the veil of ignorance is

$$U_t = \sum_{\theta \in \{\theta_L, \theta_H\}} U_t(\theta). \quad (\text{A10})$$

A.2 Labor Wedge and Labor Supply: Derivation

To solve the model, it is convenient to use the marginal rate of substitution between labor and first-period consumption:

$$MRS_{(\ell_1, c_1)} \equiv - \frac{\partial U_t(c_{1,t}, \ell_{1,t}, c_{2,t}; \theta) / \partial \ell_{1,t}}{\partial U_t(c_{1,t}, \ell_{1,t}, c_{2,t}; \theta) / \partial c_{1,t}}. \quad (\text{A11})$$

Solving the household problem and using the budget constraints, the first-order condition for optimal labor supply can be written as

$$MRS_{(\ell_1, c_1)} = (1 - \tau_\ell - \tau^{BEV} - \tau^{BIS})\omega_\theta w_t + (v_{1,t}^{BEV} \cdot \tau^{BEV} + v_{1,t}^{BIS} \cdot \tau^{BIS})\omega_\theta w_t, \quad (A12)$$

The term $v_{1,t}$ denotes the share of current contributions that is returned in present value. It is defined as:

$$v_{1,t} = \frac{\frac{1}{1+r} \frac{\partial b_{2,t+1}(\theta)}{\partial \ell_{1,t}(\theta)}}{\tau \omega_\theta w_t}. \quad (A13)$$

Thus, $1 - v_{1,t}$ measures the fraction of the contribution rate that is not returned to the individual and therefore acts as a pure tax from the individual's perspective.

We define the labor wedge:

$$\vartheta_{1,t} \equiv 1 - (1 - \tau_\ell - (1 - v_{1,t}^{BEV})\tau^{BEV} - (1 - v_{1,t}^{BIS})\tau^{BIS}). \quad (A14)$$

If $v_{1,t} = 1$, contributions are fully internalized and do not add to the labor wedge. However, if $v_{1,t} < 1$, part of the contributions effectively acts as a tax, increasing the wedge.

Using the pension formulas (A4) and (A5), we obtain

$$\frac{\partial b_{2,t+1}^{BEV}(\theta)}{\partial \ell_{1,t}(\theta)} = 0 \quad \text{and} \quad \frac{\partial b_{2,t+1}^{BIS}(\theta)}{\partial \ell_{1,t}(\theta)} = \tau^{BIS}(1 + \gamma)\omega_\theta w_t. \quad (A15)$$

With $r = \gamma$ this implies

$$v_{1,t}^{BEV} = 0 \quad \text{and} \quad v_{1,t}^{BIS} = 1, \quad (A16)$$

so that

$$MRS_{(c_1, \ell_1)}(\theta) = (1 - \tau_\ell - \tau^{BEV})\omega_\theta w_t, \quad (A17)$$

and the wedges under Beveridgean and Bismarckian systems are

$$\vartheta_{1,t}^{BEV} = \tau_\ell + \tau^{BEV} \quad \text{and} \quad \vartheta_{1,t}^{BIS} = \tau_\ell. \quad (A18)$$

With GHH preferences, the first-order conditions yield labor supply

$$\ell_1(\theta) = \ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV}) \omega_\theta \right]^\eta, \quad (A19)$$

which is the expression used in the main text. For the lump-sum and Bismarckian systems, $\tau^{BEV} = 0$.

A.3 Lifetime Budget Constraint and Redistribution

Substituting the pension formulas (A3)-(A5) into the lifetime budget constraint (A8), using $w_{t+1} = (1 + \gamma)w_t$ and $r = \gamma$, we obtain:

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = (1 - \tau_\ell - \tau^{BEV})\omega_\theta w_t \ell_{1,t}(\theta) + \mu_t + \frac{\tau^{BEV} w_t}{2} \sum_{\theta' \in \{\theta_L, \theta_H\}} \omega_{\theta'} \ell_{1,t+1}(\theta'). \quad (\text{A20})$$

For the lump-sum and Bismarckian systems, i.e. $\tau^{BEV} = 0$, the present value of contributions equals the present value of benefits at the individual level, so those terms cancel out and (A20) collapses to the no-social-security case. Under Beveridge, the last term is non-zero and captures redistribution across types.

A.4 Pension Systems: Technical Details of the Comparison

Under the lump-sum system, contributions and benefits are fixed and cancel out, so labor supply and consumption choices are unchanged relative to the no-social-security benchmark.

Proposition 3 (Lump-Sum System Neutrality) *Lump-sum social security does not affect $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$ relative to the no-social-security case.*

Proof of Proposition 3: Under the lump-sum pension system, we have $\tau^{BEV} = \tau^{BIS} = 0$. Therefore, from equation (A19), labor supply is

$$\ell_1(\theta) = \ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell) \omega_\theta \right]^\eta, \quad (\text{A21})$$

for $\theta \in \{\theta_L, \theta_H\}$, which is identical to the no-social-security case.

From the government budget constraint (A1) it follows that μ_t remains unchanged relative to the no-social-security case. Given this, the rearranged lifetime budget constraint (A20) becomes

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1 + r} = \omega_\theta w_t \ell_{1,t}(\theta) - \tau_\ell w_t \omega_\theta \ell_{1,t}(\theta) + \mu_t, \quad (\text{A22})$$

which is identical to the no-social-security case. Since neither the objective function nor the constraints are affected, the consumer's problem yields the same solution. Therefore, lump-sum social security does not impact $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$. ■

In the Bismarckian system, contributions and benefits move one-for-one with individual earnings. Since each household receives exactly what it pays in, there is no redistribution, and consumption-labor decisions remain unchanged. The system is therefore neutral.

Proposition 4 (Bismarckian System Neutrality) *Bismarckian social security does not affect $(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))$ relative to the no-social-security case.*

Proof of Proposition 4: Under the Bismarckian system, $\tau^{BEV} = 0$. Therefore, from equation (A19), labor supply is

$$\ell_1^{BIS}(\theta) = \ell_{1,t}^{BIS}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell) \omega_\theta \right]^\eta, \quad (\text{A23})$$

for $\theta \in \{\theta_L, \theta_H\}$, identical to the no-social-security case.

From the government budget constraint (A1), the transfer μ_t is also unchanged relative to the no-social-security case. Therefore, the household faces the same lifetime budget constraint as in (A22), the no-social-security benchmark, and the structure of the problem it solves is identical. Since both the household's objective function and its constraints are unchanged, the optimal choices of consumption in each period, savings, and labor supply coincide with those in the no-social-security case. Thus, the Bismarckian system is neutral. ■

Unlike the previous two systems, the Beveridgean design redistributes income: workers contribute in proportion to earnings but receive identical benefits. This redistribution from high- to low-income individuals comes at the cost of a higher labor wedge.

Proposition 5 (Beveridgean System Effects) *The Beveridgean social security reduces labor supply and redistributes from high-income to low-income individuals relative to both the no-social-security and lump-sum social security cases.*

Proof of Proposition 5: Under the Beveridgean system, contributions proportional to earnings introduce a wedge in the consumption-labor decision. From (A19), labor supply is

$$\ell_1^{BEV}(\theta) = \left[\frac{1}{\phi} (1 - \tau_\ell - \tau^{BEV}) \omega_\theta \right]^\eta, \quad (\text{A24})$$

so for $\tau^{BEV} > 0$ labor is strictly lower than in the lump-sum or Bismarckian cases.

Furthermore, the Beveridgean system redistributes from high-income to low-income individuals. From the lifetime budget constraint (A20), the net present value of pensions is

$$\begin{aligned} NPV_t^{Pen, BEV}(\theta_L) &= \tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)] > 0, \\ NPV_t^{Pen, BEV}(\theta_H) &= -NPV_t^{Pen, BEV}(\theta_L) < 0. \end{aligned} \quad (\text{A25})$$

Thus the Beveridgean system reduces labor supply and redistributes from high- to low-income agents. ■

A.5 Beveridgean-to-Bismarckian Reform: Technical Details of Steady-State Analysis

We begin by observing several important features of the model. First, regardless of the social security arrangement, high-productivity households (denoted with θ_H) supply more labor than low-productivity households (denoted by θ_L), as implied by (A19). Second, the ratio of labor

supply between high- and low-productivity households is constant across pension systems. It depends only on their relative productivity levels and the Frisch elasticity. Specifically, from equation (A19), labor supplies of the two types under any system with contribution rate τ^{BEV} satisfy:

$$\frac{\ell^{BEV}(\theta_H)}{\ell^{BEV}(\theta_L)} = \frac{\ell^{BIS}(\theta_H)}{\ell^{BIS}(\theta_L)} = \left(\frac{\omega_H}{\omega_L} \right)^\eta \equiv \varpi^\eta > 1. \quad (\text{A26})$$

Third, the percentage change in labor supply induced by the reform—from Beveridgean to Bismarckian pensions—is the same across types. Using (A19), this change is given by:

$$\frac{\Delta \ell(\theta)}{\ell^{BEV}(\theta)} \equiv \frac{\ell^{BIS}(\theta) - \ell^{BEV}(\theta)}{\ell^{BEV}(\theta)} = \left(\frac{1 - \tau_\ell}{1 - \tau_\ell - \tau^{BEV}} \right)^\eta - 1 \equiv \xi^\eta - 1. \quad (\text{A27})$$

Next, to examine the welfare effect of the reform, it is useful to focus on how the right-hand side of the lifetime budget constraint—given by equation (A20)—changes when the Beveridgean system is replaced with the Bismarckian one. This change can be decomposed into three distinct effects, reiterated here from the main text: (i) an **efficiency effect** stemming from reduced labor market distortion, (ii) a **reduction in redistribution through pensions**, (iii) an **increase in redistribution via tax system**.

To formalize this decomposition, we subtract the budget constraint under the Beveridgean system from the corresponding expression under the Bismarckian system. Rearranging terms allows us to isolate the three channels through which the reform impacts household income. For low-productivity individuals (the analysis for high-productivity individuals is analogous), the reform's effect is given by:

$$\begin{aligned} RHS_t^{BIS}(\theta_L) - RHS_t^{BEV}(\theta_L) &= \underbrace{\omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}_{\text{efficiency}} - \underbrace{\frac{1}{2} \tau w_t (\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L))}_{\text{redistribution via social security}} \\ &\quad + \underbrace{(\Delta \mu_t - \tau_\ell (1 - \tau)) \omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}_{\text{redistribution via labor taxes}}, \end{aligned} \quad (\text{A28})$$

where $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$.

This decomposition provides a transparent breakdown of how the reform alters household resources through efficiency gains, the removal of pension-based redistribution, and enhanced tax-based redistribution. In what follows, we show how each of these components maps into welfare changes.

To evaluate the welfare consequences of replacing the Beveridgean pension system with a Bismarckian one while increasing tax progressivity, we proceed in four steps:

- **Step 1: Efficiency Effect.** We begin by shutting down all redistributive channels to show that the pure efficiency effect—due to the reduction in the labor wedge—raises welfare. Specifically, we demonstrate that the allocation implied by the labor supply $\ell_1^{BIS}(\theta)$ under

the the budget constraint with no redistribution $RHS(\theta) = \omega_\theta w_t \ell_{1,t}(\theta)$ yields higher welfare than that implied by $\ell_1^{BEV}(\theta)$. This result is established in Lemma 1.

- Step 2 and 3: Redistribution Effects. We then consider the redistributive effects of the reform. The loss of pension-based redistribution is analyzed in Lemma 2, while the compensating increase in tax-based redistribution is assessed in Lemma 3.
- Step 4: Total Welfare Impact. Finally, we combine the insights from the previous steps to evaluate the overall welfare effect of the reform in Proposition 1.

Importantly, when evaluating redistribution, it suffices to consider the right-hand side of the budget constraint: if it rises exogenously, welfare increases; if it falls, welfare declines.

Efficiency effect. If we switch off all redistribution—either via social security or the tax system—the lifetime budget constraint simplifies to:

$$c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = \omega_\theta w_t \ell_{1,t}(\theta) \quad (\text{A29})$$

Lemma 1 (Efficiency Effect) *Replacing Beveridgean social security with the Bismarckian one reduces the labor wedge from $\tau_\ell + \tau$ to τ_ℓ . Consequently, the optimal labor supply given by (A19) increases for both θ_H -type and θ_L -type households. Moreover, given the resulting labor supplies, the welfare defined as*

$$\max_{(c_{1,t}(\theta), c_{2,t+1}(\theta))} U_t(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta)) \quad (\text{A30})$$

$$\text{subject to } c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = \omega_\theta w_t \ell_{1,t}(\theta) \quad (\text{A31})$$

is higher under the Bismarckian labor wedge than under the Beveridgean one, for both types of households.

Proof of Lemma 1: The results on the labor wedge and labor supply follow from equations (A19). To isolate the welfare effects of reducing distortions, denote by $\tilde{\tau}$ the distortion to labor supply that is rebated to a household in the form of a lump-sum transfer

$$\tilde{\mu}_t(\theta) = \tilde{\tau} \omega_\theta w_t \ell_{1,t}(\theta). \quad (\text{A32})$$

Define the following indirect utility of $(\tilde{\tau}, \tilde{\mu}(\tilde{\tau}))$

$$\begin{aligned} \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta) &= \max_{(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta))} U_t(c_{1,t}(\theta), c_{2,t+1}(\theta), \ell_{1,t}(\theta)) \\ &\text{subject to } c_{1,t}(\theta) + \frac{c_{2,t+1}(\theta)}{1+r} = (1 - \tilde{\tau}) \omega_\theta w_t \ell_{1,t}(\theta) + \tilde{\mu}_t(\theta) \end{aligned} \quad (\text{A33})$$

First note that for GHH preferences given by (4)

$$\ell_{1,t}(\theta) = \left[\frac{1}{\phi} (1 - \tilde{\tau}) \omega_\theta \right]^\eta \quad (\text{A34})$$

In order to show that reduction of labor distortion improves welfare it is enough to show that the total derivative $\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} < 0$ for $\tilde{\tau} \in (0, 1)$. Note

$$\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} = \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tau} + \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\mu}_t} \frac{d\tilde{\mu}_t(\tilde{\tau})}{d\tilde{\tau}} \quad (\text{A35})$$

Using the envelope theorem, we obtain

$$\frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\tau}} = -\frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)} \omega_\theta w_t \ell_{1,t}(\theta); \text{ and } \frac{\partial \tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{\partial \tilde{\mu}_t} = \frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)}$$

Substituting these into (A35) and using the expression from (A32), with $\frac{d\tilde{\mu}_t(\tilde{\tau})}{d\tilde{\tau}} = \omega_\theta w_t \ell_{1,t}(\theta) + \tilde{\tau} \omega_\theta w_t \frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}}$, we obtain

$$\frac{d\tilde{W}_t(\tilde{\tau}, \tilde{\mu}_t(\tilde{\tau}); \theta)}{d\tilde{\tau}} = \frac{\partial U_t(\cdot)}{\partial c_{1,t}(\theta)} \tilde{\tau} \omega_\theta w_t \frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}} < 0 \quad (\text{A36})$$

Since equation (A34) implies $\frac{d\ell_{1,t}(\theta)}{d\tilde{\tau}} < 0$, the derivative is negative. Therefore, reducing the labor distortion improves welfare. Moreover, since $\tilde{\tau}^{BIS} = \tau_\ell < \tau_\ell + \tau$ welfare – as defined in (A30) – is higher under the wedge implied by the Bismarckian system than under one implied by the Beveridgean system for both types of households. ■

Thus, the efficiency effect of the social security reform—from Beveridgean to Bismarckian—reduces the labor wedge, raises the labor supply, and improves welfare of both high- and low-productivity households.

Pension-Based Redistribution. To quantify redistribution via pensions we define the net present value of pensions:

$$NPV_t^{Pen}(\theta) = \frac{b_{2,t+1}(\theta)}{1+r} - \tau w_t \omega_\theta \ell_{1,t}(\theta), \quad (\text{A37})$$

and the reform-induced change in the scope of redistribution

$$\Delta NPV_t^{Pen}(\theta) = NPV_t^{Pen, BIS}(\theta) - NPV_t^{Pen, BEV}(\theta). \quad (\text{A38})$$

It is convenient to express this change as a percentage of the low-type income under the *status quo* (i.e., under the Beveridgean system), which we formalize in the following lemma.

Lemma 2 (Pension-Based Redistribution) *Suppose that the economy is in steady-state with*

the Beveridgean pension system. Consider the following reform bundle:

1. the social security system is shifted from the Beveridgean to the Bismarckian formula; and
2. the resulting fiscal adjustment is implemented via lump-sum transfers within the tax system.

Then in the new steady-state with the Bismarckian pension system, this reform reduces redistribution via social security from θ_H -type to θ_L -type households. The resulting change in the net present value of pensions, expressed as a percentage of the low-type income the Beveridgean system, is given by

$$\frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = -\frac{1}{2} \tau (\varpi^{1+\eta} - 1) = -\frac{\Delta NPV_t^{Pen}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} < 0 \quad (\text{A39})$$

where $\varpi = \omega_H / \omega_L > 1$.

Proof of Lemma 2: First, we can compute the scope of redistribution in the Beveridgean system. Substituting the Beveridgean pension formula from equation (A2) into equation (A37), we have

$$NPV_t^{Pen, BEV}(\theta) = \frac{\tau w_{t+1} \frac{1}{2} \sum_{\theta \in \{\theta_L, \theta_H\}} \omega_\theta \ell_1^{BEV}(\theta)}{1 + r} - \tau w_t \omega_\theta \ell_1^{BEV}(\theta).$$

Using $w_{t+1} = (1 + \gamma)w_t$, $r = \gamma$, and noting from equation (A19) that $\ell_1^{BEV}(\theta_H) > \ell_1^{BEV}(\theta_L)$, we obtain

$$\begin{aligned} NPV_t^{Pen, BEV}(\theta_L) &= \tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)] > 0 \\ NPV_t^{Pen, BEV}(\theta_H) &= -NPV_t^{Pen, BEV}(\theta_L) < 0 \end{aligned} \quad (\text{A40})$$

This implies that the Beveridgean system redistributes from high-ability to low-ability workers. Next, under the Bismarckian social security the net present value of pension is

$$NPV_t^{Pen, BIS}(\theta_L) = NPV_t^{Pen, BIS}(\theta_H) = 0. \quad (\text{A41})$$

Substituting from equations (A40) and (A41) into (A38) and dividing by $\omega_L w_t \ell_1^{BEV}(\theta_L)$ yields the change in the scope of redistribution:

$$\begin{aligned} \frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} &= -\frac{\tau w_t \frac{1}{2} [\omega_H \ell_1^{BEV}(\theta_H) - \omega_L \ell_1^{BEV}(\theta_L)]}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = -\frac{1}{2} \tau (\varpi^{1+\eta} - 1) < 0 \quad (\text{A42}) \\ \frac{\Delta NPV_t^{Pen}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} &= -\frac{\Delta NPV_t^{Pen}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau (\varpi^{1+\eta} - 1) > 0 \end{aligned}$$

The second equality follows from (A26) and inequality from $\varpi = \omega_H / \omega_L > 1$. Note that the term in the numerator corresponds to the pension redistribution effect from equation (A28). ■

Thus, the reform reduces the scope of redistribution through the pension system, transferring fewer resources from high- to low-productivity households.

Tax-Based Redistribution. Note that, according to equation (A19), labor supply distortions are lower under the Bismarckian system than under the Beveridgean one. Equation (A27) quantifies the percentage change in labor supply resulting from the pension system reform. The increase in labor supply, determined by the Frisch elasticity, is identical in percentage terms for both types of households—namely, $\zeta^\eta - 1$. Consequently, under a constant marginal tax rate, the corresponding increase in government revenue is proportional to the rise in labor supply.

$$\frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \frac{\tau_\ell w_t \omega_H (\Delta \ell(\theta_H)) + \tau_\ell w_t \omega_L (\Delta \ell(\theta_L))}{\tau_\ell w_t \omega_H \ell_t^{BEV}(\theta_H) + \tau_\ell w_t \omega_L \ell_t^{BEV}(\theta_L)} = \xi^\eta - 1 \quad (\text{A43})$$

Since $\xi > 1$, the derivative of equation (A43) with respect to η is given by $\xi^\eta \ln \xi > 0$ and is positive. In particular, we have:

$$\lim_{\eta \rightarrow 0} \frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \lim_{\eta \rightarrow 0} \xi^\eta - 1 = 0, \quad \lim_{\eta \rightarrow \infty} \frac{T_t^{BIS} - T_t^{BEV}}{T_t^{BEV}} = \lim_{\eta \rightarrow \infty} \xi^\eta - 1 = \infty$$

Thus, as $\eta \rightarrow 0$, we have $(\xi^\eta - 1) \rightarrow 0$, and as $\eta \rightarrow \infty$, $(\xi^\eta - 1) \rightarrow \infty$. Since the function $\xi^\eta - 1$ is continuous in η , it can attain any value on the interval $[0, \infty]$. Consequently, the percentage change in government revenue resulting from the reform can vary continuously from 0 to ∞ , depending on the value of the Frisch elasticity.

To quantify this redistribution, we define the net present value (NPV^{Tax}) of the tax as the difference between the lump-sum transfer received and the labor taxes paid by agent of type θ :

$$NPV_t^{Tax}(\theta) = \mu_t - \tau_\ell \omega_\theta w_t \ell_1(\theta). \quad (\text{A44})$$

The change in the scope of tax system redistribution induced by the reform for an agent of type θ is then:

$$\Delta NPV_t^{Tax}(\theta) = \Delta \mu_t - \tau_\ell \omega_\theta w_t (\ell_1^{BIS}(\theta) - \ell_1^{BEV}(\theta)). \quad (\text{A45})$$

where $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$. It is convenient to express this change as a percentage of the low-type income under *status quo* which is the Beveridgean system, as we do in the following lemma.

Lemma 3 (Tax-Based Redistribution) *Suppose that the economy is in the steady-state with the Beveridgean pension system. Consider the following reform bundle:*

1. *the social security system is shifted from the Beveridgean to the Bismarckian formula; and*
2. *the resulting fiscal adjustment is implemented via lump-sum transfers within the tax system.*

Then in the new steady-state with the Bismarckian pension system, this reform increases redistribution via the tax system from θ_H -type to the θ_L -type households. This effect, expressed as a percentage of the low-type income under the Beveridgean system is given by

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) = -\frac{\Delta NPV_t^{Tax}(\theta_H)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} > 0 \quad (A46)$$

where $\varpi = \omega_H/\omega_L > 1$. Moreover, the magnitude of this redistribution effect also increases with the Frisch elasticity η and the marginal tax rate τ_ℓ .

Proof of Lemma 3: We express the change in scope of redistribution for θ_L from equation (A45) as a percentage of the low-type income under the Beveridgean system, i.e., relative to $\omega_L w_t \ell_1^{BEV}(\theta_L)$:

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{\Delta \mu_t - \tau_\ell \omega_L w_t (\ell_1^{BIS}(\theta_L) - \ell_1^{BEV}(\theta_L))}{\omega_L w_t \ell_1^{BEV}(\theta_L)}$$

Here $\Delta \mu_t = \mu_t^{BIS} - \mu_t^{BEV}$ and the numerator represents the tax redistribution effect as shown in equation (A28). Using:

$$\Delta \mu_t = \frac{1}{2} \tau_\ell \left(\sum_{\theta \in \{\theta_L, \theta_H\}} \omega_\theta w_t (\ell_1^{BIS}(\theta) - \ell_1^{BEV}(\theta)) \right) \quad (A47)$$

and substituting for ℓ_1 from (A19), we obtain the following formula that represents the net present value change in taxation for θ_L -type households

$$\frac{\Delta NPV_t^{Tax}(\theta_L)}{\omega_L w_t \ell_1^{BEV}(\theta_L)} = \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) > 0 \quad (A48)$$

The sign of inequality follows from the fact that $\varpi = \omega_H/\omega_L > 1$. Moreover, the net tax change for θ_H -type households is equal in magnitude but opposite in sign.

Additionally, as shown in equation (A43), both $\xi^\eta - 1$ and $\varpi^{1+\eta}$ increase with the Frisch elasticity η . Hence, a larger η implies a greater tax redistribution effect. Finally, it follows from equation (A48) that the tax redistribution effect is also increasing in the marginal labor tax rate τ_ℓ . ■

Thus, the reform increases the extent of redistribution through the tax system, transferring more resources from high- to low-productivity households. The magnitude of this effect depends on both the Frisch elasticity and the marginal labor tax rate.

Total effect. Finally, we show that the reform bundle—which involves switching from the Beveridgean to the Bismarckian pension formula and redistributing the additional labor tax through lump-sum transfers—can improve welfare. In fact, under certain conditions, it is possible to

achieve both welfare improvement under the veil of ignorance as well as a Pareto welfare improvement, where both types of households experience a welfare gain. Proposition 1 establishes the conditions under which tax system redistribution can substitute for the pension-based redistribution to the extent that renders the reform ex ante and Pareto welfare improving.

Proof of Proposition 1: [Steady-state welfare effects of reform]

The proof combines the results of the previous lemmas. First, Lemma 1 demonstrates that replacing the Beveridgean social security system with the Bismarckian one reduces the effective labor wedge, which increases labor supply and raises welfare of both θ_L - and θ_H -type households. Second, Lemma 2 shows that eliminating redistribution in the social security reduces the welfare of θ_L -type households while improving that of θ_H -type households. Third, Lemma 3 establishes that redistributing additional tax revenue - generated by the efficiency effect - via lump-sum transfers favors θ_L -type households. In their case, the extra transfer exceeds the additional tax they pay, whereas the opposite holds for θ_H -type households.

It is evident that θ_H -type households always benefit, as the efficiency effect more than offsets the tax redistribution effect (see equation (A28)), and the pension redistribution effect is positive for them. However, a welfare gain is not ensured for θ_L -type households.

To determine when a Pareto improvement is possible, note that, since the efficiency effect is always positive, it suffices for the two redistribution effects for θ_L -type households to cancel out. Define $\tilde{\eta}$ such that the net redistribution effect for θ_L -type households is zero; that is, the sum of the pension and tax redistribution effects equals zero:

$$\frac{\Delta NPV^{Tax}(\theta_L)}{\omega_L w_t \ell_t^{BEV}(\theta_L)} + \frac{\Delta NPV^{Pen}(\theta_L)}{\omega_L w_t \ell_t^{BEV}(\theta_L)} = 0 \quad \Leftrightarrow \quad \frac{1}{2} \tau_\ell (\xi^\eta - 1) (\varpi^{1+\eta} - 1) = \frac{1}{2} \tau (\varpi^{1+\eta} - 1) \quad (A49)$$

This relationship is derived from equations (A39) and (A46). Notice that a positive $\tilde{\eta} > 0$ satisfying equation (A49) exists. To see this, observe that after canceling the common factor $\frac{1}{2}(\varpi^{1+\eta} - 1)$, the left-hand side becomes an increasing function of η , while the right-hand side is constant. Moreover, as η ranges from zero to infinity, the left-hand side takes on all values between zero and infinity, ensuring that there exists a unique $\tilde{\eta} > 0$ such that the net redistribution effect is exactly zero.

For $\eta = \tilde{\eta}$, the redistribution effects cancel out exactly, so the welfare gain for θ_L -type households comes solely from the positive efficiency effect. By continuity of the left-hand side of equation (A49) and of the utility function $U(\theta)$, there exists a threshold $\bar{\eta} < \tilde{\eta}$ at which welfare of θ_L -type households remains unchanged after the reform. Consequently, for all $\eta \geq \bar{\eta}$, the reform constitutes a Pareto improvement.

Regarding utilitarian social welfare, the continuity of both the left-hand side of equation (A49) and the utility function implies that for all η 's in a sufficiently small neighborhood below $\bar{\eta}$, any decline in $U(\theta_L)$ is small enough to be offset by an increase in $U(\theta_H)$. Hence, there

exists $\underline{\eta} < \bar{\eta}$ such that $\forall \eta \geq \underline{\eta}$ the reform improves the utilitarian social welfare function $W = \sum_{\theta \in \{\theta_L, \theta_H\}} U(\theta)$.

Regarding the final point. By substituting $\tau^{BEV} = \tau$ and the expression for ξ from equation (A27) into equation (A49), and applying using the implicit function theorem, we obtain

$$\frac{\partial \tilde{\eta}}{\partial \tau_\ell} = -\frac{\xi^{\tilde{\eta}} - 1 + \tau_\ell \tilde{\eta} \xi^{\tilde{\eta}-1} \frac{\tau}{(1-\tau_\ell-\tau)^2}}{\tau_\ell \xi^{\tilde{\eta}} \ln \xi} < 0. \quad (\text{A50})$$

By continuity of the left-hand side of equation (A49) and of the $U(\theta)$ function, both $\underline{\eta}(\tau_\ell)$ and $\bar{\eta}(\tau_\ell)$ are decreasing with τ_ℓ . ■

A.6 Transition Path: Technical Details

Proof of Proposition 2: [Welfare effects along the transition path]

For the initial old generation (born in period $t - 1$), the reform occurs after they have retired; thus, no efficiency effect arises. Moreover, since these retired households are not subject to labor income taxation, there is no change in redistribution through the tax system. However, because the labor supply of the initial young increases—as implied by equations (A19) and (A24)—the pension benefits of the initial old rise relative to the original steady-state, see formula (A2). As a result, their welfare improves.

For the initial young and all future generations, the adjustment mirrors that between two steady-states. First, since this is a partial equilibrium analysis, wages and interest rates remain unchanged. Second, the labor wedge immediately adjusts to its new steady-state level, so the efficiency effect is exactly as implied by the steady-state comparison. Third, the labor supply of young workers in the first period jumps to its new steady-state level—as given by formula (A23)—which is higher than in the previous steady-state, as given by formula (A24). Consequently, the redistribution effect via the tax system matches that implied by the steady-state comparison. Finally, since pensions are determined by labor supply and the exogenous wage growth rate, and because labor supply instantaneously adjusts to its new steady-state level, pensions also adjust accordingly. Thus, the pension redistribution effect is exactly as implied by the steady-state comparison.

Since all three effects—efficiency, tax redistribution, and pension redistribution—match those in the steady-state, the overall adjustment for the initial young and all future generations is identical to that between two steady-states. ■

B Technical Derivations from Computational Model

B.1 Equilibrium and Model Solving

We define equilibrium in our economy using the notion of a recursive equilibrium. Recall that the state of an agent of age j in period t is fully characterized by $s_{j,t} = (a_{j,t}, f_{j,t}, \epsilon_{j,t}) \in \Omega$. We denote the probability measure over the state space Ω for agents of age j at time t by $\mathbb{P}_{j,t}$. Below we define an equilibrium for the baseline system. Equilibrium for the reformed system is defined analogously.

Definition 1 (Recursive competitive equilibrium) *A recursive competitive equilibrium consists of a sequence of value functions $\{(V_{j,t}(s_{j,t}))_{j=1}^J\}_{t=0}^\infty$, policy functions $\{(c_{j,t}(s_{j,t}), \ell_{j,t}(s_{j,t}), a_{j+1,t+1}(s_{j,t}), f_{j+1,t+1}(s_{j,t}))_{j=1}^J\}_{t=0}^\infty$, prices $\{r_t, w_t\}_{t=0}^\infty$, government policies $\{\tau_c, \tau_k, \tau_l, \lambda, \mu_t, D_t\}_{t=0}^\infty$, social security parameters $\{\tau, S_t, \rho_m\}_{t=1}^\infty$, aggregate quantities $\{L_t, A_t, K_t, C_t, Y_t\}_{t=0}^\infty$, and a probability measure $\{\mathbb{P}_{j,t}\}_{t=0}^\infty$ such that:*

- **consumer problem:** for each j and t , the value functions $(V_{j,t}(s_{j,t}), V_{j+1,t+1}(s_{j+1,t+1}))$ and the policy functions $(c_{j,t}(s_{j,t}), \ell_{j,t}(s_{j,t}), a_{j+1,t+1}(s_{j,t}), f_{j+1,t+1}(s_{j,t}))$ solve the Bellman equation (15) given prices and government policies;
- **firm problem:** for each t , prices (r_t, w_t) are given by equations (17);
- **government sector:** the consolidated government budget constraint—including both general government operations and the PAYG social security system—is satisfied, i.e., equations (18) through (20) hold;
- **markets clear:**

$$\begin{aligned}
 \text{labor market: } L_t &= \sum_{j=1}^J N_{j,t} \int_{\Omega} \omega_{j,t}(s_{j,t}) \ell_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}; \\
 \text{capital market: } A_{t+1} &= \sum_{j=1}^J N_{j,t} \int_{\Omega} a_{j+1,t+1}(s_{j,t}) d\mathbb{P}_{j,t}, \\
 K_{t+1} &= A_{t+1} + D_{t+1}; \\
 \text{goods market: } C_t &= \sum_{j=1}^J N_{j,t} \int_{\Omega} c_{j,t}(s_{j,t}) d\mathbb{P}_{j,t}, \\
 Y_t &= C_t + K_{t+1} - (1-d)K_t + G_t;
 \end{aligned}$$

- **probability measure:** for all t and for all j , the probability measure $\mathbb{P}_{j,t}$ is consistent with productivity processes and policy functions.

We solve the consumer problem using value function iterations. To reduce the dimensionality of the state space, we adopt the implicit tax approach following Butler (2002). We discretize

the state space $\hat{\Omega} = \hat{A} \times \hat{F} \times \hat{H}$, with grids $\hat{A} = \{a^1, \dots, a^{n_A}\}$, $\hat{F} = \{f^1, \dots, f^{n_F}\}$, and $\hat{H} = \{\epsilon^1, \dots, \epsilon^{n_H}\}$, where $n_A = 300$, $n_F = 15$, and $n_H = 5$.

We interpolate policy and value functions using piece-wise linear functions based on Powell's recursive algorithm. For each discrete state $\hat{s}_{j,t} \in \hat{\Omega}$, we compute optimal consumption and labor supply numerically with the Newton-Raphson method. This is necessary due to the nonlinearity of the labor income tax schedule.

Given an initial distribution $\hat{\mathbb{P}}_{1,t}$, a transition matrix $\Pi(\epsilon_{j,t}|\epsilon_{j-1,t-1})$, and policy functions $\{a_{j+1,t+1}(\hat{s}_{j,t}), f_{j+1,t+1}(\hat{s}_{j,t})\}_{j=1}^J\}_{t=1}^\infty$, we can iterate forward to obtain the distribution at all future ages and periods.

After computing distributions and policy functions, we aggregate consumption, labor supply, and savings using Gaussian quadrature. Once the individual decision problem is solved for a given set of prices and fiscal policies, we update the aggregate capital stock using the Gauss-Seidel method. We repeat the procedure until the difference in aggregate capital across iterations is below a tolerance of 10^{-12} in l_1 -norm.

B.2 Implicit Tax: Linking Pension Benefits to Contributions

In this section, we examine how the structure of the pension system—specifically, the degree to which pension benefits are linked to contributions—affects households' labor supply decisions. When contributions to the pension system are effectively rebated in the form of future benefits, individuals partially internalize these payments as forced savings rather than pure taxes. This reduces the labor-supply distortion relative to systems where contributions and benefits are weakly or not at all connected.

To capture this mechanism formally, we derive the first-order condition from the household's optimization problem and introduce the concept of the implicit tax rate. This implicit tax reflects the net cost of contributing to the pension system after accounting for the expected present value of future benefits. A higher degree of internalization corresponds to a lower implicit tax and thus smaller labor market distortions.

We begin by analyzing the reformed pension system, where the link between contributions and benefits is explicit. Then we contrast it with the status quo system, where the connection is weaker and more complex, leading households to treat contributions more like regular taxes.

Reformed Social Security We begin by defining the present value of future pensions of an agent of age j in period t , who will retire at age $\bar{J} > j$, $PV_{j,t}^b$. It is given by the following:

$$PV_{j,t}^b = PV_{\bar{J},t(j,t,\bar{J})}^b \left[\prod_{s=1}^{\bar{J}-j} \left(\frac{1 + r_{\ell,t+s}}{1 + (1 - \tau_{k,t+s})r_{t+s}} \right) \right] \quad (\text{B1})$$

where $t(j, t, \bar{J}) = t + \bar{J} - j$ is the retirement period for someone aged j in t , and $PV_{\bar{J}, t + \bar{J} - j}^b$ denotes the present value of future pensions at retirement:

$$PV_{\bar{J}, t(j, t, \bar{J})}^b = \sum_{\kappa=0}^{J-\bar{J}} \left[\prod_{s=1}^{\kappa} \frac{(1 + r_{\ell, t(j, t, \bar{J}) + s})}{(1 + (1 - \tau_{k, t(j, t, \bar{J}) + s})r_{t(j, t, \bar{J}) + s})} \right] b_{\bar{J} + \kappa, t(j, t, \bar{J}) + \kappa} \quad (B2)$$

To understand how the link between contributions and pension affects household decisions, we derive the following first-order condition characterizing consumption-labor choice:

$$\phi \ell_{j, t}(s_{j, t})^{\frac{1}{\eta}} = \frac{c_{j, t}(s_{j, t})^{-\sigma}}{1 + \tau_c} \left[(1 - (1 - \tau)\mathcal{T}'(y_{j, t}(s_{j, t})) - \tau)w_t\omega_{j, t}(s_{j, t}) + \frac{\partial PV_{j, t}^b}{\partial \ell_{j, t}} \right], \quad (B3)$$

To interpret this better, we define the implicit tax $v_{j, t}$, as the fraction of contributions that are effectively rebated via future pensions:

$$v_{j, t} = \frac{\frac{\partial PV_{j, t}^b}{\partial \ell_{j, t}}}{\tau w_t \omega_{j, t}(s_{j, t})} \quad (B4)$$

Substituting from (B4) to (B3) yields:

$$\phi \ell_{j, t}(s_{j, t})^{\frac{1}{\eta}} = \frac{c_{j, t}(s_{j, t})^{-\sigma}}{1 + \tau_c} [1 - (1 - \tau)\mathcal{T}'(y_{j, t}(s_{j, t})) - (1 - v_{j, t})\tau] w_t \omega_{j, t}(s_{j, t}) \quad (B5)$$

If $v_{j, t} = 1$, then contributions are fully internalized by individuals and do not distort their labor supply—i.e., contributions behave like forced savings. In contrast, if $v_{j, t} = 0$, then contributions act like a pure tax and fully distort labor supply. Interestingly, because the pension system annuitizes contributions, the effective return may exceed that of private savings, implying in the reformed system $v_{j, t}^R > 1$ is possible.

We compute $v_{j, t}$ from (B4) using the formula for pension benefits in the reformed system (13):

$$b_{\bar{J}, t}^R = f_{\bar{J}, t}^R / LE_{t, \bar{J}} \quad \text{and} \quad \forall j > \bar{J} \quad b_{j, t}^R = (1 + r_{\ell, t})b_{j-1, t-1}^R, \quad (B6)$$

where the conditional life expectancy is $LE_{t, \bar{J}} = 1 + \sum_{s=0}^{J-\bar{J}-1} (\prod_{i=1}^s \pi_{\bar{J}+i, t+i})$. We also need the formula for the evolution of entitlements given by (14)

$$f_{j+1, t+1}^R = (1 + r_{\ell, t})/\pi_{j, t} f_{j, t}^R + (1 + r_{\ell, t})/\pi_{j, t} \tau \omega_{j, t} w_t \ell_{j, t} \quad (B7)$$

From these formulas, we find:

$$v_{j, t}^R = v_{\bar{J}, t(j, t, \bar{J})}^R \left[\prod_{s=1}^{\bar{J}-j} \left(\frac{(1 + r_{\ell, t+s})}{(1 + (1 - \tau_{k, t+s})r_{t+s})\pi_{j+s, t+s}} \right) \right] \quad (B8)$$

where

$$v_{\bar{j},t(j,t,\bar{j})}^R = \left[\sum_{\kappa=0}^{J-\bar{j}} \prod_{s=1}^{\kappa} \frac{(1 + r_{\ell,t(j,t,\bar{j})+s})}{(1 + (1 - \tau_{k,t(j,t,\bar{j})+s})r_{t(j,t,\bar{j})+s})} \frac{1}{LE_{t(j,t,\bar{j}),\bar{j}}} \right]. \quad (\text{B9})$$

Baseline Social Security Under the status quo, the U.S. Social Security system operates as a pay-as-you-go, defined-benefit program with a progressive benefit formula. Pension benefits are based on a worker's Average Indexed Monthly Earnings (AIME), and the replacement rate applied to those earnings declines with income. Because the benefit formula is nonlinear and redistributive, the link between additional labor supply and future pension benefits is weak. In particular, an individual's marginal return from paying additional payroll taxes is small, especially relative to the contribution paid.

As a result, workers are typically modeled as not perceiving Social Security contributions as deferred compensation, but rather as a pure tax. That is, they do not internalize the future benefits when making labor-supply decisions. This approach is standard in the literature, as in Nishiyama and Smetters (2007) and McGrattan and Prescott (2017), where payroll contributions are treated as distortionary taxes that do not yield marginal returns to the individual.

Following this convention, we set the implicit tax rate in the baseline system to zero: $v_{j,t}^B = 0$. That is, contributions under the current system are fully distortionary from the household's perspective.

B.3 Measuring welfare effects

We express the welfare effects of the reform using a consumption equivalent variation, measured as a percentage change of lifetime consumption. To evaluate this, we separately account for the utility from consumption and the disutility from labor. Define the expected lifetime utility from consumption (under the veil of ignorance) as:

$$W_t^c = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{c(s_{j,t+j-1})^{1-\sigma}}{1-\sigma} \right] \quad (\text{B10})$$

where $c(s_{j,t})$ denotes the optimal consumption at age j and period t . Analogously, define the expected lifetime disutility from labor as:

$$W_t^\ell = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{\phi}{1 + \frac{1}{\eta}} \ell(s_{j,t+j-1})^{1+\frac{1}{\eta}} \right] \quad (\text{B11})$$

where $\ell(s_{j,t})$ denotes optimal labor supply.

To compute welfare changes in consumption equivalent terms, define:

$$W_t^c(\Lambda_t) = \mathbb{E}_t \left[\sum_{j=1}^J \delta^j \frac{((1 + \Lambda_t)^c(s_{j,t+j-1}))^{1-\sigma}}{1 - \sigma} \right]. \quad (\text{B12})$$

From homotheticity, it follows that:

$$W_t^c(\Lambda_t) = (1 + \Lambda_t)^{1-\sigma} W_t^c. \quad (\text{B13})$$

Let B denote the baseline (status quo) and R the reformed system. The welfare gain from the reform, expressed as a consumption equivalent percentage of lifetime consumption Λ_t , is defined implicitly by:

$$W_t^{c,B}(\Lambda_t) - W_t^{\ell,B} = W_t^{c,R} - W_t^{\ell,R} \quad (\text{B14})$$

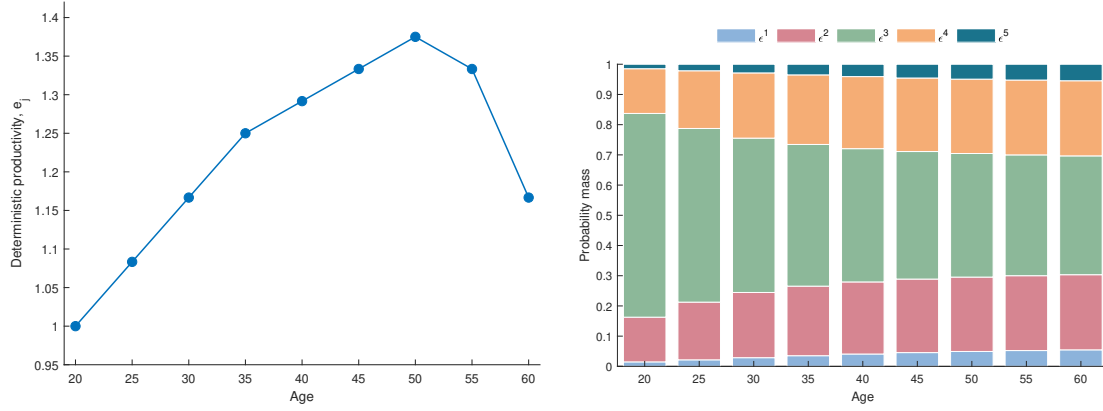
Solving for Λ_t , we obtain:

$$\Lambda_t = \left(\frac{W_t^{c,R} - (W_t^{\ell,R} - W_t^{\ell,B})}{W_t^{c,B}} \right)^{\frac{1}{1-\sigma}} - 1. \quad (\text{B15})$$

This expression gives the welfare effect as a consumption equivalent—that is the proportional increase in lifetime consumption in the baseline economy required to make an individual indifferent between the baseline and the reform scenarios.

C Model calibration

Figure C1: Labor Productivity



(a) Deterministic productivity component e_j by age (b) Distribution of idiosyncratic productivity shocks by age

Notes: Panel C1 reports the deterministic age component of labor productivity, e_j . Panel C2 reports the age-specific distribution over the five discretized realizations of the idiosyncratic productivity shock, ϵ^h , with $h = 1, \dots, 5$. The realizations are ordered from the lowest to the highest value: $\epsilon^1 = 0.28$, $\epsilon^2 = 0.53$, $\epsilon^3 = 1.00$, $\epsilon^4 = 1.87$, and $\epsilon^5 = 3.51$. Probability masses in Panel C2 sum to one within each age group.

Table C1: Tax Rates Calibration

Macroeconomic parameters	Calibration	OECD code	revenue as % of GDP
τ_l labor tax	0.037	1110	9.2%
τ_c consumption tax	0.044	5100, 5121	2.8%
τ_k capital tax	0.243	1120, 1200, 4100, 4400	5.4%

Notes: Tax rates are calibrated following Mendoza et al. (1994), based on five-year averages (2011-2015) of revenue-to-GDP ratios for labor, capital, and consumption taxes.

Table C2: Calibrated Parameters in the Initial Steady-State Across Different Frisch Elasticities

Parameter	values of η														
	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3.0
ϕ	694	36.91	13.88	8.41	6.25	5.10	4.41	4.01	3.67	3.41	3.21	3.09	2.94	2.87	2.77
δ	1.02	1.01	1.00	0.99	0.99	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.96	0.96	0.96
τ_l	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
τ_c	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
τ_k	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

Notes: ϕ denotes the disutility from work, δ the discount factor, τ_l the labor income tax, τ_c the consumption tax, and τ_k the capital income tax. The calibration targets remain constant across all alternative values of the Frisch elasticity. For each case, the risk aversion parameter is fixed at $\sigma = 2$, the annual depreciation rate at $d = 0.06$, the degree of labor tax progression at $\lambda = 0.137$, the social security contribution rate at $\tau = 0.075$, and the pension scaling factor at $\rho_m = 0.55$.

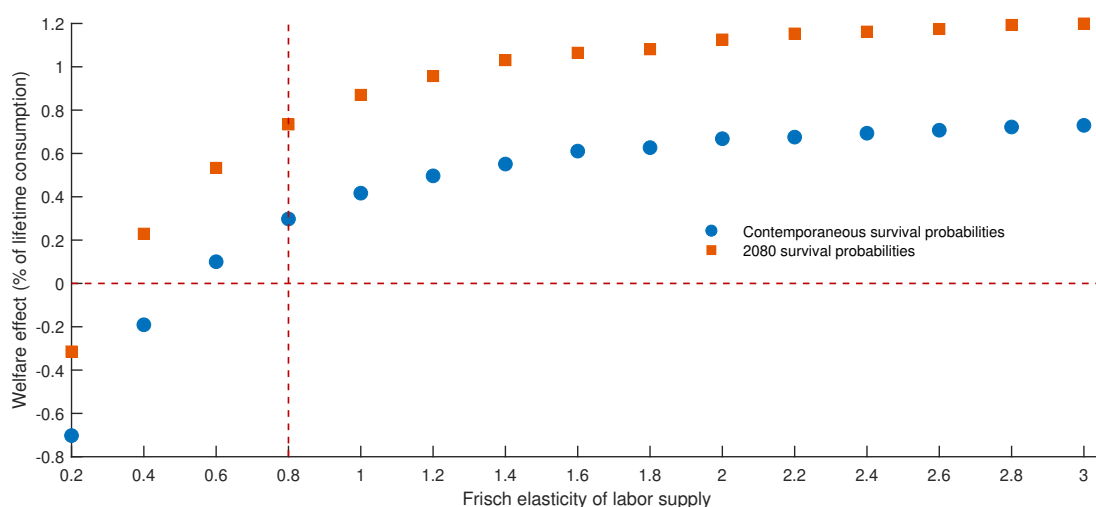
D Sensitivity Analyses to Steady-State Results

D.1 Population aging

Rising longevity across birth cohorts is a central motivation for reforming the U.S. Social Security system. The current system is both redistributive and defined-benefit in nature. However, sustaining this model under demographic pressure would require either a roughly 40% increase in contribution rates (Braun and Joines 2015, Vogel et al. 2017), or a rise in the federal deficit by about 2% of GDP by 2080 (Feldstein 2016). Prior research has shown that such adjustments would carry substantial welfare costs (e.g. Kotlikoff et al. 1999, Huggett and Ventura 1999, Genakoplos et al. 2000, Kitao 2014). In contrast, moving to a defined contribution structure renders the pension system fiscally neutral.¹⁵

This explains why welfare gains from our proposed reform are larger when longevity rises. Figure D1 replicates the analysis from Figure 4, but uses projected survival probabilities $\pi_{j,t}$ for the year 2080. To maintain consistency across systems, we also raise the retirement age $\bar{J}$ in both the baseline and the reform under the longevity scenario.

Figure D1: Welfare Effects Across Alternative Calibrations of the Frisch Elasticity: Population Aging



Notes: Each dot represents the welfare effect under the veil of ignorance for a given value of the Frisch elasticity. Welfare effects are expressed as consumption-equivalent changes in lifetime consumption. The current-demography series uses contemporaneous survival probabilities, while the aging-demography series uses survival probabilities from the 2080 UN forecast. In each case, the status quo and reform economies are computed under the same survival probabilities. Calibrated parameters are as reported in Table C2 in the Appendix. The vertical dashed line denotes our preferred calibration.

Longer lifespans also promote greater capital accumulation and modestly higher labor supply.

¹⁵Longer lifespans reduce per-period pension payments for future cohorts, making defined contribution systems more sustainable. This type of reform has been proposed for the U.S. (Feldstein 2005) and recommended internationally by institutions such as the World Bank and IMF. It has been implemented in many countries since the 1990s, including Sweden, Chile, Mexico, and much of Central and Eastern Europe (Holzmann 2013).

As shown in Figure D2, this reduces the post-reform decline in the capital-labor ratio $k = K/L$ compared to Figure 5. As a result, welfare gains emerge even for Frisch elasticities as low as 0.4. Compared to the baseline calibration, welfare losses at low elasticity values are smaller, and welfare gains at higher elasticity values are nearly twice as large.

These larger gains stem from improved efficiency. In the baseline, aggregate capital grows by less than labor in response to the reform, lowering capital per effective unit of labor, depressing wages, and dampening labor supply. Under longer lifespans, capital accumulation is stronger, mitigating wage declines and strengthening the labor supply response. Consequently, rising longevity amplifies efficiency gains and expands redistribution via progressive labor taxation. (See Figure D3 versus Figure 6.)

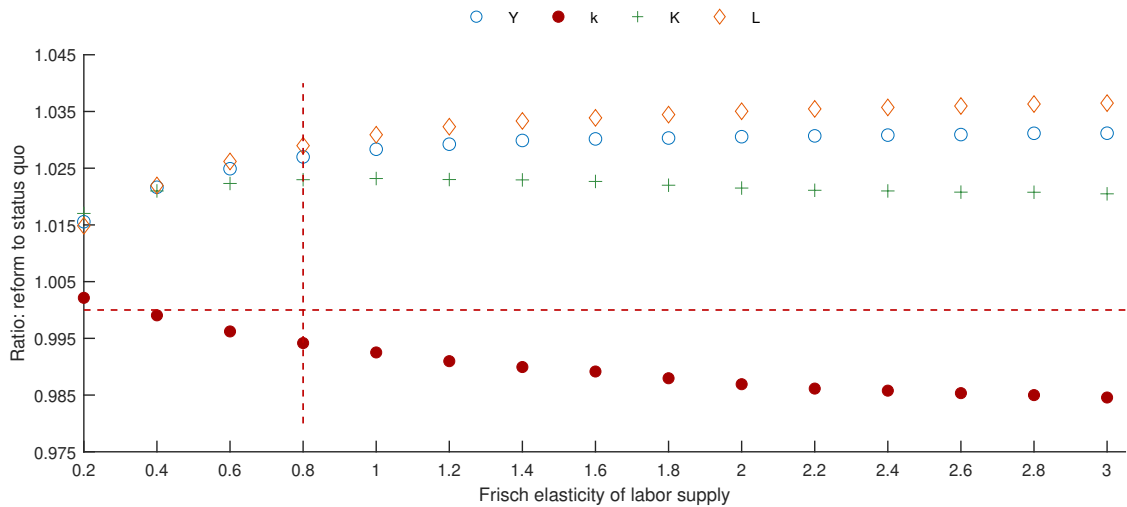
D.2 Drivers of labor supply response

Because our results hinge on the labor supply response to improved incentives, we assess how sensitive the welfare outcomes are to the strength of this response. In our setup, the reform substantially reduces the labor wedge by altering how social security contributions are perceived: what was previously treated as a pure tax is now understood as a deferred income stream. Given the magnitude of the contribution rate, the resulting increase in labor supply—ranging from approximately 1.5% to 4%—is internally consistent within the model framework.

Numerous studies review behavioral responses to tax reforms and provide bounds for plausible labor supply reactions. Evidence from Denmark by Chetty, Friedman, Olsen and Pistaferri (2011) suggests that individuals are more responsive to explicit changes in taxation—such as changes clearly reflected in paychecks—than to implicit or less visible changes. A similar pattern is found for Germany by Tazhitdinova (2020). However, most of this literature focuses on direct changes in labor income taxation, while reforms that alter the lifetime labor wedge—such as changes to pension formulas—are less frequently studied. One exception is Lachowska and Myck (2018), who find significant labor supply responses to relatively subtle adjustments in pension benefit calculation rules. Given this mixed evidence, we explore the sensitivity of our results to the extent to which individuals internalize the changes in social security incentives.

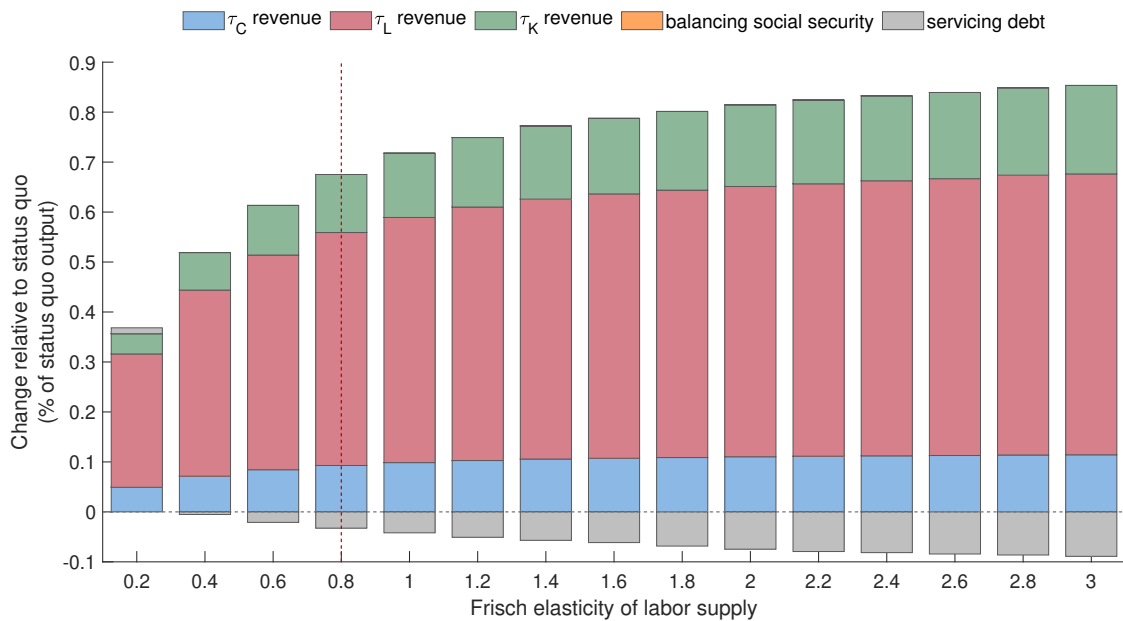
We conduct the following experiment: for each working-age group, a fraction of contributions is governed by equation (10), while the remaining share follows equation (13). Specifically, assuming a Frisch elasticity of 0.8, we vary the proportion of income subject to equation (13) from 0% to 100%, with the remainder governed by equation (10). This setup captures the extent to which individuals internalize changes in social security incentives, as discussed in Section B.2. The results, presented in Figure D4, show with aging population, even a 60% internalization of incentives is sufficient to generate aggregate welfare gains. By contrast, in a scenario with a current population, welfare improvements require individuals to internalize incentives on roughly 80% of their labor income. We conclude that the effectiveness of social security reform does

Figure D2: Macroeconomic Adjustments Across Alternative Calibrations of the Frisch Elasticity: Population Aging



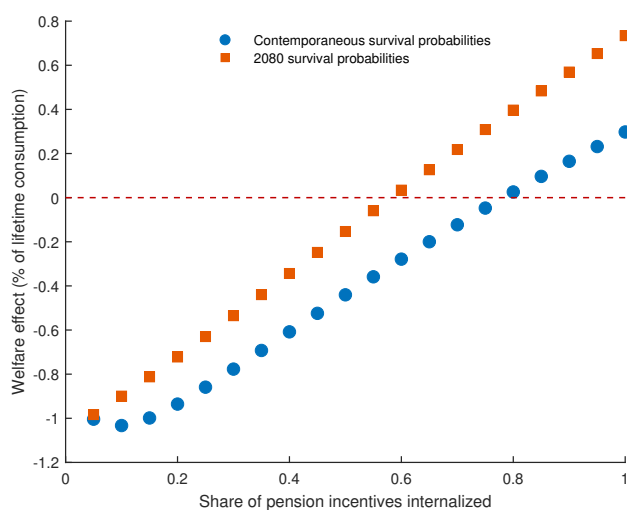
Notes: The figure displays the ratios of selected macroeconomic variables—aggregate output (Y), capital per effective unit of labor (k), aggregate capital (K), and effective aggregate labor (L)—between the reform and the status quo scenarios, across different values of the Frisch elasticity under the aging-demography calibration. Values above one indicate that the variable is higher under the reform. The vertical dashed line denotes the preferred calibration.

Figure D3: Fiscal Position Changes Across Alternative Calibrations of the Frisch Elasticity: Population Aging



Notes: The figure shows changes in fiscal revenues and expenditures between the reform and status quo scenarios across values of the Frisch elasticity under the aging-demography calibration. Positive values increase fiscal space, whereas negative values reduce it. Changes are expressed as a percentage of status quo aggregate output. The vertical dashed line denotes the preferred calibration.

Figure D4: Welfare Effects Under Partial Internalization of Social Security Reform

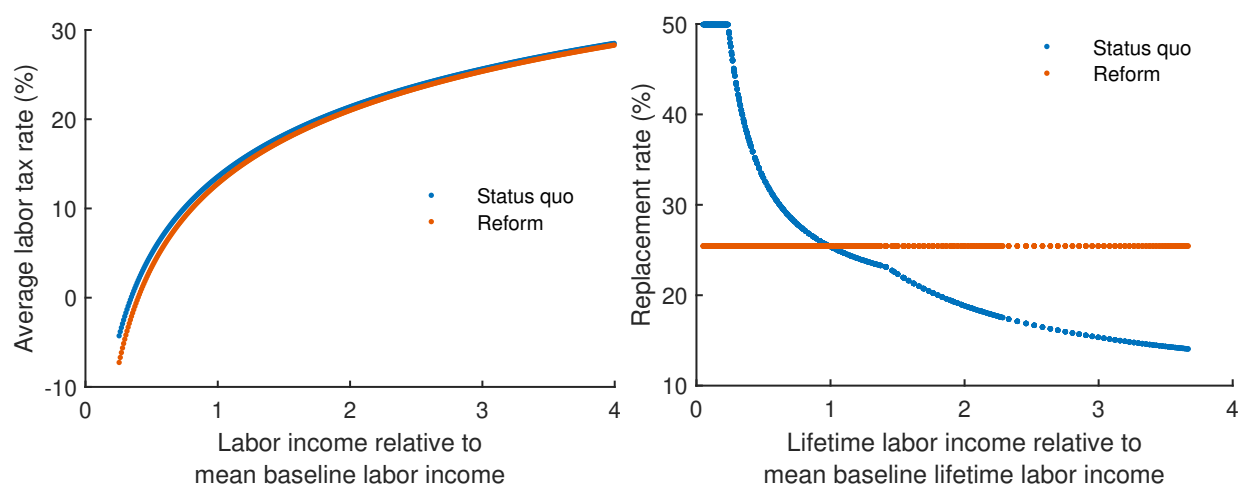


Notes: The figure reports welfare effects under the veil of ignorance for a Frisch elasticity of 0.8. The horizontal axis measures the share of pension incentives internalized by individuals. The rightmost point corresponds to full internalization and matches the welfare effect reported in the baseline analysis. Points to the left show outcomes under partial internalization, where only a fraction of individuals perceive the reduction in the implicit tax introduced by the reform. Welfare effects are expressed as consumption-equivalent changes in lifetime consumption.

not depend on full rationality—a reasonable degree of responsiveness to incentives is enough to deliver the intended efficiency gains.

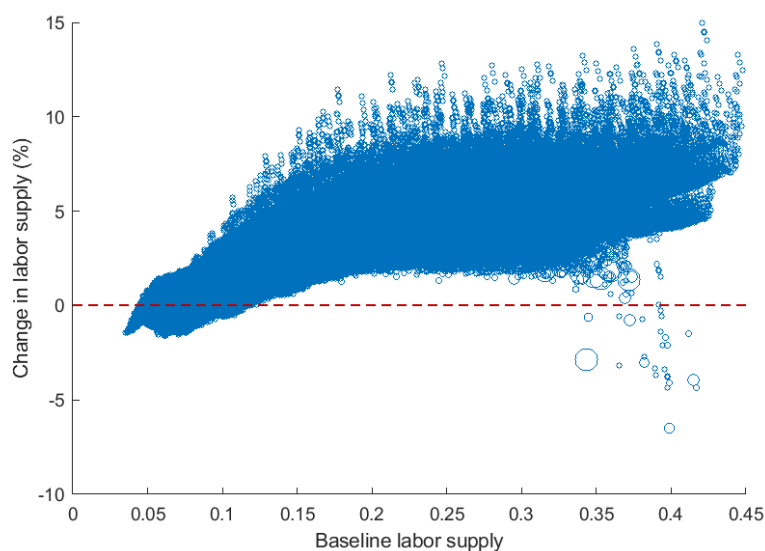
E Additional Results: Steady State

Figure E1: Average tax rate (left) and average replacement rate (right)



Notes: Level of the average tax rates along the income distribution in status quo in the left panel. Lifetime income at retirement is the total stream of pension benefits (adjusted for survival). Lifetime earned income is the total stream of earned income (the social security contribution base, likewise adjusted for survival). The ratio between the two streams signifies the replacement rate, here displayed along the income distribution in the status quo.

Figure E2: Labor Supply Response to the Reform: Probability-Weighted Shock Realizations



Notes: The figure scatters labor supply under the status quo against the percentage change in labor supply induced by the reform. Each dot corresponds to an individual with a given shock realization. The size of the dot is proportional to the probability of that shock realization.

F Additional Results: Transition Path

Figure F1: Macroeconomic and Fiscal Variables Along the Transition Path

