PWBM Social Security Dynamic OLG Analysis

Penn Wharton Budget Model

September 23, 2026

What does dynamic analysis add?

THE QUESTIONS

Households

How do taxes and future benefits change work, saving, and consumption?

Fiscal, Production, and Economy

How do those decisions change capital, wages, output, and the federal budget?

Generations

Who gains or loses over a lifetime, including people not yet born?

Tracing the flows of fiscal policy at the microeconomics level using the OLG model is required for grounded macroeconomic and welfare calculations.

Two views of the same policy

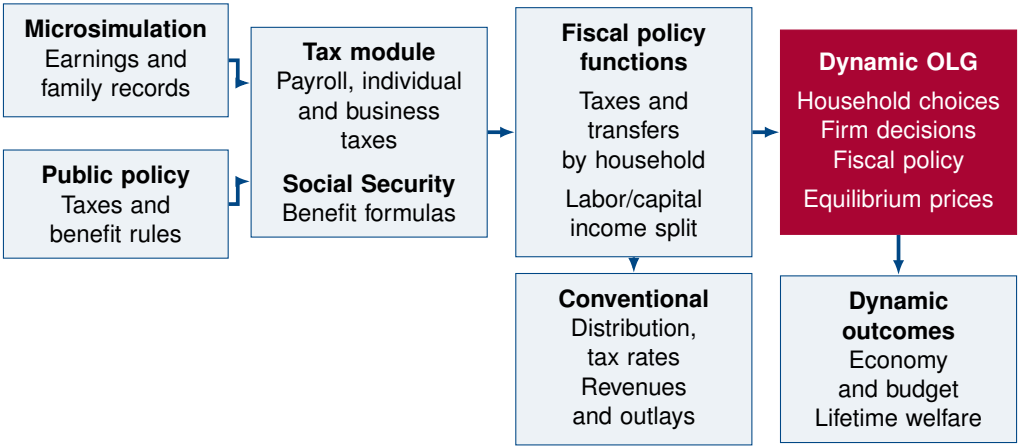
Conventional calculations

- Detailed earnings and family records.
- Eligibility, benefit formulas, and policy timing.
- Taxes, benefits, and trust-fund finances under the specified economic path.

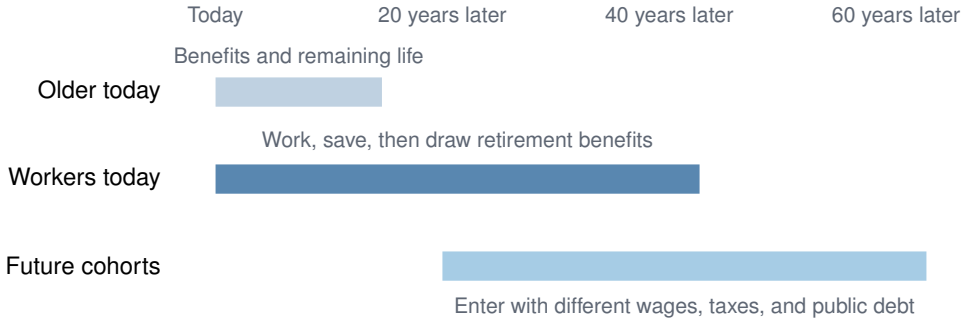
Dynamic OLG analysis

- Households choose over their lifetimes facing wage, health and longevity uncertainty.
- Corporations and pass-through firms invest and hire at equilibrium prices.
- Detailed fiscal policy space required to capture first-order interactions.
- Economic paths and lifetime welfare by income and generation must be fully consistent with all policy and price changes.

From policy rules to economic and distributional outcomes



Overlapping generations connects today with the future



The same reform reaches each cohort at a different point in its life cycle.

Note: Cohort lengths are illustrative, not demographic estimates.

Each household carries an economic history

HOUSEHOLD STATE

Life cycle
Age and household composition

Resources
Assets and earnings history

Earnings capacity
Labor productivity

Health
Current health status

Medical needs
Expenditure shocks

Coverage
Health insurance status

Two households with the same current income can respond differently because their histories and risks differ.

Households choose a path through the life cycle

Choices each year

- Consumption and saving.
- Work and leisure.
- Health insurance enrollment.
- Whether to receive or forgo treatment.

What those choices anticipate

- Future wages and asset returns.
- Taxes and retirement benefits.
- Earnings and health shocks.
- Survival and medical expenses.

Announced future policy can change saving and work before its first payment or tax change.

Households: state, preferences, and earnings

TAKE THE PATH OF PRICES, POLICIES, AND DISTRIBUTIONS AS GIVEN

$$s = (j, a, b, z, h, d, i), \qquad \Psi_t^T = \{p_u, \psi_u, X_u\}_{u=t}^T.$$

$$u(c, \ell) = \frac{\left(c^\theta \ell^{1-\theta}\right)^{1-\gamma}}{1-\gamma}, \qquad y_t^G = w_t e(j, h, z)\left[\Omega_{a,t}(j)\ell_{\max} - \ell\right].$$

- a: wealth; b: historical earnings; z: ability; h: health; d: medical needs; i: insurance.
- $\Omega_{a,t}(j)$ is the number of adults; $e(j, h, z)$ is labor efficiency.
- θ weights consumption relative to leisure; γ governs utility curvature.

Note: Gross earnings apply at working ages.

Households: the dynamic optimization problem

$$V_t(s;\Psi_t^T) = \max_{c,\ell,a',i',\iota} \Big\{ u(c,\ell) + \beta\delta_t(j,h)\mathbb{E}_t V_{t+1}(s';\Psi_{t+1}^T) + \beta(1-\delta_t(j,h))\zeta\mathcal{A}(s) \Big\}.$$

$$c \geq \underline{c}, \quad 0 \leq \ell \leq \Omega_{a,t}(j)\ell_{\max}, \quad a' \geq a'_{\min}(s), \quad i' \in \mathcal{I}_t(s), \quad 0 \leq \iota \leq 1.$$

- Survival is $\delta_t(j,h)$; $\zeta\mathcal{A}(s)$ is the death-state payoff.
- The expectation is over idiosyncratic household risks.
- $\mathcal{I}_t(s)$ imposes insurance eligibility; ι governs medical treatment.
- The optimizer delivers $\Gamma_{h,t}(s) = \{c_t, \ell_t, a'_t, i'_t, \iota_t, b'_t\}$.

Note: $T = t + J_D - j$ is the household's terminal date.

Households: taxes and transfers enter the budget

$$
\begin{aligned}
c + a' = (1 + r_t)a + y_t^P + B_t^{SS}(j,b) + SN_t(s,\ell) + SSI_t(s,\ell) \\
- \tau_{I,t}\big(y_t^T, \widetilde{r}_t a, B_t^{SS}(j,b)\big) - \tau_{P,t}(y_t^T) - \tau_{S,t}(y_t^T) \\
- \tau_{C,t}(\psi_t^C c) - P_t^{\text{net}}(s,\ell) - \iota \ \text{oop}_t(m_t(s), i).
\end{aligned}
$$

$$
y_t^P = y_t^G - \mathbf{1}_{ESI}\eta^{ESI}\Omega_{a,t}(j)p_{p,t}(j), \qquad y_t^T = y_t^G - \mathbf{1}_{ESI}\Omega_{a,t}(j)p_{p,t}(j).
$$

- B_t^{SS} denotes OASI benefits; SN_t and SSI_t are transfers.
- P_t^{net} is the household premium after employer and ACA subsidies.
- $\widetilde{r}_t$ preserves the tax treatment of corporate, pass-through, bond, and capital-gain returns.

Note: Benefit dependence on historical prices is suppressed in the notation.

Social Security: earnings become a persistent state

$$b' = \begin{cases} \dfrac{(j-21)b\, w_t/w_{t-1} + \min\{y_t^T/\Omega_{a,t}(j), \vartheta_{\max,t}\}}{j-20}, & j < J_{R,t}, \\ b, & j \geq J_{R,t}. \end{cases}$$

$$B_t^{SS}(j,b) = \Omega_{a,t}(j)\, \mathcal{B}_t(j, b; \psi_t, p_{\leq t}).$$

- Current covered earnings are capped at $\vartheta_{\max,t}$; prior earnings are wage-indexed.
- $\mathcal{B}_t$ maps per-adult earnings history into benefits under the specified policy.
- The model compresses earnings history and fixes it after $J_{R,t}$; claiming age is not a separate choice in this decision vector.

Note: The recursive earnings-history approximation differs from an exact highest-35-years AIME calculation.

Health risk and insurance prices are endogenous links

$$z' \sim \pi_z(\cdot \mid z), \qquad h' \sim \pi_h(\cdot \mid j, h, d, \iota), \qquad d' \sim \pi_d(\cdot).$$

$$p_{p,t}(j) = \frac{\omega_j^{HI}}{\sum_{\tilde{j}} \omega_{\tilde{j}}^{HI} \Omega_{a,t}(\tilde{j}) N_{p,t}(\tilde{j})} \frac{\int_S \mathbf{1}_{\{i=private\}} \iota_t(s)[m_t(s) - \mathrm{oop}_t(m_t(s), i)]\, dX_t(s)}{1 - \kappa_p}.$$

- Treatment affects health transitions; health affects earnings and survival.
- $N_{p,t}(j)$ is enrolled household mass; ω_j^{HI} sets relative age premiums.
- Private insurers break even after administrative costs κ_p; coverage for next year is chosen before next year's shocks.

Note: ι weights reimbursed care; automatic public enrollment follows eligibility rules.

The distribution evolves with household decisions

$$Q_t(s, ds'; \Gamma_{h,t}) = \mathcal{D}_{g_t(s)}(dj', da', db', di')\pi_z(dz' \mid z)\pi_h(dh' \mid j, h, d, \iota_t(s))\pi_d(dd').$$

$$X_{t+1}(ds') = \pi^s_{t+1}(j') \left[\int_S \widetilde{\delta}_t(j,h)\, Q_t(s, ds'; \Gamma_{h,t})\, dX_t(s) + E_{t+1}(ds') \right].$$

- $g_t(s) = (j+1, a'_t(s), b'_t(s), i'_t(s))$; $\mathcal{D}_{g_t(s)}$ is a point mass at those choices.
- $\widetilde{\delta}_t = \delta_t - em^{rate}_t(j)$ is survival net of emigration.
- E_{t+1} collects new entrants and immigrants; newborn cohorts use the entry distribution.
- $\pi^s_{t+1}(j')$ matches age-specific population counts to microsimulation.

Firms: sectoral production and final-good demand

$$Y_t = \prod_{k=1}^{n} Y_{k,t}^{\zeta_k}, \qquad \sum_k \zeta_k = 1, \qquad p_{k,t} = \zeta_k \frac{Y_t}{Y_{k,t}}.$$

$$Y_{v,k,t} = A_{k,t} K_{v,k,t}^{\alpha_{k,t}^f} L_{v,k,t}^{1-\alpha_{k,t}^f}, \qquad (K_{v,k,t}, L_{v,k,t}) = \omega_{v,k,t}(K_{k,t}, L_{k,t}).$$

- k indexes sectors; $v \in \{corp, pass\}$ indexes business form.
- The final good is the numeraire; competition determines intermediate-good prices.
- $\sum_v \omega_{v,k,t} = 1$; business-form shares are exogenous, while sectoral allocations respond to prices and taxes.

Firms: the corporate investment problem

FOR A CORPORATION IN SECTOR k, SUPPRESS THE BUSINESS AND SECTOR SUBSCRIPTS

$$V_t^f(K) = \max_{K',L,B} \left\{ \mathcal{R}_t(K,L,B) - (1-\Gamma_t)I + \frac{V_{t+1}^f(K')}{1+r_t} \right\}, \qquad I = K' - (1-\delta_k)K.$$

$$\Gamma_t = \psi_t^I + \sum_{m=0}^{T_f} \left[\prod_{u=1}^{m} (1+r_{t+u}^D)^{-1} \right] \frac{P_t^Y}{P_{t+m}^Y} \widetilde{\tau}_{t+m} \phi_{t,m}.$$

- Choose next-period capital K', labor L, and business borrowing B.
- $\mathcal{R}_t$ is after-tax operating cash flow, including financing terms.
- Γ_t combines investment credits ψ_t^I with the discounted tax value of depreciation deductions $\phi_{t,m}$; P_t^Y is the output price index.

Note: Historical allowance payments and aggregate adjustment-cost charges are taken as given by the firm.

Firms: taxes change operating cash flow

$$\mathcal{R}_t(K,L,B) = \left[1-\tau_t^f(1-d_t^f)\right]\left[p_tF(K,L)-w_tL\right]+\chi_t p_tF(K,L)$$
$$+\tau_t^f\phi_t^{int}[\rho_tB+\mathcal{L}_t(B,K)]-\mathcal{L}_t(B,K)+\overline{V}_t,$$

$$\mathcal{L}_t(B,K) = \frac{q_t\nu_2K}{\nu_1}\left(\frac{B}{q_t\nu_2K}\right)^{\nu_1}.$$

- τ_t^f: business tax rate; d_t^f: other deduction share; χ_t: production credit.
- ϕ_t^{int} determines interest deductibility; ρ_t is the borrowing rate; $\mathcal{L}_t$ is the leverage cost.
- $\overline{V}_t$ collects predetermined allowances and charges; pass-through income is taxed at the household level.

Note: q_t is the price of existing capital; ν_1, ν_2 parameterize leverage costs.

Firms: labor demand and the user cost of capital

$$w_t = \frac{1-\tau_t^f(1-d_t^f)+\chi_t}{1-\tau_t^f(1-d_t^f)} p_t F_L(K_t, L_t) = \frac{1-\tau_t^f(1-d_t^f)+\chi_t}{1-\tau_t^f(1-d_t^f)}(1-\alpha_k^f)\frac{p_t Y_t^k}{L_t^k}.$$

$$(1+r_t)(1-\Gamma_t) = \partial_K \mathcal{R}_{t+1}(K_{t+1}, L_{t+1}, B_{t+1}) + (1-\delta_k)(1-\Gamma_{t+1}).$$

- The labor condition follows by differentiating operating cash flow with respect to L.
- The capital condition equates today's after-tax acquisition cost with future marginal cash flow and undepreciated capital value.
- With interior borrowing, $\partial_B \mathcal{R}_t = 0$; tax and financing wedges enter the capital return.

Note: Corporate conditions determine sectoral allocation; pass-through quantities follow the business-form shares.

Fiscal policy: aggregate taxes and program outlays

$$T_{I,t} = \int_S \tau_{I,t}\left(y_t^T, \widetilde{r}_t a, B_t^{SS}\right) dX_t, \quad T_{P,t} = \int_S \tau_{P,t}(y_t^T) dX_t,$$

$$TR_{SS,t} = \int_S B_t^{SS}(j,b)\, dX_t, \qquad T_{C,t} = \int_S \tau_{C,t}(\psi_t^C c_t)\, dX_t.$$

$$PD_t = C_{G,t} + TR_{SS,t} + M_{ACA,t} + M_{Mcare,t} + \varrho_t^M M_{Mcaid,t} + \varrho_t^{SN} TR_{SNAP,t} + TR_{SSI,t} - T_{I,t} - T_{P,t} - T_{C,t} - T_{corp,t} - T_{E,t} - T_{exog,t} + mm_t.$$

- Policy functions are credible; their tax bases and eligible populations respond endogenously.
- ϱ^M, ϱ^{SN} are federal cost shares; T_E is estate-tax revenue.
- mm_t is the signed baseline fiscal adjustment, entering the primary deficit as written.

Note: Medicare outlays are net of premiums; T_{exog} collects other revenue. The primary deficit PD excludes interest.

Fiscal policy: debt service and budget closure

$$D_t^G = \mathbf{1}^\top d_t, \qquad NI_t^G = d_t^\top ey_t, \qquad D_{t+1}^G = D_t^G + NI_t^G + PD_t.$$

Baseline: $D_{t+1}^G = \overline{D}_{t+1}^G \implies mm_t$ adjusts,

Policy closure: $mm_t = \overline{mm}_t, \quad D_{t+1}^G = D_t^G \ (t \geq T_c) \implies \tau_{C,t}$ adjusts.

- d_t is the vector of debt by remaining maturity; ey_t is its effective coupon vector.
- In the transition, inherited coupons and new issuance determine debt service.
- States balance their budgets: $T_{S,t} = (1 - \varrho_t^M) M_{Mcaid,t} + (1 - \varrho_t^{SN}) TR_{SNAP,t}$.

General equilibrium: saving, capital, and public debt

$$A_{t+1} = \int_S a'_t(s)\, dX_t(s), \qquad \mathcal{V}^K_{t+1} + D^G_{t+1} - W_{F,t+1} = A_{t+1}.$$

$$r_t = \frac{R_{corp,t} + R_{pass,t} + r^D_t (D^G_t - W_{F,t}) + \Delta q_t K_t}{A_t}.$$

- $\mathcal{V}^K$ is the acquisition value of capital claims; it equals physical capital K when its acquisition price is one.
- Foreign investors hold W_F of government debt; domestic saving finances the remaining debt and capital claims.
- The mutual fund earns zero profits; business distributions, bond income, and capital gains pass through to households.

Note: Capital-claim value differs from physical capital when $q \neq 1$. At a unit acquisition price, $K_{t+1} = A_{t+1} + W_{F,t+1} - D^G_{t+1}$.

General equilibrium: market clearing and aggregation

$$\sum_{v,k} L_{v,k,t} = \int_{\{j<J_{R,t}\}} e(j,h,z)[\Omega_{a,t}(j)\ell_{\max} - \ell_t(s)]\, dX_t(s), \qquad K_t = \sum_{v,k} K_{v,k,t}.$$

$$C_t = \int_S c_t(s)\, dX_t(s), \qquad M_t = \int_S \frac{\iota_t(s) m_t(s)}{1-\kappa_i}\, dX_t(s).$$

- Labor supply equals firm demand; firms allocate the available capital across sectors.
- The household distribution determines consumption, saving, and medical demand.
- Final-good firms, private insurers, and the mutual fund satisfy their zero-profit conditions.

Note: κ_i denotes administrative expenses by insurance type.

A competitive equilibrium is a consistent sequence

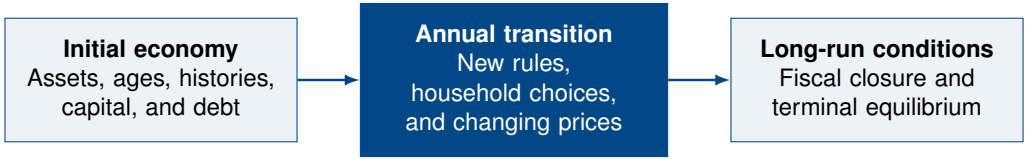
$$\left\{X_{t+1}, K_{t+1}, L_t, D^G_{t+1}, W_{F,t+1}, p_t, \psi_t, mm_t, \Gamma_{h,t}, \Gamma_{f,t}\right\}_{t=T_0}^{\infty}.$$

- **Optimization:** household and firm rules solve their problems at the same price and policy paths.
- **Distribution:** $X_{t+1} = \mathcal{T}_t(X_t, \Gamma_{h,t})$, including demographic entry and exit.
- **Markets:** labor and asset markets clear; final-good producers and intermediaries break even.
- **Government:** federal debt evolves consistently with fiscal policy; state budgets balance.

Given the initial distribution, debt, foreign holdings, and capital history, solve for the entire transition to the specified terminal equilibrium.

Note: Exogenous demographic paths, yield-curve inputs, business-form shares, and fiscal closure are part of the experiment.

Solve the transition, not just the endpoint



- Solve decisions backward from future conditions.
- Move the household distribution and capital forward through time.
- Update prices until the full path is consistent.

September reform illustrations

Different financing choices, different economic outcomes

Taxes and benefits operate through different channels

Higher payroll taxes

- Reduce current take-home resources.
- Change the return to working.
- Improve program financing.
- Preserve benefits when benefit rules are unchanged.

Lower future benefits

- Reduce expected retirement resources.
- Can encourage additional saving and work.
- Improve program financing.
- Change lifetime transfers and insurance.

Timing and household circumstances determine the net response; equal financing gains need not produce equal capital accumulation.

September Social Security reform simulations

- **Seven packages, A–G:** a range from tax increases to benefit reductions.
- **Common financing goal:** all seven packages avoid combined OASDI trust-fund depletion and eliminate the 75-year actuarial shortfall (2026–2100).
- **Dynamic macro and welfare:** selected macro years through 2070.
- **Policy specifications:** taxable-maximum levels and delayed-retirement-credit limits differ between the conventional and dynamic calculations.

The seven packages have roughly the same impact on federal Treasury debt by the year 2050. Despite their similarities on paper, they have very different economic effects.

Three packages make the mechanisms visible

Package	Financing emphasis	Benefit treatment
A: Tax-only	Higher payroll rate, higher cap, and surtax	Benefit provisions unchanged
G: Balanced	Higher payroll rate and cap	Changes to benefit factors, COLAs, and the retirement-age formula
F: Benefit-only	Keeps payroll rate and cap	Larger benefit changes, phased in by eligibility year and cohort

"Retirement age" in the policy formula is not a mandate to stop working.

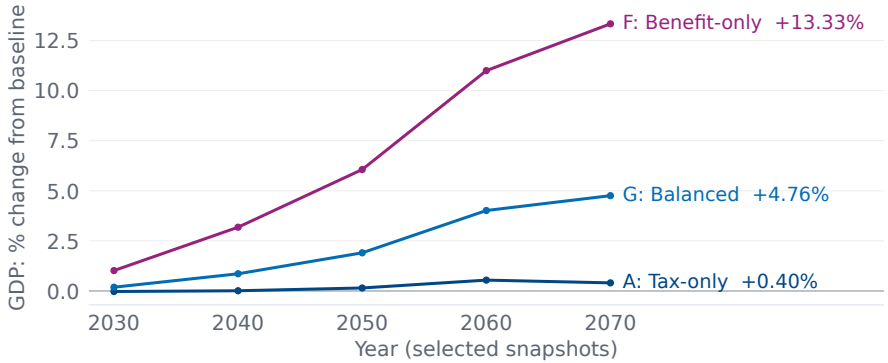
Similar financing balances, different policy choices

75-YEAR SUMMARIZED RATES (% OF BASELINE TAXABLE PAYROLL)

Package	Income	Cost	Balance
Baseline	13.64	18.42	-4.78
A: Tax-only	18.36	18.42	-0.05
G: Balanced	16.41	16.39	0.01
F: Benefit-only	13.37	13.29	0.08

These packages avoid combined OASDI depletion through 2100; that combined result assumes pooling across the funds.

The GDP effects build over decades



By 2070, GDP is 0.40% above baseline under A, 4.76% under G, and 13.33% under F.

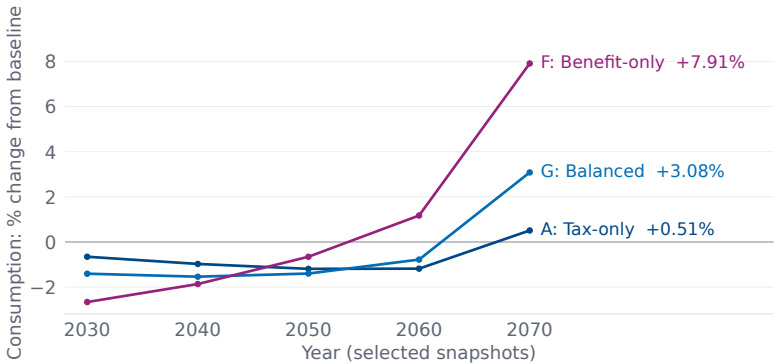
Capital accumulation is central to these results

PERCENT CHANGE FROM BASELINE IN 2070

2070 outcome	A	G	F
GDP	+0.40	+4.76	+13.33
Private capital	+1.03	+10.23	+29.35
Wages	+0.51	+4.26	+11.42
Hours worked	-0.03	+0.68	+1.90

In these simulations, the larger output gains accompany much larger capital gains and more modest changes in hours.

Higher future output comes with a consumption transition



Consumption is below baseline in 2030 and 2050 under all seven packages.

Debt reduction alone does not rank the GDP effects



By construction, each package avoids Trust Fund depletion and eliminates conventional 75-year actuarial shortfall. This figure shows that they also have a fairly similar impact on Treasury debt, even with dynamic effects. But the packages have very different impacts on economic growth because all three of these traditional measures do not comprehensively describe resource allocations across generations.

All seven packages: macroeconomic effects in 2070

PERCENT CHANGE FROM DYNAMIC BASELINE; DEBT/GDP IS PERCENT CHANGE IN THE RATIO

Package	GDP	Capital	Wages	Hours	Cons.	Debt/GDP
A	+0.40	+1.03	+0.51	-0.03	+0.51	-10.25
B	+2.30	+4.99	+2.15	+0.20	+1.79	-13.53
C	+2.55	+5.68	+2.48	+0.25	+1.80	-16.58
D	+5.86	+12.56	+5.15	+0.89	+3.72	-17.32
E	+11.92	+26.10	+10.25	+1.67	+7.36	-26.20
F	+13.33	+29.35	+11.42	+1.90	+7.91	-25.21
G	+4.76	+10.23	+4.26	+0.68	+3.08	-17.28

A: tax-only; B: tax-heavy; C: tax-leaning; D: benefit-leaning;
E: benefit-heavy; F: benefit-only; G: balanced.

Welfare asks what the entire policy path is worth

EQUIVALENT VARIATION: A MONEY MEASURE OF LIFETIME WELL-BEING

$$V_t^{\text{baseline}}(a + EV,\ \bar{s}) = V_t^{\text{policy}}(a,\ \bar{s})$$

- How much additional wealth in the baseline would make a household as well off as under the reform?
- The comparison includes consumption, leisure, future prices, and risks.
- a is wealth; $\bar{s}$ contains the other household states.
- Positive EV means a welfare gain; negative EV means a loss.

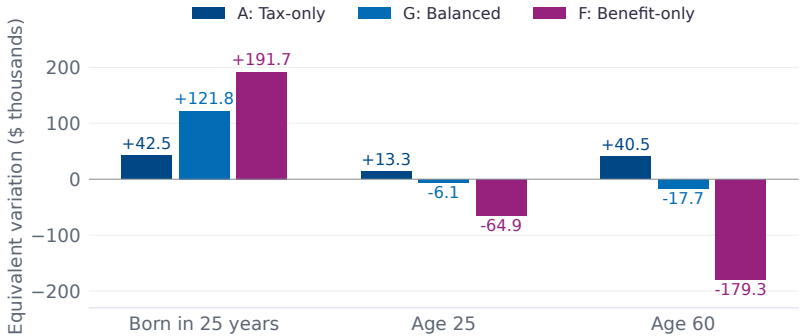
EV is a lifetime value measure. It is neither an annual benefit change nor a cash payment promised by the policy.

EV measures the full welfare change at each household state, including direct changes in taxes and transfers, equilibrium macroeconomic effects, and changes in insurance against idiosyncratic risks.

EV is calculated over the entire state space, then averaged by age and income group for presentation.

Growth gains do not benefit every generation

MIDDLE GROSS-INCOME QUINTILE WITHIN EACH AGE



Under F, the age-60 middle quintile loses about $179,000 in EV; the cohort born in 25 years gains about $192,000.

All seven packages: welfare across generations

MIDDLE WITHIN-AGE GROSS-INCOME QUINTILE; EV IN THOUSANDS OF DOLLARS

Package	Born in 25 years	Age 25	Age 60
A	+42.5	+13.3	+40.5
B	+37.0	-11.9	-29.4
C	+62.0	-6.3	-18.7
D	+162.0	-3.0	-14.8
E	+165.3	-64.2	-175.8
F	+191.7	-64.9	-179.3
G	+121.8	-6.1	-17.7

Households of the same age can face different stakes

AGE 60: EQUIVALENT VARIATION IN THOUSANDS OF DOLLARS

Package	Bottom 20%	Middle 20%	Top 20%
A: Tax-only	+32.6	+40.5	+68.9
G: Balanced	-20.2	-17.7	-31.8
F: Benefit-only	-63.2	-179.3	-300.2

Quintiles rank gross income separately within age 60.

Dollar EV measures combine the size of the exposure with the value households place on the policy change.

Read financing, growth, and welfare together

- **Financing:** the timing and composition of taxes and benefits matter.
- **Growth:** identify the path of capital, work, wages, and output.
- **Consumption:** include the adjustment years, not only a distant endpoint.
- **Welfare:** report effects across ages and income groups, including future cohorts.

A reform can improve program financing and raise long-run GDP while reducing welfare for some households alive today.

What the dynamic model makes visible

Behavior

How households respond to their changing lifetime resources and incentives.

Adjustment

How saving, production, prices, and fiscal policy evolve together.

Distribution

How policy redistributes well-being across households and generations.

The economic evaluation of Social Security reform starts with the households whose decisions and resources it changes.

Sources and the scope of this presentation

- **Core model:** PWBM OLG model and policy-simulation documentation.
- **Working paper:** Arnon, Haystead, Reichling, Sánchez Sánchez, Smetters, and Villero, *The Economic and Fiscal Impact of STEM Immigration in General Equilibrium*, July 27, 2026. PWBM Working Paper w2026-1.
- **Social Security results:** PWBM Social Security reform simulations, September 2026.
- **Presentation precedents:** May 2026 Niskanen deck and the September conventional-calculations companion.

The working paper describes an immigration application of the OLG framework. This presentation applies the framework to Social Security reform.