Social Security Depletion: Worker Responses, Bailout Financing, and Policy Timing

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Abstract

When the Social Security trust fund is exhausted, current law reduces every benefit by a common payable factor that clears the program's cash flow. The Trustees project exhaustion in 2032. We compute equilibrium transition paths of an overlapping-generations economy in which that factor and worker behavior are determined together, with claiming and retirement separate irreversible choices. Workers rush to claim before the cut, then claim later for good, work longer, and save more. Depletion removes the shortfall from the consolidated budget, so the wage tax falls. A bailout returns both. Consumption financing costs an entering cohort the least and wage financing the most. The capital tax contracts capital most and costs an entering cohort less than the wage tax does. A deep capital contraction is not what makes an instrument expensive: the wage tax leaves the lowest output and the lowest consumption of the three. Among program reforms, only a higher full retirement age delays depletion. The announcement date allocates that cost among the cohorts now alive.

Keywords: Social Security; trust-fund depletion; payable benefits; benefit claiming; endogenous retirement; bailout financing; policy timing.

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1 Introduction

The Trustees project that the Social Security trust fund will be exhausted in 2032.[1] The program cannot borrow. Without new legislation, a common payable factor $\phi_t \leq 1$ then scales every scheduled benefit: a worker entitled to b^{sch} collects $\phi_t\, b^{sch}$. The factor is not a policy parameter. It clears the program's cash flow, so it is determined together with the saving, claiming, and retirement decisions it provokes.

We ask four questions.

1. *No new legislation.* What does the economy look like when workers respond optimally to an impending benefit cut and markets clear?

2. *Financing under new legislation.* If legislation restores full benefits, which tax pays for them, what does each one cost, and who bears the cost?

3. *Reform of the program's own rules.* Can a change in the program's rules do the work that taxation would otherwise do?

4. *Timing.* Does it matter whether legislation is finalized before or after the fund empties?

We answer them inside an overlapping-generations economy with idiosyncratic earnings risk, a neoclassical firm, and a government that taxes labor, capital, and consumption, issues debt, and administers the trust fund. Workers decide how much to consume, when to stop working, and when to claim benefits. The last two decisions are separate and both are irreversible. We calibrate an initial stationary equilibrium to the 2025 economy and compute perfect-foresight transition paths from 2026 to a terminal stationary equilibrium. The payable path $\{\phi_t\}$ is a fixed point: workers choose against it, and their choices determine it.

The reserves run out in 2032, the same year the Trustees project, and the fund is empty from 2033. The payable factor ϕ_t drops to 0.773 in 2033, recovers to about 0.79, and declines over the following half century to 0.546. The mean claim age falls to 63.9 in the years before the cut and rises to 69.2 after it. The mean retirement age rises from 62.7 to 66.2. Every working cohort saves against a smaller pension. The capital–output ratio rises from 3.00 to 3.19, the interest rate falls from 6.0 to 5.3 percent, and the wage rises. Current law also cuts the wage tax in the long run, from 0.220 to 0.190, because depletion removes the Social Security deficit from the consolidated budget. Current law delivers a benefit cut to retirees and a tax cut to workers in the same year.

[1] Social Security in this paper refers to the Old-Age and Survivors Insurance (OASI) program: its payroll tax, its benefits, and its trust fund. We do not consider Disability Insurance.

A deep capital contraction is not what makes a financing instrument expensive. Consumption financing costs a terminal-steady-state newborn 4.8 percent of lifetime consumption, capital financing 8.7 percent, and wage financing 11.6 percent. The capital tax carries the largest terminal rate, 0.480, and produces the deepest capital contraction, a capital–output ratio of 2.77 against the baseline's 3.19. It is not the costliest. The wage tax is. It distorts the one response through which the economy had relieved the payability pressure, it shrinks its own base, and it leaves the lowest output and the lowest consumption of the three.

Inside the program, raising the full retirement age does the solvency work. It delays depletion by ten years, from 2033 to 2043; it raises the long-run payable factor from 0.546 to 0.621; and it cuts the residual wage tax from 0.292 to 0.262. Raising the taxable maximum and lowering the top replacement rate in the benefit formula leave the depletion year where it is and raise the long-run payable factor by at most 1.7 points, to 0.551 and 0.563. They change the incidence, not the arithmetic.

The announcement date redistributes among the cohorts alive today. Under wage-tax financing workers of every age alive today prefer delay. Under capital and consumption financing near-retirees prefer advance notice, which lets them re-plan saving, filing, and retirement while those decisions are still open.

The Congressional Budget Office and the Penn Wharton Budget Model score reform with the benefit cut held exogenous (Congressional Budget Office, 2026; Shin and Smetters, 2026). İmrohoroğlu et al. (1995), De Nardi et al. (1999), İmrohoroğlu and Kitao (2012), Kitao (2014), and Braun and Joines (2015) put worker responses inside general-equilibrium transitions. Oshio (2004), Auerbach and Lee (2011), and Auerbach et al. (2018) compute equilibrium adjustment to shortfalls under self-balancing rules. We solve the depletion transition itself, from the first year of the cut through the long run, with the payable path as a fixed point and with claiming and retirement as separate dynamic programming problems.

Coile et al. (2002), Gustman and Steinmeier (2015), and Pashchenko and Porapakkarm (2024) establish that claiming benefits is distinct from labor-force exit.[2] Behaghel and Blau (2012), Seibold (2021), and Deshpande et al. (2024) measure how workers respond to the statutory ages in the benefit formula. Attanasio and Rohwedder (2003) and Lindeboom and Montizaan (2020) measure the saving offset to pension wealth. Rogerson (1988), Ljungqvist and Sargent (2014), Holter et al. (2025), and Graves et al. (2026) supply the time-averaging method, and Graves et al. (2026) compare fixed-price with equilibrium responses.

[2] French (2005) estimates the life-cycle model of retirement on which much of this literature rests, and finds health, wealth, and the wage process to be its main drivers. We abstract from health.

Conesa and Krueger (1999), Nishiyama and Smetters (2007), Conesa and Garriga (2008), and Hosseini and Shourideh (2019) compute the intergenerational incidence of alternative fiscal instruments. Moore and Pecoraro (2020) show that the closing instrument is substantive. Trabandt and Uhlig (2011) compare tax-instrument menus. Gomes et al. (2012), Luttmer and Samwick (2018), Caliendo et al. (2019), Shoven et al. (2021), Clark and Mitchell (2025), and Bello et al. (2026) measure worker responses to uncertain policy change.

Section 2 describes the institution and the quantitative economy. Section 3 describes the calibration and its verification. Section 4 describes the transition without new legislation. Section 5 describes the financing of full scheduled benefits. Section 6 describes reforms of the program's rules and the bailout they leave. Section 7 describes the timing of the bailout. Section 8 concludes.

2 The Institution and the Quantitative Economy

We construct an overlapping-generations model populated by workers, a representative firm, a government, and the Social Security trust fund. Time is discrete, and each model period is one calendar year. Workers live from age 20 to age 100 and face idiosyncratic earnings risk while they work. They choose consumption and saving, retirement, and the age at which they claim Social Security benefits. Claiming and retirement are distinct irreversible choices. A representative firm produces goods with neoclassical technology. A government levies labor, capital, and consumption taxes, issues public debt, and administers the trust fund ledger.

2.1 Demographics

The population evolves as projected by the Social Security Administration (SSA) in the 2026 Trustees Report.[3] Model ages of workers, $j = 0, \ldots, J-1$, correspond to ages 20 through 100. Time is indexed by $t = \ldots, -1, 0, 1, \ldots$; $t = -1$ is 2025 and $t = 0$ is 2026. The SSA projection supplies the number $P_{j,t}$ of people of age j in year t; it also provides the one-period survival probability $s_{j,t}$, with $s_{J-1,t} = 0$. We freeze the population counts and the survival probabilities $\{P_{j,t}, s_{j,t}\}$ beyond 2085, so that the economy converges to a stationary equilibrium inside the transition horizon.

We normalize the total population of 2025 to one, $N_{-1} = 1$, where N_t denotes the total population

[3] Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds (2026).

in year t:[4]

$$N_{j,t} = \frac{P_{j,t}}{\sum_j P_{j,-1}}, \qquad N_t = \sum_j N_{j,t}, \qquad f_{j,t} = \frac{N_{j,t}}{N_t}, \qquad \text{for all } j \text{ and } t. \tag{1}$$

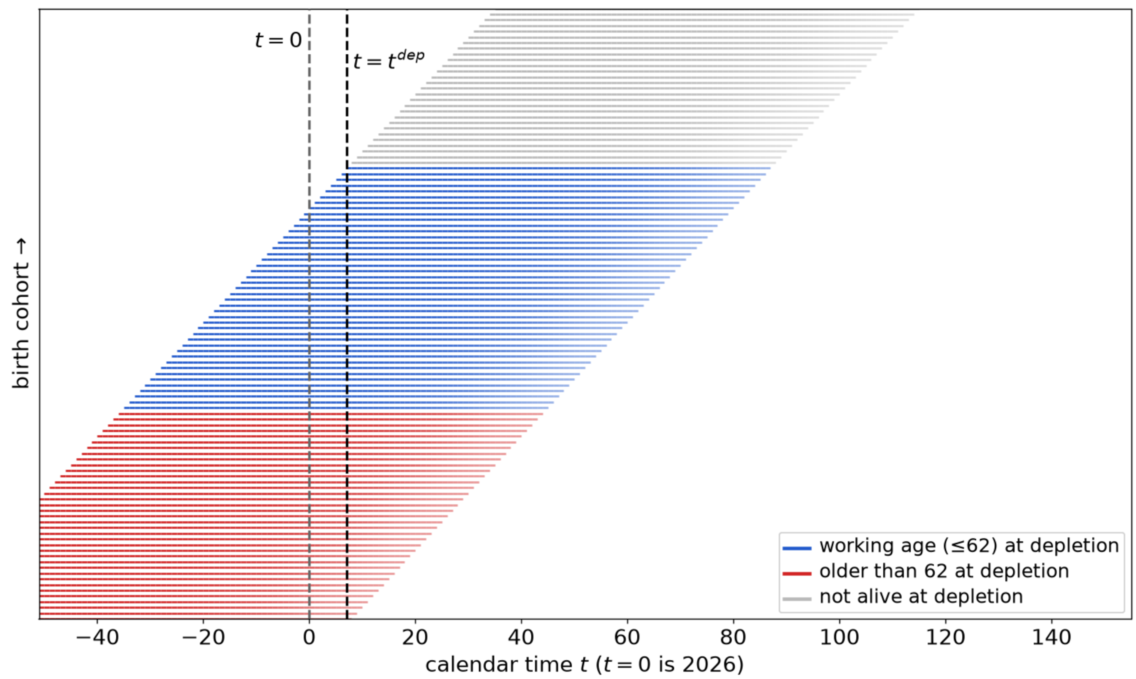


Figure 1: Birth cohorts across calendar years. The vertical lines mark $t = 0$ (which for us is 2026) and the depletion date (t^{dep}), an endogenous variable; the colors distinguish cohorts of ages above (red) and below (blue) the early-eligibility age when the fund is exhausted.

Figure 1 plots birth year on the vertical axis and calendar year on the horizontal axis. Each line begins in a cohort's birth year and ends in the last year of life of its last survivor. The vertical lines mark $t = 0$, which is 2026, and the depletion date t^{dep}, which is endogenous and differs across our scenarios. A cohort alive in 2026 reaches t^{dep} as a prime-age worker, as a worker near retirement, or as a retiree. Its saving, claiming, and retirement decisions in the years before t^{dep} differ accordingly.

[4]The projection embeds immigration, so cohort masses need not satisfy $N_{j+1,t+1} = s_{j,t} N_{j,t}$.

2.2 The trust fund and the payable factor

The age structure moves Social Security's cash flow. It sets the number of workers who pay the payroll tax and the number of recipients who collect benefits. The SSA projects the aged-dependency ratio, the population aged 65 and over per person aged 20 to 64, to rise from 0.32 in 2025 to 0.50 in 2085.

The trust fund F_t is an entry in a ledger. The reserves it carries into year t are special-issue Treasury securities. The Treasury owes F_t to the fund, and the fund is part of the government, so in terms of the consolidated federal budget constraint the government owes F_t to itself. Current law nonetheless requires $F_t \geq 0$ for all t, and that requirement limits Social Security's authority to pay future benefits.

The fund balance F_t is an aggregate. Every other quantity in the paper is per capita, so the population level N_t scales the year's flows into F_{t+1}:

$$F_{t+1} = (1+r^F)F_t + N_t\left(Rev_t^{ss} - \phi_t\left(B_t^{sch} - Wh_t^{sch}\right)\right), \qquad F_t \geq 0. \tag{2}$$

Here r^F is the interest rate credited on the account F_t,[5] B_t^{sch} is the benefit bill, and Wh_t^{sch} is earnings-test withholding. These are scheduled amounts, computed from the benefit formulas of Section 2.3, in contrast to the payable amounts, which multiply them by the payable factor ϕ_t: the ledger deducts $\phi_t\left(B_t^{sch} - Wh_t^{sch}\right)$ and retains the withholding. Program revenue is

$$Rev_t^{ss} = \tau^{ss} Pay_t + \kappa_b \phi_t\left(B_t^{sch} - Wh_t^{sch}\right), \tag{3}$$

where τ^{ss} is the payroll tax, Pay_t is taxable payroll, and κ_b is the tax rate on benefits received.[6]

Worker i of age j in year t entitled to the scheduled benefit $b_{i,j,t}^{sch}$ receives

$$b_{i,j,t}^{pay} = \phi_t b_{i,j,t}^{sch}. \tag{4}$$

[5] The trust fund holds special-issue securities of the Treasury. The Treasury credits interest on the account at the rate r^F, which is purely accounting. We set $r^F = 0.02$ (the Trustees project a rate between 1.7 and 2.3 percent in the coming decades, Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds, 2026).

[6] We set τ^{ss} to the combined employer and employee OASI rate and levy it on the worker's earnings, so earnings are measured gross of the employer share and the worker bears the whole payroll tax. Section 3 reports how we set κ_b.

Without new legislation, the payable factor that scales down every Social Security benefit equals

$$\phi_t = \min\left\{1, \frac{(1+r^F)F_t + N_t \tau^{ss} Pay_t}{N_t(1-\kappa_b)\left(B_t^{sch} - Wh_t^{sch}\right)}\right\}. \tag{5}$$

Equation (5) imposes two restrictions. The program never pays more than the scheduled benefit, so $\phi_t \leq 1$. The program never borrows, so $F_{t+1} \geq 0$. So long as the inherited balance plus current revenue cover the scheduled bill, $\phi_t = 1$ and any surplus remains in the fund. The numerator is what the program can draw on, the balance it carries in plus the payroll tax it collects. The denominator is what it owes, the scheduled bill net of the withholding it keeps and of the benefit tax that returns to it.

We date depletion at the first year the fund is empty,

$$t^{dep} = \min\{t : F_t = 0\}. \tag{6}$$

We call $t^{dep} - 1$ the first shortfall year. In that year the program pays out its remaining reserves, so $\phi_{t^{dep}-1} < 1$ and $F_{t^{dep}} = 0$. The fund is empty thereafter. The Trustees date reserve depletion to the year in which the reserves run out, our first shortfall year $t^{dep} - 1$.

From the depletion date t^{dep} on, current law states that the Social Security program must take in exactly what it pays out. Its revenue is the payroll tax plus the tax on the benefits it pays; its cost is the benefits actually paid, net of the withholding it retains. In per-capita terms, in which N_t divides out,

$$\underbrace{\tau^{ss} Pay_t + \kappa_b \phi_t \left(B_t^{sch} - Wh_t^{sch}\right)}_{\text{program revenue}} = \underbrace{\phi_t \left(B_t^{sch} - Wh_t^{sch}\right)}_{\text{net benefits paid}}, \qquad \text{for all } t \geq t^{dep}. \tag{7}$$

The initial cross-section $\{\mu_{j,0}\}_{j=0}^{J-1}$ of Section 2.3 records the assets, earnings histories, and claim statuses that the workers of 2026 carry into the transition, and those summarize every payable factor of earlier years. Each date-t aggregate therefore depends on the payable path $\{\phi_t\}_{t=0}^{\infty}$ and not on the payable factors of years before 2026. We write taxable payroll, the scheduled benefit bill, and scheduled withholding as

$$Pay_t\left(\cdot, \{\phi_t\}_{t=0}^{\infty}\right), \qquad B_t^{sch}\left(\cdot, \{\phi_t\}_{t=0}^{\infty}\right), \qquad Wh_t^{sch}\left(\cdot, \{\phi_t\}_{t=0}^{\infty}\right),$$

where the dot collects the prices, the transfer, the tax rates, and the demographic sequences $\{N_{j,t}, s_{j,t}\}_{t=0}^{\infty}$.

Solving (7) for the payable factor ϕ_t gives

$$\phi_t = \frac{\tau^{ss}\, Pay_t\big(\cdot\,,\{\phi_t\}\big)}{(1-\kappa_b)\big[B_t^{sch}\big(\cdot\,,\{\phi_t\}\big) - Wh_t^{sch}\big(\cdot\,,\{\phi_t\}\big)\big]}, \qquad \text{for all } t \geq t^{dep}. \tag{8}$$

Workers' behavior and the legislation governing the trust fund, with the balance F_t generated from the path by (2), imply the operator

$$\Phi_t\big(\{\phi_t\}_{t=0}^{\infty}\big) = \begin{cases} 1, & t < t^{dep}-1, \\ \min\left\{1,\ \dfrac{(1+r^F)F_t + N_t\tau^{ss}Pay_t\big(\cdot\,,\{\phi_t\}\big)}{N_t(1-\kappa_b)\big[B_t^{sch}\big(\cdot\,,\{\phi_t\}\big) - Wh_t^{sch}\big(\cdot\,,\{\phi_t\}\big)\big]}\right\}, & t = t^{dep}-1, \\ \min\left\{1,\ \dfrac{\tau^{ss}Pay_t\big(\cdot\,,\{\phi_t\}\big)}{(1-\kappa_b)\big[B_t^{sch}\big(\cdot\,,\{\phi_t\}\big) - Wh_t^{sch}\big(\cdot\,,\{\phi_t\}\big)\big]}\right\}, & t \geq t^{dep}. \end{cases} \tag{9}$$

The date t^{dep} in (9) is the depletion date implied by the candidate sequence $\{\phi_t\}_{t=0}^{\infty}$ through (2) and (6). Write $\Phi = \{\Phi_t\}_{t=0}^{\infty}$ for the operator that collects the coordinates (9). It maps payable paths into payable paths. An equilibrium payable path is a fixed point of Φ,

$$\{\phi_t\}_{t=0}^{\infty} = \Phi\big(\{\phi_t\}_{t=0}^{\infty}\big). \tag{10}$$

The operator Φ is decreasing. A higher payable factor pays a larger benefit, so workers claim earlier and retire earlier; taxable payroll Pay_t falls, the scheduled bill B_t^{sch} rises, and (9) returns a smaller number. An undamped iteration on a decreasing operator oscillates, so we damp the one that computes (10). Appendix B.4 reports the cycling that damping does not remove, which occurs at the first shortfall year because that date is an integer. We have no proof that (10) has a unique solution.

In a stationary economy with a fund that is always depleted, every aggregate quantity is a function of the single number ϕ_∞:

$$\phi_\infty = \Phi_\infty(\phi_\infty) \equiv \min\left\{1,\ \frac{\tau^{ss}\, Pay_\infty(\cdot\,,\phi_\infty)}{(1-\kappa_b)\big(B_\infty^{sch}(\cdot\,,\phi_\infty) - Wh_\infty^{sch}(\cdot\,,\phi_\infty)\big)}\right\}. \tag{11}$$

Here Φ_∞ is a continuous decreasing map of $[0,1]$ into itself, so it has exactly one fixed point.

2.3 The worker's problem

Workers have perfect foresight. Each of them chooses when to retire, when to claim, and how much to save against the whole future of the payable factor $\{\phi_t\}_{t\geq 0}$.

A worker i of age j enters period t with state vector

$$x_{i,j,t} = \left(a_{i,j,t}, z_{i,j,t}, e_i, \text{AIME}_{i,j,t}, \chi_{i,j,t}\right), \tag{12}$$

where a is assets; z is the idiosyncratic productivity shock; e is permanent ability, drawn at entry; AIME is the earnings-history state; and $\chi \in \{0, 62, 63, \ldots, 70\}$ denotes the claim status: 0 if the worker has not yet claimed, and otherwise the effective claim age. A retirement flag $\iota \in \{0,1\}$ records whether retirement has occurred; we carry it as a superscript on the value functions below rather than as a coordinate of (12), since no constraint reads it. A worker first decides whether to work or retire, then whether to file or wait, and then how much to save. Retirement can occur at any age and is irreversible. Filing occurs once between ages 62 and 70 and is compulsory at age 70. Figure 2 records this within-period timing of decisions.

Figure 2: Timing of a worker's choices within a period. Claiming and retirement are separate choices; both are irreversible.

An employed worker supplies one unit of labor and earns

$$y_{i,j,t} = w_t z_{i,j,t} e_i \varepsilon_j, \tag{13}$$

where ε_j is a deterministic age-efficiency profile.[7] An idiosyncratic component of productivity follows

$$\log z_{i,j+1,t+1} = \rho \log z_{i,j,t} + \sigma_z \varepsilon_{i,j+1,t+1}, \qquad \varepsilon_{i,j+1,t+1} \sim N(0,1), \qquad \text{for all } j \leq J-2 \text{ and } t. \tag{14}$$

Flow utility is $u(c_{i,j,t}) - \eta\, n_{i,j,t}$, where $n_{i,j,t} \in \{0,1\}$ indicates work and η is the disutility of working. We set the coefficient of relative risk aversion to one, so $u(c) = \log c$. The discount factor is β and $s_{j,t}$ is the survival probability. A worker values the estate a' through a warm-glow bequest

[7] The profile follows Holter et al. (2025): $\varepsilon_j \propto \exp(\gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3) \big/ \left[1 + \exp\left(\xi_1 (j + 20 - \xi_2)\right)\right]$, with its mean over ages 20 to 65, $\bar{\varepsilon}$, set so that mean earnings per worker equal one in the initial stationary equilibrium.

function (De Nardi, 2004)

$$v^B(a') = \zeta_1 \left(1 + \frac{a'}{\zeta_2}\right)^{1-\sigma_b}. \tag{15}$$

With $\sigma_b > 1$ and $\zeta_1 < 0$, v^B is increasing and concave in a'.

The tax code and Social Security payments shape the worker's budget constraint. Let χ^b denote the claim status chosen at the beginning of the period. A worker who has not yet claimed Social Security benefits can choose to wait or to file inside the statutory window. A current recipient of Social Security benefits keeps the current status, apart from the earnings-test credit described in equation (20). Denote the set of admissible claim choices χ^b by $\mathscr{X}_j(\chi)$. $\mathscr{X}_j(0) = \{0\}$ below age 62, $\{0, j+20\}$ at ages 62 to 69, and $\{70\}$ at age 70; $\mathscr{X}_j(\chi) = \{\chi\}$ for $\chi > 0$, so the decision to claim is irreversible. A worker who files at age j receives the age-j benefit in that year. The worker's time t budget constraint is

$$\begin{aligned}(1+\tau_{c,t})c_{i,j,t} + a_{i,j+1,t+1} = {} & \left[1 + r_t(1-\tau_{k,t})\right] a_{i,j,t} + tr_t \\ & + n_{i,j,t}\left[(1-\tau_{\ell,t})y_{i,j,t} - \tau^{ss}\min(y_{i,j,t}, \bar{y})\right] \\ & + (1-\kappa_b)\phi_t\left(b^{sch}_{i,j,t} - wh^{sch}_{i,j,t}\right), \qquad a_{i,j+1,t+1} \geq 0.\end{aligned} \tag{16}$$

The rates $\tau_{c,t}$, $\tau_{\ell,t}$, and $\tau_{k,t}$ tax consumption, labor income, and capital income. The transfer tr_t distributes accidental bequests. The workers who die at the end of year t leave the estates $a_{i,j+1,t+1}$ they had accumulated, and the government pays those estates in equal amounts to every worker alive in year t:

$$tr_t = \sum_j f_{j,t}\left(1 - s_{j,t}\right) \int g^{a'}_{j,t}(x)\, \mathrm{d}\mu_{j,t}(x). \tag{17}$$

The payroll tax applies to earnings below the taxable maximum $\bar{y}$.

The scheduled benefit depends on the worker's earnings history and effective claim age. The AIME state is a moving average of past capped earnings that accumulates while the worker works and freezes at retirement:

$$\mathrm{AIME}_{i,j+1,t+1} = \mathrm{AIME}_{i,j,t} + \psi \mathbf{1}\{n_{i,j,t} = 1\} \begin{cases} \min(y_{i,j,t}, \bar{y}) - \mathrm{AIME}_{i,j,t}, & \chi^b = 0, \\ \max\{\min(y_{i,j,t}, \bar{y}) - \mathrm{AIME}_{i,j,t}, 0\}, & \chi^b > 0. \end{cases} \tag{18}$$

Equation (18) approximates the statutory highest-35-years earnings record. The accrual weight ψ makes it an exponentially weighted moving average, whose effective window is $2/\psi - 1$ years; we set $\psi = 0.055$, which gives about thirty-five years. The second branch permits only upward recomputation for a worker still working after filing.

The ordinary Social Security benefit, or primary insurance amount (PIA), is the piecewise-linear function

$$\mathrm{PIA}(\mathrm{AIME}) = \begin{cases} 0.90\,\mathrm{AIME}, & \mathrm{AIME} \le b_1, \\ 0.90 b_1 + 0.32(\mathrm{AIME} - b_1), & b_1 < \mathrm{AIME} \le b_2, \\ 0.90 b_1 + 0.32(b_2 - b_1) + 0.15(\mathrm{AIME} - b_2), & \mathrm{AIME} > b_2. \end{cases} \tag{19}$$

The thresholds $b_1 < b_2$ are the two statutory bend points. The scheduled benefit is $b^{sch}_{i,j,t} = \mathrm{AF}(\chi^b)\mathrm{PIA}(\mathrm{AIME}_{i,j,t})$. The actuarial factor $\mathrm{AF}(\chi)$ is the multiple of the primary insurance amount determined by a worker's effective claim age, reported in Table 1. Claiming before the full retirement age lowers the multiple; claiming after the full retirement age raises it. The convention $\mathrm{AF}(0) = 0$ gives an unclaimed worker no benefit.

claim age χ	62	63	64	65	66	**67**	68	69	70
$\mathrm{AF}(\chi)$	.70	.75	.80	.8667	.9333	**1.00**	1.08	1.16	1.24

Table 1: The actuarial factor $\mathrm{AF}(\chi)$ by effective claim age, at a full retirement age of 67.

The retirement earnings test withholds benefits from a worker who had claimed earlier and remains below the full retirement age (FRA):

$$wh^{sch}_{i,j,t} = \mathbf{1}\{n_{i,j,t} = 1,\ \chi^b < \mathrm{FRA}\} \min\left\{ b^{sch}_{i,j,t}, \vartheta_j \max(y_{i,j,t} - y^{ex}_j, 0) \right\}. \tag{20}$$

The statutory rate ϑ_j is one-half before the year the full retirement age is reached, one-third in that year, and zero thereafter; y^{ex}_j is the exempt amount. The withheld amount remains in the fund. The effective claim age advances one year toward the full retirement age with probability $\pi^{wh}_{i,j,t} = wh^{sch}_{i,j,t}/b^{sch}_{i,j,t}$, capped at the full retirement age. An unclaimed worker has $wh^{sch}_{i,j,t} = 0$ and hence $\pi^{wh}_{i,j,t} = 0$, so the advance never moves a worker out of the claim status $\chi^b = 0$. The actuarial factor $\mathrm{AF}(\chi)$ then rises for life. The credit is matched in expectation to a first order, so the earnings test defers benefits rather than taxing them; the match is not exact, because $\mathrm{AF}(\chi)$ in Table 1 is not linear in χ.

We cast the worker's optimization problem in terms of two value functions. Let $V^1_{j,t}$ and $V^0_{j,t}$ denote optimal values of age-j retired and still-working workers entering period t. Figure 3 traces the layers within a period: a retired worker stays retired because retirement is absorbing, while a still-working worker compares the value of retiring this period, $V^1_{j,t}$, with the value of continuing to work, $V^{0,\text{work}}_{j,t}$, and makes the optimal retirement decision.

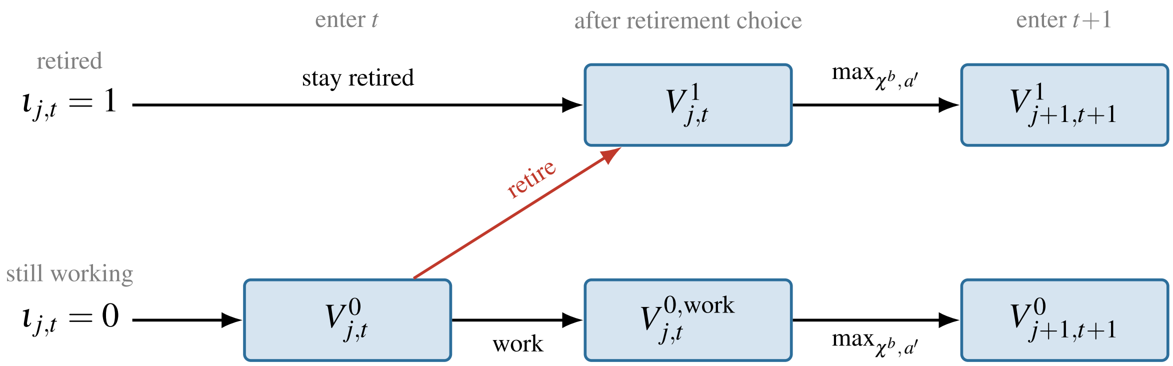


Figure 3: Within-period flow of the value functions. A retired worker stays retired. A still-working worker compares retiring now with working on; after the retirement decision, both layers choose filing and saving.

After the retirement decision, value functions for retired and still-working age-j workers satisfy the Bellman equations

$$V^1_{j,t}(x) = \max_{\chi^b \in \mathscr{X}_j(\chi),\, a' \geq 0} \Big\{ u(c) + \beta s_{j,t} \mathbb{E}_{z'|z} V^1_{j+1,t+1}(a', z', e, \text{AIME}, \chi^b) + \beta(1 - s_{j,t}) v^B(a') \Big\}, \tag{21}$$

$$\begin{aligned} V^{0,\text{work}}_{j,t}(x) = \max_{\chi^b \in \mathscr{X}_j(\chi),\, a' \geq 0} \Big\{ & u(c) - \eta + \beta s_{j,t}(1 - \pi^{wh}) \mathbb{E}_{z'|z} V^0_{j+1,t+1}(a', z', e, \text{AIME}', \chi^b) \\ & + \beta s_{j,t} \pi^{wh} \mathbb{E}_{z'|z} V^0_{j+1,t+1}\big(a', z', e, \text{AIME}', \min(\chi^b + 1, \text{FRA})\big) \\ & + \beta(1 - s_{j,t}) v^B(a') \Big\}, \end{aligned} \tag{22}$$

where maximization is subject to budget constraint (16) and AIME$'$ follows (18). The second continuation term in (22) carries weight $\pi^{wh} = 0$ whenever $\chi^b = 0$, so the advanced claim status never arises outside the statutory window. The start-of-period value of a still-working worker is the upper envelope

$$V^0_{j,t}(x) = \max \Big\{ V^{0,\text{work}}_{j,t}(x), V^1_{j,t}(x) \Big\}. \tag{23}$$

Denote by $g^n_{j,t}(x_{i,j,t})$, $g^\chi_{j,t}(x_{i,j,t})$ and $g^{a'}_{j,t}(x_{i,j,t})$ the optimal policies for working, claiming Social Security benefits, and saving.

2.3.1 Evolution of probability measures

Let $\mu_{j,t}$ denote the distribution of age-j workers over the individual state space $\mathscr{S}$, conditional on being alive; the state vector $x \in \mathscr{S}$ is specified in (12). Mortality depends on age and calendar time but not on other state variables of the worker. This lets us track the population mass $N_{j,t}$ and the within-cohort conditional distribution $\mu_{j,t}$ separately at each age and date:

$$\mu_{j+1,t+1}(x') = \int Q_{j,t}(x,x')\,\mathrm{d}\mu_{j,t}(x), \qquad \text{for all } j \leq J-2 \text{ and } t, \tag{24}$$

where $Q_{j,t}$ is the transition rule of the individual state variables that combines the workers' optimal choices with the idiosyncratic shocks.

A worker enters at age 20 with no assets and no earnings history, unclaimed and working. Permanent ability e is drawn from the probability distribution π_e,[8] and initial productivity z from the stationary distribution π_z of (14). Denote by $\mu_{0,t}$ the newborn population distribution.

2.4 Technology, aggregation, and public accounts

The representative firm operates a Cobb–Douglas technology and pays competitive factor prices:

$$Y_t = ZK_t^{\alpha}L_t^{1-\alpha}, \qquad r_t = \alpha Z(K_t/L_t)^{\alpha-1} - \delta, \qquad w_t = (1-\alpha)Z(K_t/L_t)^{\alpha}. \tag{25}$$

The parameters Z, α, and δ are total factor productivity, the capital share, and the depreciation rate.

Aggregate variables in year t are averages of individual quantities under the age-j distribution $\mu_{j,t}$, weighting each age by its population share $f_{j,t}$. They are worker wealth A_t, efficiency labor L_t, consumption C_t, taxable payroll Pay_t, the scheduled benefit bill B_t^{sch}, and scheduled withholding Wh_t^{sch}:

$$A_t = \sum_j f_{j,t} \int a\,\mathrm{d}\mu_{j,t}, \qquad L_t = \sum_j f_{j,t} \int z e \varepsilon_j n\,\mathrm{d}\mu_{j,t}, \tag{26}$$

$$C_t = \sum_j f_{j,t} \int c\,\mathrm{d}\mu_{j,t}, \qquad Pay_t = \sum_j f_{j,t} \int \min(y,\bar{y})\,n\,\mathrm{d}\mu_{j,t}, \tag{27}$$

$$B_t^{sch} = \sum_j f_{j,t} \int b^{sch}\,\mathrm{d}\mu_{j,t}, \qquad Wh_t^{sch} = \sum_j f_{j,t} \int wh^{sch}\,\mathrm{d}\mu_{j,t}. \tag{28}$$

[8] We adopt a five-point discretization of $\log e \sim N(0,\sigma_a^2)$, with the levels normalized so that $\mathbb{E}[e] = 1$, and a seven-point discretization of (14) normalized the same way.

Aggregate physical capital equals worker wealth less government debt,

$$K_t = A_t - D_t. \tag{29}$$

A single consolidated government budget constraint holds in every period t. The government pays for debt $(1+r_t)D_t$ falling due at t, government consumption G_t, and the Social Security deficit, $\phi_t\left(B_t^{sch} - Wh_t^{sch}\right) - Rev_t^{ss}$;[9] it collects general taxation revenue, $\tau_{\ell,t} w_t L_t + \tau_{k,t} r_t A_t + \tau_{c,t} C_t$, and issues debt D_{t+1}. All quantities are per capita; the population ratio N_{t+1}/N_t scales the debt dynamics:

$$(1+r_t)D_t + G_t + \left[\phi_t\left(B_t^{sch} - Wh_t^{sch}\right) - Rev_t^{ss}\right] = \tau_{\ell,t} w_t L_t + \tau_{k,t} r_t A_t + \tau_{c,t} C_t + \frac{N_{t+1}}{N_t} D_{t+1}. \tag{30}$$

The bracketed term in (30) is the program's contribution to the net-of-interest deficit in the consolidated federal budget constraint. Current legislation lets it be positive while $\phi_t = 1$, so long as the ledger entry F_t is sufficiently positive. When the fund cannot cover the scheduled bill, current legislation requires ϕ_t to adjust so that the program draws down at most its remaining balance. In the first shortfall year the bracketed term equals that drawdown and $\phi_t < 1$. From the depletion date t^{dep} on, the balance is zero and current legislation requires ϕ_t to adjust each year to set

$$\left[\phi_t\left(B_t^{sch} - Wh_t^{sch}\right) - Rev_t^{ss}\right] = 0. \tag{31}$$

The trust fund balance F_t therefore enters the consolidated government budget constraint (30) indirectly, through ϕ_t. Without new legislation ϕ_t follows (5): once the fund is depleted, ϕ_t falls to equate program revenue to payable benefits, and from then on the Social Security deficit and the ledger F_t are both zero.[10] A bailout instead sets $\phi_t = 1$ for all t by new legislation. When $\left(B_t^{sch} - Wh_t^{sch}\right) - Rev_t^{ss} > 0$ after the depletion date, a bailout requires the tax rate and debt sequences on the right side of (30) to adjust enough to keep (30) satisfied at $\phi_t = 1$.

Goods-market clearing requires

$$Y_t + IMM_t = C_t + I_t + G_t, \tag{32}$$

[9]While reserves last, the program pays this deficit by redeeming the securities it holds, (2). Because those securities are intragovernmental debt, the Treasury finances each redemption, and the deficit reaches the consolidated constraint through that transfer.

[10]Under depletion the payable factor ϕ_t cancels the Social Security terms, so no Social Security deficit presses on the budget constraint. Taxation and debt still move, because workers' retirement, claiming, and saving responses change the aggregates L_t, A_t, and C_t on which general taxation is levied.

where I_t is investment and IMM_t is the asset endowment carried by net immigrants.[11] Investment is $I_t = (N_{t+1}/N_t)K_{t+1} - (1-\delta)K_t$, with the population ratio scaling next period's per-capita capital.

2.5 Equilibrium

Definition 1 (Equilibrium)**.** Given initial conditions $\left(\{\mu_{j,0}\}_{j=0}^{J-1}, F_0, D_0\right)$, demographic sequences $\{N_{j,t}, s_{j,t}\}_{t=0}^{\infty}$, Social Security policy $\left(\tau^{ss}, \bar{y}, \kappa_b, r^F, \mathrm{FRA}, \mathrm{PIA}(\cdot), \mathrm{AF}(\cdot), \{\vartheta_j, y_j^{ex}\}_{j=0}^{J-1}\right)$, and laws governing the trust fund and benefits after exhaustion, an equilibrium is a collection of sequences

- value functions $\{V_{j,t}^0, V_{j,t}^1\}_{t=0}^{\infty}$, optimal policies $\{g_{j,t}^n, g_{j,t}^\chi, g_{j,t}^{a'}\}_{t=0}^{\infty}$, and cross-sectional distributions $\{\mu_{j,t}\}_{t=0}^{\infty}$,
- prices and bequest transfer $\{r_t, w_t, tr_t\}_{t=0}^{\infty}$, and aggregate quantities $\{A_t, K_t, L_t, C_t, Y_t\}_{t=0}^{\infty}$,
- public accounts $\{\phi_t, F_t, D_t\}_{t=0}^{\infty}$ and fiscal policy $\{\tau_{\ell,t}, \tau_{k,t}, \tau_{c,t}, G_t\}_{t=0}^{\infty}$,

that satisfy the following conditions:

1. the value functions and optimal policies solve workers' optimization problems (21)–(23),
2. the population evolution is (24),
3. aggregate quantities satisfy (26)–(28),
4. Equations (25), (29), and (17) hold, so that labor and capital markets clear and the transfer equals accidental bequests,
5. the government budget constraint (30) and the resource constraint (32) are satisfied, and the trust fund and the payable factor ϕ_t satisfy (2)–(5).

A stationary equilibrium is one in which the demographic and policy sequences are constant, so that optimal values, policies, cross-sectional distributions, prices, aggregate quantities and objects appearing in public accounts do not depend on t.

Two stationary equilibria form boundary conditions for our calculated transition paths. An *initial stationary equilibrium* is the economy before depletion, in which the program pays every benefit as scheduled; we calibrate it as the 2025 economy in Section 3. We compute it at frozen 2025 demographics and 2025 policy. Its cross-section supplies the initial condition $\{\mu_{j,0}\}_{j=0}^{J-1}$. Its own accumulation does not pin down the public accounts that the transition inherits, because a fund that

[11] Appendix A gives the demographic and aggregate accounting details.

runs a deficit cannot hold F constant; we therefore set F_0 and D_0 from the recorded 2025 trust-fund position and the recorded debt-to-output ratio. Every input sequence for the transition equilibrium must stabilize towards a constant as $t \to T$: the demographic sequences are frozen beyond 2085, and all the policy variables must have settled at constant values long enough before T. The year-T economy is in the stationary equilibrium under the year-T policy variables, demographics, and the specified legislation; we call it a *terminal stationary equilibrium*. The economy starts from the initial condition in 2026 and converges to the terminal stationary equilibrium within the horizon $T = 150$; the terminal stationary equilibrium provides the continuation values with which each forward-looking worker solves its problem backward during the transition.

2.6 Scenarios

We compute equilibrium sequences that share preferences, technology, projected demographics, and initial conditions. They differ in their benefit policies, in the policies the government uses to finance Social Security benefits, in the dates at which the government chooses continuation fiscal plans, and in the dates at which workers learn about those plans.

In every scenario the consolidated government budget constraint (30) holds in every year t. Equation (30) contains several policy variables: the three tax rates $\tau_{\ell,t}$, $\tau_{k,t}$, and $\tau_{c,t}$, government consumption G_t, and the debt D_{t+1} issued in year t. Legislation sets the rule for the payable factor path $\{\phi_t\}_{t=0}^{\infty}$: under current law ϕ_t follows (5); under a bailout $\phi_t = 1$; a reform of Social Security rules affects Social Security expenditures and receipts from the Social Security payroll tax. Our scenarios restrict equilibrium sequences as follows.

1. **Government consumption.** Government consumption is a fixed fraction of output in every year. We compute the initial stationary equilibrium at the 2025 tax rates, debt-to-output ratio, and Social Security rules and compute government consumption G_{2025} from the budget constraint (30). The share $\bar{g} = G_{2025}/Y_{2025}$ equals 0.168, and we impose $G_t = \bar{g}Y_t$ for all t in every scenario. Government consumption does not enter the utility function. Fixing its share of output denies the government a fourth financing instrument: no scenario pays for benefits by cutting G.[12]

2. **Public debt.** Given other fiscal variable sequences, the debt sequence $\{D_t\}_{t=0}^{T}$ follows from the government budget constraint (30) at equilibrium quantities and a terminal condition:

[12] An instrument that contracts output therefore also sheds waste. Terminal G per capita is 0.206 in the baseline equilibrium sequence and 0.178 under the wage tax, the largest reduction among the three instruments of Section 5; the welfare cost we report there for the wage tax is understated relative to the other two for that reason.

we fix the terminal stationary equilibrium's debt-to-output ratio at its initial 2025 level, $D_T/Y_T = \theta_D$ with $\theta_D = D_{2025}/Y_{2025}$ as calibrated. Debt changes smooth deficits and surpluses during a transition but not in the long run.

3. **Tax rates.** In each scenario, the payroll tax τ^{ss} stays at its current statutory rate, and we adjust one tax rate sequence $\{\tau_{i,t}\}_{t=0}^{\infty}$, $i \in \{\ell, k, c\}$, to satisfy the government budget constraint; the other two tax rate sequences $\{\tau_{i',t}\}_{t=0}^{\infty}$, $i' \neq i$, stay flat at their 2025 values $\tau_{i',2025}$. The adjusted tax rate sequence has two boundary conditions: before the transition it equals its 2025 rate, $\tau_i^0 = \tau_{i,2025}$, and in the long run it equals the rate τ_i^∞ that balances the consolidated government budget constraint (30) in the terminal stationary equilibrium. We restrict the adjusted sequence to the three-piece step function[13]

$$\tau_{i,t} = \begin{cases} \tau_i^0, & t < t^*, \\ \tau_i^{\text{trans}}, & t^* \leq t < t^* + 50, \\ \tau_i^\infty, & t \geq t^* + 50, \end{cases} \tag{33}$$

where t^* is the year in which the tax adjustment starts. The step function has one free parameter, the transitory rate τ_i^{trans}: the boundary conditions fix τ_i^0 and τ_i^∞. Given t^*, a unique τ_i^{trans} satisfies the terminal debt ratio boundary condition; we find it with a shooting algorithm. We date years by the calendar. In equilibria in which the government adjusts a tax rate sequence immediately, $t^* = 2026$, the first year of the transition. In equilibria with no bailout or a bailout financed by a deferred tax rate sequence adjustment, t^* is the Social Security fund's first shortfall year, the year $t^{dep} - 1$ of (6). The two dates are distinct: t^* dates the tax increase and t^{dep} dates the empty fund. Under current law they satisfy $t^{dep} = t^* + 1$, except where the tie-breaking convention of the next footnote applies. The first shortfall year is endogenous, since workers' claiming and retirement choices, and along with them Pay_t and B_t^{sch} in (2), differ across scenarios.[14]

Our scenarios differ in the benefit regime, in the Social Security system's eligibility rules, in the tax rate sequence that we adjust, and in two dates, namely, when the government acts and when workers learn about that date. The next four subsections describe the equilibrium scenarios that we compute.

[13] We use the constant-transition-tax assumption of Huang et al. (1997) and De Nardi et al. (1999).

[14] Appendix B.4 describes the iteration that locates the first shortfall year and the convention that breaks a tie when it cycles between two adjacent years.

2.6.1 The benefit regime

Computing an equilibrium sequence without a bailout requires at least one tax rate sequence $\{\tau_{i,t}\}_{t=0}^{\infty}$, $i \in \{\ell, k, c\}$, to adjust so that the consolidated government budget constraint (30) is satisfied. The demographic transition and workers' responses to the benefit cut move the taxation bases away from their values in the initial stationary equilibrium. To construct what we call the *baseline equilibrium sequence*, we let only the wage tax rate sequence adjust. Section 4 describes that equilibrium sequence.

Under our various bailout scenarios, new legislation guarantees every scheduled benefit, so $\phi_t = 1$ for all t, and the government adjusts one of the three continuation tax rate sequences starting at $t^* = 2026$, holding the other two at their 2025 values. When we let the wage tax sequence adjust, the equilibrium path is the *wage-tax bailout sequence* of Section 5. The wage tax rates differ between the baseline equilibrium sequence and the wage-tax bailout sequence because bailing out Social Security costs something. Table 2 describes our no-bailout and wage-tax-financed bailout scenarios.

Equilibrium sequence	What workers learn, and when	Benefit legislation	Adjusting tax and start date t^*
Baseline equilibrium sequence: fund depletion, no bailout (Section 4)	nothing; workers expect no rescue	current law: $\phi_t < 1$ from the first shortfall year on, $F_t = 0$ from t^{dep} on	t^* = first shortfall year; τ_ℓ
Wage-tax bailout (Section 5)	2026: the bailout	bailout: $\phi_t = 1$ in every year	$t^* = 2026$; τ_ℓ

Table 2: Benefit regimes. The two sequences differ in whether legislation guarantees scheduled benefits and in the year the wage tax starts to adjust.
Note: the adjusting tax rate follows (33), and the other two stay at their 2025 values. Under current law ϕ_t follows (5) and F_t follows (2).

2.6.2 Financing instruments

A bailout can also be financed by the capital tax or by the consumption tax. Letting $\{\tau_{k,t}\}_{t=0}^{\infty}$ adjust gives the *capital-tax bailout sequence*; letting $\{\tau_{c,t}\}_{t=0}^{\infty}$ adjust gives the *consumption-tax bailout sequence*. Section 5 compares worker responses and aggregates across the three.

Welfare comparisons need an equilibrium sequence with fund depletion and no bailout for each instrument. Call the sequence with fund depletion and no bailout in which τ_i adjusts the *reference sequence for instrument i*, $i \in \{\ell, k, c\}$. The baseline equilibrium sequence of Section 4 is the reference sequence for the wage tax; we compute two more, one for the capital tax and one for the consumption tax. We pair each bailout sequence with the reference sequence that adjusts the same tax. Within a pair the two sequences differ only in the benefit guarantee and in the taxes that pay for it. Table 3 lists the three pairs.

Equilibrium sequence	What workers learn, and when	Benefit legislation	Adjusting tax and start date t^*
Wage tax (Table 2)			
Reference sequence: the baseline	nothing; workers expect no rescue	current law	$t^* =$ first shortfall year; τ_ℓ
Wage-tax bailout	2026: the bailout	$\phi_t = 1$	$t^* = 2026$; τ_ℓ
Capital tax			
Reference sequence, capital tax	nothing; workers expect no rescue	current law	$t^* =$ first shortfall year; τ_k
Capital-tax bailout	2026: the bailout	$\phi_t = 1$	$t^* = 2026$; τ_k
Consumption tax			
Reference sequence, consumption tax	nothing; workers expect no rescue	current law	$t^* =$ first shortfall year; τ_c
Consumption-tax bailout	2026: the bailout	$\phi_t = 1$	$t^* = 2026$; τ_c

Table 3: Financing instruments. Within each pair the same tax adjusts, so the two sequences differ only in the benefit guarantee and in the taxes that pay for it. The wage-tax pair repeats Table 2.
Note: the adjusting tax rate follows (33), and the other two stay at their 2025 values. Under current law ϕ_t follows (5) and F_t follows (2); under a bailout $\phi_t = 1$ in every year.

2.6.3 Reforms of the program's rules

The government can instead change Social Security's own rules. We study three changes. The full retirement age rises from 67 to 69. The taxable maximum rises to \$250,000. The top marginal replacement rate in the PIA formula falls from 0.15 to 0.05. The government announces each change in 2026, commits to it, and applies it to every cohort at once.

We run each reform twice. Under current law ϕ_t still falls at the first shortfall year, and the reform only postpones that year. Under the wage-tax bailout $\phi_t = 1$ and the wage tax covers the deficit that the reform leaves. We compare both runs with the baseline equilibrium sequence. Table 4 lists the six sequences.

2.6.4 Policy timing

A bailout has two dates: the year the government announces and commits to it, and the year t^* at which taxes start to rise. Section 7 varies the two dates under each financing instrument. In the *immediate scenario* both dates are 2026; these are the bailout sequences of Section 5. In the

Equilibrium sequence	What workers learn, and when	Benefit legislation	Adjusting tax and start date t^*
Full retirement age: FRA 67 $\to$ 69 *in* AF(χ) *and* (20)			
Standalone	2026: the reform	current law	t^* = first shortfall year; τ_ℓ
With the wage-tax bailout	2026: the reform and the bailout	$\phi_t = 1$	$t^* = 2026$; τ_ℓ
Taxable maximum: $\bar{y} \to$ \$250,000 *in* (16) *and* (18)			
Standalone	2026: the reform	current law	t^* = first shortfall year; τ_ℓ
With the wage-tax bailout	2026: the reform and the bailout	$\phi_t = 1$	$t^* = 2026$; τ_ℓ
Progressive PIA: top rate 0.15 $\to$ 0.05 *in* (19)			
Standalone	2026: the reform	current law	t^* = first shortfall year; τ_ℓ
With the wage-tax bailout	2026: the reform and the bailout	$\phi_t = 1$	$t^* = 2026$; τ_ℓ

Table 4: Reforms of Social Security's rules. We run each reform under current law and again with the wage-tax bailout, and compare both with the baseline equilibrium sequence.
Note: the adjusting tax rate follows (33), and the other two stay at their 2025 values. Under current law ϕ_t follows (5) and F_t follows (2); under a bailout $\phi_t = 1$ in every year. Each reform applies to every cohort at once.

preannounced scenario the government commits in 2026 and defers the tax increase to Social Security's first shortfall year. Each scenario is a single transition path to the bailout terminal stationary equilibrium. Workers learn the plan in 2026 and from then on expect both $\phi_t = 1$ and the tax increase that pays for it. Under a bailout the fund still runs down. Its emptying no longer reduces any benefit; it dates the tax increase.

In the *unanticipated scenario* the rescue is an MIT shock. The government does nothing in 2026, workers expect no rescue, and the economy follows the reference sequence for that instrument. In the first shortfall year the government commits to the bailout and raises the financing tax at once. The benefit cut that workers had expected never occurs.

The transition is two connected paths. The first is the reference sequence's path up to t^*; it delivers the cross-sectional distribution $\{\mu_{j,t^*}\}_{j=0}^{J-1}$, the fund balance F_{t^*}, and the debt D_{t^*}. Along it workers hold the beliefs of the reference sequence for every year, and only its first t^* years are realized. The second path runs under the bailout legislation from t^* on, starting from those three. Table 5 lists the three scenarios.

Path	What workers learn, and when	Benefit legislation	Adjusting tax and start date t^*	Initial condition
Immediate scenario (the bailout sequences of Section 5)				
One path, $t \geq 0$	2026: the bailout	$\phi_t = 1$	$t^* = 2026$; τ_i	$(\{\mu_{j,0}\}_{j=0}^{J-1}, F_0, D_0)$
Preannounced scenario				
One path, $t \geq 0$	2026: the bailout, the tax increase deferred	$\phi_t = 1$	$t^* =$ first shortfall year; τ_i	$(\{\mu_{j,0}\}_{j=0}^{J-1}, F_0, D_0)$
Unanticipated scenario: two connected paths				
First path, $0 \leq t < t^*$	nothing; workers expect the reference sequence for instrument i in every year	current law, so $\phi_t = 1$ up to t^*	$t^* =$ the reference sequence's first shortfall year; τ_i	$(\{\mu_{j,0}\}_{j=0}^{J-1}, F_0, D_0)$
Second path, $t \geq t^*$	t^*: the bailout, an MIT shock	$\phi_t = 1$	t^*; τ_i from t^* on	$(\{\mu_{j,t^*}\}_{j=0}^{J-1}, F_{t^*}, D_{t^*})$ from the first path

Table 5: Policy timing, for each financing instrument $i \in \{\ell, k, c\}$. The immediate and preannounced scenarios share the announcement year and differ in the year taxes rise. The unanticipated scenario's first path ends at t^* and hands its terminal cross-section, fund balance, and debt to the second.
Note: the adjusting tax rate follows (33), and the other two stay at their 2025 values. Under current law ϕ_t follows (5) and F_t follows (2).

3 Calibration and Verification

We calibrate an initial stationary equilibrium at the 2025 economy. Demographics, the earnings process, fiscal parameters, and Social Security rules are model inputs. We calibrate three preference parameters inside the model.

External

Demography and survival follow the SSA projection. The earnings process follows Holter et al. (2025): a deterministic experience profile, permanent ability, and the annual AR(1) shock of (14), whose persistence is $\rho = 0.396$ and whose innovation standard deviation is $\sigma_z = 0.322$.[15] We calibrate it to their estimates for men. Utility is logarithmic, as in Holter et al. (2025) and Graves et al. (2026). Technology follows Conesa and Krueger (1999). The tax rates on labor, capital, and consumption follow Kitao (2014), and the debt ratio is federal debt held by the public relative to output. The Social Security tax rates, benefit formula, actuarial schedule, earnings test, taxable

[15] Blundell and French (2025), discussing Holter et al. (2025), question the estimated wage process. They note that the estimated persistence of idiosyncratic wage shocks is unusually low, far below the values near 0.95 that are common in this literature, and argue that the two-step procedure, which removes experience from log wages before estimating the shock process, can bias the persistence parameter downward because actual work experience is endogenous and therefore correlated with past shocks and with unobserved heterogeneity. Persistence matters here: less persistent shocks leave more room for time-averaging and weaken precautionary saving. A higher persistence would strengthen precautionary saving and deepen the capital response to depletion. We have not recomputed the transition at a higher persistence.

maximum, and initial trust-fund position take their legislated or recorded values. All units in our computation are normalized to the average wage index (AWI): mean earnings per worker equal one in the initial stationary equilibrium, and one model unit is $\bar{B}$ dollars.[16] The program's statutory amounts, the taxable maximum $\bar{y}$, the bend points b_1 and b_2, and the exempt amounts y_j^{ex}, are their 2025 values in this unit.

We set $\tau^{ss} = 0.106$, the combined OASI payroll tax rate. We set κ_b, the tax rate on benefits received in (3), to the Trustees' 2025 tax on benefits per dollar of benefit payments: the program's income rate was 0.1124 of taxable payroll and its payroll-tax receipts 0.1071, which exceed the statutory $\tau^{ss} = 0.106$ because the Trustees' receipts carry adjustments for earlier years,[17] so the tax on benefits contributed 0.0053 of taxable payroll; dividing by the 2025 cost rate of 0.1362[18] gives $\kappa_b = 0.03891$. Table 6 lists the externally set parameters and their sources.

[16]We use the AWI for 2025, $\bar{B} = \$72{,}025.07$, the Trustees' estimate.

[17]Appendix A.2 reconciles the two and reports the model's own 2025 income rate.

[18]This is OASI benefit payments divided by taxable payroll, the Trustees' cost rate net of administrative expenses and the Railroad Retirement financial interchange.

Parameter	Description	Value	Source
Preferences			
σ	CRRA (log utility)	1	Holter et al. (2025); Graves et al. (2026)
Preferences (bequest)			
ζ_2	Bequest luxury shifter	11.6	De Nardi (2004)
σ_b	Bequest curvature	1.5	De Nardi (2004)
Technology			
α	Capital share	0.36	Conesa–Krueger (1999)
δ	Depreciation rate	0.06	Conesa–Krueger (1999)
Z	Total factor productivity	1	Normalization
Demographics			
J	Lifespan (ages 20–100)	81	Model
$s_{j,t}$	Survival probabilities by age and year	projection	Trustees Report
pop.	Population by single year of age	projection	Trustees Report
Government & taxes			
τ_ℓ	Labor income tax	0.22	Kitao (2014)
τ_k	Capital income tax	0.3	Kitao (2014)
τ_c	Consumption tax	0.05	Kitao (2014)
D/Y	Debt–output ratio	1	FRED
Social Security			
τ^{ss}	OASI payroll tax rate	0.106	Social Security Act
income rate	OASI income / taxable payroll, 2025	0.1124	Trustees Report
κ_b	Benefit tax rate	0.03891	Trustees Report
$\bar{y}$	Taxable maximum / AWI	2.445	Social Security Act
b_1, b_2	PIA bend points / AWI	$0.2043/1.231$	Social Security Act
PIA rates	PIA marginal replacement rates	$0.9/0.32/0.15$	Social Security Act
AF(χ)	Actuarial factor at claim ages 62/67/70	$0.7/1/1.24$	Social Security Act
FRA	Full retirement age	67	Social Security Act
ϑ_j	Earnings-test withholding rate, below FRA	0.5	Social Security Act
ϑ_j	Earnings-test withholding rate, FRA year	0.3333	Social Security Act
y_j^{ex}	Earnings-test exempt amount / AWI, below FRA	0.3249	Social Security Act
y_j^{ex}	Earnings-test exempt amount / AWI, FRA year	0.863	Social Security Act
$\bar{B}$	AWI 2025, dollars per model unit	\$72,025.07	Trustees Report
r^F	Interest rate credited on the trust fund	0.02	Trustees Report
$F_0/(B^{sch}_{2025} - Wh_{2025})$	Initial reserves relative to benefit payments	1.626	Trustees Report
ψ	AIME accrual rate	0.055	Approximation
Earnings			
σ_a	Permanent-ability SD	0.315	Holter et al. (2025)
ρ	Productivity shock persistence	0.396	Holter et al. (2025)
σ_z	Productivity shock innovation SD	0.322	Holter et al. (2025)
N_e	Ability types	5	Holter et al. (2025)
$\gamma_{1,2,3}$	Experience cubic	$0.061/-0.00106/9.3\times10^{-6}$	Holter et al. (2025)
ξ_1, ξ_2	Old-age depreciation (rate, inflection)	$0.2/85$	Holter et al. (2025)
$\bar{\varepsilon}$	Earnings-profile scale	0.8233	Normalization

Table 6: Externally set parameters and sources.

Internal

We estimate the discount factor β, the work disutility η, and the bequest strength ζ_1 by simulated method of moments (Table 7). The targets are the median retirement age, the mean claim age, both for men, and the capital–output ratio.[19] The discount factor governs saving and the value of delayed benefits. The work disutility affects the retirement age. The bequest strength governs aggregate wealth.

[19]Let $\theta = (\beta, \eta, \zeta_1)$, let $m(\theta)$ be the three model moments computed from the simulated panel of the initial stationary equilibrium, and let $\hat{m}$ be their targets. Then $\hat{\theta} = \arg\min_\theta \left(m(\theta) - \hat{m}\right)' W \left(m(\theta) - \hat{m}\right)$ with $W = \mathrm{diag}\left(0.5^{-2}, 0.5^{-2}, 0.05^{-2}\right)$. We use the Nelder–Mead simplex algorithm for the parameter search. The system is just-identified, three parameters against three moments, and the criterion is zero at $\hat{\theta}$.

A. Internally calibrated parameters			
Symbol	Description	Value	
β	Discount factor	0.9739	
η	Disutility of work	1.233	
ζ_1	Bequest strength (De Nardi form)	-51.99	
B. Targeted moments (jointly matched)			
Moment	Target	Model	Source
Median retirement age	64.48	64.48	CPS ASEC 2019–2025
Mean claim age, 2024	65.02	65.02	SSA Statistical Supplement 2025
Capital–output ratio K/Y	3	3	Conesa–Krueger (1999)
C. Untargeted verification			
OASI cost rate, 2025	0.1362	0.1357	Trustees Report

Table 7: Internally calibrated parameters, targeted moments, and the untargeted OASI cost rate.

Verification

The OASI cost rate is benefit payments divided by taxable payroll. Our experiments depend on it, and we do not target it. Panel C of Table 7 reports 0.1357 in the model against 0.1362 in the Trustees' record for 2025. The model understates it by five hundredths of a percentage point.

Figure 4 plots the claim-age distribution against SSA data and employment by age against the CPS. Our experiments move both profiles. The calibration targets one summary statistic per profile, the mean claim age and the median retirement age. The model tracks the shape of the claim-age distribution and its spikes at the statutory ages, and it tracks the decline of employment after 62. Across the nine claim ages the mean absolute deviation between the model's cumulative shares and the data's is 0.049; across the 26 employment rates by age it is 0.074. Sections 4–7 report the *mean* retirement age, which is 62.7 in 2026 against the targeted median of 64.48; the early retirements in the left tail separate the two.

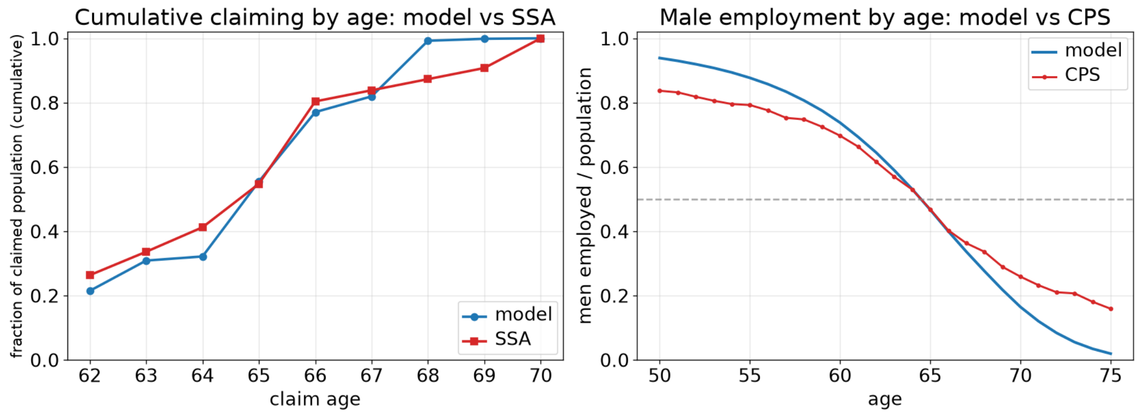


Figure 4: Claim-age distribution against SSA data and employment by age against CPS data in the initial stationary equilibrium.

4 Adjusting to Fund Depletion: No New Legislation

We first let current law operate without new legislation. Workers know the demographic and policy sequences, the depletion date, and the whole path of the payable factor ϕ_t. We call this the baseline equilibrium sequence. The wage tax sequence $\{\tau_{\ell,t}\}_t$ adjusts so that the government budget constraint (30) is satisfied.

Depletion removes the Social Security deficit from the consolidated budget constraint, so the wage tax falls once the reserves are gone. It falls a long way. The 2025 rate is $\tau_\ell^0 = 0.220$; the transitory rate is $\tau_\ell^{\text{trans}} = 0.185$ and the terminal rate is $\tau_\ell^\infty = 0.190$.[20] Current law therefore delivers a benefit cut to retirees together with an immediate general tax cut of about three and a half percentage points to workers, and a cut of three points in the long run. The combination is legislated, not chosen by us: the consolidated budget must reach the terminal debt ratio, so some instrument must adjust. Within each comparison we report below, the same instrument adjusts on both sides.

[20]Figure 19 in Appendix D reports the path.

4.1 Trust-fund depletion and the payable path

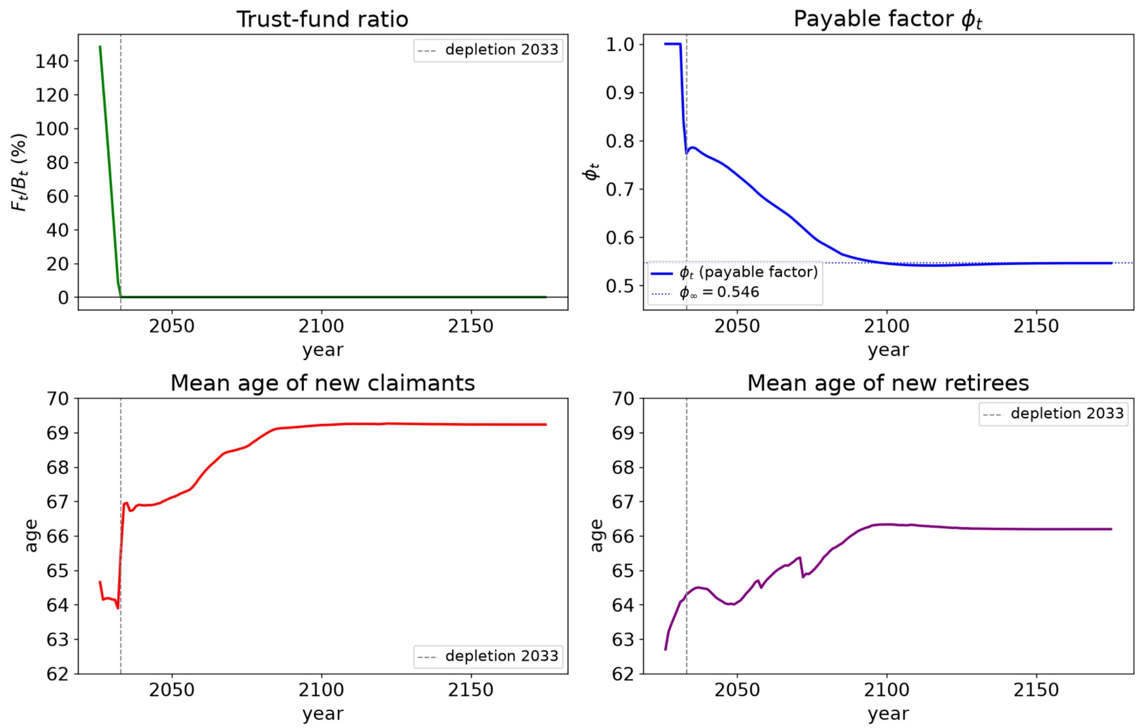


Figure 5: Trust-fund reserves relative to scheduled benefits, the payable factor ϕ_t, and the mean ages of new claimants and retirees in the baseline equilibrium sequence. The vertical line marks depletion.

As shown in Figure 5, the first shortfall year is 2032 and the fund is empty in 2033. The first cut therefore falls in 2032, the year the program pays out its last reserves: $\phi_{2032} = 0.842$. The payable factor then drops to 0.773 in 2033, when the reserves are gone, recovers to about 0.79, and declines over the following half century to $\phi_\infty = 0.546$. In the bottom panels, the mean claim age dips to 63.9 in the years before the cut and then rises to 69.2; the mean retirement age rises from the start of the transition, from 62.7 to 66.2.

At depletion our cut is close to the Trustees'. In 2033, the first year in which the fund is empty and the whole benefit is cut, they project that continuing income will cover 78 percent of scheduled benefits and we compute 77.3 percent.[21] By 2100 they project 62 percent, against our 54.6 percent

[21] Both figures are measured in the same year. The Trustees date reserve depletion to 2032, the year the reserves run out, which is our first shortfall year; the 78 percent applies from the year after. See Section 2.2.

in the terminal stationary equilibrium.[22] In the long run our general-equilibrium transition diverges from their projection, which holds behavior fixed, because workers respond to depletion and to the declining payable factor.

The two intertemporal responses of workers, later claiming and later retirement, operate through the benefit formula. By (4), the benefit paid to a worker in year t is

$$b^{pay}_{i,j,t} = \phi_t \,\mathrm{AF}(\chi^b)\,\mathrm{PIA}(\mathrm{AIME}_{i,j,t}), \tag{34}$$

where the payable factor ϕ_t is common to every benefit paid in year t, and the actuarial factor $\mathrm{AF}(\chi^b)$ of Table 1 is the worker's own, fixed at filing. Depletion scales ϕ_t downward for every claimant; a worker chooses $\mathrm{AF}(\chi^b)$ through the claim age.

The level of the payable factor does not by itself move the claim age. In (34) ϕ_t multiplies every claim age alike, so a permanent proportional cut leaves the gross return to delay unchanged. Two forces move it. The projected survival probabilities improve while the actuarial schedule of Table 1 stays at its statutory values, so a later claim buys the higher benefit for more years; Section 5 finds the same force under the bailouts, where no benefit is cut. The loss of pension wealth extends careers, and the earnings test of (20) withholds the benefits of a worker who has claimed and works on, so longer careers carry claiming with them. The path of ϕ_t works against both forces. It declines after depletion, so a worker who delays collects under the lower factors of later years, and the gross return to delay is smaller than the actuarial schedule alone implies. The claim age rises to 69.2 against that headwind. The same path works against delay most sharply in the years before the cut, when filing early still buys benefits paid in full, and Section 4.2 takes up that response. Later claiming changes the scheduled benefits per claimant; later retirement changes the number of covered workers and the taxable payroll.

[22] The two long-run figures are not measured at the same horizon: the Trustees report a calendar year and we report a stationary equilibrium.

4.2 An early-claiming rush

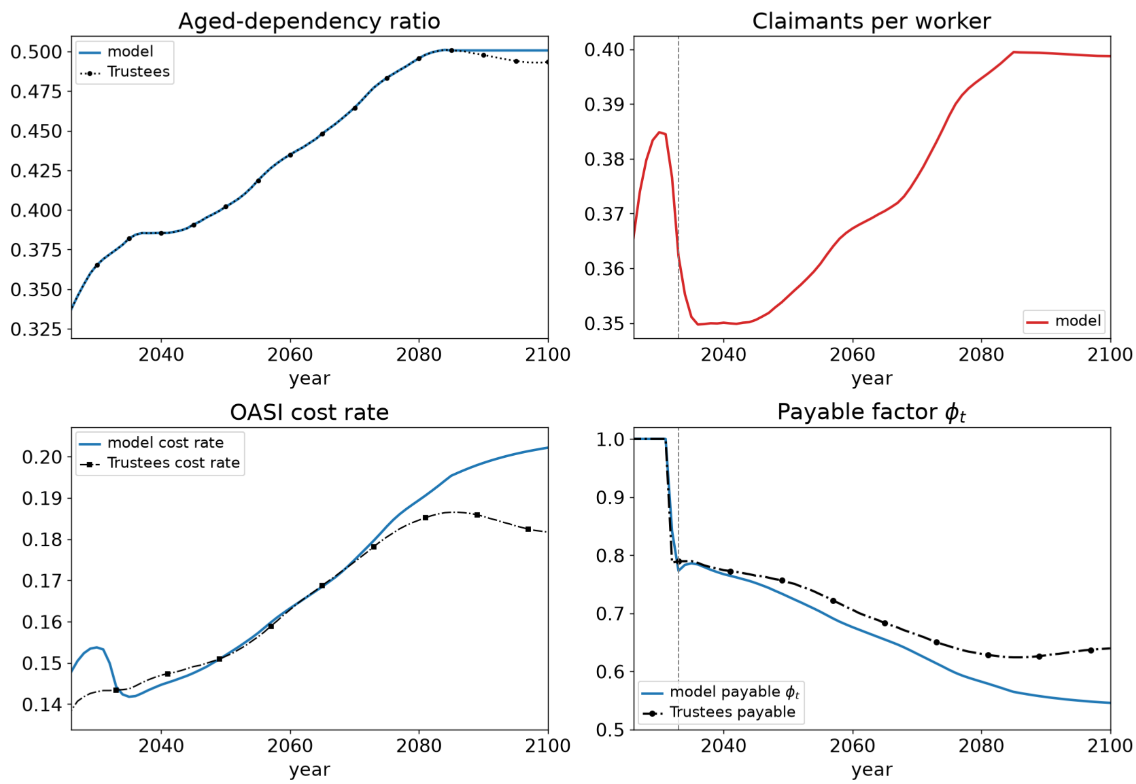


Figure 6: The aged-dependency ratio, claimants per worker, the OASI cost rate, and the payable factor ϕ_t in the baseline equilibrium sequence. Dash-dotted lines report the Trustees' projection.

Filing rates for benefits surge before the cut, then drop afterward, as shown in the claimants-per-worker panel of Figure 6. The workers who rush are those already inside the statutory claim window in the six years before the cut, the cohorts aged 62 to 69 from 2026 through 2031; a worker already 70 has no choice left, because filing is compulsory at that age. They trade a permanently lower actuarial factor for a few years of benefits paid in full. A worker who files while $\phi_t = 1$ adds full-benefit payments during the remaining window that a delayer would forgo. Filing fixes the actuarial factor $\text{AF}(\chi^b)$ in (34), not the future payable factor ϕ_t; every later payment is still scaled by the payable factor ϕ_t of its year of receipt. The incentive disappears when no future payment is made in full.

The rush raises claimants per worker and bumps the cost rate just before depletion, as the cost-rate panel shows. Afterward, delayed filing holds the claimant count down until population aging dominates. The Trustees' projection does not take into account an endogenous filing response and thus has no pre-depletion bump.

4.3 Saving and macroeconomic adjustment

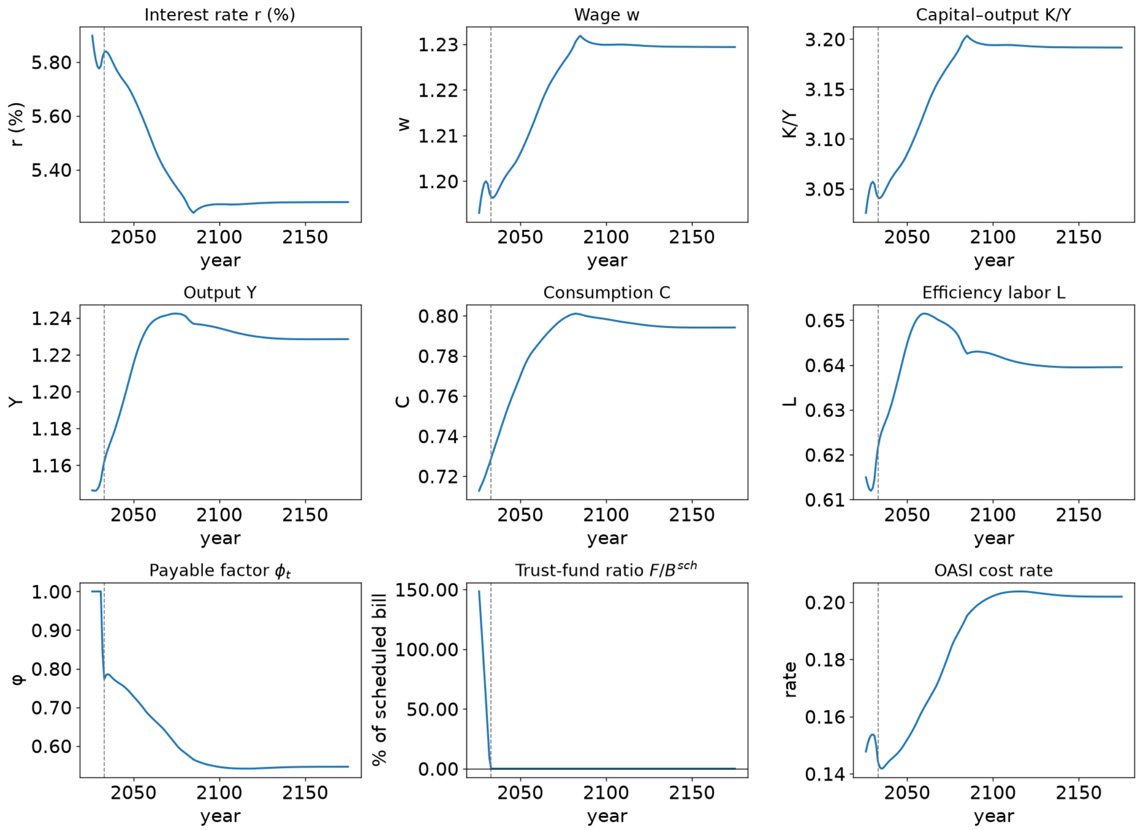


Figure 7: Prices, macroeconomic aggregates, and Social Security accounts in the baseline equilibrium sequence.

The transition has more labor, more saving, and a higher wage, as shown in Figure 7. Later retirement raises efficiency labor. Every working cohort saves against a smaller pension, so capital deepens.[23] The capital–output ratio rises from 3.00 to 3.19. The marginal product of capital falls and the real wage rises: the interest rate falls from 6.0 to 5.3 percent and the wage rises by about three percent.

[23]Figure 15 in Appendix C shows the same adjustment as a life-cycle consumption profile.

4.4 Taxable payroll and scheduled benefits

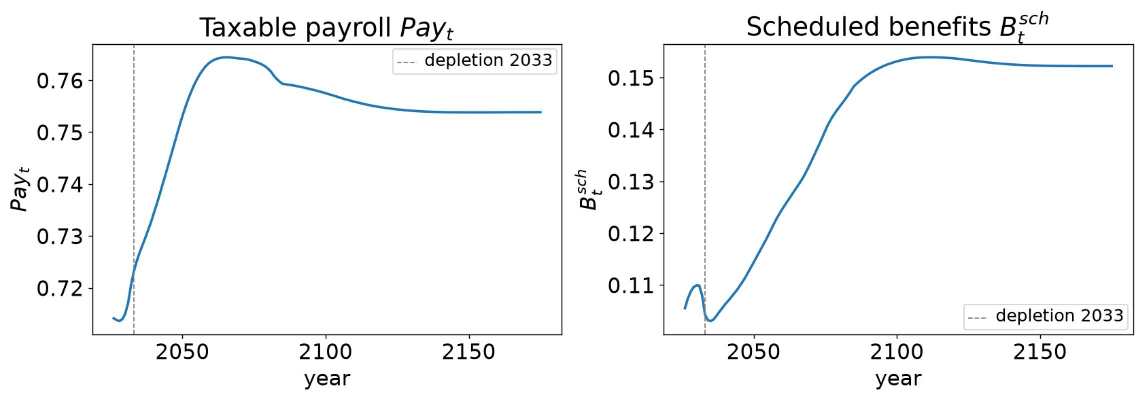


Figure 8: Taxable payroll and scheduled benefits in the baseline equilibrium sequence. The vertical line marks depletion.

Later retirement and later claiming move the two terms of (8). Later retirement adds taxable earnings in the year it occurs and raises the scheduled bill decades later. Later claiming lowers the scheduled bill in the year it occurs and raises it when the delayed filers begin to collect. Figure 8 plots the two terms: taxable payroll Pay_t, the numerator of (8), and the scheduled benefit bill B_t^{sch}, the main term of its denominator. After depletion, (8) makes ϕ_t proportional to Pay_t/B_t^{sch}, the inverse of the cost rate of Figure 6.[24]

Taxable payroll begins rising before the cut, peaks about three decades after it, and settles above its initial level. The gain has no lag: a worker who postpones retirement adds that year's taxable earnings to the payroll base, and the higher wage raises the taxable earnings of every worker below the taxable maximum in the year it is paid. Most of the gain is in place within two decades of depletion; payroll then recedes as population aging thins the workforce.

Scheduled benefits rise with the rush to claim, fall as workers delay filing, and then rise for the rest of the century, mostly after mid-century. Later claiming lowers the bill immediately by reducing the number of claimants. It raises the bill with a lag, when the delayed filers start to collect benefits carrying higher actuarial factors. The rise of the scheduled benefit bill during the transition is therefore gradual: the reduction in the number of claimants is immediate, and the increase in the scheduled benefit per claimant is delayed. The higher wage also raises scheduled benefits with a delay: the benefits paid in year t are determined by earnings histories, which carry the lower wages of earlier years.

[24]The earnings-test withholding in the denominator of (8) is negligible after depletion.

The timing asymmetry stabilizes the payable factor for a few years. In the years after depletion, taxable payroll rises at once while the scheduled benefit bill falls and then rises only with a delay, so the payable factor recovers slightly, as Figure 5 shows. The stabilization is transitory: it fades as the delayed increases in scheduled benefits arrive.

Those delayed increases also set our long run apart from the Trustees' projection. Our cost rate stays close to theirs from depletion until about 2075; then the higher bills of later claims and longer careers arrive, and it rises above theirs, to 0.202 against 0.182 in 2100. Most of the long-run gap in the payable factor comes from there.

5 Financing Full Scheduled Benefits

Without new legislation, the payable factor cuts every benefit to what the program's own cash flow can pay, and workers adjust their claiming, retirement, and saving to the cut. Under a bailout, new legislation instead keeps every scheduled benefit whole, $\phi_t = 1$. The Social Security deficit that the payable factor would have closed stays in the government budget constraint (30), and the government finances it with taxation and debt. The choice of tax governs three things. It sets how much revenue the government must collect. It sets how workers' retirement, claiming, and saving respond. It sets which cohorts bear the cost. We compare three instruments: the wage tax, the capital tax, and the consumption tax.

5.1 Bailout experiments

In each scenario the government announces and commits to a guaranteed bailout today and takes action immediately: from 2026 on it pays every scheduled benefit in full and raises one of the three tax rates, the wage tax τ_ℓ, the capital tax τ_k, or the consumption tax τ_c, to finance the Social Security deficits, holding the other two at their 2025 rates. The financing tax rate follows (33) with $t^* = 2026$: a transitory rate from 2026 through 2075 and the terminal rate from 2076 on. Workers learn today that scheduled benefits will be paid in full and which tax finances them, and they adjust their optimal choices of retirement, claiming, and saving, $(g^n_{j,t}, g^\chi_{j,t}, g^{a'}_{j,t})$, to the instrument. We call the three resulting equilibrium transition paths the wage-tax bailout sequence, the capital-tax bailout sequence, and the consumption-tax bailout sequence.

We compare each bailout sequence with the reference sequence for its own instrument, defined in Section 2.6.2: no new legislation, the payable factor ϕ_t of (5), and the same tax closing (30) from the program's first shortfall year. Under the wage tax the reference sequence is the baseline equilibrium sequence of Section 4. All three reference sequences have their first shortfall year in 2032 and an empty fund in 2033. Within a pair the two sequences adjust the same tax, so they differ only in the guarantee of full scheduled benefits and in the taxation that pays for it. The consumption-equivalent variation of Section 5.3 prices that guarantee and its financing, not a change of instrument.

5.2 Fiscal requirements and macroeconomic distortions

	bailout			reference sequence					
Financing instrument	τ^{trans}	τ^{∞}	Δ vs. τ^0	τ^{trans}	τ^{∞}	K/Y	r	C/Y	L
Wage tax τ_ℓ	0.2294	0.2919	+0.0719	0.1854	0.1902	3.117	0.0555	0.653	0.560
Capital tax τ_k	0.3264	0.4800	+0.1800	0.1969	0.2059	2.767	0.0701	0.674	0.612
Consumption tax τ_c	0.0581	0.1134	+0.0634	0.0162	0.0207	3.181	0.0532	0.650	0.594
Baseline: no bailout, τ_ℓ	—	—	—	0.1854	0.1902	3.192	0.0528	0.646	0.640

Each reference sequence closes the same budget with the same instrument on its own path;
the bailout rate's gap from the reference rate is the cost of restoring scheduled benefits under that financing.
The last row reports terminal aggregates of the baseline equilibrium sequence of Section 4.

Table 8: Financing tax rates in the three bailout sequences and in their reference sequences, and terminal aggregates. The last row is the baseline equilibrium sequence of Section 4.

Table 8 reports, for each bailout sequence, the transitory rate τ^{trans} and the terminal rate τ^{∞} of the financing tax and the increase of the terminal rate over the 2025 rate τ^0; the transitory and terminal rates of the same instrument in the reference sequence; and the bailout sequence's terminal capital–output ratio, interest rate, consumption–output ratio, and efficiency labor. The last row reports the same terminal aggregates for the baseline equilibrium sequence.[25] In every reference sequence the rate falls below its 2025 level from the program's first shortfall year on, because the payable factor removes the Social Security deficit from the government budget constraint. A bailout keeps the deficit in the constraint, and the gap between the bailout rate and the reference rate is the cost of paying scheduled benefits in full under that instrument.

The three taxes enter the worker's budget constraint (16) at different places. The wage tax lowers the after-tax wage $(1-\tau_{\ell,t})y$, the reward to another year of work; efficiency labor is lowest

[25]Figure 20 in Appendix D reports the transition paths behind these terminal values; Figure 22 reports each instrument's rate along its reference sequence.

under the wage tax. The capital tax lowers the after-tax return $r_t(1-\tau_{k,t})$, the reward to saving, and reduces the capital accumulated in the economy; the capital–output ratio is lowest and the interest rate highest under the capital tax. The consumption tax raises the price of consumption $(1+\tau_{c,t})$ at every age, in working life and in retirement alike. It does not tilt the choice between working on and retiring the way the wage tax does, and it leaves the after-tax return to saving unchanged. The consumption-tax bailout sequence's capital–output ratio and interest rate stay close to the baseline equilibrium sequence's, 3.181 against 3.192 and 5.32 against 5.28 percent. Under the wage tax the capital–output ratio is 3.117 and the interest rate 5.55 percent, between the consumption tax's and the capital tax's; the ratio is below the baseline equilibrium sequence's and the rate above it. The higher wage tax lowers after-tax labor income, and shorter careers shrink lifetime earnings; workers save less, and capital deepens less than in the baseline equilibrium sequence.

Output and consumption follow from the ratios that Table 8 reports. Terminal output is lowest under the wage tax, 1.06 against the capital tax's 1.08, the consumption tax's 1.14, and the baseline equilibrium sequence's 1.23; terminal consumption orders the same way.[26] The capital tax contracts capital most and output least of the two income taxes. The welfare ordering of Section 5.3 is the ordering of terminal output and of terminal consumption. It is not the ordering of the capital–output ratio.

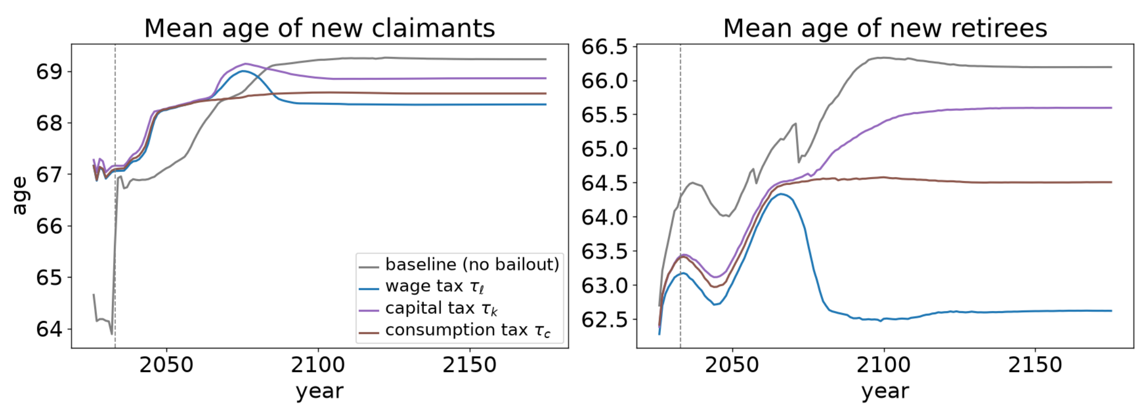


Figure 9: Mean ages of new claimants and of new retirees in the three bailout sequences and in the baseline equilibrium sequence. The vertical line marks depletion in the baseline equilibrium sequence.

Figure 9 plots the mean age of new claimants and the mean age of new retirees in the three

[26] Equation (25) gives $Y = Z^{1/(1-\alpha)}(K/Y)^{\alpha/(1-\alpha)}L$, so the capital–output ratio and efficiency labor of Table 8 determine Y, and C/Y then determines C. Terminal consumption is 0.693 under the wage tax, 0.731 under the capital tax, 0.740 under the consumption tax, and 0.794 in the baseline equilibrium sequence.

bailout sequences and in the baseline equilibrium sequence. The three bailout sequences barely differ in the age at which workers claim benefits. None has an early-claiming rush: with every scheduled benefit paid in full, the mean claim age does not dip before 2033. It still rises over the transition under every instrument, because the projected survival probabilities improve while the actuarial factor of Table 1 stays fixed, so a later claim buys the higher benefit for more years. The higher taxation that pays for the guarantee moves claiming only once the terminal rates take effect in 2076, and it moves it in opposite directions. The capital tax lowers the after-tax return to saving, against which the actuarial increment competes, and claiming is latest under it. The wage tax pulls retirement forward and claiming with it, and claiming is earliest under it. All three end below the baseline equilibrium sequence's, in which the benefit cut adds a reason to delay.

The three bailout sequences differ substantially in the age at which workers retire, the response that had enlarged taxable payroll under depletion. Under the wage tax, careers do not lengthen: the mean retirement age rises until the late 2060s, falls back as workers approaching retirement face the higher terminal rate that takes effect in 2076, and ends close to where it began in 2026. Under the capital tax the mean retirement age rises nearly as much as in the baseline equilibrium sequence; under the consumption tax it rises by a little more than half as much. Under the wage tax the retirement response aggravates the financing pressure. Shorter careers shrink taxable payroll, which widens the Social Security deficit the tax must cover. They also shrink the earnings on which the tax itself is levied, which pushes the wage tax rate higher.

5.3 Welfare across entering cohorts

For a cohort entering in year t_0, lifetime welfare is

$$W_{t_0} = U_{c,t_0} + U_{n,t_0} + U_{beq,t_0}, \tag{35}$$

$$U_{c,t_0} = \sum_j \beta^j \omega_{j,t_0} \mathbb{E}u(c_j), \tag{36}$$

$$U_{n,t_0} = -\eta \sum_j \beta^j \omega_{j,t_0} \mathbb{E}n_j, \tag{37}$$

$$U_{beq,t_0} = \sum_j \beta^{j+1} \omega_{j,t_0} \mathbb{E}\left[(1-s_{j,t_0+j}) v^B(a'_j)\right], \tag{38}$$

where ω_{j,t_0} is the probability that the entrant survives to age j. The expectation integrates over permanent ability and the idiosyncratic earnings shocks. The consumption-equivalent variation λ_{t_0} is the proportional change in consumption, at every age and in every state, that the cohort entering in year t_0 in the reference sequence would need in order to be as well off as the same cohort in the bailout sequence. Under log utility it solves

$$W_{t_0}^{ref} + \Omega_{t_0} \log(1+\lambda_{t_0}) = W_{t_0}^{bail}, \qquad \Omega_{t_0} = \sum_j \beta^j \omega_{j,t_0}, \tag{39}$$

or $\lambda_{t_0} = \exp[(W_{t_0}^{bail} - W_{t_0}^{ref})/\Omega_{t_0}] - 1$.[27] The compensation applies to consumption at every age and in every state. It leaves the bequest term U_{beq,t_0} unchanged, because v^B is not logarithmic. A negative λ_{t_0} means that the bailout lowers the cohort's welfare by as much as a proportional cut of $|\lambda_{t_0}|$ in its lifetime consumption in the reference sequence would.

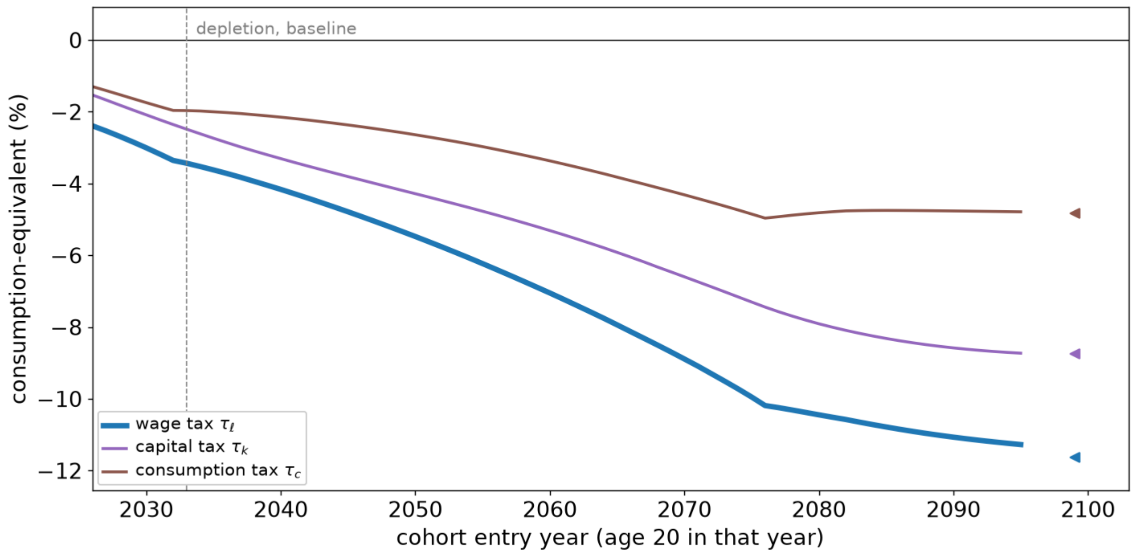


Figure 10: Consumption-equivalent variation by entering cohort in the three bailout sequences, each relative to its reference sequence; the markers at the right edge are terminal-steady-state newborns.

Figure 10 plots λ_{t_0} for the cohorts entering from 2026 to 2095 in each bailout sequence, relative to that instrument's reference sequence; the markers at the right edge are terminal-steady-state newborns, cohorts that live entirely in the terminal stationary equilibria of the two sequences. Cohorts that enter in different years live through different stages of the transition. An early entrant works for decades under the transitory rate and, in the reference sequence, spends its first years before depletion, with full benefits and the 2025 tax rate. A later entrant spends more of its life under the terminal rate and under a higher aged-dependency ratio. The two kinks mark the cohorts

[27]The components U_{c,t_0}, U_{n,t_0}, and U_{beq,t_0} are summed over ability types under their population weights before (39) is solved, so λ_{t_0} is the population-weighted compensation of the entering cohort rather than an equal-weight mean across types.

entering in the years in which the tax rates shift, as defined in (33): the reference sequence's rate falls at the program's first shortfall year, and the bailout's rate steps from its transitory to its terminal value in 2076.

Every cohort's value is negative, under every instrument and at every entry date. An entering cohort pays the financing tax through its working life to restore the benefits of the retirees of those years, whose number relative to workers is rising, and receives its own restored benefit only decades later. At the projected aged-dependency ratio, the taxes a cohort pays to keep scheduled benefits whole are worth more to it than the restored benefits it later receives. The losses grow with the entry date, because later entrants spend more of their lives under the terminal rate and the higher aged-dependency ratio; a terminal-steady-state newborn loses several times what the cohort entering in 2026 loses.

The ordering of the instruments is the same at every entry date: the consumption tax costs an entering cohort the least, the capital tax more, and the wage tax the most. For a terminal-steady-state newborn the three cost 4.8, 8.7, and 11.6 percent of lifetime consumption. The wage tax carries the most negative consumption-equivalent variation because it distorts retirement, the response through which the economy had relieved the payability pressure under depletion, and shrinks its own base. In addition, the wage tax reaches the cohort's earnings from its first year of work. The capital tax reaches income from assets and, by reducing the capital stock, lowers the wage rate. The higher wage that capital deepening brings in the reference sequence enlarges taxable payroll and eases the payability pressure; under the capital tax that support is lost, and taxable payroll falls through the wage rather than through shorter careers. The consumption tax is the least distortionary of the three for the responses through which the economy balances the deficit: taxable payroll falls least under it, and it reaches spending at every age, including the retirement years in which the restored benefits are spent. Taxable payroll is the wage times efficiency labor, and the two need not move together: efficiency labor in Table 8 is higher under the capital tax than under the consumption tax, but the capital tax also lowers the wage, so their product falls further.

Each λ_{t_0} compares a bailout with the reference sequence that adjusts the same tax, so the three numbers do not share a benchmark, and the ordering across instruments mixes the cost of the guarantee with differences among the three reference sequences. Appendix D reports the three bailouts against a single benchmark, the baseline equilibrium sequence of Section 4, and the ordering is unchanged.

6 Program Reforms and the Residual Bailout

Beyond the fiscal instruments, the government can reform the program itself. Changes to its rules can narrow the cash-flow gap and raise the payable factor ϕ_t. We study three reforms of the program's statutory rules, each on its own and each combined with the wage-tax bailout. We ask three questions of each. How many years does the reform delay depletion, and how much does it raise the long-run payable factor, when the government does nothing else? How much wage tax does it save when scheduled benefits are also guaranteed? Which entering cohorts gain and which lose?

6.1 Reform design

The government announces and commits to each reform today, and the new rule applies to every cohort at once and stays in force.

- Full retirement age: the government raises the full retirement age from 67 to 69 for every worker, current beneficiaries included. The actuarial factor AF(χ) falls by about 13 percent at every claim age, to the values in Table 9. The claim window stays at ages 62 to 70, and the earnings test of (20) applies below age 69.
- Taxable maximum: the government raises the taxable maximum $\bar{y}$ from its 2025 statutory value to \$250,000. The payroll tax base in (16) widens, and the capped earnings that accrue into AIME by (18) rise with it.
- Progressive PIA: the government lowers the top marginal replacement rate in (19) from 15 to 5 percent. This reduces the scheduled benefits only of workers whose AIME exceeds the upper bend point b_2.

claim age χ	62	63	64	65	66	67	68	**69**	70
AF(χ)	.60	.65	.70	.75	.80	.8667	.9333	**1.00**	1.08

Table 9: The actuarial factor AF(χ) by effective claim age at the reformed full retirement age of 69.

Workers learn the new rules today and adjust their optimal choices of retirement, claiming, and saving, $(g^n_{j,t}, g^\chi_{j,t}, g^{a'}_{j,t})$. These responses change taxable payroll Pay_t and the scheduled benefit bill B^{sch}_t, and with them the trust fund F_t of (2). We carry out each reform in two cases.

- Standalone: the government changes the rule and does nothing else. The fund is depleted at the reform's own date; from then on the payable factor ϕ_t follows (5), and the wage tax $\tau_{\ell,t}$ follows (33) with t^* at the reform's own first shortfall year, as in the baseline equilibrium sequence of Section 4. We measure how many years the reform delays depletion and how much it raises the long-run payable factor ϕ_∞.
- With the wage-tax bailout: the government also announces and commits to a guaranteed bailout financed by the wage tax, the wage-tax bailout sequence of Section 5. We measure the residual wage tax that the reform still requires to pay scheduled benefits in full.

We compare both cases with the baseline equilibrium sequence of Section 4.

6.2 Standalone solvency and residual financing

	standalone		with wage-tax bailout		
Reform	depletion year	ϕ_∞	τ_ℓ^∞	K/Y	r
No reform	2033	0.5462	0.2919	3.117	0.0555
Full retirement age 67→69	2043	0.6210	0.2622	3.140	0.0547
Taxable max →\$250k	2033	0.5511	0.2927	3.119	0.0554
Progressive PIA (15%→5%)	2033	0.5634	0.2869	3.127	0.0551

Table 10: Depletion year and long-run payable factor ϕ_∞ of each standalone reform, and the residual wage tax and terminal aggregates with the wage-tax bailout; the first row is no reform.

Table 10 reports, for each reform, the depletion year and the long-run payable factor ϕ_∞ when the reform stands alone, and the terminal wage tax τ_ℓ^∞, capital–output ratio, and interest rate when the reform is combined with the wage-tax bailout. The first row is the case of no reform: the baseline equilibrium sequence of Section 4 in the standalone columns and the wage-tax bailout sequence of Section 5 in the others.[28]

As the table shows, raising the full retirement age does the solvency work. On its own it is the only reform that moves the depletion year, by ten years, from 2033 to 2043, and it raises the long-run payable factor from 0.546 to 0.621. Combined with the wage-tax bailout it lowers the residual wage tax by about three percentage points, from 0.292 to 0.262, in the long run and during

[28]Figure 21 in Appendix D reports the transition paths of the three reforms combined with the wage-tax bailout.

the transition alike. The other two reforms leave the depletion year unchanged. They raise the long-run payable factor only slightly, to 0.551 and 0.563, and they move the residual wage tax by half a percentage point or less.

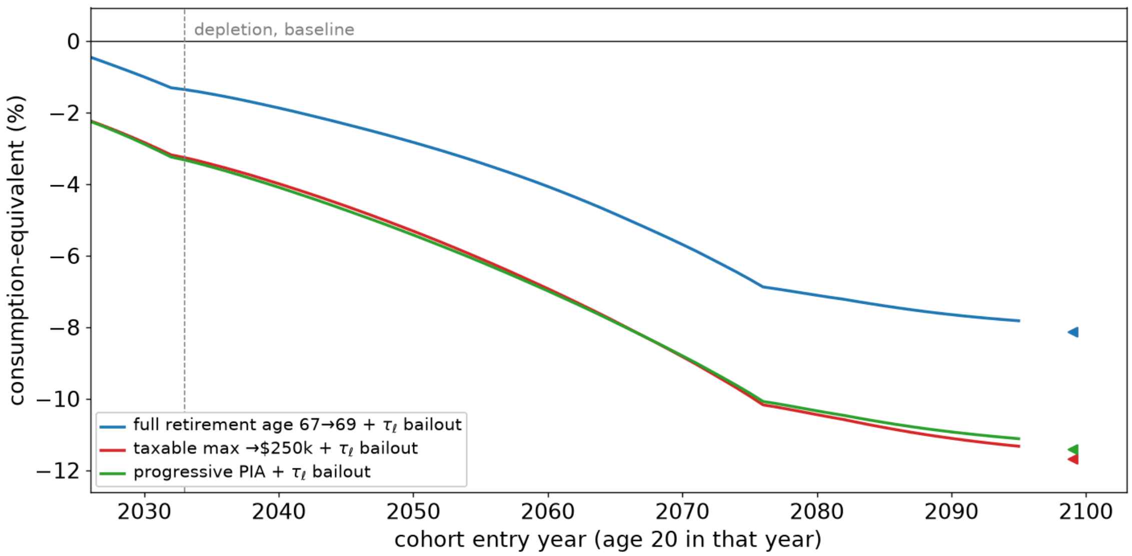
The retirement-age reform works by cutting the scheduled benefit: the actuarial factor is lower at every claim age, for current beneficiaries as well as future ones, so the scheduled benefit bill B_t^{sch} falls at once. A worker can recover part of the cut by claiming later, which raises the actuarial factor, but the claim window still closes at age 70, so the recovery is capped. The scheduled bill therefore stays lower, and the payable factor ϕ_t that clears the program's cash flow against it is higher even in the long run.

The taxable-maximum and progressive-PIA reforms redistribute the adjustment more than they shrink the gap. The higher taxable maximum raises taxable payroll, but the additional capped earnings accrue into AIME and raise the scheduled bill once they have entered benefits. The depletion year does not move, the long-run payable factor barely rises, and the residual wage tax is essentially unchanged: slightly lower during the fifty-year window, when the additional contributions arrive before the additional benefits, and slightly higher in the long run. The lower top replacement rate reduces the scheduled benefits only of the workers whose AIME exceeds the upper bend point, a small part of the scheduled bill. The depletion year does not move. The long-run payable factor rises to 0.563, three and a half times as far as under the higher taxable maximum but less than a quarter of the way to the retirement-age reform's 0.621, and the residual wage tax falls only to 0.287.

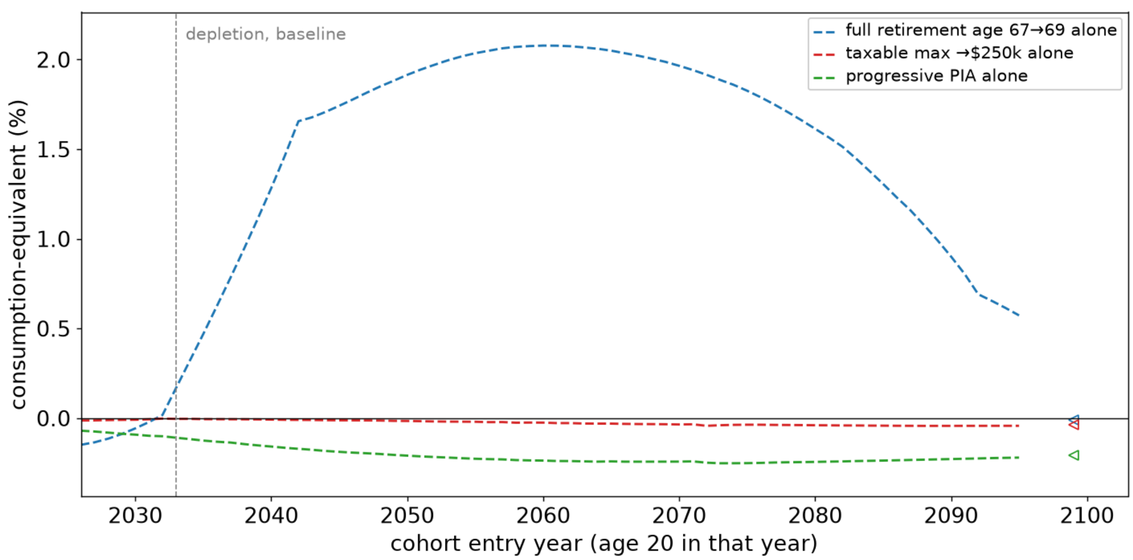
6.3 Welfare consequences

Figure 11 plots the consumption-equivalent variation, computed as in Section 5.3, of the cohorts entering from 2026 to 2095 relative to the baseline equilibrium sequence of Section 4; the markers at the right edge are terminal-steady-state newborns. Panel (a) combines each reform with the wage-tax bailout; panel (b) lets each reform stand alone. The two panels separate the reform itself from the taxation needed to guarantee scheduled benefits, and their vertical scales differ by an order of magnitude.

In panel (a) every entering cohort's value is negative under all three reforms, and the losses deepen with the entry date, as they do in the wage-tax bailout sequence without reform in Figure 10. The financing dominates the comparison: the wage tax required to pay full benefits costs an entering cohort more than any of these reforms returns to it. The taxable-maximum and progressive-PIA reforms leave the value essentially where the wage-tax bailout without reform leaves it, at every



(a)



(b)

Figure 11: Consumption-equivalent variation by entering cohort relative to the baseline equilibrium sequence: (a) each reform combined with the wage-tax bailout; (b) each reform alone. The markers at the right edge are terminal-steady-state newborns.

entry date. The retirement-age reform raises it at every entry date, and by more for later entrants: the smaller scheduled benefit costs an entering cohort less than the wage tax it saves.

In panel (b) the taxable-maximum and progressive-PIA reforms leave the value near zero at every entry date. The retirement-age reform delivers a positive value for the cohorts entering from the 2030s on: the higher payable factor offsets most of the cut in the actuarial factor for them, and the wage tax they pay during the reform's fifty-year window is lower than in the baseline equilibrium sequence, because the smaller scheduled bill reduces the Social Security deficit that the budget covers. In the long run the higher payable factor and the lower actuarial factor almost offset each other for an entering cohort, and the value fades to zero.

7 The Timing of the Bailout

The final experiment studies guaranteed bailout scenarios that differ in two timings: when the government announces and commits to the bailout, and when tax financing starts. We carry out the experiments under each of the three alternative tax financing instruments.

7.1 Three timing scenarios

The date at which the government commits affects the choices of the cohorts living today, in particular near-retirees, who are at the stage of making retirement and filing decisions that cannot be reversed. We compute three scenarios for each financing instrument. In every scenario the government commits to a guaranteed bailout: every claimant receives the full scheduled benefit, and the financing tax follows (33). The scenarios differ in when the government announces and commits and in when tax financing starts.

- Immediate: the government announces and commits to a guaranteed bailout today and takes action immediately: it raises the financing tax rate to cover the Social Security deficits. These are the bailout sequences of Section 5.
- Preannounced: the government announces and commits to a guaranteed bailout today but defers raising taxation until the program's first shortfall year. Workers update their beliefs: scheduled benefits will be paid in full, at the cost of higher general taxation in the future. They adjust their optimal choices of retirement, claiming, and saving, $(g^{n}_{j,t}, g^{\chi}_{j,t}, g^{a'}_{j,t})$. These responses change taxable payroll Pay_t and the scheduled benefit bill B^{sch}_t, and with them the trust fund F_t of (2). The fund still runs down under the guarantee. Its emptying no longer

reduces any benefit; it dates the tax increase. The depletion date t_{pre}^{dep} is determined in the perfect-foresight equilibrium, and the tax adjustment of (33) starts in this scenario's own year of first shortfall. Table 11 reports t_{pre}^{dep}.

- Unanticipated: the government announces nothing and does nothing today. The economy evolves as if everyone believes that the payable factor ϕ_t will decline after depletion, as in that instrument's reference sequence. In that sequence's first shortfall year t^* the government unexpectedly announces and commits to a last-minute rescue: it raises taxation immediately to finance the Social Security deficits and pays the scheduled benefits in full. The financing tax follows (33) from t^*. The bailout is an MIT shock to workers. The full transition of the economy consists of two connected paths. The first runs from today to t^* under the belief that no new legislation will come. It provides the initial condition, the cross-sectional distribution, the fund balance, and the public debt at t^*, $\left(\{\mu_{j,t^*}\}_{j=0}^{J-1}, F_{t^*}, D_{t^*}\right)$, to the second path along which the economy evolves under the bailout legislation.

The immediate and preannounced scenarios share the date of information disclosure and differ in when tax financing starts. The unanticipated scenario differs in the date of information disclosure: until t^* workers expect no rescue, so the assets, career lengths, and filing choices in place at t^* are those they would not have made had they known.

	transitory rate τ^{trans}			preannounced		
Financing instrument	immediate	unanticipated	preannounced	depletion t_{pre}^{dep}	delay (yrs)	τ^{∞}
Wage tax τ_{ℓ}	0.2294	0.2339	0.2370	2035	+2	0.2919
Capital tax τ_k	0.3264	0.3375	0.3478	2035	+2	0.4800
Consumption tax τ_c	0.0581	0.0618	0.0648	2035	+2	0.1134
Tax start year t^*	2026	2032	2034			

Table 11: Transitory and terminal financing tax rates under the three timing scenarios, the year t^* in which each starts to raise taxation, the preannounced scenario's depletion date t_{pre}^{dep}, and its delay relative to the reference sequence.

As Table 11 shows, the reserves of the preannounced scenario outlast those of the reference sequence of each financing instrument in Section 5.1, by two years under all three instruments. The guarantee removes the early-claiming rush, so the cost rate has no pre-cut bump. The immediate scenario starts to raise taxation in 2026, the unanticipated in 2032, and the preannounced in 2034.

The preannounced scenario therefore taxes two years later than the unanticipated one although it commits six years earlier, because the guarantee is what stretches depletion to 2035 and the first shortfall year with it, to 2034. The later tax financing starts, the higher the transitory rate required to meet the same terminal debt target.

7.2 Welfare incidence by age and instrument

For a worker of age $\bar{j}$ in 2026, we measure welfare over its remaining lifetime along each transition path,

$$W_{\bar{j}} = \sum_{j \geq \bar{j}} \beta^j \omega_{j|\bar{j}} \mathbb{E}\big[u(c_j) - \eta\, n_j + \beta\big(1 - s_{j,\, j-\bar{j}}\big) v^B(a'_j)\big], \tag{40}$$

where $\omega_{j|\bar{j}}$ is the probability of surviving from age $\bar{j}$ to age j along the cohort's calendar path, the model date at which this worker reaches age j is $t = j - \bar{j}$, and the expectation integrates over the cross-sectional distribution $\mu_{\bar{j},0}$ of age-$\bar{j}$ workers across the state (12). In the unanticipated scenario, the utilities before t^* come from the first of its two connected paths, and the utilities from t^* on come from the second, after the workers reoptimize at the state they carry into t^*. The consumption-equivalent variation $\lambda_{\bar{j}}$ solves $W_{\bar{j}}^{ref} + \Omega_{\bar{j}} \log(1+\lambda_{\bar{j}}) = W_{\bar{j}}^{bail}$ with $\Omega_{\bar{j}} = \sum_{j \geq \bar{j}} \beta^j \omega_{j|\bar{j}}$, as in (39), where $W_{\bar{j}}^{ref}$ is the welfare of the same workers in the financing instrument's reference sequence of Section 5.1.

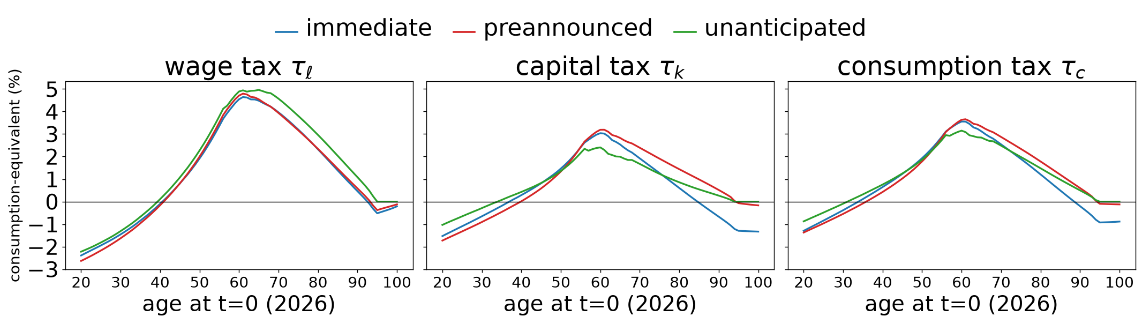


Figure 12: Consumption-equivalent variation by age in 2026, one panel per financing instrument and one line per timing scenario, relative to the reference sequence.

Section 5.3 measured the bailout against cohorts that have yet to enter, and found every one of them worse off. The cohorts already alive in 2026 divide differently. As Figure 12 shows, a bailout redistributes among them. Its value is negative for the young under every timing scenario and financing instrument, and positive for near-retirees and retirees. A near-retiree receives the restored benefit soon and pays the financing tax for few remaining working years. A young worker pays higher taxation for decades and receives the restored schedule much later. The redistribution between young and old is largest under wage-tax financing: its revenue comes entirely from earnings, which retirees no longer supply. A worker aged 60 in 2026 gains 4.5, 4.7, and 4.9 percent of remaining lifetime consumption under wage-tax financing in the immediate, preannounced, and unanticipated scenarios. A worker aged 25 loses 1.9, 2.2, and 1.8 percent.

Under wage-tax financing, waiting in the dark beats announcing at every age. Workers in the unanticipated scenario spend the years before depletion accumulating assets against a cut they believe permanent.[29] Every worker saved against a cut that never came. Those savings are the economy's capital stock at t^*. Waiting preserves the untaxed years and the higher wage that the inherited capital supports.

Under capital and consumption financing, the elderly prefer the preannounced scenario. These instruments fall on what the elderly hold: the capital tax reduces the return on assets that near-retirees have already accumulated, and the consumption tax reaches the same assets when they are spent. Relative to the immediate scenario, deferral leaves fewer of their remaining years taxed. Relative to the unanticipated scenario, the gain is information: workers who expected a permanent cut enter the restoration with assets over-accumulated against it, and the capital and consumption taxes then fall on that extra wealth. Preannouncement keeps the guarantee and defers the tax. Knowing the schedule that will be paid, the elderly re-plan saving, filing, and retirement while those decisions are still open.

8 Concluding Remarks

Current law fixes a rule and leaves the response open. It reduces every benefit by a common factor when the fund is empty. It says nothing about the claiming, retirement, and saving decisions that the reduction provokes. Those decisions determine what the program can pay, so the rule and the response are determined together. We compute them together, as a fixed point of a system of difference equations that describe government budgets, technology, and workers' optimizing behavior.

The benefit formula runs on two clocks. Current wages enter the payroll base at once. Earnings histories reach the entitlement base decades later. Longer careers add contributors immediately. Later filing lowers the scheduled bill immediately and raises it per claimant only when those workers collect. The payable factor therefore recovers for a few years after the cut and then resumes its

[29] Figure 23 in Appendix D reports the unanticipated scenario's aggregate paths.

decline. This anatomy is legible because a worker chooses when to claim separately from when to retire.

The financing instrument and the announcement date govern different things. What orders the welfare cost is terminal output and terminal consumption, not the capital intensity of the terminal economy. The capital tax contracts capital most and still costs an entering cohort less than the wage tax does. The wage tax leaves the lowest output and the lowest consumption of the three, and it is also the costliest: it distorts the retirement margin through which the economy had relieved the payability pressure, and it shrinks its own base. The announcement date divides one rescue differently among the living. Workers who expect a permanent cut save against it, and their savings are the economy's capital stock when the rescue arrives; under wage-tax financing, waiting in the dark keeps both the untaxed years and the wage that capital supports. The capital and consumption taxes reach the wealth that near-retirees already hold and the spending it will fund, so waiting in the dark spares them little. Those workers value the guarantee itself, which lets them plan against the schedule that will be paid.

Raising the full retirement age is the one program reform we study that changes the arithmetic. It lowers the actuarial factor for every claimant at once, current beneficiaries included, and the claim window closes at age 70, so a worker can recover only part of the cut. Raising the taxable maximum and lowering the top replacement rate move the incidence and leave the depletion year where it was, though the lower replacement rate does raise the long-run payable factor by 1.7 points.

We have held the demographic projection, the earnings process, and the terminal debt ratio fixed across every scenario. The projection is the Trustees'. The earnings process is estimated for men. We have also held government consumption at a fixed share of output, so an instrument that contracts output sheds government consumption along with it: terminal G per capita is 0.178 under the wage tax against 0.206 in the baseline equilibrium sequence. The welfare cost we report for the wage tax is understated relative to the other two for that reason. Our welfare comparisons price a guarantee and its financing, not a change of instrument. These choices bound what our numbers can be asked to bear.

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A Institutional and Aggregate Accounting

A.1 Allocating the shortfall

Current law caps aggregate payments once the trust fund is exhausted without fixing how the reduction is allocated across beneficiaries. The SSA Chief Actuary has testified that the law is unclear on the mechanism, and names an equal percentage cut for all beneficiaries, a cut graduated by earnings, and delayed payment among the ways the reduction could be accomplished (Glenn, 2026). The Congressional Research Service describes two possible outcomes, partial benefits paid on time or full benefits paid late (Huston, 2024).

The Trustees project that OASI reserves will be exhausted in 2032 (Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds, 2026). Continuing income then covers 78 percent of scheduled benefits, declining to 62 percent by 2100. We adopt a proportional reduction: the common factor ϕ_t of (4) multiplies every benefit.

A.2 Taxation of benefits

Program income exceeds payroll-tax receipts because the program also taxes benefits. The model carries that tax as a flat rate κ_b on benefits received. We set κ_b to the Trustees' 2025 income from taxation of benefits per dollar of benefit payments:

$$\kappa_b = \frac{\text{taxation-of-benefits rate}}{\text{net cost rate}} = \frac{0.1124 - 0.1071}{0.1362} \approx 0.03891. \tag{41}$$

The taxation-of-benefits rate is OASI income from the taxation of benefits divided by OASI taxable payroll. It is the OASI income rate, non-interest income divided by taxable payroll (0.1124), less the payroll-tax income rate, payroll-tax receipts divided by taxable payroll (0.1071). The net cost rate is OASI benefit payments divided by OASI taxable payroll (0.1362). It is the Trustees' cost rate, OASI cost divided by taxable payroll (0.1372), net of administrative expenses and the Railroad Retirement financial interchange. The model levies the statutory payroll tax rate $\tau^{ss} = 0.106$. The Trustees' 2025 payroll-tax receipts, 0.1071 of taxable payroll, include adjustments for earlier years, so the model's 2025 income rate is 0.1113, 0.11 of a percentage point below the Trustees' 0.1124.

A.3 Demography, immigration, and resources

Figure 13 displays the projection that the population weights (1) read.

The projection embeds immigration: the age-j mass in year $t+1$ exceeds the survivors of the age-$(j-1)$ mass of year t, and net immigration is that difference. We reweight the cross-sectional distribution to the projected age distribution each period rather than injecting immigrant workers with assigned states, so the immigrant mass carries the native age-specific distribution of assets, earnings histories, and claim status, and the assets it brings in are the endowment IMM_t of (32). Per-capita capital and public debt widen each period as the population grows; the account F_t is an absolute value and needs no widening. These terms close (32).

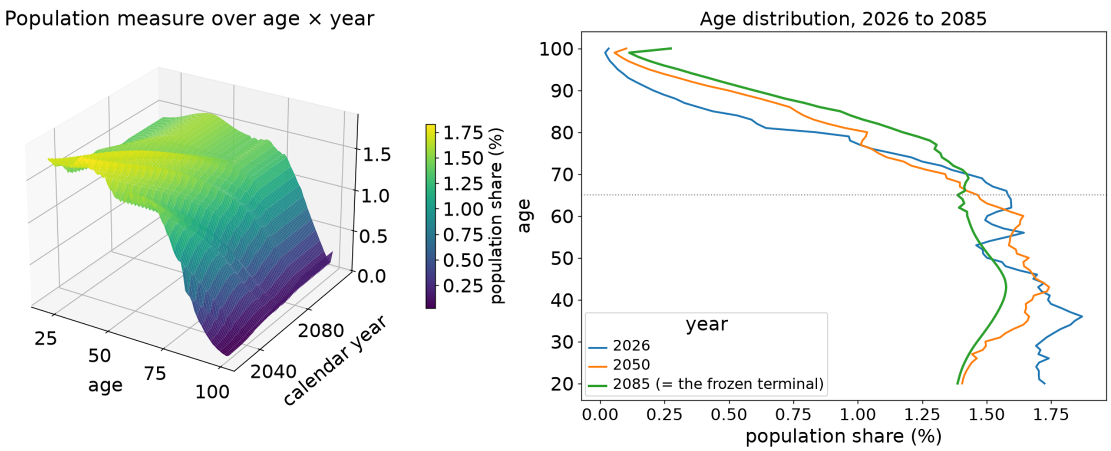

Figure 13: Model population from the SSA immigration-inclusive single-year projection: the age-share surface over age and calendar year (left) and pyramid snapshots with the frozen 2085 terminal structure (right).

B Computation

B.1 Stationary equilibria and the transition

We compute two objects: stationary equilibria that anchor the economy before depletion and in the long run, and the perfect-foresight transition that connects them when the fund is exhausted and the payable factor ϕ_t begins to clear the program's cash flow each period. A single construction produces both. The stationary equilibrium is the degenerate case of the transition, a constant-price path that reproduces its own cross-sectional distribution. Each scenario is that same transition evaluated under its own initial condition, terminal value, and financing instrument.

B.2 The worker's problem

We solve the lifecycle problem by backward induction over ages, carrying the two value layers of (21)–(23). Saving is a continuous choice on a grid that is locally refined around current holdings: the next-period asset is $a' = \text{clip}\left(a + h\left(a + a_{\text{base}}\right), 0, a_{\max}\right)$ for h on a grid over $[-1, 1]$ dense near zero, with the continuation value interpolated at the resulting a'. The two discrete decisions are each the sign of a value difference: retiring compares the retired layer with the value of working on, and filing compares the value at the claim state this age would set with the value of waiting. The values are interpolated first and differenced afterwards, so no $0/1$ policy is ever stored. Each worker carries its own AIME as a continuous state and its own claim state χ as an integer, so its scheduled benefit is evaluated at its own earnings and claiming history. The backward pass solves on a nine-node AIME grid that includes the two benefit-formula bend points, and the continuation value is interpolated between the nodes.

The backward pass stores the continuation value rather than the worker's policy, and the forward pass recomputes each worker's decision from that stored value at its actual state.

B.3 Simulation and aggregation

We form the cross-sectional distribution $\mu_{j,t}$ of §2.4 by simulating a panel of workers forward through calendar time. In each period we re-optimize every age group at its workers' actual (a, AIME) and reduce the outcomes to the aggregates of (26) at the population weights. Only then does the panel advance: every group ages one year, the oldest group dies, and an entering group arrives with no assets, no earnings history, and the entry draw of productivity.

We draw all idiosyncratic uncertainty once into a fixed panel of 80,000 workers per age cell under a single seed and reuse it: initial ability and productivity, the productivity innovations, and the lottery that advances the effective claim age under the earnings test. Each date's cross-section is therefore $81 \times 80{,}000$ records, the same 80,000 lifetime histories replayed once per birth cohort. Every equilibrium sequence draws that same panel, so the two steady states, the depletion transition, and each experiment face the same workers and the same shocks.

B.4 The two fixed points

The stationary equilibrium is a joint fixed point, found by Anderson acceleration (Algorithm 1). The set of iterated unknowns depends on the financing instrument. The initial stationary equilibrium iterates (r, tr) with $\phi \equiv 1$, and government consumption is the budget residual that defines the share

$\bar{g}$. The depleted terminal iterates (r, tr, ϕ, τ), with τ its permanent balancing rate. Each financed terminal iterates (r, tr, τ) with $\phi \equiv 1$ and τ its own instrument's balancing rate. Those τ^{∞} are the terminal rates the transition scenarios step to.

Algorithm 1 Stationary equilibrium.

Require: initial guess $\mathbf{x}_0$: $(r,\, tr)$ scheduled, $(r,\, tr,\, \phi,\, \tau)$ depleted, $(r,\, tr,\, \tau)$ financed; tolerance ε

for $k = 0, 1, \ldots$ **do**

  $w \leftarrow w(r)$ from (25)

  $\{V_j^0, V_j^1\}_{j=0}^{J-1} \leftarrow$ backward induction over (21)–(22)

  Reoptimize N workers from (V^0, V^1) at actual states; aggregate (26)

   $\rightarrow (A,\, L,\, C,\, Rev,\, Ben,\, Wh^{sch},\, beq)$

  $D \leftarrow \theta_D Y;\quad K \leftarrow A - D;\quad r' \leftarrow \alpha Z (K/L)^{\alpha-1} - \delta$

  $\phi' \leftarrow$ cash-flow condition (11) (depleted; else $\phi' \equiv 1$); $tr' \leftarrow beq$

  $\tau' \leftarrow$ the rate balancing (30) at $G = \bar{g} Y$ and $D_{t+1} = D_t = \theta_D Y$ ▷ depleted and financed terminals

  $\mathbf{f}_k \leftarrow \mathbf{x}'_k - \mathbf{x}_k$

  if $\|\mathbf{f}_k\|_\infty < \varepsilon$ **then break**

  end if

  $\mathbf{x}_{k+1} \leftarrow$ Anderson-accelerated update of $\mathbf{x}_k$ from the history of $(\mathbf{x},\, \mathbf{f})$

end for

return converged $(r^*,\, w^*,\, K^*,\, \phi^*,\, tr^*,\, \tau^*,\, \mu)$

We solve the transition as a dampened iteration on the stacked unknown $(r_t, tr_t, \phi_t; \tau^{\text{trans}})$, the price and transfer paths, the payable factor where it is free, and the instrument's single transitory rate (Algorithm 2). The wage is recovered from the firm condition (25) inside each evaluation rather than iterated as a separate unknown. Every financing instrument studied in Sections 5–7 shares this solver and differs only in which terms the closing step leaves free. In the scenarios without new legislation each iterate applies the fund law of motion, which sets ϕ'_t; the bailout scenarios hold $\phi_t = 1$ and only record the fund. Every iterate re-bisects τ^{trans} so that the integrated debt path lands on its terminal target. The published τ^{trans} and D/Y paths are consistent with the aggregates reported beside them.

In the scenarios without new legislation the tax adjustment starts at the program's first shortfall year, and that year is itself an equilibrium object. The iteration finds the two together: workers respond to the tax path, their responses move the fund, and the fund fixes the shortfall year. With an annual period the iteration can cycle between two adjacent years, each implying the other, and no equilibrium then places t^* at the first shortfall year. Where the iteration cycles, we take the convention that the tax adjustment starts one year after the first shortfall year.

Algorithm 2 Perfect-foresight transition equilibrium.

Require: endpoints ss_{-1}, ss_T; fund F_0; financing instrument $\mathscr{C}$; horizon T; tolerance ε; damping schedule ν_k

```
x_0: r_t, tr_t, and φ_t where free ramp from ss_{-1} to ss_T over fifty years and hold; τ^trans starts at τ^∞
for k = 0, 1, ... do
    Backward sweep (store continuation values, not policies):
    for t = T−1, ..., 0 do
        w_t ← w(r_t) from (25); solve all J ages at (r_t, w_t, φ_t, tr_t)
        Store V^c_{t,j} ← (V^0_{t+1,j+1}, V^1_{t+1,j+1})
    end for
    Forward sweep (reoptimize from stored V^c):
    μ_0 ← cross-sectional distribution from ss_{-1}
    for t = 0, ..., T−1 do
        Reoptimize each worker at actual (a, AIME) from V^c_t; aggregate at the shares f_{j,t} of (26)
         → (A_t, L_t, Rev_t, Ben_t, Wh^sch_t, beq_t)
        Age the cross-section: the oldest group dies, an entering group is admitted, and the shares become
        {f_{j,t+1}}_{j=0}^{J−1}
    end for
    Close: the fund law of motion (2)–(5) sets φ'_t in the scenarios
     without new legislation, and τ^trans' ← bisection landing the
     integrated debt path on D_T / Y_ssT = θ_D
    K_t from asset clearing;   r'_t from (25);   tr'_t ← beq_t
    x_{k+1} ← x_k + ν_k (x'_k − x_k), the step under-relaxed toward a floor as k grows
    if ||x'_k − x_k||_∞ < ε then break
    end if
end for
return {r_t, w_t, φ_t, tr_t, μ_{j,t}}_{t=0}^{T−1} and τ^trans
```

B.5 An untargeted earnings gradient

Figure 14 sorts workers by their realized-earnings (AIME) quintile and plots where each quintile retires and claims benefits. The model produces a weakly positive earnings–retirement gradient, in line with Holter et al. (2025).

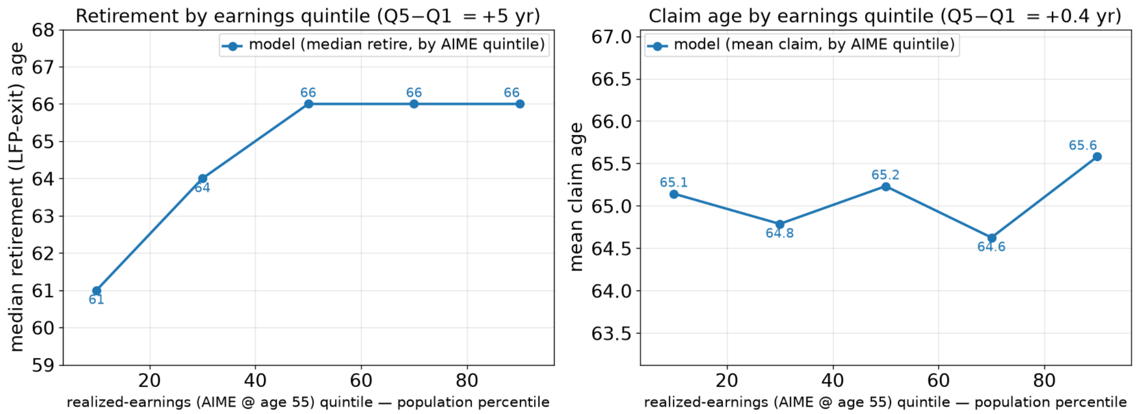

Figure 14: Median retirement age (left) and mean claim age (right), in years, across quintiles of the model's realized-earnings (AIME at age 55) distribution, plotted against the population percentile at each quintile midpoint. Model series only.

B.6 Settings and reproduction

Table 12 lists the numerical settings. The state space carries 81 ages, real ages 20 to 100. Its nine average-earnings nodes are seven base nodes plus the two benefit-formula bend points. The transition takes the scenario's terminal stationary equilibrium as its terminal condition. We find the three internally calibrated parameters by a derivative-free simplex (Nelder–Mead), which suits the discrete simulated age moments. The replication package contains the full solver and every setting used here, and reproduces the baseline depletion path, the fiscal-closure and welfare comparison, and the calibration.

C Consumption and Assets over the Transition

Figures 15–18 display cross-sectional moments of the simulated panel over the plane of age and calendar year. In each pair the left panel is the mean across the workers of that age in that year and the right panel is the standard deviation across the same workers. For each calendar year the

Setting	Value	Setting	Value
Ages J	81	Transition horizon T	150
Asset nodes N_a	48	Local saving grid N_h	45
Asset grid maximum $a_{\max}$	25	Saving-span base a_{base}	5
Productivity states N_z	7	Earnings types N_e	5
Average-earnings nodes N_{AIME}	9	Claiming states N_χ	10
Simulation panel N (per age)	80,000	Seed	0
Stationary tolerance ε	10^{-7}	Transition tolerance ε	10^{-4}

Table 12: Grid, horizon, panel, and solver settings.

curve over age is that year's profile, and the translucent vertical plane marks depletion without new legislation, 2033. The first three pairs report consumption, in the baseline equilibrium sequence and under the wage-tax and capital-tax bailouts; the fourth reports assets in the baseline equilibrium sequence.

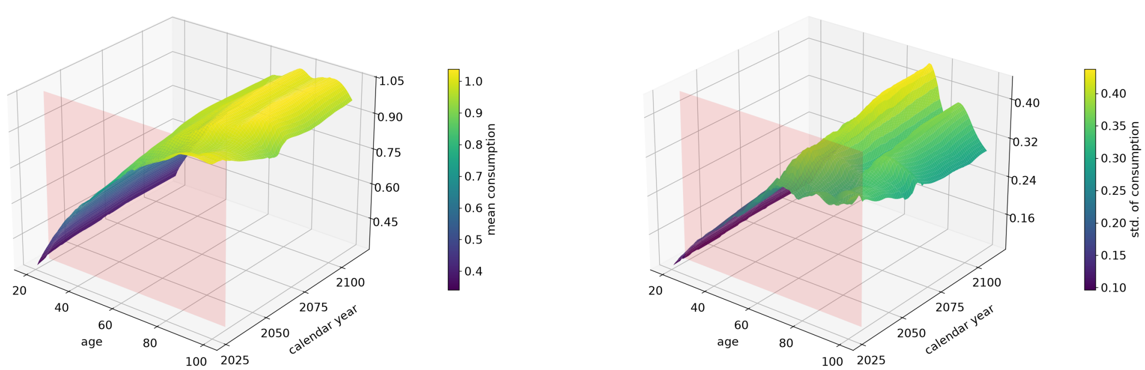

Figure 15: Consumption by age and calendar year in the baseline equilibrium sequence: the mean (left) and the standard deviation (right).

D Financing, Reform, and Timing Supplements

D.1 The wage tax without new legislation

Figure 19 reports the wage tax that closes (30) in the baseline equilibrium sequence.

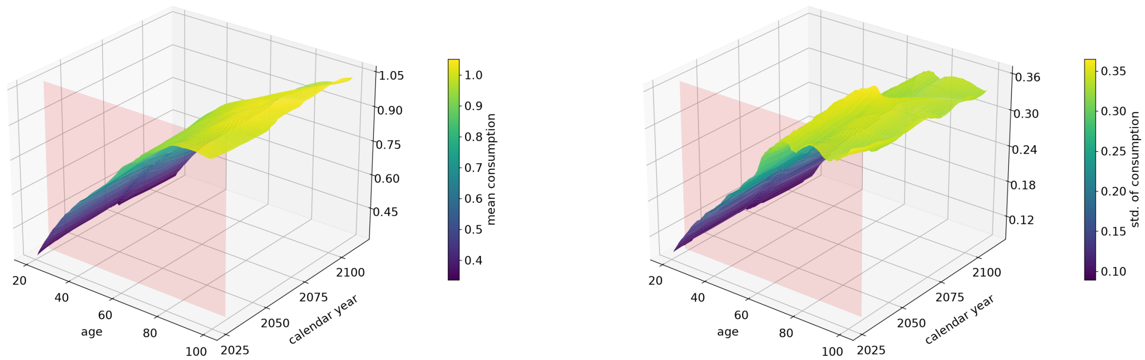

Figure 16: Consumption by age and calendar year under wage-tax financing: the mean (left) and the standard deviation (right).

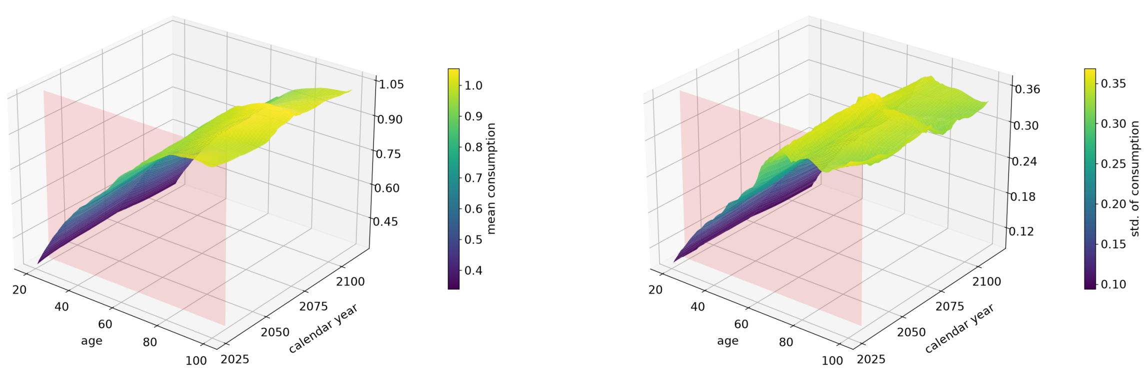

Figure 17: Consumption by age and calendar year under capital-tax financing: the mean (left) and the standard deviation (right).

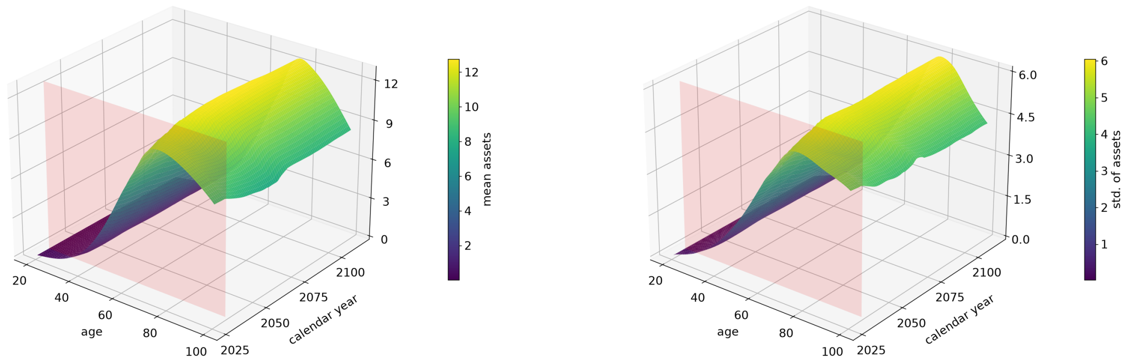

Figure 18: Asset holdings by age and calendar year in the baseline equilibrium sequence: the mean (left) and the standard deviation (right).

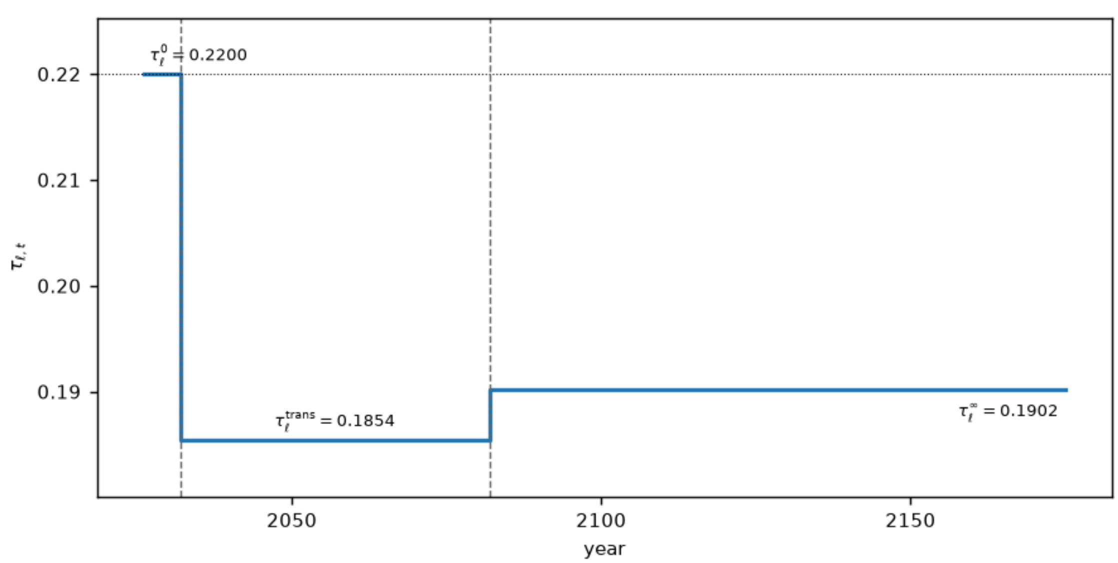

Figure 19: The wage tax $\tau_{\ell,t}$ in the baseline equilibrium sequence: the base rate before depletion, the transitory rate from the first shortfall year $t^* = 2032$ (the fund is empty at $t^{dep} = 2033$), and the terminal balancing rate after the window closes; the dashed lines mark the window.

D.2 Transition paths under the three financing instruments

Figure 20 reports the full transition paths behind the terminal-steady-state comparison of Table 8: prices, the macroeconomic aggregates, and the financing tax rate under each of the three instruments of Section 5, on the same nine-panel layout as the baseline Figure 7.

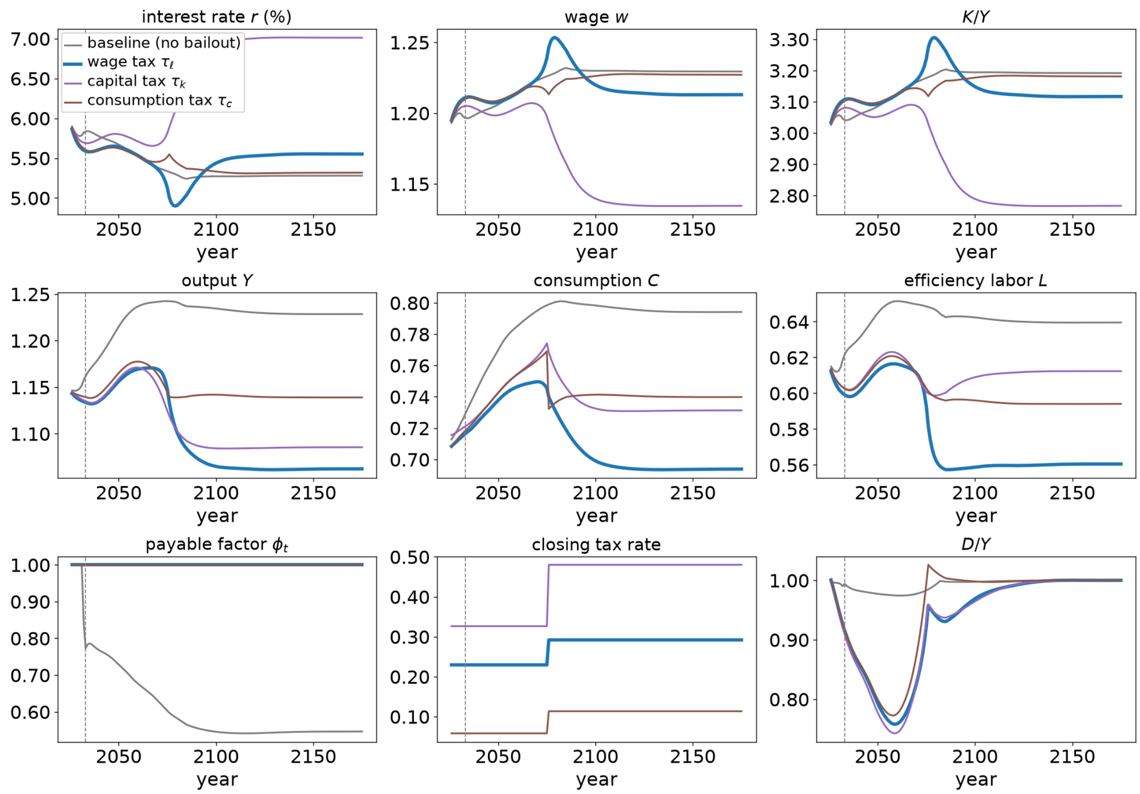

Figure 20: The immediate scenario ($\phi_t = 1$ from 2026) under the three financing instruments and the baseline equilibrium sequence. Panels: the interest rate, wage, and K/Y; output, consumption, and efficiency labor; the payable factor ϕ_t, each instrument's own financing tax rate, and D/Y. The vertical line marks depletion.

D.3 Program-reform transition paths

Figure 21 reports the corresponding transition paths for the program reforms of Section 6, each paired with the transitional wage tax that restores full scheduled benefits.

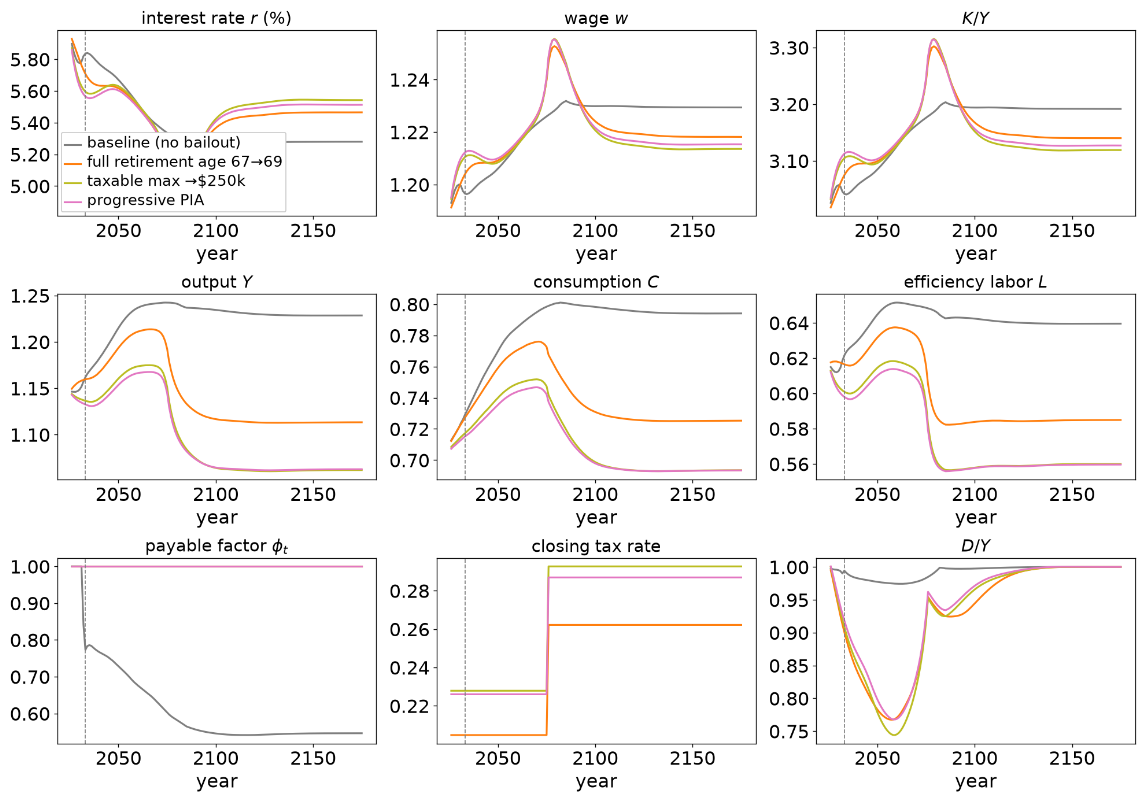

Figure 21: Macroeconomic paths under the three reforms, each financed by the transitional wage tax that holds $\phi_t = 1$, against the baseline equilibrium sequence. Reforms: full retirement age 67 $\rightarrow$ 69, taxable maximum $\rightarrow$ \$250k, progressive PIA. Panels: the interest rate, wage, and K/Y; output, consumption, and efficiency labor; the payable factor ϕ_t, the closing wage tax τ_ℓ, and D/Y; the vertical line marks depletion.

D.4 Fiscal and aggregate paths under the timing scenarios

Figure 22 collects the fiscal paths of every financed scenario, one column per instrument, beside each instrument's reference sequence. Figure 23 collects the aggregate paths of the unanticipated scenario, whose immediate-scenario counterpart is Figure 20.

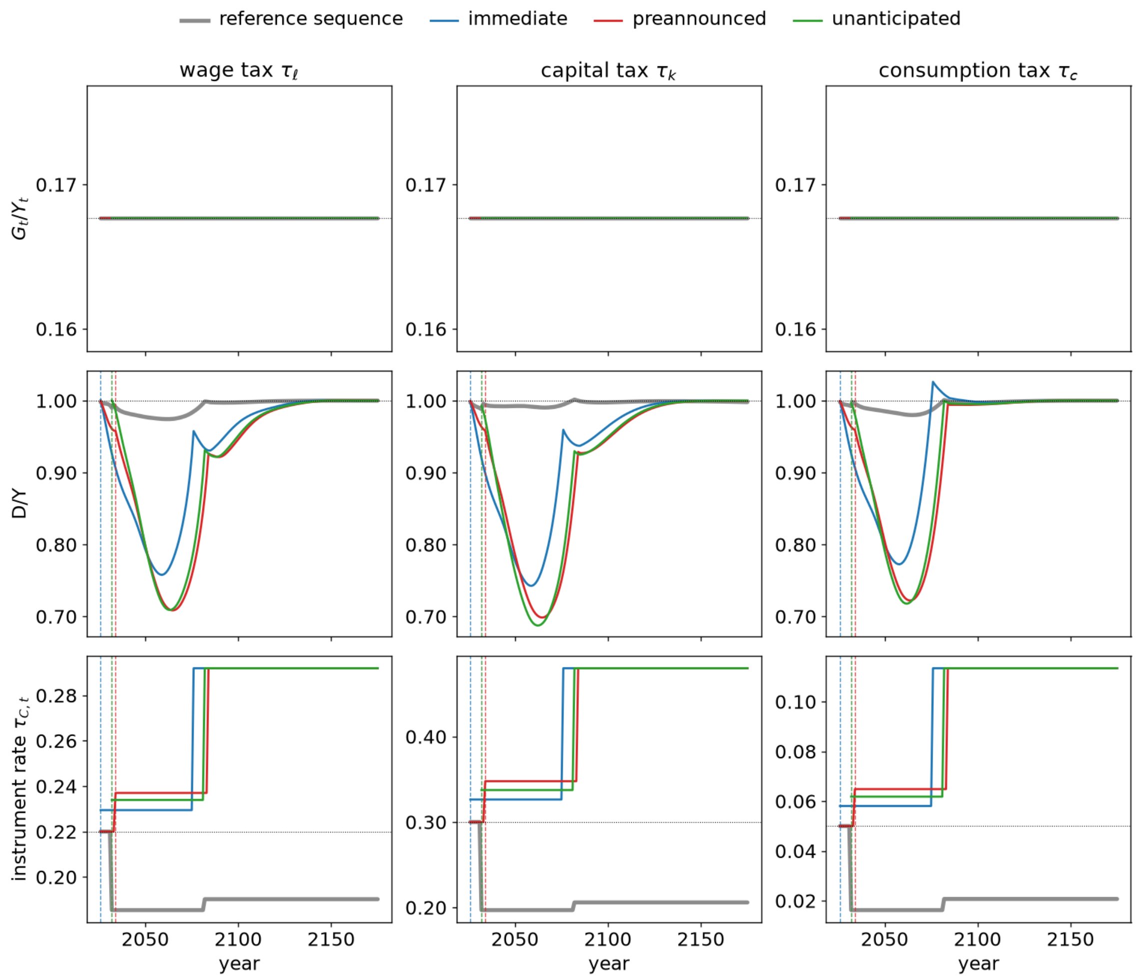

Figure 22: Fiscal paths under wage-tax, capital-tax, and consumption-tax financing (columns). Rows: the government-consumption share G_t/Y_t; the debt ratio D/Y; the instrument's rate. Blue, red, and green: the immediate, preannounced, and unanticipated scenarios; grey: the reference sequence; dashed verticals mark the scenarios' tax-start years.

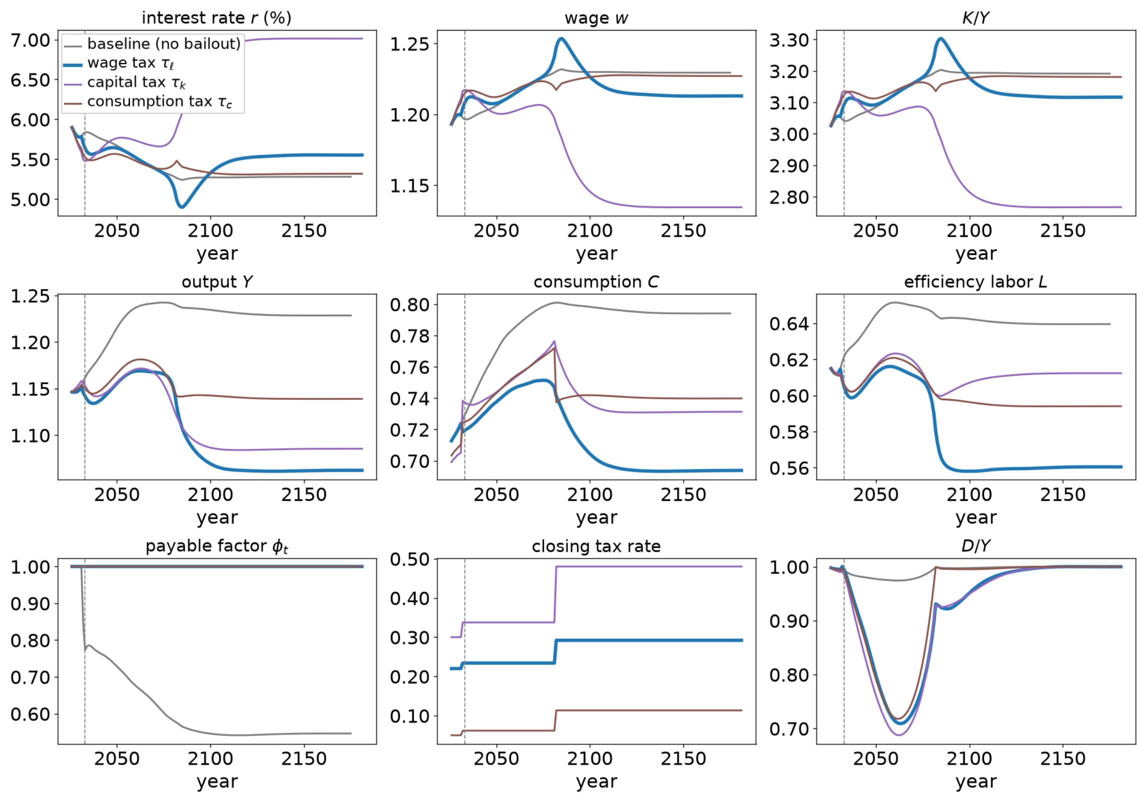

Figure 23: Aggregate paths of the unanticipated scenario, each instrument's path drawn on its own reference sequence prefix: full benefits are restored unexpectedly in the first shortfall year of each instrument's reference sequence. The vertical line marks depletion. Each panel shows the baseline equilibrium sequence and the three financing instruments: wage tax τ_ℓ, capital tax τ_k, consumption tax τ_c. Layout as in Figure 20.

D.5 The three bailouts against a common benchmark

Each consumption-equivalent variation of Section 5.3 compares a bailout with the reference sequence that adjusts the same tax, so the three do not share a benchmark. We recompute all three against one benchmark, the baseline equilibrium sequence of Section 4, in which the wage tax closes (30). Only the benchmark changes; the bailout sequences are the ones of Section 5. Figure 24 plots λ_{t_0} against that common benchmark over the entry dates of Figure 10; the markers at the right edge are terminal-steady-state newborns, measured against the newborn of the baseline equilibrium sequence's terminal stationary equilibrium. The wage-tax line is the line of Figure 10, because the baseline equilibrium sequence is the wage tax's own reference sequence. The capital-tax and consumption-tax lines lie below their lines of Figure 10, because the reference sequences of those two instruments leave an entering cohort worse off than the baseline equilibrium sequence does. The ordering of Section 5.3 is unchanged at every entry date and for the terminal newborns: the consumption tax costs an entering cohort the least, the capital tax more, and the wage tax the most. Against the common benchmark the three cost a terminal-steady-state newborn 6.5, 9.6, and 11.6 percent of lifetime consumption, against the 4.8, 8.7, and 11.6 percent of Section 5.3.

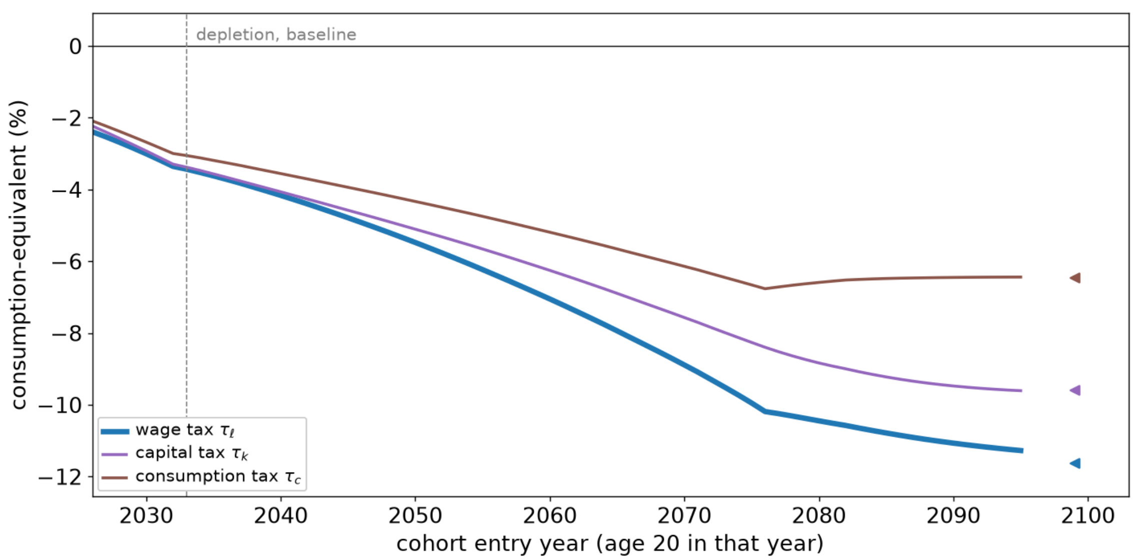

Figure 24: Consumption-equivalent variation by entering cohort in the three bailout sequences, each relative to the baseline equilibrium sequence; the markers at the right edge are terminal-steady-state newborns.