Economic Slowdown, Pension Generosity, and the Intergenerational Distribution of Wealth

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Abstract

When growth slows, pay-as-you-go pension budgets no longer balance. Closing the gap by raising contribution rates rather than cutting benefits reduces the net wages out of which workers save, while preserving resources that retirees partly bequeath. In an overlapping-generations model, slow growth therefore tilts wealth toward the elderly, the more so the more generous the pension system. Household data from European countries confirm these predictions. The elderly are wealthiest, and inheritances largest, where pensions are generous and growth has been slow. During the 2010–2023 slowdown, retiring cohorts accumulated wealth fastest, and workers slowest, in generous, slow-growth countries, where labor taxation cut net wages most.

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Between 2010 and 2023, as economic growth in Europe stalled, wealth shifted toward the old. The median per-adult wealth of individuals aged 70–85 rose from 1.50 to 1.74 times that of working-age adults,[1] a shift observed in other advanced economies. This tilt is most pronounced where pensions are most generous. Panel A of Figure 1 shows that countries offering higher retirement benefits, measured relative to the average wage, are also those where wealth is most concentrated among the elderly. In France and Spain, which have among the most generous pension systems in Europe, households above 70 hold 60 to 100 percent more wealth than working-age households. As the elderly accumulate wealth, gifts and inheritances become increasingly important to the economic well-being of younger generations. Panel B shows that pension generosity also predicts how much workers above age 45 have already received in gifts and inheritances.

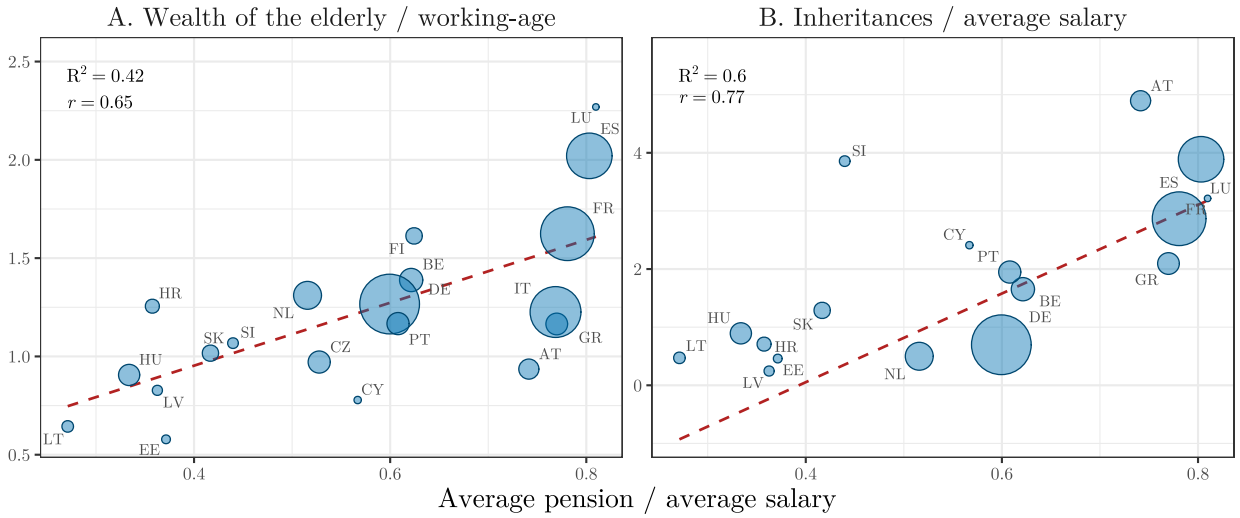


Figure 1: Pension generosity, the relative wealth of the elderly and inheritances *Notes:* HFCS, 2021 and 2023 waves pooled. Circle areas are proportional to population. The horizontal axis represents the average PAYG (unfunded) pension divided by the average gross employee income. Panel A plots the mean net wealth per adult of individuals aged 70–85 over that of the working-age population (ages 26–59). Panel B plots the gifts and inheritances received by households whose reference person is aged 45–65, revalued to survey-year prices and capitalized at a 2% annual real return from the year of receipt, divided by the country's average gross employee income. The red dashed lines are population-weighted OLS fits. Appendix B details the variable definitions.

At a time when many countries must close funding gaps in their retirement systems, these correlations raise the question of whether generous pensions contribute to the shift of the wealth

[1]Figure C.1 in Appendix C plots the population-weighted mean of the country-level ratios of median wealth by survey wave, for the fixed set of the 14 first-wave countries of the Household Finance and Consumption Survey (HFCS).

distribution towards older generations, and subsequently reinforce the role of inheritance in the transmission of wealth. If so, will the recent slowdown of economic growth in Europe strengthen the redistribution from younger to older cohorts that pension systems generate? And how does the answer depend on how the fiscal burden of the slowdown is shared between retirees and workers?

The canonical account of how wealth tilts across generations is a race between the rate of return on capital, which compounds the wealth the old set aside while they worked, and the growth of the economy, which raises the resources of the young (Piketty, 2011). By that logic, a slowdown tilts the distribution of wealth toward the old as long as the return falls by less than the growth rate. This paper adds a third runner: pension reform. When growth slows, the budget of pay-as-you-go (PAYG) systems no longer balances, and governments must close the gap by raising contribution rates or by cutting or shortening benefits. Raising contributions falls on the net wages out of which workers accumulate, and spares the benefits out of which retirees consume and bequeath. This third runner differs from the first two in one essential respect. Unlike the race between r and g, which policy barely controls, the way a pension budget is closed is chosen by voters and policymakers, and could be chosen otherwise.

This paper formalizes this argument in an overlapping-generations model with a PAYG system in which retirees derive a warm glow from bequeathing wealth to their descendants. It then tests the model's predictions on household balance sheets across European countries of the Household Finance and Consumption Survey (HFCS).

The model is in the spirit of Diamond (1965), augmented with an unfunded pension system. It is populated by two generations at a time: workers, who save to fund their old age, and retirees, who save to bequeath. The object of interest is the per-capita wealth of the old relative to the young, s^o/s^y. Economic growth is driven by exogenous technological progress and fertility. A single parameter spans the spectrum of policy responses to changes in economic growth, from balancing the budget entirely through benefits, holding the tax rate fixed, to fully insulating retirees and letting the contribution rate rise. The model delivers three predictions.

The first prediction identifies the benchmark in which the third runner plays no role. When the contribution rate is held fixed, as in the notional defined contribution (NDC) accounts adopted by Sweden and Italy, the pension system does not contribute to the rise in the relative wealth of retirees s^o/s^y, whether growth slows because fertility falls or because productivity stalls. The economic

intuition is reminiscent of the $r - g$ logic: a fixed contribution rate aligns the rate of return of a PAYG system with economic growth (Aaron, 1966), whereas raising taxes to honor promised benefits instead pays retirees a return on their contributions above realized growth. In the case of a pure productivity slowdown, the fixed contribution rate also leaves benefits unchanged relative to net wages, so retirees and workers see their income fall in the same proportion. Under this design the pension system is neutral, and market forces alone decide the race between inherited and newly minted wealth. The realistic case is partial adjustment, in which taxes rise when growth slows, as even Sweden and Italy phased NDC accounts in gradually.

Second, away from this benchmark, the race between pension reform and tax hikes comes into play. The elasticity of s^o/s^y to growth increases linearly with the elasticity of the payroll tax rate to the fall in growth — a measure of a government's propensity to raise taxes rather than adjust retirement rules. Whenever a slowdown tilts wealth toward the old, the tilt is increasing in the generosity of the system, because the fiscal forces are proportional to the size of the pension budget. This interaction between growth and generosity is the model's central testable prediction.

Third, the source of stagnation matters. Demographic and productivity slowdowns open the same budgetary gap, but only the productivity slowdown reduces the growth of wages. The two are equivalent for the share of *aggregate* wealth held by the old. A demographic slowdown, however, also thins the ranks of the young, raising their resources *per capita*, and is therefore less likely to raise s^o/s^y. The distinction is timely as Europe's demographic drag is several decades old, while Western Europe's productivity stagnation is more recent.[2]

These predictions are hard to test, because they do not lend themselves to within-country quasi-experimental variation. Both the object they concern — the distribution of wealth between overlapping cohorts — and the mechanism that drives it — the balancing of the pension budget — are national by construction. Testing them requires comparing how the wealth distribution evolves across countries with different pension systems and rates of economic growth. As an economically integrated area whose pension systems remain national, the European Union offers the most promising empirical setting.

Our empirical analysis therefore takes the model's predictions to the HFCS, a harmonized

[2]Figure B.1 in Appendix B plots log GDP per hour worked since 1950 for sixteen European countries, from the Long-Term Productivity Database of Bergeaud et al. (2016).

multi-country survey coordinated by the European Central Bank (ECB). Since 2010, the HFCS has recorded the earnings, pension benefits and balance sheets of households in fourteen to twenty European countries that differ widely both in pension generosity and in productivity growth over the past generation. A key advantage of the survey is that these countries share a relatively integrated capital market, so that returns on wealth are broadly common across them while growth and pension generosity are not.

Our analysis focuses on changes in the wealth distribution over the HFCS sample period (2010–2023), which coincides with sluggish productivity growth in most of Europe. We first compare households at the same age and position in the income distribution in the pooled 2010–2014 and 2021–2023 waves, scaling wealth by the national average wage. We measure pension generosity across the income distribution by comparing retirement benefits, restated to their value at award, with the earnings of workers in the same decile, and account for the extent to which pension rules link benefits to wages. In countries with generous pensions and slow productivity growth, working-age households hold less wealth relative to wages than earlier cohorts did at the same age, while retirees hold more. At higher productivity growth, this steepening of the age profile largely disappears.

We then follow birth cohorts across survey waves to examine the wealth accumulation underlying this shift. Decile × cohort fixed effects allow us to compare, across countries, the pace at which retirees at similar positions in the income distribution accumulate wealth. We find that retirees accumulate wealth faster, relative to the rest of the population, when they receive higher pensions, and that this effect is stronger where productivity growth has been slower: it is about twice as large when productivity grows at 1% rather than 2%. Consistent with the model, this amplification is concentrated in countries whose pension benefits are less closely linked to wages.

The most challenging test of the model extends this analysis to working-age cohorts. In line with the model's predictions, we find the opposite pattern below retirement age. Working-age households accumulate wealth more slowly in countries with more generous pension systems, an effect amplified by lower productivity growth. To explain the patterns in the data, a confounder would therefore also have to generate a reversal in the signs of the coefficients around the transition to retirement. The same pattern emerges when we scale each cohort's wealth by the average wage instead of the country's average wealth and exclude gifts and inheritances received during the

sample period.

One endogeneity concern is that governments that favor retirees might also support house prices. In the data, however, the geography runs the other way: house prices stagnated in the generous, slow-growth countries and boomed in the fast-growing East, while controlling for national house-price trends only strengthens the finding. The result is also robust to including indicators for countries in the former Soviet bloc or those at the center of the European sovereign debt crisis.

Why should the interaction of high pensions and low growth lead workers to accumulate wealth more slowly? In the logic of the model, a slowdown opens a larger funding gap in more generous pension systems and therefore implies a larger increase in taxes on labor when benefits do not adjust. To document this mechanism, we first show that the decline in economic growth over recent decades, interacted with pension generosity and the extent to which benefits are insulated from wage growth, predicts both the rise in the overall tax wedge on wages and the increase implied by pension-budget balancing. Both measures predict slower wealth accumulation among working-age households, net of their own wage growth. We then instrument the realized rise in the tax wedge with the wedge change that the pension budget predicts from the composition of employment across industries in 1995, a Bartik-style approach, scaled by the share of the funding gap that the indexation rules in force in 1995 pass on to contributions. The instrumented estimates are larger than their least-squares counterparts and remain similar when we control for initial income per capita or use industry growth rates that predate the estimation window. The estimated effect disappears among retirees, providing a natural placebo test of the mechanism. Finally, excluding received inheritances increases the estimated burden on workers by a quarter to a third, consistent with the model's prediction that they recover part of their taxes through larger inheritances.

Contribution to the literature. This paper contributes to the literatures on pension systems, saving, and inheritance. The importance of inheritances in the economy is well documented (Kotlikoff and Summers, 1981), as is their rise over recent decades (Alvaredo et al., 2017). Two forces have traditionally featured prominently in explanations of this rise. The first is the race between the rate of return on capital, which compounds the value of existing wealth, and economic growth, which dilutes its importance relative to newly created resources (Piketty, 2011). The second is households' propensity to bequeath wealth at death. A substantial share of the population appears

to have an operative bequest motive, even among households without children (Kopczuk and Lupton, 2007), consistent with a warm-glow motive. Moreover, the propensity to bequeath rises with wealth, suggesting that this warm glow behaves as a luxury good (De Nardi, 2004).

Our first contribution is to bring these strands together in a unified model in which the race between r and g is complemented by government transfers across generations. The idea that retirees may ultimately bequeath part of their pension benefits arises naturally under Ricardian equivalence in models with dynastic altruism (Barro, 1974) and is supported by causal empirical evidence (Lee and Tan, 2023). Our model uses this insight to study how the fiscal adjustment required to close pension-system funding gaps can amplify the effect of slower economic growth on the importance of inherited wealth.

A key implication is that this amplification depends on how the pension budget is balanced: by reducing benefits or by raising taxes on workers. In this respect, the paper also contributes to the literature on intergenerational risk sharing in unfunded pension systems (Auerbach and Lee, 2011). Whereas that literature primarily evaluates the welfare consequences of alternative risk-sharing rules, our focus is positive: we use those rules to explain an empirical phenomenon, the rising concentration of wealth among the elderly.

Our work also belongs to the long literature studying how pension systems affect private wealth accumulation, dating back to the debate between Feldstein (1974) and Barro (1974). Much of this literature focuses on displacement: households may accumulate less private wealth because they expect to receive Social Security benefits in retirement (Alessie et al., 2013; Attanasio and Brugiavini, 2003; Attanasio and Rohwedder, 2003; Gale, 1998; Lachowska and Myck, 2018). Our analysis differs along two dimensions. First, rather than the level of aggregate private saving, we study the *distribution* of wealth across overlapping generations.[3] Second, we study how changes in the pace of economic growth shift this distribution through the endogenous fiscal adjustment of the pension system.

The rise in elderly wealth is not unique to Europe and is also observed in the United States (Bauluz and Meyer, 2024). Existing research has emphasized the role of rising asset prices in explaining this trend (Catherine et al., 2025b; Fagereng et al., 2025; Greenwald et al., 2021). This

[3] Feldstein (1976), Sabelhaus and Volz (2022) and Catherine et al. (2025a) study how Social Security mitigates wealth inequality.

mechanism differs from the conventional r versus g logic. When the discount rate r falls, the valuation of the existing stock of assets, disproportionately held by older households, *rises*, making those assets more expensive for younger households to acquire. The pension channel we study complements this mechanism. When interest rates and economic growth decline together, younger households may face a pincer movement: the assets they seek to acquire become more expensive, even if financing costs fall, while taxes on labor rise to finance pension promises made under faster-growth conditions.

Our findings further complement the literature studying how *demographic* change affects aggregate saving and equilibrium returns in quantitative models (Abel, 2003; Attanasio et al., 2007; Auclert et al., 2025; Krueger and Ludwig, 2007). We emphasize that a slowdown in *productivity* growth can generate a distinct but related force through the pension system. Rather than focusing primarily on general-equilibrium movements in saving and returns, we provide direct empirical evidence on the fiscal channel through which slower growth changes the distribution of wealth across generations and, ultimately, the importance of inheritance.

The shift of the wealth distribution towards the old has important implications for social dynamics within families. Young adults with higher parental wealth enjoy protection against labor income risk (Boar, 2021; Fagereng et al., 2026), can become homeowners sooner (Benetton et al., 2024), take up higher-status but lower-paying jobs (Boar and Lashkari, 2025) and, in some countries, enjoy better marriage prospects (Wei and Zhang, 2011). Receiving an inheritance also helps people retire sooner (Bø et al., 2019; Brown et al., 2010).

Finally, our results connect to the political economy literature on the provision and design of pension systems (Boldrin and Rustichini, 2000; Browning, 1975; Cooley and Soares, 1999; Mulligan and Sala-i Martin, 1999); Galasso and Profeta (2002) provide a review. That literature studies how political forces determine the scale and structure of intergenerational transfers. We show that these political choices also shape the distributional consequences of economic slowdowns: whether a pension funding gap is closed through lower benefits or higher taxes is central to whether slower growth translates into a larger concentration of wealth among the elderly.

1 Model

We study a closed, two-period overlapping-generations economy in the tradition of Diamond (1965). Time is discrete and a period is a generation — thirty years in the calibration. Each generation lives for two periods: young, it supplies one unit of labor, pays the pension contribution, receives a bequest, consumes, and saves in capital; old, it collects the return on its savings and a pay-as-you-go pension, consumes, and leaves a bequest to its descendant.

1.1 Agents and environment

Population, technology and factor prices Each household has $1 + g_n$ descendants, so the cohort born at t has a population $N_t = (1+g_n)\, N_{t-1}$. A representative firm produces with a Cobb–Douglas technology in capital K_t and labor — each young household supplies one unit — with productivity A_t:

$$Y_t = K_t^{\alpha}\,(A_t N_t)^{1-\alpha}, \qquad \alpha \in (0,1), \tag{1}$$

where productivity grows at the constant rate g_a: $A_t = (1 + g_a)\, A_{t-1}$. On a balanced path, output and aggregate earnings grow at the total growth rate $g \equiv (1+g_a)(1+g_n) - 1$. Because a generation is long, we let capital fully depreciate within the period. Competitive markets pay each factor its marginal product:

$$1 + r_t = \alpha\, K_t^{\alpha-1}(A_t N_t)^{1-\alpha}, \qquad w_t = (1-\alpha)\,\frac{Y_t}{N_t}, \qquad \Pi_t \equiv (1+r_t)\,K_t = \alpha\, Y_t, \tag{2}$$

with w_t the wage of a young household's unit of labor. The aggregate wage bill $W_t \equiv w_t N_t = (1-\alpha)\, Y_t$ grows at the total rate g along the balanced path and will serve as the natural deflator for balanced-growth ratios. Competitive forces split output between aggregate profits Π_t and W_t, and their ratio is a constant $\Pi_t / W_t = \alpha/(1-\alpha)$ of the technology.

The pension system The public pension system is unfunded. Period by period, the contributions of the young pay the benefits of the old. Benefits b_t are tied to the retiree's own past earnings through the replacement rate $\rho_t \in (0,1)$, and the budget equates the contributions of the workers

to the benefits of the retirees:

$$\underbrace{b_t = \rho_t\, w_{t-1}}_{\text{benefits rule}}, \qquad \underbrace{\tau_t\, W_t = \rho_t\, W_{t-1}}_{\text{budget constraint}}, \quad \Longrightarrow \quad \tau_t = \frac{\rho_t}{1+g}. \tag{3}$$

On a balanced growth path the replacement rate and the contribution rate are both constant, and linked by the growth rate of the economy g.

Households Each household born at t derives utility from its consumption when young and old, and a warm glow from the *bequest* it leaves to its descendant:

$$V_t = u(c_t^y) + \beta\big[u(c_{t+1}^o) + \varphi\, u(s_{t+1}^o)\big], \qquad u(c) = \frac{c^{1-\gamma}}{1-\gamma}, \qquad \gamma > 0,\ \varphi > 0, \tag{4}$$

where β is the discount factor, φ the weight on the gift, and γ the coefficient of relative risk aversion.

When young, each household of this cohort receives its share $s_t^o/(1+g_n)$ of the estate $s_t^o \geq 0$ left by its predecessor, earns after-tax labor income $(1-\tau_t)\, w_t$, consumes c_t^y, and saves the rest, s_t^y, in capital:

$$c_t^y + s_t^y = (1-\tau_t)\, w_t + \frac{s_t^o}{1+g_n}. \tag{5}$$

When old, it holds gross assets $(1+r_{t+1})\, s_t^y$ and collects its pension b_{t+1}. These resources, denoted j_{t+1}^o, are divided between consumption and a bequest to its own descendant:

$$c_{t+1}^o + s_{t+1}^o = \underbrace{(1+r_{t+1})\, s_t^y + b_{t+1}}_{\equiv\ j_{t+1}^o}. \qquad s_{t+1}^o \geq 0, \tag{6}$$

The household chooses $\{c_t^y, s_t^y, c_{t+1}^o, s_{t+1}^o\}$ to maximize (4) subject to (5)–(6). Each generation splits its own consumption between the two periods of the life cycle to equalize the marginal utility of each dollar of present value:

$$(c_t^y)^{-\gamma} = \beta\,(1+r_{t+1})\,(c_{t+1}^o)^{-\gamma}. \tag{7}$$

In retirement, the division of its resources between its own consumption and the gift is a static prob-

lem: the marginal utility of consuming must equal the marginal warm glow, $(c^o_{t+1})^{-\gamma} = \varphi\,(s^o_{t+1})^{-\gamma}$, so the old bequeath a fixed share of their resources and consume the rest:

$$s^o_{t+1} = \Phi\, j^o_{t+1}, \qquad c^o_{t+1} = (1-\Phi)\, j^o_{t+1}, \qquad \Phi \equiv \frac{\varphi^{1/\gamma}}{1+\varphi^{1/\gamma}} \in (0,1). \tag{8}$$

1.2 Equilibrium

The balanced growth path On the balanced growth path every aggregate grows at the pace of the economy g. We therefore solve the model in cohort aggregates. Denote $C^y_t \equiv N_t\, c^y_t$ and $S^y_t \equiv N_t\, s^y_t$ for the consumption and saving of the young cohort, and $C^o_t \equiv N_{t-1}\, c^o_t$ and $S^o_t \equiv N_{t-1}\, s^o_t$ for the old. Scaling by the contemporaneous aggregate payroll W_t then removes the trend. For any aggregate X_t, let $\hat{X} \equiv X_t/W_t$ and define

$$\Lambda \equiv \frac{W_{t+1}/(1+r)}{W_t} = \frac{1+g}{1+r}, \tag{9}$$

the market value today of a claim on the next generation's earnings, per unit of current payroll.

Resources in old age. The capital stock is the saving of the young cohort, $K_{t+1} = S^y_t$. Since capital fully depreciates within a generation, buying the capital stock is buying its payout Π_{t+1}, worth $\hat{\Pi}$ units of the earnings of the generation working then, or equivalently $\Lambda\hat{\Pi}$ today:

$$\hat{S}^y = \Lambda\,\hat{\Pi} = \frac{1+g}{1+r}\frac{\alpha}{1-\alpha}. \tag{10}$$

One period later, these savings, grossed up by the return on capital and combined with the taxes paid by the next generation, constitute the resources of the old cohort $\hat{J}^o \equiv \hat{\Pi} + \tau$, determined by the technology parameter α and the share of wages τ allocated to pensions. As previously discussed, a share $1-\Phi$ is consumed and a share Φ is passed on:

$$\hat{C}^{\,o} = (1-\Phi)\,(\hat{\Pi}+\tau), \qquad \hat{S}^o = \Phi\,(\hat{\Pi}+\tau). \tag{11}$$

Equilibrium condition. The resource constraint is $C_t^y + C_t^o + K_{t+1} = Y_t$. Noting that $Y_t = W_t/(1-\alpha)$, the constraint can be expressed per unit of the payroll:

$$\hat{C}^y + \hat{C}^o + \hat{S}^y = \frac{1}{1-\alpha}, \tag{12}$$

and combined with (10)–(11), delivers the young's consumption:

$$\hat{C}^y = \frac{1}{1-\alpha} - (1-\Phi)\,(\hat{\Pi} + \tau) - \Lambda\,\hat{\Pi}. \tag{13}$$

The life-cycle Euler equation (7) pins down the return households require to accept this consumption path. Since the young cohort of period t and the old cohort of period $t+1$ are the same N_t households, the slope of the lifetime consumption profile equals the ratio of the cohort aggregates, $c_{t+1}^o/c_t^y = C_{t+1}^o/C_t^y = (1+g)\,\hat{C}^o/\hat{C}^y$, where the factor $1+g$ appears because the two aggregates are scaled by payrolls one period apart. Substituting this slope into (7) gives the required return:

$$1 + r = \frac{1}{\beta}\left[(1+g)\,\frac{\hat{C}^o}{\hat{C}^y}\right]^{\gamma}. \tag{14}$$

The saving of the young must therefore satisfy two conditions at once: it is the present value of the profits the capital stock will pay, (10), and it is an amount households are willing to defer at the return (14). Substituting (11)–(13) into the pair collapses the system to one equation in the single unknown Λ:

$$(1-\Phi)\,(\hat{\Pi} + \tau)\,(1+g) = \left[\frac{\beta\,(1+g)}{\Lambda}\right]^{1/\gamma}\left[\frac{1}{1-\alpha} - (1-\Phi)\,(\hat{\Pi} + \tau) - \Lambda\,\hat{\Pi}\right]. \tag{15}$$

The left side does not depend on Λ while the right side is strictly monotonic in it from $+\infty$ to zero on the admissible range — the interval of candidate values of Λ for which the young's consumption (13) is positive. The balanced growth path exists and is unique, with no restriction on the primitives. In particular, at log utility the fixed point is closed form:

$$\gamma = 1: \qquad \Lambda = \frac{\beta\left[\dfrac{1}{1-\alpha} - (1-\Phi)\,(\hat{\Pi} + \tau)\right]}{(1-\Phi)\,(\hat{\Pi} + \tau) + \beta\,\hat{\Pi}}. \tag{16}$$

Capital intensity and the wage path. Given the equilibrium Λ, the firm's first-order condition (2) pins capital per efficiency unit of labor and hence the wage,

$$\tilde{k} \equiv \frac{K_t}{A_t N_t} = \left(\frac{\alpha \Lambda}{1+g} \right)^{\frac{1}{1-\alpha}}, \qquad w_t = (1-\alpha)\, \tilde{k}^{\alpha} A_t, \tag{17}$$

so the wage grows at the productivity rate g_a along the path — but its *level* now moves with anything that moves Λ, the pension included.

1.3 Generational distribution of wealth

At any date two generations hold the economy's wealth: the old, whose resources end as consumption and an estate, and the young, whose saving is the capital stock. The model's measure of the balance between them is the estate-to-saving ratio s^o/s^y — the estate of an old household relative to the saving of a young one, the ratio of means that the survey data measure directly. This is where the composition of growth re-enters: the two cohorts differ in size, so converting the scaled aggregates into per-head quantities brings in their relative mass. The estate per old household is $s^o_t = S^o_t/N_{t-1}$ and the saving per young household $s^y_t = S^y_t/N_t$, so $s^o/s^y = (N_t/N_{t-1})\, \hat{S}^o/\hat{S}^y = (1+g_n)\, \hat{S}^o/\hat{S}^y$, and (11)–(10) deliver it in closed form:

$$\frac{s^o}{s^y} = (1+g_n)\, \frac{\Phi(\hat{\Pi}+\tau)}{\Lambda\, \hat{\Pi}} = \Phi\, \frac{1+r}{1+g_a} \left[1 + \frac{1-\alpha}{\alpha}\, \tau \right]. \tag{18}$$

The numerator is the propensity to bequeath Φ multiplied by retirement resources that technology and the pension budget pin. The denominator is the present value of the profits the next capital stock will pay.

2 Theoretical predictions

In this economy, an economic slowdown can tilt wealth toward the older cohort through two channels. First, wealth is redistributed toward the old when the equilibrium return falls by less than growth, widening the $r - g$ gap. Second, wealth concentrates among the old when the pension system's budget gap is closed by raising payroll taxes. Proofs for the propositions in this section

can be found in Appendix A.4

2.1 Spectrum of pension adjustment rules

In a PAYG system, a lower g implies either a reduction in the replacement rate, a rise in the tax rate, or a combination of the two to balance the budget. We span the possibilities with a single parameter $\theta \in [0, 1]$,

$$\rho(g) = \rho_0 \left(\frac{1+g}{1+g_0} \right)^{\theta}, \qquad \tau(g) = \frac{\rho(g)}{1+g} = \tau_0 \left(\frac{1+g}{1+g_0} \right)^{-(1-\theta)}, \tag{19}$$

where (g_0, ρ_0, τ_0) describes the path for which the system was designed, and g the total growth the economy actually delivers; and θ and $-(1-\theta)$ are the elasticities of benefits and taxes to growth:

$$d \ln \rho = \theta \, d \ln(1+g), \qquad d \ln \tau = -(1-\theta) \, d \ln(1+g). \tag{20}$$

The polar cases are the fixed-replacement-rate and fixed-contribution-rate rules of Musgrave (1981); θ interpolates between them. At $\theta = 0$, the system holds the *replacement rate fixed*: retirees are insulated and a slowdown raises the contribution rate one-for-one in logs. At $\theta = 1$, it holds the *contribution rate fixed*: the tax rate never moves and the replacement rate falls with total growth — each participant remains exposed to the growth rate of aggregate earnings.

More generally, θ captures a government's ability to keep the internal rate of return of the pension system aligned with economic growth, by reducing benefits or raising the retirement age rather than shifting the burden onto later generations. Although many advanced economies have introduced automatic adjustment rules in recent decades, the experience of the past forty years does not support treating θ as a fixed characteristic of any given country and the division of the budgetary adjustment has often been the product of ad hoc policy choices.

2.2 The response of estates and savings to declining total growth

To analyze how a slowdown affects the relative wealth of the elderly, we examine two components in turn: how the scaled estate of the old $\hat{S}^o$ depends on growth, and how the scaled saving of the young $\hat{S}^y$ does.

2.2.1 Estate

The scaled estate (11) is a preference share of old-age resources $\hat{\Pi} + \tau$, so growth reaches it only through the contribution rate:

$$\frac{d \ln \hat{S}^o}{d \ln(1+g)} = -(1-\theta)\frac{\tau}{\hat{\Pi} + \tau}\,. \tag{21}$$

The elasticity is the product of the share of benefits in the old's resources, $\tau/(\hat{\Pi} + \tau)$, and the fraction $1 - \theta$ of the budgetary adjustment borne by contributions. Under a fixed replacement rate ($\theta = 0$), the benefit bill relative to contemporaneous aggregate earnings ($\tau = N_{t-1}b_t/W_t$) rises when total growth falls, which raises the estate in proportion to the retirees' marginal propensity to bequeath, Φ. At the opposite end of the spectrum ($\theta = 1$), the budget is balanced by letting the replacement rate fall. In this case, benefits relative to contemporaneous earnings, and with them the scaled estate, do not move.

2.2.2 Savings of the young

Under a fixed contribution rate ($\theta = 1$). For the capital market to clear, the savings of the young must equal the present value of profits. Holding the discount rate r fixed, a one percent increase in $1 + g$ raises that present value by one percent, and with it the required savings of the young.

At the same time, households require a higher rate of return to postpone consumption when the economy grows faster. Per equation (14), assuming for a moment that the consumption ratio $\hat{C}^o/\hat{C}^y$ stays put, a one percent increase in $1 + g$ raises the equilibrium gross return by γ percent. The net effect on the present value of future profits is $1 - \gamma$ percent.

As their present value must be met by the savings of the young, the consumption ratio $\hat{C}^o/\hat{C}^y$ does not, in fact, quite stay put. The extra saving must come out of the young's consumption: $d\hat{C}^y = -\hat{\Pi}\, d\Lambda$ by (13). With a lower $\hat{C}^y$ the consumption path is steeper still, and the required return (14) rises a little further, reducing the value of future profits. Solving for the fixed point:

$$\left.\frac{d \ln \hat{S}^y}{d \ln(1+g)}\right|_{\theta=1} = \frac{1-\gamma}{D}, \qquad D \equiv 1 + \gamma\,\frac{\hat{S}^y}{\hat{C}^y} > 1. \tag{22}$$

The feedback D dampens the direct effect but never reverses it. A slowdown raises the young's

scaled saving if $\gamma > 1$, lowers it if $\gamma < 1$, and leaves it unchanged at log utility.

When the tax rate changes ($\theta < 1$). When the level of pensions does not fully adjust to the new pace of total growth, taxes must increase to balance the budget. Each additional contribution euro is transferred to the old, who consume $1 - \Phi$ of it and return the rest through the estate.

The old's consumption therefore rises by $1 - \Phi$ per euro and the young's resources fall by the same amount, steepening the slope of the lifetime consumption path $\hat{C}^o/\hat{C}^y$. Before the young's saving responds, the tilt per euro of contributions is

$$\Psi \equiv \left.\frac{\partial \ln\left(\hat{C}^o/\hat{C}^y\right)}{\partial \tau}\right|_{\hat{S}^y} = (1-\Phi)\left(\frac{1}{\hat{C}^o} + \frac{1}{\hat{C}^y}\right). \tag{23}$$

To accept a steeper consumption plan, households require a higher return (14) and the same feedback loop D as before dampens the effect on their savings:

$$\frac{\partial \ln \hat{S}^y}{\partial \tau} = -\frac{\gamma\,\Psi}{D} < 0. \tag{24}$$

Combining the growth channel and its amplification by the fiscal adjustment (20) gives the total response:

$$\frac{d \ln \hat{S}^y}{d \ln(1+g)} = \underbrace{\frac{1-\gamma}{D}}_{\text{growth channel}} + \underbrace{\frac{(1-\theta)\,\gamma\,\tau\,\Psi}{D}}_{\text{fiscal amplification}}. \tag{25}$$

2.3 Trends in the relative wealth of the elderly

The estate and saving responses (21) and (25) combine into a single statistic — the response of the young's scaled saving net of the scaled estate's, signed so that a positive R tilts wealth toward the old:

$$R \equiv \frac{(1-\theta)\,\tau}{\hat{\Pi} + \tau} + \frac{1-\gamma}{D} + \frac{(1-\theta)\,\gamma\,\tau\,\Psi}{D}, \tag{26}$$

which either source of growth reaches only through g. The three terms are the two fiscal forces and the race: the gross-up of the estate and the crowding out of the young's saving, both proportional to $(1-\theta)\,\tau$, and the race term $(1-\gamma)/D$, positive exactly when the equilibrium return falls less than one-for-one with growth. The wealth ratio (18) adds the cohort factor $1 + g_n$, which responds

to a demographic slowdown and not to a productivity one, so the two compositions part ways at exactly this step.

Proposition 1 (Productivity versus demographic slowdowns). *Whatever the design θ, the generosity of the system, and the curvature γ, a demographic slowdown moves the per-capita wealth ratio by exactly one log point per log point of growth less than an equal-sized productivity slowdown:*

$$-\frac{d\ln(s^o/s^y)}{d\ln(1+g_a)} = R, \qquad -\frac{d\ln(s^o/s^y)}{d\ln(1+g_n)} = R-1\,. \tag{27}$$

On a balanced growth path, cohort-level aggregate statistics grow at the same rate as the economy, including the budget constraint of the PAYG system. However, unlike productivity gains, fertility growth dilutes the aggregate wealth of each subsequent generation on a per capita basis.

We measure the relative income of the elderly by the pension of a retiree relative to the net wage of a contemporaneous worker. By the benefits rule $b_t = \rho_t\, w_{t-1}$ and the growth of the wage at the productivity rate along a balanced path,

$$\frac{b_t}{(1-\tau_t)\,w_t} = \frac{\rho_t}{(1+g_a)\,(1-\tau_t)}\,. \tag{28}$$

Consider a slowdown in which productivity growth and fertility both change, $d\ln(1+g_a) \le 0$ and $d\ln(1+g_n) \le 0$, so that total growth falls by $d\ln(1+g) = d\ln(1+g_a) + d\ln(1+g_n) < 0$, and the budget is balanced along the rule (20).

Proposition 2 (Effect of pension balancing on the relative income of the elderly).

The ratio of pensions to net wages responds to the slowdown by

$$d\ln\frac{b_t}{(1-\tau_t)\,w_t} = \frac{\theta-\theta^*}{1-\tau}\,d\ln(1+g), \quad \theta^* \equiv \frac{d\ln(1+g_a)+\tau\,d\ln(1+g_n)}{d\ln(1+g_a)+d\ln(1+g_n)}\,. \tag{29}$$

It is unchanged if and only if $\theta = \theta^*$, rises if $\theta < \theta^*$, and falls if $\theta > \theta^*$. The neutral rule θ^* is the average of 1 and τ weighted by the shares of productivity and fertility in the slowdown: $\theta^* = 1$ for a pure productivity slowdown and $\theta^* = \tau$ for a pure demographic one.

The wealth ratio (18) responds to the contribution rate, at a given growth rate, by

$$\kappa \equiv \frac{\partial \ln(s^o/s^y)}{\partial \tau} = \frac{1}{\hat{\Pi} + \tau} + \frac{\gamma \Psi}{D} > 0, \tag{30}$$

the gross-up of the estate and the crowding out of the young's saving (24). By Proposition 1, the wealth ratio responds to the slowdown by

$$d \ln \frac{s^o}{s^y} = \underbrace{-(1-\theta)\,\tau\kappa\, d\ln(1+g)}_{\text{fiscal channel}} \underbrace{-\frac{1-\gamma}{D}\, d\ln(1+g)}_{r-g \text{ race}} + \underbrace{d\ln(1+g_n)}_{\text{cohort factor}}, \tag{31}$$

where only the first term depends on the pension system: the race between the return and growth is the same under every rule, and the cohort factor is the demographic dilution of Proposition 1.

Proposition 3 (Effect of pension balancing on the relative wealth of the elderly).

(a) The fiscal channel tilts wealth toward the elderly if and only if $\theta < 1$.

(b) The response of the wealth ratio to a slowdown of either composition is affine in the elasticity of the tax rate to the fall in growth, $1 - \theta = -d\ln\tau / d\ln(1+g)$*, with slope* $\tau\kappa$*: the fiscal channel is* κ *times the tax increase, itself proportional to the fall in growth and to the generosity of the system, while the race term and the cohort factor do not depend on the rule. The slope* $\tau\kappa$ *is strictly increasing in the replacement rate at every curvature* $\gamma > 0$ *and bequest share* $\Phi \in (0,1)$.

Since $\theta^* \leq 1$, keeping the budget adjustment from tilting wealth toward the elderly requires retirees to absorb a larger share of the funding gap than the share preserving their relative income, except when the slowdown is purely a productivity one and the two rules coincide at $\theta^* = 1$.

The intuition parallels the race between r and g. Just as the relative wealth of the old depends on whether the return on capital outruns economic growth, it depends on whether the return past pension contributions outruns the realized growth of the payroll that funds it. Along a balanced path the two are equal (Aaron, 1966), an equality that fixed contribution rate ($\theta = 1$) preserves through the slowdown. On the other hand, any rule that partially shields retirees ($\theta < 1$) lets pensions grow faster than the payroll, and retirees earn a return on contributions above the new

growth rate. As reflected in Proposition 3(b), the importance of this mechanism is proportional to the size of the pension system.

The race term of (31) also depends on the generosity of the system, through the feedback D, so extending the generosity gradient to the whole response of the wealth ratio requires two mild assumptions.

Corollary 1 (Role of pension generosity). *Assume $\gamma \geq 1 - \Phi$ and $\rho \leq \hat{\Pi}(1+g)$. Whenever a slowdown of either composition raises the relative wealth of the elderly, the rise is strictly increasing in the replacement rate, so that the gradient of Proposition 3(b) extends from the fiscal channel to the whole response: for every rule $\theta \in [0,1]$, comparing economies at a common initial growth rate,*

$$R > 0 \qquad \Longrightarrow \qquad \frac{\partial R}{\partial \rho} = \frac{\partial (R-1)}{\partial \rho} > 0. \tag{32}$$

For $1 - \Phi \leq \gamma \leq 1$ the conclusion holds whether or not the slowdown raises relative wealth, except at $\gamma = 1$, $\theta = 1$, where the fiscal channel and the race term both vanish and the derivative is zero.

The two assumptions are mild. The first, $\gamma \geq 1-\Phi$, asks that curvature exceed the share of their resources that the old consume; it guarantees that a more generous pension, by crowding out the young, sharpens the feedback ($\partial D/\partial \tau < 0$). The second, $\rho \leq \hat{\Pi}(1+g)$ — equivalently $\tau \leq \hat{\Pi}$ — caps benefits at the payout to capital and is needed only for $\gamma > 1$. In terms of observables, it implies that pay-as-you-go outlays may not exceed the capital share of GDP. Across the OECD, public pension spending runs 5 to 16 percent of GDP against a gross capital share of 35 to 40 percent, so the condition holds with room to spare.

Proposition 4 (Conditions under which a slowdown raises the relative wealth of the elderly). *Across balanced-growth paths, a permanent fall in productivity growth g_a raises the wealth ratio s^o/s^y if and only if $R > 0$, i.e.*

$$\underbrace{\frac{(1-\theta)\,\tau}{\hat{\Pi}+\tau}}_{\substack{\text{gross-up of scaled} \\ \text{estate } \hat{S}^o\ (>0)}} + \underbrace{\frac{(1-\theta)\,\gamma\,\tau\,\Psi}{D}}_{\substack{\text{fiscal crowd-out of} \\ \text{young saving } \hat{S}^y\ (>0)}} > \underbrace{\frac{\gamma-1}{D}}_{\substack{\text{race term: deepening} \\ \text{of young saving } \hat{S}^y\ (\gtrless 0)}}, \tag{33}$$

that is, if and only if the two fiscal forces on the left — the gross-up of the estate and the crowding out of the young's saving, both proportional to $(1-\theta)\,\tau$ *— outweigh the race term on the right, the deepening response of the young's saving to the slowdown itself* (22)*, which favors the old only when the return falls less than one-for-one with growth. A permanent fall in demographic growth* g_n *raises* s^o/s^y *if and only if the same forces clear the higher threshold* $R > 1$*: they must beat not only the deepening force but the cohort arithmetic. In particular:*

- *under a fixed contribution rate (*$\theta = 1$*), a productivity slowdown raises the ratio if and only if* $\gamma < 1$*; a demographic slowdown never does, since* $R = (1-\gamma)/D < 1$ *for every* $\gamma > 0$*;*
- *under a fixed replacement rate (*$\theta = 0$*), for a productivity slowdown every curvature* $\gamma \leq 1$ *qualifies, and curvatures above one qualify as long as the fiscal and crowding-out forces outweigh the deepening force; a demographic slowdown requires the strictly stronger condition* $R > 1$ *at every curvature.*

2.4 Simulations

The propositions compare balanced growth paths; we now trace the full perfect-foresight transition between them, for each composition of the slowdown in turn. In the *productivity* experiment, annual productivity growth g_a falls unexpectedly and permanently from 2 to 1 percent between generations 0 and 1, with demographic growth at zero throughout. In the *demographic* experiment, the total fertility rate falls from 2 to 1.5 over the same dates — the cohort factor $1 + g_n$ drops from 1 to 0.75 — while productivity growth is unchanged. In both, generation 0 worked and saved under the old expectation, so its realized return and benefit come as a surprise, and every later generation sees the slow path coming.

2.4.1 Calibration

A generation lasts 30 years. The gross capital share is $\alpha = 0.40$ and the discount factor compounds an annual 0.98, so $\beta = 0.98^{30} \approx 0.545$. We set relative risk aversion to $\gamma = 1$, which shuts down the traditional $r - g$ race, to isolate the pension channels. The warm-glow weight $\varphi = 0.5$ implies the old bequest $\Phi = 1/3$ of their old-age resources. On the initial path productivity grows at 2 percent a year and the total fertility rate is 2, so cohorts do not grow ($g_n = 0$). The replacement

rate is $\rho = 0.56$, the average of the Eurostat aggregate replacement ratio across the countries of our sample at the end of the period (2023). These choices imply, on the initial balanced path, a contribution rate of $\tau = \rho/(1+g) = 0.309$ of earnings, saving of the young of $\hat{S}^y = 0.364$ per unit of earnings, an annual interest rate of 4.1 percent — comfortably above total growth, so the economy is dynamically efficient and participation is a burden — and an estate-to-saving ratio of $s^o/s^y = 0.89$: the old begin with slightly less wealth than the young.

The two choices least disciplined by outside evidence are the curvature γ and the warm-glow weight φ, which by Proposition 4 decide whether a productivity slowdown tilts wealth toward the elderly. Figure A.1 in Appendix A.5 maps the response R over the plane of the intertemporal elasticity of substitution $1/\gamma$ and the bequest share Φ, one panel per generosity level: a productivity slowdown tilts wealth toward the elderly ($R > 0$) in most of the parameter space, and the relative wealth of the elderly declines only where the elasticity of substitution is particularly low and the pension system small, so that the return falls sufficiently more than growth.

2.4.2 Productivity slowdown

Fixed replacement rate across generosity levels. Panel A of Figure 2 shows the transition under the fixed-replacement-rate rule ($\theta = 0$) for $\rho \in \{0.3,\ 0.56,\ 0.7\}$. With retirees insulated, the whole budgetary adjustment falls on the contribution rate and benefits increase relative to after-tax wages.

The estate-to-saving ratio rises by 17 log points within a generation and by 24 across balanced growth paths for $\rho = 0.56$, which is in the ballpark of recent empirical trends of roughly 1% per year. Quantitatively, the mechanism is therefore a plausible explanation for a meaningful part of the rise in the elderly share of wealth.

The interest-rate panel shows the non-neutrality at work twice. On impact, the return realized by generation 0 falls by about 0.6 percentage points at every replacement rate. In the long run, the rate falls by less than the fall in growth — in particular in high-replacement-rate economies — because the expanding pension crowds out private savings and props the return up, the more so the more generous the system.

The adjustment spectrum. Panel B of Figure 2 fixes $\rho = 0.56$ and spans the design rule, $\theta \in \{0, \frac{1}{2}, 1\}$. At log utility the fixed-contribution-rate pole is the knife-edge of Proposition 4: with τ

frozen and $\gamma = 1$, neither the estate nor the saving of the young moves per unit of earnings, and the coral line in the ratio panel is exactly flat — date by date, surprises included, by the constant-saving-rate rule of Appendix A.6. What does move under the fixed contribution rate is the price of capital: the interest rate falls one-for-one with growth, from 4.1 to 3.1 percent, and the retirees' replacement rate absorbs the slowdown, drifting from 0.56 down to 0.42. The fixed-replacement-rate rule is the mirror image: the replacement rate never moves, the contribution rate absorbs the slowdown, and the ratio tilts most — the ranking implied by Proposition 3, with the $\theta = \frac{1}{2}$ path settling in between (11 log points against 24). The comparison makes the incidence of the design choice plain: θ decides whether a slowdown is paid by workers, through contributions that finance a gross-up of the old's estates, or by retirees, through benefits that shrink with the economy while the distribution of wealth between generations stays put.

2.4.3 Demographic slowdown

Figure A.2 in Appendix A.6 repeats the fixed-replacement-rate experiment for the demographic slowdown of Section 2.4. The two experiments are of comparable size: the fall in fertility moves $\ln(1+g)$ by -0.29, against -0.30 for the fall in productivity growth.

Since the detrended economy depends only on total growth (Section 2.3), the hat objects follow nearly the same paths as in Panel A of Figure 2: at $\rho = 0.56$ the contribution rate climbs from 0.31 to 0.41 and the interest rate settles half a point lower, as before.

The per-capita wealth ratio, however, falls where the productivity slowdown raised it, and the gap between the two experiments is the cohort factor of Proposition 1. At $\rho = 0.56$ the fiscal forces, worth 24 log points, are outweighed by the $\ln 0.75 = -0.29$ fall in the cohort factor: the ratio falls to 0.79 on impact and recovers to 0.85 across balanced paths, a net fall of 5 log points against a rise of 24 under the productivity slowdown. The generosity gradient survives, in line with Corollary 1, but even the most generous system barely reaches the $R > 1$ threshold of Proposition 4: at $\rho = 0.7$ the local response is $R = 0.88$, the change across balanced paths is close to one log point per log point of growth, and the fertility slowdown leaves the ratio where it was.

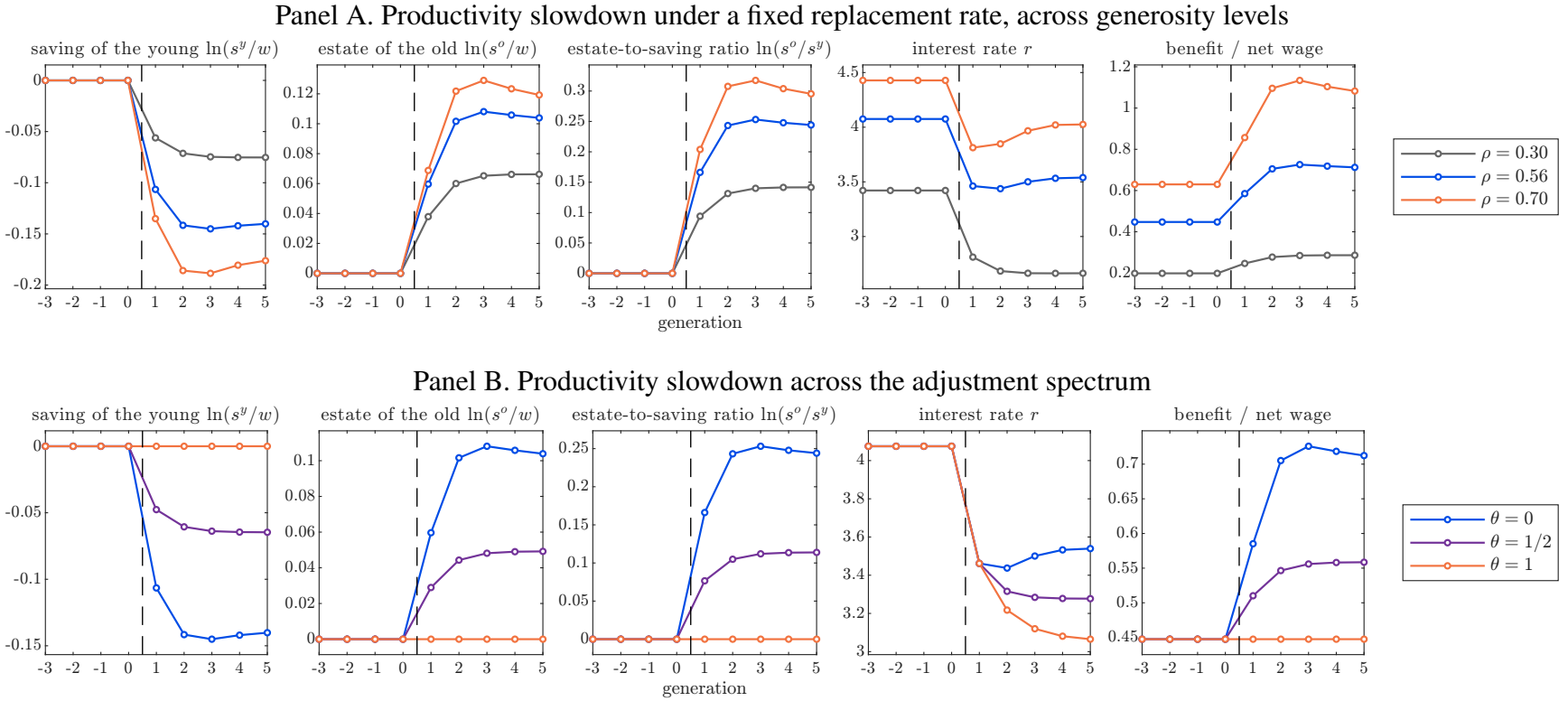


Figure 2: Transitions after a productivity slowdown. Panel A: annual productivity growth falls unexpectedly and permanently from 2 to 1 percent between generations 0 and 1 (dashed line), under the fixed-replacement-rate rule ($\theta = 0$) for replacement rates $\rho \in \{0.3, 0.56, 0.7\}$. Panel B: the experiment of Panel A at $\rho = 0.56$ for the one-parameter family of designs indexed by θ, the share of the adjustment borne by benefits: a fixed replacement rate ($\theta = 0$), the midpoint ($\theta = \frac{1}{2}$), and a fixed contribution rate ($\theta = 1$). In each panel, the first two plots show the saving of a young household s^y and the estate of an old household s^o, both relative to the wage per worker w, and the third their ratio; these three plots are in logs, normalized to zero on the initial balanced path (generations -3 to 0), so the third is the difference between the second and the first.

3 Data

3.1 The Household Finance and Consumption Survey

Our main data source is the Household Finance and Consumption Survey (HFCS), a harmonized household survey coordinated by the European Central Bank. We use all five currently available waves, with reference years 2010, 2014, 2017, 2021 and 2023, drawn from the public User Database (UDB).[4] The HFCS records detailed household balance sheets together with the income, labor-market status, and demographics of every household member. Table B.1 in Appendix B details the country coverage of each wave: 15 countries participate in 2010, and the survey grows to 21 from 2017 on as it expands into Central and Eastern Europe; Poland participates only in 2014 and 2017. Malta takes part in every wave but is excluded from all our analyses because age is not released in its User Database extract, leaving between 14 and 20 countries per wave. We treat each country–wave as the relevant population and weight every statistic by the household weight.

Missing values in the UDB are multiply imputed: each observation is provided in five *implicates*. Every regression is estimated separately on each implicate and the estimates are combined using Rubin's rules, so that all reported standard errors incorporate both sampling and imputation uncertainty; purely descriptive statistics pool the implicates.

We supplement the survey with several country-level series. Growth is the growth of real GDP per working-age adult between 1991 and 2019: national-accounts real GDP from the Penn World Table (10.01), which ends in 2019, over the resident population aged 15–64 from the World Bank's World Development Indicators. To express inheritances received in past decades in survey-year prices, we use the Eurostat HICP (all-items annual average index, available from 1996), extended backward to 1960 by chaining World Bank CPI growth rates onto the 1996 level in the Western countries; in the Eastern countries, whose index starts between 1996 and 1998, transfers received earlier are revalued from the first index year. Finally, the house-price control of Section 4.2 uses the Eurostat harmonized house price index (total dwellings, annual average), deflated by the same HICP; the index covers every sample country from 2010 on, except Greece, which does not report

[4] European Central Bank, Household Finance and Consumption Survey, User Database, waves 1–5. The survey is conducted under a common methodology, which makes balance-sheet and income variables comparable across countries and over time.

it. The reconstruction of the replacement rate described in the next subsection uses two further series: the nominal average wage per employee, computed from Eurostat's national accounts as compensation of employees over the number of employees, and a country-by-year record of the statutory rule under which pensions in payment were raised, assembled from the OECD's *Pensions at a Glance*, the European Commission's Ageing Reports, the MISSOC comparative tables and the legislation and publications of the national pension institutions, covering every public pay-as-you-go scheme of each country weighted by its share of pension expenditure; the same record underlies the indexation parameter of Appendix D.

3.2 Pension generosity and replacement rates

We summarize the generosity of a country's pension system by the ratio of pensions to current salaries,

$$\varrho_{ct} = \frac{\bar{b}_{ct}}{\bar{w}_{ct}}, \tag{34}$$

where $\bar{b}_{ct}$ is the weighted average total pension (public plus occupational and private) among pension recipients, and $\bar{w}_{ct}$ the weighted average gross employee income among employees in the survey. Because we focus on the part of pensions funded by current workers, the numerator counts public pensions only for the Netherlands, whose funded occupational pillar, which dominates Dutch pension income, is not a pay-as-you-go transfer. This ratio is the counterpart of the model's contribution rate $\tau_t = b_t/w_t$, the pension of the current old relative to the wage of the current young, equal to $\rho/(1+g)$ on the balanced path.

The pension a retiree reports differs from the benefit that was awarded, because pensions follow country-specific indexation rules, so ϱ_{ct} is not the empirical counterpart of the model's replacement rate ρ. To recover it, we first restate the pension of each retiree:

$$\hat{b}_{ict} = b_{ict}\,\frac{\mathscr{P}_{c,r(i)}}{\mathscr{P}_{c,t}}\,\frac{\mathscr{W}_{c,t}}{\mathscr{W}_{c,r(i)}}\,\mathscr{C}_{c,r(i)}, \tag{35}$$

where $r(i)$ is the year retiree i turned 63, which we take as the award year; $\mathscr{P}_{c,s}$ is the cumulative uprating of pensions in country c up to year s, and $\mathscr{W}_{c,s}$ the nominal average wage per employee from the national accounts; both are evaluated at the income reference year of wave t, the calendar

year before the interview; $\mathscr{C}_{c,s}$ is the earnings-base correction defined below, equal to one where the pension formula revalues past earnings with wages. Both indexes equal one in 1996, the first year of the wage series, and retirees who turned 63 earlier are restated from 1996. Dividing by $\mathscr{P}_{c,t}/\mathscr{P}_{c,r(i)}$ undoes the uprating the pension received since award, and multiplying by $\mathscr{W}_{c,t}/\mathscr{W}_{c,r(i)}$ expresses the benefit at award at current wage levels, so that, before the last factor, $\hat{b}_{ict}/\mathscr{W}_{c,t}$ equals the ratio of the initial benefit to the average wage in the year of award. Where benefits are indexed to wages, the two factors cancel and $\hat{b}_{ict} = b_{ict}$. Where they are indexed to prices and real wages have grown, the restated pension exceeds the reported one, because the initial benefit was higher relative to wages at the time of retirement.

The first two factors express the benefit at award relative to the average wage of the award year. The model's replacement rate is defined relative to the retiree's own earnings, and the two differ wherever the pension formula revalues past earnings with prices rather than with wages. A benefit computed on the last or best N years of a career rests on earnings that lag the award year by half of N on average. If the formula brings them forward with the consumer price index, the earnings base falls short of the same earnings revalued with wages by the real wage growth over that lag, and the benefit relative to the average wage at award understates the benefit relative to own earnings by the same amount. The last factor of equation (35) undoes this shortfall. For each public scheme k of country c, let $B_k(s)$ be the years of the earnings base for an award in year s and $V_{k,u}$ the index with which the scheme revalues the earnings of year u. The correction of the scheme is the inverse of the mean, over the base years $u \in B_k(s)$, of the revaluation of year-u earnings relative to wage growth, $(V_{k,s}/V_{k,u})/(\mathscr{W}_{c,s}/\mathscr{W}_{c,u})$, and $\mathscr{C}_{c,s}$ is the expenditure-weighted mean of the scheme corrections. It equals one where the base is revalued with wages, where points are valued at award, for a final salary and for a flat benefit; where the base is revalued with prices it exceeds one by the real wage growth forgone over the lag of the base. The scheme rules, base lengths and revaluation indexes are those of Appendix D, listed in Appendix D.3; the wage and price series are those of this section, extended back to 1954 with the growth rates of the AMECO database. For a pension awarded in 2007 the factor is 1.25 in Belgium, whose 45-year career average is revalued with prices, between 1.02 and 1.05 in Austria, Finland, France, Greece, Portugal and Spain, 0.97 in Italy, where the revaluation of the base at the cost-of-living index plus one point outran real wages, and one elsewhere.

The index $\mathscr{P}_c$ is reconstructed for every country from the statutory rules and discretionary decisions that governed the uprating of pensions in payment (Appendix D), and $\mathscr{W}_c$ is the compensation of employees per employee of Section 3. The initial replacement rate of decile d is:

$$\rho_{dc} = \frac{\bar{\hat{b}}_{dc}}{\bar{w}_{dc}}, \tag{36}$$

where $\bar{\hat{b}}_{dc}$ is the weighted mean restated pension of pension recipients aged 70–85 who fall in decile d of the total income distribution of their own five-year cohort, in the pooled 2021/2023 waves, and $\bar{w}_{dc}$ the weighted mean earnings of decile d of working-age employees aged 26–59 who report at least ten weekly hours in their main job, in the same waves. The numerator is the benefit at award relative to the retiree's own wage-revalued earnings, expressed at current wage levels, and the denominator the current earnings of the same rank, so ρ_{dc} measures the benefit against the wage of the retiree's own working years, the model's replacement rate ρ. Figure C.2 in Appendix C shows, by country, how the restatement changes the average pension of retirees aged 70–85 relative to the average wage.

3.3 Wage indexation rules

Another key parameter of the model is θ, which measures the propensity of the system to close budget gaps by adjusting pensions. Part of this parameter is a political object, subject to discrete policy choices, but it is also reflected in statutory rules that adjust pension levels automatically. Given our focus on the productivity slowdown, we pay particular attention to the way the determination of pension benefits is tied to the mean level of wages.

There are essentially two ways in which benefit rules can link the level of pensions to that of wages: through the computation of the initial benefit, and through its subsequent indexation. Pension benefits are typically computed as a function of past earnings. Before applying the benefit formula, some countries adjust past earnings for the evolution of the consumer price index, whereas others also take into account the growth of wages. Similarly, after retirement, some systems adjust benefits for inflation only, while others let them grow at the rate of wages or at a combination of the two indices. When indexation is to wages on both sides, the level of pension benefits fully adjusts to the mean wage index.

To reflect these institutional differences, we define the rule-based indexation to wages as the weighted average of two components:

$$\theta_a^{\text{rule}} = \omega_0 \, \theta_{a,0}^{\text{rule}} + (1 - \omega_0) \, \theta_{a,1}^{\text{rule}}, \tag{37}$$

where $\theta_{a,0}^{\text{rule}}$ is the degree of indexation in the computation of the initial benefit and $\theta_{a,1}^{\text{rule}}$ the degree of indexation to real wages. The relative weights of the two components in the pension budget depend on the horizon. In the short run, the current stock of pensioners matters most, so $\theta_{a,1}^{\text{rule}}$ dominates the fiscal impact of wage growth. In the longer run, as a greater share of the retired population rotates, the initial benefit rule becomes more important. We calibrate $\omega_0 = 0.53$, which corresponds to a horizon of 30 years, as in the model.[5] We use a large language model (Claude Fable 5.1) to analyze the legislation in place in each country during our sample period and estimate the two components of θ. Appendix E reproduces the markdown files detailed its instructions.

Figure 3 plots the three parameters by country and shows a substantial amount of heterogeneity in both components of θ and its total value.

The overall generosity of a pension system can be thought of as the combination of an initial replacement rate and an indexation rule, and the two do not necessarily go together. France, Spain and Italy offer very high initial replacement rates but index benefits in payment to inflation only, so that retirees start with a high level of benefits relative to wages and see it decline over time. Germany and the Netherlands, on the other hand, tie benefits closely to wages at both stages, in the computation of the initial benefit and in its subsequent uprating, so that benefits keep pace with salaries throughout retirement but start from a markedly lower level than in France or Spain. These arrangements imply very different budgetary dynamics: a productivity slowdown opens a large budgetary gap in high-ρ, low-θ countries such as France or Spain, but not in Germany or the Netherlands.

[5] Consider one-year cohorts of equal size who work for $N = 40$ years and draw a pension for $R = 25$ years, and a permanent fall of δ in the growth rate of wages at date 0, so that the log wage falls short of its previous path by δs at any date $s \geq 0$. The initial benefit of the cohort retiring at T is proportional to its past earnings revalued to T with elasticity $\theta_{a,0}^{\text{rule}}$ to wages, and it is then indexed with elasticity $\theta_{a,1}^{\text{rule}}$. To first order in δ, aggregate pensions relative to the wage bill at date t rise by $\delta \left[(1-\theta_{a,0}^{\text{rule}}) \, \Lambda(t) + (1-\theta_{a,1}^{\text{rule}}) \, P(t)\right]$, where $P(t) = R^{-1} \sum_{s=0}^{R-1} \min(s,t)$ is the mean number of post-slowdown years in payment of the retirees alive at t, and $\Lambda(t) = R^{-1} \sum_{s=0}^{R-1} \left[(t-s)^+ - N^{-1} \sum_{k=1}^{N} (t-s-k)^+\right]$, with $x^+ = \max(x, 0)$, the mean lag of their earnings base behind their award wage, counted over post-slowdown years. The award stage therefore carries the weight $\omega_0 = \Lambda(t)/[\Lambda(t) + P(t)]$. At $t = 30$, $P = 12$ and $\Lambda = 13.5$, so $\omega_0 = 0.53$; the weight rises to 0.63 as $t \to \infty$, where $\Lambda \to (N+1)/2$.

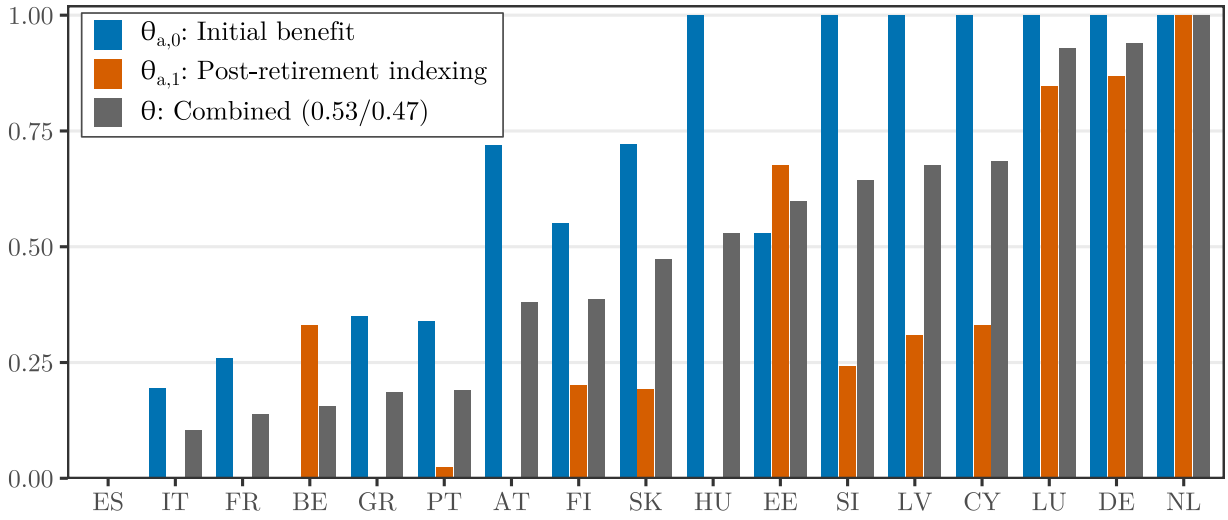


Figure 3: The indexation parameter by country.

3.4 Other variables

Table B.3 in Appendix B lists the User Database variables we use, with their code names. From these inputs we construct the following variables; throughout, i indexes individuals, h households, c countries, and t survey waves.

Net wealth per partner. Net wealth is recorded at the household level and is, to a first approximation, held jointly by the couple at the head of the household. We split household net wealth equally between the reference person and their spouse or partner: $\tilde{s}_{ict} = \text{net wealth}_{hct}/n_{hct}$, where $n_{hct} \in \{1, 2\}$ counts the spouse or partner. A household whose only head or partner is widowed keeps $n_{hct} = 2$, because a lone widow or widower holds the wealth accumulated by a former couple. All other household members — including co-resident adult children and other adult relatives — are treated as dependents. Including deceased spouses at the denominator neutralizes the mechanical rise in per-person net wealth among the elderly.[6]

Income and ranks. Individual income is the sum of gross employee earnings and public and private pension income. We use it to sort the retired of a cohort into groups of equal population weight within each country and wave, and gross employee earnings to sort working-age employees in the same way. Ranking the two populations separately and matching them by rank keeps the

[6]The descriptive exhibits — Figure 1 and Figure C.1 — divide household wealth by the number of reference persons and partners present, without the widow convention.

ratios below well behaved at the bottom, where few working-age adults have any earnings at all.

Inheritances. We measure received inheritances as the sum of the reported gift and inheritance values. Values are reported in prices of the year of receipt, which the survey also records; whenever we use them, we revalue each dated transfer to survey-year prices with the national all-items HICP and capitalize it at a two-percent annual real return from the year of receipt.

4 Empirical evidence

The empirical analysis is organized around the model's prediction that the wealth of the elderly, relative to their working-age descendants, depends on pension generosity, on productivity growth over recent decades, and on their interaction.

4.1 The shift in the age profile of wealth

Our primary prediction is that, when productivity growth is low, the relationship between wealth and age becomes steeper in countries with generous pensions, unless benefits are linked to the evolution of wages (Proposition 3).

To test this prediction, we compare the age profile of wealth in the pooled 2010 and 2014 waves with that in the pooled 2021 and 2023 waves. In each country and wave, we scale net wealth by the average wage and sort households aged 30 to 85 into five-year age bands and, within each band, into deciles of total income. For each country c, age band g and decile d, the outcome $\Delta\overline{\ln s}_{gdc}$ is the annualized change in the cell's mean log wage-scaled wealth between the two dates: the growth in the wealth of, for instance, households aged 70 to 74 in the top decile relative to households of the same age and rank a decade earlier.

Specifically, we estimate:

$$\Delta\overline{\ln s}_{gdc} = \beta_b^k\,\rho_{dc} + \beta_a^k \ln\big(1+g_{a,c}\big) + \beta_{ba}^k\,\big(1-\theta_a^{\text{rule}}\big)\,\rho_{dc}\ln\big(1+g_{a,c}\big) + \beta_h^k\,\Delta h_{gdc} + \delta_{gd} + \varepsilon_{gdc}, \quad (38)$$

where k indexes the ten-year age group of band g, from 30–39 to 80–85; ρ_{dc} is the initial replacement rate of decile d in country c, $g_{a,c}$ is productivity growth over 1991–2019, θ_a^{rule} is the rule-based wage indexation of benefits, Δh_{gdc} is real house-price growth, and δ_{gd} are age band $\times$

decile effects. The replacement rate and growth are centered, so β_b^k is the generosity gradient of age group k at average growth.

Figure 4 plots, for each age group, the effect of a one-standard-deviation increase in the initial replacement rate (0.188) on the annual growth of wealth relative to the average wage, at productivity growth of 1% and 2%, and at the population-weighted average of the wage-indexation parameter across countries ($\theta_a^{\text{rule}} = 0.41$). The profile has the shape the model predicts. Under a slow-growth regime of 1%, living in a country with generous pensions makes it harder for working-age households to accumulate as much wealth, in wage units, as earlier cohorts did at the same age. The opposite is true above retirement age: cohorts above age 70, who have been collecting benefits for at least a few years, report higher wealth relative to current wages.

Under a 2% productivity-growth regime, the differential between retirees and working-age households mostly vanishes: all coefficients move much closer to the population-weighted average of the six effects, represented by the dashed lines in the figure. This result implies a stable age gradient of the wealth distribution under the productivity growth observed around 1990, and a steepening of the gradient under a growth rate more representative of the past twenty years.

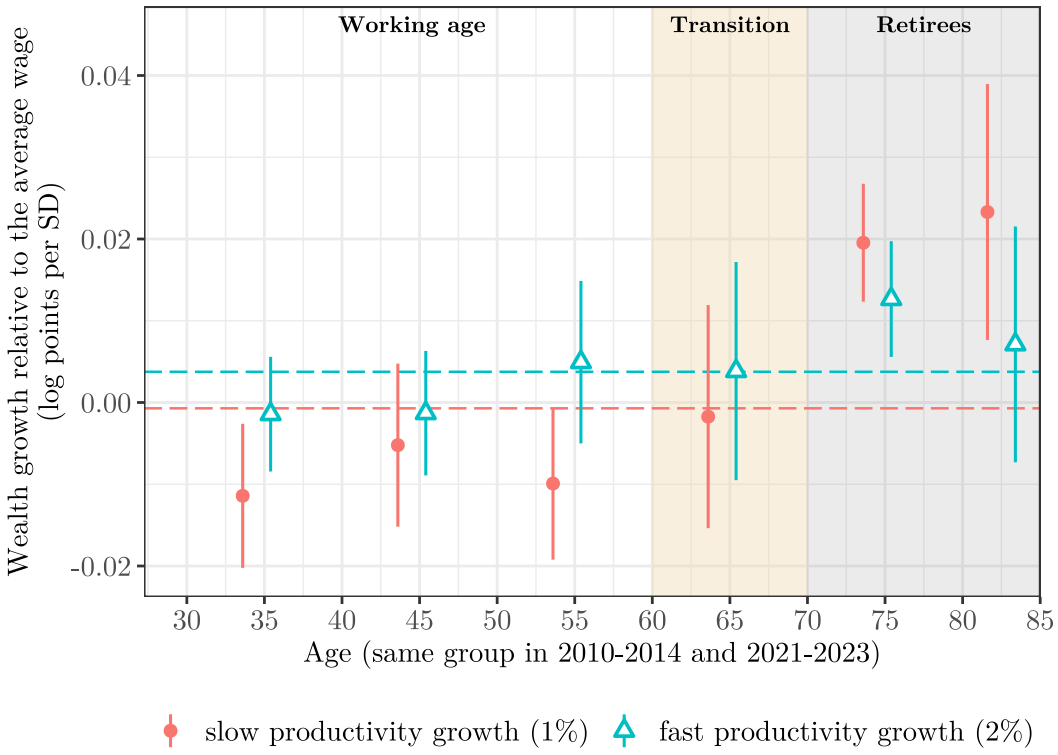


Figure 4: The shift in the age profile of wealth relative to the average wage, 2010–2014 to 2021–2023. Estimates of equation (38): for each ten-year age group, the effect of a one-standard-deviation increase in the initial replacement rate (0.188) on the annual growth of the group's wealth relative to the average wage, at productivity growth of 1 percent (circles) and 2 percent (triangles), the interaction evaluated at the cell-weighted mean of $1 - \theta_a^{\text{rule}}$. The cells are country $\times$ five-year age band $\times$ income decile, with the same age band at both dates; 80–85 is the survey's topcode band. Bars are 95 percent confidence intervals, clustered by country. The dashed lines are the population-weighted averages of the six effects at each growth rate. Shading: working age (30–59), mixed working and retired status (60–69), retired (70–85). Table C.4 in Appendix C reports the coefficients.

4.2 Wealth accumulation among retirees

Our first finding provided the closest empirical counterpart of the model's prediction, since it directly measures the evolution of s^o/s^y. One limitation is that, by comparing the same age group a decade apart, it did not allow us to follow the wealth accumulation of a given group of households.

To remedy this issue, we now follow retiree cohorts across survey waves and compare the pace at which households at similar positions in the income distribution accumulate wealth. Our new outcome variable is the mean log of scaled wealth of each cohort–decile cell between the beginning and end of the sample period. As before, we pool two survey waves at each endpoint.

First, we estimate the following equation for cohorts aged 70–85 at the end of the period:

$$\Delta\overline{\ln s}_{gdc} = \beta_b\,\rho_{dc} + \beta_a \ln\bigl(1+g_{a,c}\bigr) + \beta_{ba}\left(1-\theta_a^{\text{rule}}\right)\rho_{dc}\ln\bigl(1+g_{a,c}\bigr) + \beta_h\,\Delta h_{gdc} + \delta_{gd} + \varepsilon_{gdc}, \quad (39)$$

where s_{ict} is household i's wealth per partner and $\bar{s}_{ct}$ its country's average in wave t, so that $\overline{\ln s}_{gdct}$ is the mean of $\ln\bigl(s_{ict}/\bar{s}_{ct}\bigr)$ over the households of the cell; Δ denotes the annualized change over the sample period; ρ_{dc} is the initial replacement rate and θ_a^{rule} the indexation parameter of country c ; Δh_{gdc} is real house-price growth over the cell's own window, annualized in the same way; and δ_{gd} are cohort $\times$ decile effects. Replacement rate and growth are centered at their weighted means and the interaction is formed from the centered variables, so β_b is the generosity gradient at average growth.

Our objective is to estimate the effect of pension generosity on the pace of wealth accumulation under different productivity-growth regimes, $\beta_b + \beta_{ba}\ln(1+g_a)$. The cohort $\times$ decile fixed effects δ_{gd} absorb whatever is common across countries to a given income decile at a given stage of the life cycle. Identification therefore rests on comparing the same decile of the same cohort across countries, and the identifying assumption is that differences in the speed at which these groups accumulate wealth are caused by differences in the generosity of the pension system and in productivity growth, or by factors uncorrelated with them.

A potential threat to identification is that returns on wealth themselves correlate with pension generosity or growth. One advantage of our setting is that we study countries with independent retirement systems in an otherwise integrated capital market, which should limit gaps in financial returns across them. On the other hand, returns on real estate remain dominated by local factors,

Table 1: The initial replacement rate, growth, and the within-cohort change since 2010–2014 in the wealth of the elderly relative to the country average (aged 70–85 in 2021/2023)

	(1)	(2)	(3)	(4)	(5)
Rank-matched pension/earnings	-15.501***	-12.195***	-15.802***	-17.388***	-48.941***
$\times (1-\theta_a^{\text{rule}}) \log(1+g_a)$	(4.755)	(4.382)	(4.559)	(5.540)	(15.264)
	[0.004]	[0.012]	[0.010]	[0.006]	[0.069]
Rank-matched pension/earnings					16.743**
$\times \log(1+g_a)$, unweighted					(7.399)
					[0.124]
Rank-matched pension/earnings	0.125***	0.108***	0.129***	0.128***	0.101***
	(0.016)	(0.023)	(0.015)	(0.016)	(0.011)
	[0.020]	[0.050]	[0.007]	[0.005]	[0.005]
$\log(1+g_a)$ (centered)	1.139**	0.801	0.632	1.034	1.462**
	(0.457)	(0.692)	(0.639)	(0.895)	(0.706)
	[0.356]	[0.293]	[0.345]	[0.347]	[0.115]
Real house-price growth		0.078	0.128	0.101	0.051
		(0.134)	(0.141)	(0.138)	(0.123)
		[0.602]	[0.463]	[0.496]	[0.713]
Effect of a one SD increase in pension generosity:					
at 1% productivity growth	0.029***	0.024***	0.029***	0.030***	0.026***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.002)
	[0.008]	[0.041]	[0.014]	[0.028]	[0.001]
at 2% productivity growth	0.012***	0.011***	0.012***	0.011**	0.004
	(0.004)	(0.004)	(0.003)	(0.005)	(0.005)
	[0.015]	[0.090]	[0.011]	[0.148]	[0.522]
R^2	0.401	0.176	0.404	0.406	0.416
Countries	16	16	16	16	16
House-price control	No	Yes	Yes	Yes	Yes
Soviet-bloc dummy	No	No	No	Yes	Yes
Decile×cohort FE	Yes	No	Yes	Yes	Yes

Notes: An observation is a country × income-decile × five-year-cohort cell: heads and partners aged 70–85 in the pooled 2021/2023 waves, sorted within country and cohort into deciles of equal population weight by total income and compared with their own birth cohorts in the pooled 2010/2014 waves. The dependent variable is the annualized change in the cell's mean log net wealth per partner, scaled by the country's average wealth per partner. Pension generosity is the initial replacement rate of equation (36), the decile's mean pension among the retired, restated to its value at award relative to the retiree's own earnings and expressed at current wage levels, over the mean earnings of the same decile of working-age employees (standard deviation 0.18 across cells); the interaction is multiplied by $1-\theta_a^{\text{rule}}$, equation (37). g_a is the average annual growth of real GDP per working-age adult over 1991–2019. Both regressors are centered at their weighted means; the bottom panel reports the effect of one standard deviation of generosity at the stated growth rate and the mean weight. Column (1) has decile × cohort fixed effects only; column (2) cohort effects and the real house-price growth control (unavailable for Greece, dropped from every column); column (3) both; column (4) adds an unreported indicator for the former Soviet-bloc countries. Cells with fewer than three persons at either end are dropped; cells are weighted by population; households with non-positive net wealth are dropped before wealth is winsorized at the 1st and 99th percentiles within country at each end, as is the outcome across cells; estimates are combined across the five imputation implicates by Rubin's rules. Standard errors clustered by country are in parentheses; p-values from a wild cluster bootstrap by country (999 replications), combined across implicates by the Licht–Rubin method, are in brackets. Stars reflect the asymptotic t statistics: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

which is why we control for national changes in house prices. One could imagine that countries that politically favor elderly citizens would favor more generous pensions and promote policies that support house prices.[7]

Columns (1)-(4) of Table 1 reports our findings. First, greater pension generosity allows old households to accumulate wealth faster than the rest of the population. This is important yet not particularly surprising. The sharper prediction of the model, which our findings confirm, is that this effect is stronger in countries that have experienced lower productivity growth over recent decades. Based on our point estimates, a one-standard-deviation increase in initial replacement rate (0.18) raises the annual *differential* rate at which retirees accumulate wealth by 1.3 to 1.9 percentage points more in a country where productivity grew by 1% a year than in one where it grew by 2%.

For context, productivity growth in Western Europe fell from 3% a year over 1970–1990 to 1.5% over 1990–2010 and 0.5% thereafter. As discussed in the introduction, the median per-adult wealth of individuals aged 70–85 rose from 1.50 to 1.74 times that of working-age adults between 2010 and 2023, roughly 16% faster over a thirteen-year period. The simulations of Figure 2 give the total effect of the same slowdown at a replacement rate of 0.56, roughly 20% over a generation, of the same order as the differential the estimates attribute to one standard deviation of generosity.

Some endogeneity concerns remain. First, countries from the former Soviet bloc offer low replacement rates, enjoyed faster economic growth, and emerged from the 1980s with a smaller stock of capital. The inclusion of a Soviet-bloc dummy leaves the estimates unchanged, so the East–West contrast is not what drives them. A related concern is that our findings could reflect the euro-area crisis, which unfolded early in our sample period. Greece, the country most affected, is absent from Table 1 because Eurostat's house-price index does not cover it. Appendix Table C.2 addresses the remaining crisis countries in two ways, re-estimating the specification with an indicator for them and excluding Italy, Spain and Portugal from the sample altogether. The indicator is small and insignificant, and the coefficients of interest keep their magnitude and statistical significance with it inclusion. When excluding these three countries, the coefficient keeps its magnitude

[7]The pattern in the data actually runs the other way. Between 2010 and the last waves, the real house price index (the Eurostat harmonized index for total dwellings, deflated by the national HICP) fell in Italy, Spain and Finland and was flat in France, the generous, slow-growth countries where the elderly are wealthiest. By contrast, it rose by 30 to 60 log points in the fast-growing Baltics, Hungary and Czechia, where their relative wealth is lowest.

as well but the sample is restricted to 13 countries and the wild bootstrap p-value rises to 10%.

Second, the measure of generosity must not itself contain the growth rate. The ratio of observed pensions to current earnings, the counterpart of the model's $\tau = \rho/(1 + g_a)$, does. The initial replacement rate is instead the counterpart of the model's replacement rate ρ, the benefit at award relative to the retiree's own earnings. It is the parameter that is comparable across countries, holding indexation rules fixed. The erosion of benefits relative to wages that Proposition 2 attributes to growth and to $1 - \theta$ is thus left to the interaction term, as in the model.

Finally, columns (1)–(4) cannot show whether variation in $1 - \theta_a^{\text{rule}}$ contributes to our findings. To evaluate that contribution, column (5) introduces the interaction between the pension/earnings ratio and productivity growth as a control. The triple interaction term now shows that $1-\theta_a^{\text{rule}}$ plays a central role. Slow productivity growth tilts wealth toward the elderly through pension generosity in countries whose retirement benefits do not follow wages, such as France, but not in countries whose benefits are close to full wage indexation, such as Germany.

4.3 Wealth accumulation across age groups

If some age groups pulled ahead, others must be in the opposite situation. While this is partly mechanical, the model provides a specific prediction as to the period of the life cycle for which the mechanism should have no effect. Before retirement, households in low-growth countries without benefit adjustment must pay the bill, so the model predicts an effect of the opposite sign and, assuming two workers per pensioner, roughly half the magnitude of that on retirees. Those who received roughly as much in pensions as in salary during the sample period should not have been, in net, affected in their ability to save over that time. This should be the situation of households in their sixties at the end of the sample period.

To test this prediction, we extend the within-cohort analysis to all age groups, including households still in the labor force. Figure 5 replicates column (4) of Table 1 for all households aged 40 to 85 at the end of the period, covering most adults who were above age 30 at the beginning of it, with each age group compared with its own birth cohorts at the baseline as in Table 1, and every coefficient allowed to vary by age group rather than pooled across cohorts: 40–49, 50–59, 60–69 and the 70–85 group of Section 4.2. The figure reports the generosity gradient at annual growth rates of 1% and 2%, for a one-standard-deviation increase (0.188) in the initial replacement rate.

Since we study changes in log wealth, the average effect need not be zero even after scaling by the mean wealth of each survey: the mean of log wealth moves with wealth inequality, which changes over the life cycle, a Jensen term. To net out this drift, we express each age group's effect net of the population-weighted average of the four age-group effects at that growth rate. As a consequence, the zero line can be interpreted as the average household in the figure's age range, and a positive estimate means the group gained on the rest of the population.

The results are consistent with the predictions of the model. In a low-productivity-growth regime, high replacement rates are associated with slower-than-average wealth accumulation among working-age households and faster-than-average accumulation among retirees. The overall pattern aligns well with economic intuition. Both the effect of pension generosity and its interaction with productivity growth change sign around retirement age. The fact that some coefficients must be of opposite sign to others is mechanical, but the specific profile, and in particular the change in sign during the transition from employment to retirement, is an empirical signature of the model. To produce this pattern, a confounder would need to slow the wealth accumulation of working-age households and speed up that of retirees in the same countries, and to do so not only in proportion to pension generosity but in proportion to its interaction with productivity growth as well, with the sign reversing at the transition to retirement.

The model makes a somewhat stronger prediction. High replacement rates in a low-growth environment should not just widen the differential in wealth accumulation between retirees and workers. First, they should increase the pace at which retirees accumulate wealth relative to the growth rate of gross wages, largely a consequence of the pension-to-wage ratio being higher in a low-growth environment. Second, they should slow down workers' wealth accumulation relative to their own gross wages, a consequence of the fiscal burden of financing these pensions, which can only be offset by gifts and inheritances.

To estimate the ability of each age group to build wealth on its own, we repeat the same analysis but scale wealth by the national average wage instead of average wealth, and exclude the gifts and inheritances received over the sample period. The new scale detrends the data following the logic of the model's balanced growth path but, importantly, it no longer mechanically imposes opposite signs on the two parts of the life cycle. Figure 6 reports our findings and reveals a pattern similar to that of Figure 5. For a confounding variable to explain the pattern, it would now need to raise

the wealth of retirees relative to wages and lower that of workers relative to their own wages in the same countries, in proportion to pension generosity and to its interaction with productivity growth, without operating through transfers between the two groups, since gifts and inheritances have been netted out.



Figure 5: The generosity gradient of within-cohort wealth growth, by age group. Per-age-group slope of the initial replacement rate in the specification of Table 1, column (4), with the cells cut by five-year endpoint age group (80–85 at the survey's age topcode) and every coefficient by age group, 40–49, 50–59, 60–69 and 70–85, rather than pooled. Each point is the annual effect of a one standard-deviation increase in the replacement rate (0.188 across these cells), at annual growth of 1 percent (circles) and 2 percent (triangles), with the interaction multiplied by $1 - \theta_a^{\text{rule}}$ as in Table 1 and the gradients evaluated at the cell-weighted mean of the weight, expressed as a deviation from the population-weighted average of the four age-group effects at that growth rate: zero marks the average household aged 40 to 85, and an age group gains on the rest of the population when its estimate is positive. The bars are 95 percent confidence intervals. All regressors are interacted with the age groups, and the fixed effects are five-year age band $\times$ income decile; all other conventions are those of Table 1. Table C.3 in Appendix C reports the full set of coefficients.

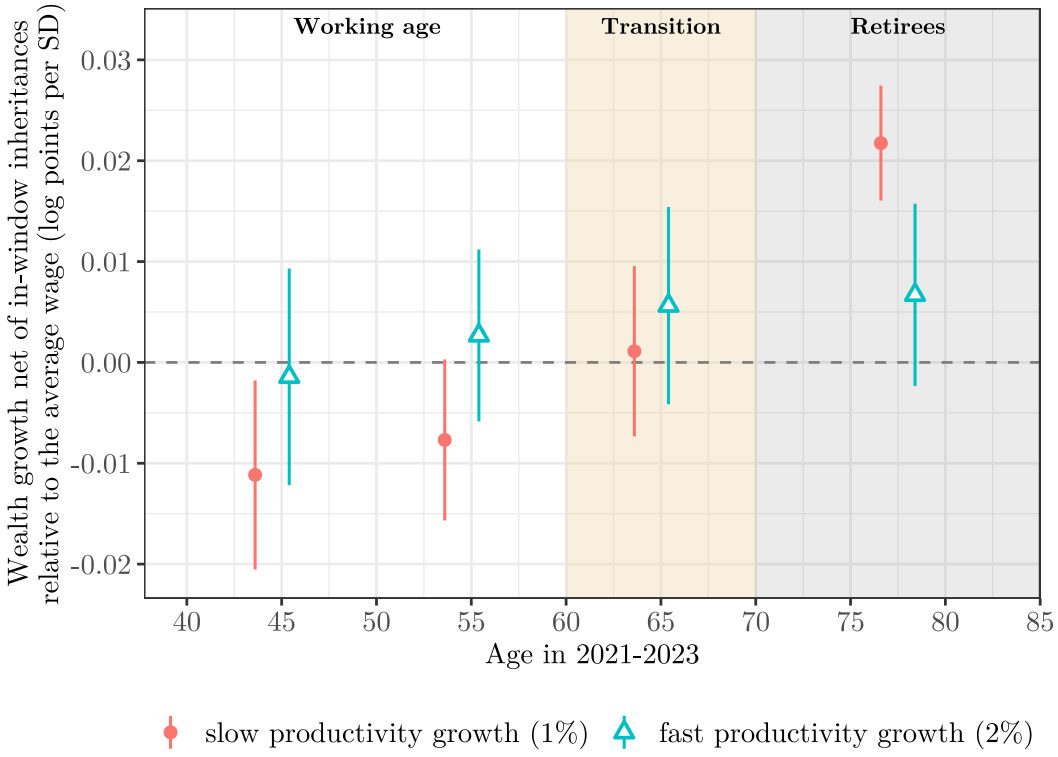


Figure 6: The generosity gradient of within-cohort wealth growth relative to the average wage, net of the inheritances received over the window, by age group. This figure repeats the estimation of Figure 5 with the survey mean employee wage as the scale, and with the gifts and inheritances received after the country's first baseline wave (2010, or 2014 for the countries that entered the survey then), revalued and capitalized as in Figure 1, subtracted from the household's net wealth at both ends of the window before the split between partners: the outcome is the cohort's wealth growth net of what it inherited over the window, the in-window inheritances of the vertical axis. All other conventions are those of Figure 5, with the sample of Table C.1; the estimates are not demeaned, the wage being a scale outside the wealth distribution.

4.4 Fiscal adjustment channel

In the model, a slowdown implies a greater fiscal adjustment in countries offering more generous pensions. This adjustment falls on the net wages out of which the young save. The simulations in Panel A of Figure 2 show that, for a given θ, the ratio of benefits to net wages increases substantially more in high-replacement-rate countries. Although we have implicitly attributed the negative coefficients for working-age households in Figure 6 to the burden of payroll taxes, we have not yet tested it directly.

To do so, we first need to measure how the pension system led to higher labor taxation over

recent decades, which is not straightforward. Unlike in the United States, several European countries partially finance their PAYG system with taxes that are not earmarked for pensions, such as the *contribution sociale généralisée* in France. We therefore measure the change in labor tax wedge over a horizon matching the growth window with two series:

1. The *realized* tax wedge change converts the implicit tax rate on labor into the share of labor cost workers keep. We measure the annualized log change of the tax wedge as:

$$\nu_c^{\text{real}} = -\frac{\ln(1 - \text{ITR}_{c,2019}) - \ln(1 - \text{ITR}_{c,1995})}{2019 - 1995}. \tag{40}$$

   where ITR is the sum all taxes and social contributions levied on employed labor, divided by total compensation of employees, compiled by the European Commission for each country.

2. The *predicted* tax wedge change is the one implied by the retirement budget alone. Denote $\Delta\tau_c$ the change in the pension implicit contribution rate, defined as aggregate pension expenditures divided by aggregate labor income, from each country's first available year to 2019.[8] We stop in 2019, before the wage-bill collapse of the pandemic mechanically inflates the ratio. A system that balances its budget levies exactly this change on labor. Holding other taxes fixed, it moves the tax wedge from $\text{ITR}_{c,1995}$ to $\text{ITR}_{c,1995} + \tau_c$, so the predicted annualized log change of the tax wedge is:

$$\nu_c^{\text{pred}} = -\frac{1}{2019 - t_0} \ln\left(1 - \frac{\Delta\tau_c}{1 - \text{ITR}_{c,1995}}\right), \tag{41}$$

   where t_0 is the first year of availability of the aggregate pension expenditure data.

According to the model, tax wedges increase in countries that experienced an economic slowdown, offer high replacement rates, and had no mechanisms in place to adjust pension benefits. The transmission of the productivity slowdown to the tax wedge should be proportional to the product of these variables. To confirm that this is the case, Figure 7 plots the annualized change

[8] Pension expenditures are defined as old-age, anticipated, partial and survivors' pension expenditure (Eurostat ESSPROS). The labor-income base includes wages and salaries scaled up to impute the labor income of the self-employed; the resulting change is converted to the compensation-of-employees base of the implicit tax rate with the country's mean ratio of the contribution rate measured on the two bases. The window opens in 1995, to match the window of the implicit tax rate, in Western countries and later where the pension series starts later: Slovenia 1996, Latvia 1997, Estonia and Hungary 1999, Cyprus 2000.

in each measure of the tax wedge against the product of the average replacement rate, the decline in economic growth between 1980–1999 and 2000–2019, and one minus the rule-based indexation parameter θ_a^{rule}. The figure is restricted to long-established market economies for which productivity data from Bergeaud et al. (2016) go further back than the fall of the Soviet Union (see Figure B.1). In line with the model's logic, tax wedges increased the most where generous promises met large slowdowns and benefits were not tied to wages.

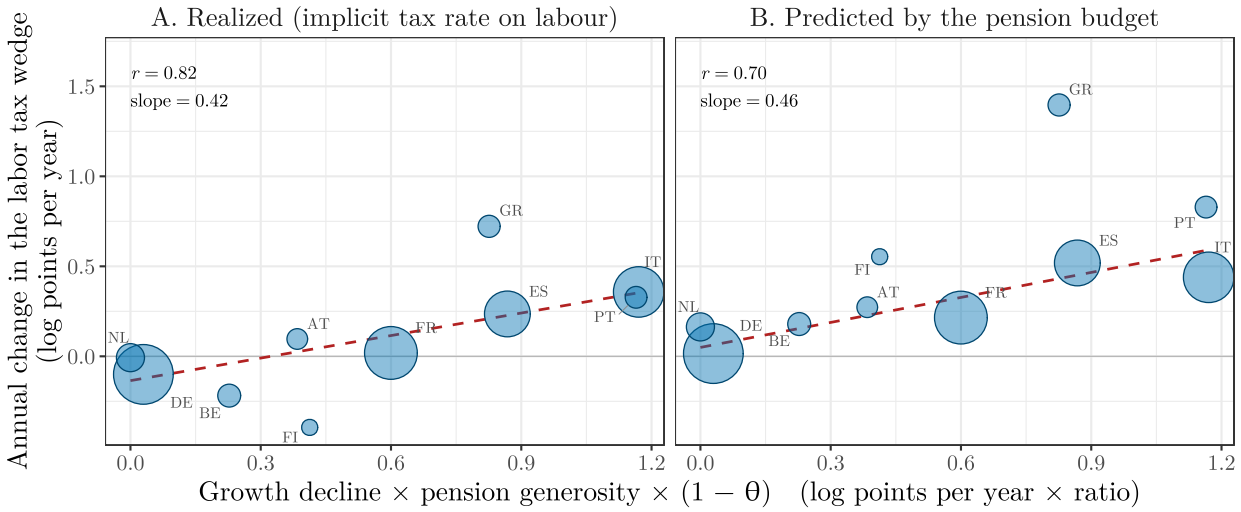


Figure 7: The change in the labor tax wedge and the generosity-scaled slowdown weighted by the indexation rule. The vertical axis is the annualized log change of the labor tax wedge under each measure: the change implied by the implicit tax rate on labor from 1995 to 2019 (Panel A) and the change predicted by the pension budget, equation (41), over each country's window (Panel B). The horizontal axis is the product of three terms: pension generosity, the average PAYG (unfunded) pension of persons aged 70–85 over the average earnings of employees aged 26–59 in the pooled 2021/2023 waves; the decline in the average annual growth rate of total real GDP between 1980–1999 and 2000–2019 (Penn World Table 10.01); and one minus the rule-based indexation parameter θ_a^{rule} of equation (37), which ranges from zero in the Netherlands to one in Spain, so that the wedge change is compared with the generosity-scaled slowdown weighted by the share of the budget gap that falls on contributions. Circle areas are proportional to the population aged 15–64 in 2019. Dashed lines are population-weighted OLS fits.

The second step of the fiscal adjustment channel is that a rising tax wedge limits the ability of workers to build wealth. We test this both through OLS and a 2SLS approach. First, Table 2 regresses wealth accumulation among working-age cohorts on the two measures of the tax wedge change. As before, the population of each country is divided into five-year cohorts (40–44 through 55–59 at the endpoint), each sorted into ten income deciles. The outcome is the annualized change

in a cell's mean log wealth over the sample period. Because the argument is about the ability to save, wealth is scaled by each cell's own average wage.[9] Specifically, writing $\bar{w}_{gdct}$ for the cell's own average wage, and ν_c for one of the two tax wedge changes, we estimate:

$$\Delta\overline{\ln s}_{gdc} - \Delta \ln \bar{w}_{gdc} = \beta_\nu \, \nu_c + \beta_a \ln\big(1 + g_{a,c}\big) + \beta_b \, \rho_{dc} + \beta_h \, \Delta h_{gdc} + \beta_E \, E_c + \delta_{gd} + \varepsilon_{gdc}, \quad (42)$$

where the left-hand side is the annualized mean log change in wealth, net of the growth of the cell's own wage, ν_c is the realized tax wedge change in columns (1)–(3) and the pension-predicted one of (41) in columns (4)–(6).

The results confirm that the rise in the tax wedge slows wealth accumulation among working-age households. A tax-induced decline of one log point a year in the net wage reduces annual wealth accumulation by four to six log points, an amplification consistent with a channel operating through saving flows out of net income rather than through a revaluation of existing wealth.

The tax wedge changes of Table 2 are policy outcomes. Governments raise labor taxes in response to the state of their economy and of their public finances, and the pressures that lead a country to tax labor more heavily may correlate with whatever else governs how fast its households build wealth. The pension-predicted series narrows this concern by fixing the budget arithmetic, but its input, the growth of pension expenditure relative to the wage bill, is itself partly chosen. To address these concerns, we instrument the realized wedge change with a shift-share predictor in the tradition of Bartik (1991): the composition of employment across industries at the start of the window, interacted with European industry growth rates. Formally,

$$\hat{\Delta}\mathrm{VA}_c = \sum_i s_{ic,1995} \, g_{i,-c}, \qquad g_{i,-c} = \frac{\ln \mathrm{VA}^{-c}_{i,2019} - \ln \mathrm{VA}^{-c}_{i,1995}}{24}, \quad (43)$$

where $s_{ic,1995}$ is the share of industry i in country c's 1995 employment, over the 64 industries of the NACE classification, and $g_{i,-c}$ is the annualized log growth of the industry's real value added in the European aggregate excluding country c itself. $\hat{\Delta}\mathrm{VA}_c$ is thus the growth of the labor-income base that the initial industry mix predicts.

The budget arithmetic links the growth of the tax base to changes in the tax wedge. Regressing

[9] Cells with no employed member at one of the two ends drop out, about a sixth of them.

Table 2: Fiscal adjustment and wealth accumulation in the working-age population

	(1)	(2)	(3)	(4)	(5)	(6)
Tax wedge change ν^{real}	-5.998***	-6.002***	-5.479**			
	(2.129)	(2.131)	(2.453)			
	[0.044]	[0.057]	[0.154]			
Tax wedge change ν^{pred}, pension-predicted				-3.883***	-3.901***	-4.596**
				(1.310)	(1.343)	(1.943)
				[0.002]	[0.016]	[0.188]
$\log(1+g_a)$ (centered)	-2.641**	-2.641**	-3.360**	-1.066	-1.041	-1.608
	(1.284)	(1.264)	(1.491)	(0.840)	(0.842)	(1.085)
	[0.133]	[0.197]	[0.084]	[0.311]	[0.380]	[0.282]
Replacement rate at award		0.000	0.010		0.005	0.018
		(0.026)	(0.029)		(0.025)	(0.028)
		[0.977]	[0.808]		[0.951]	[0.713]
Real house-price growth			0.230*			0.160
			(0.126)			(0.183)
			[0.144]			[0.773]
Soviet bloc	0.020	0.020	0.023	0.003	0.003	0.005
	(0.015)	(0.016)	(0.016)	(0.012)	(0.013)	(0.013)
	[0.345]	[0.359]	[0.334]	[0.827]	[0.821]	[0.727]
Cohort×decile FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.367	0.367	0.380	0.370	0.370	0.386
Cells	569	569	545	569	569	545
Countries	17	17	16	17	17	16

Notes: Cells are the country × five-year cohort × income-decile cells of Table 1, built for household heads and partners aged 40–59 at the endpoint. The dependent variable is the annualized change between the two ends in the cell's mean log net wealth per partner, net of the growth of the cell's own average wage, the mean employee earnings of its members reporting positive earnings; cells with no such earner at either end are dropped. All other conventions are those of Table 1, and the generosity control of columns (2), (3), (5) and (6) is the initial replacement rate ρ_{dc} of equation (36), the measure of that table. In columns (1)–(3) the regressor is the annualized log change of the labor tax wedge implied by the implicit tax rate on labour (European Commission, DG TAXUD), $-[\ln(1-\text{ITR}_{2019})-\ln(1-\text{ITR}_{1995})]/24$; in columns (4)–(6) it is the tax wedge change predicted by the retirement budget alone, equation (41): the change, from each country's first available year (1995, later in the East) to 2019, in the ratio of pension expenditure (Eurostat ESSPROS) to labor income, converted to the compensation-of-employees base as described in the text, divided by one minus the 1995 implicit tax rate, in exact log form and annualized by the window length. All columns include an indicator for the former Eastern-bloc countries and cohort × decile fixed effects. Cells are weighted by their population and the five imputation implicates are combined by Rubin's rules. Standard errors clustered by country are in parentheses. The p-values in brackets come from a wild cluster bootstrap at the country level (null imposed, Rademacher weights, 999 replications), computed within each implicate and combined across implicates by the Licht–Rubin method. Stars reflect the asymptotic t statistics: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

the annualized change in the contribution ratio $\Delta\tau_c$ of equation (41) on $\hat{\Delta}\text{VA}_c$ and the Eastern-bloc indicator yields a coefficient of -1.08 (standard error 0.17, $R^2=0.77$), showing the contribution ratio rose markedly less where the initial sectoral mix implied a fast-growing tax base. We map the fitted change through equation (41) to obtain a predicted wedge change. Because realized changes already reflect the indexation rules in force, this prediction corresponds to the average pass-through

of the sample. We divide it by the weighted mean of $1-\theta_{c,1995}$, equal to 0.49, and denote by $\hat{\nu}_c$ the wedge change that would have occurred had contributions absorbed the whole gap. Our instrument is $\hat{\nu}_c\,(1-\theta_{c,1995})$, where $1-\theta_{c,1995}$ is the share of the gap that the rules in force in 1995 passed on to contributions, computed as in Section 3.3.

The identifying assumption is that the 1995 industry mix, scaled by the 1995 indexation rule, affects the wealth accumulation of working-age households only through the tax wedge. The outcome is net of each cell's own wage growth and all specifications control for realized growth, so a favorable mix cannot operate through earnings. The rule adds a condition: workers in countries that protected benefits in 1995 must not have accumulated wealth differently for other reasons. The shift-share ranks countries by how far their 1995 mix had moved from agriculture and manufacturing toward services; it is closely correlated with GDP per capita in 1995 and largely contrasts the euro-area crisis countries with the rest. Two columns of Table 3 address these concerns. Column (4) controls for the log of GDP per capita in 1995. Column (5) rebuilds the instrument from the 1980–1995 industry growth rates, so that it carries no shock realized during the window.

Table 3 presents two-stage least squares estimates for the specifications of columns (1)–(3) of Table 2, instrumenting with $\hat{\nu}_c\,(1-\theta_{c,1995})$. In columns (1)–(3) the first stage is strong by the standards appropriate to clustered data (Montiel Olea and Pflueger, 2013), with cluster-robust F statistics between 35 and 49, and its coefficient of about one quarter says that a quarter of the wedge change predicted under the 1995 rules materialized over the window. The instrumented coefficients are stable across specifications and larger than their least-squares counterparts in Table 2, 10 to 11 log points against 5.5 to 6.0, the pattern expected if measurement error in the implicit tax rate attenuates the latter. Column (4) adds the 1995 level of development. The control absorbs much of the cross-country variation of the instrument, so the first stage weakens to an F of 11, but the estimate rises to 12.2 log points and the reduced form is, if anything, sharper, while the least-squares coefficient on the same sample falls to 3.7. Column (5) instruments with the pre-window shifts: the first stage keeps an F of 24, and the estimate of 8.6 log points lies within a standard error of column (4). Because the model is just identified in every column, the reduced form of the outcome on the instrument is the test of Anderson and Rubin (1949) and remains valid whatever the strength of the first stage; its wild-bootstrap p values are 0.04 or below in columns (1), (2), (4) and (5) and 0.12 in column (3), in line with the bootstrap inference of Table 2.

Table 3: Instrumenting the tax wedge change with the 1995 industry mix and indexation rule

	Instrument: $\hat{\nu}_c\,(1-\theta_{c,1995})$, 1995–2019 shifts				1980–95 shifts
	(1)	(2)	(3)	(4)	(5)
Tax wedge change ν^{real}	-10.181***	-10.213***	-10.881***	-12.184***	-8.582***
	(2.286)	(2.301)	(2.924)	(4.382)	(2.385)
$\log(1+g_a)$ (centered)	-4.789***	-4.796***	-5.064***	-5.592**	-4.237**
	(1.406)	(1.416)	(1.470)	(2.717)	(1.654)
Replacement rate at award		0.002	0.010	0.004	0.014
		(0.026)	(0.031)	(0.041)	(0.034)
Real house-price growth			0.076	0.047	0.135
			(0.258)	(0.255)	(0.183)
Soviet bloc	0.036**	0.036**	0.036*	0.033	0.037*
	(0.016)	(0.018)	(0.019)	(0.025)	(0.021)
Log GDP per capita, 1995				-0.010	0.008
				(0.037)	(0.023)
First stage	0.255***	0.262***	0.224***	0.265***	0.372***
	(0.038)	(0.038)	(0.038)	(0.081)	(0.076)
First-stage F	44.1	48.7	34.9	10.7	24.1
Reduced form	-2.595***	-2.678***	-2.436***	-3.223***	-3.189***
	(0.421)	(0.452)	(0.419)	(0.554)	(0.750)
	[0.041]	[0.031]	[0.119]	[0.008]	[0.033]
Cohort×decile FE	Yes	Yes	Yes	Yes	Yes
Cells	569	569	545	545	545
Countries	17	17	16	16	16

Notes: Two-stage least squares versions of columns (1)–(3) of Table 2: cells, dependent variable, fixed effects, weights, clustering and the combination of the implicates are unchanged, the endogenous regressor is the realized tax wedge change ν^{real} in every column, and the least-squares coefficients on the samples of columns (1)–(3) are those of that table. The instrument in columns (1)–(4) is the predicted wedge change under the 1995 indexation rule, $\hat{\nu}_c\,(1-\theta_{c,1995})$: the change in the pension contribution ratio fitted on the shift-share $\hat{\Delta}\text{VA}_c$ of equation (43) and the Eastern-bloc indicator, mapped through equation (41) and divided by the population-weighted mean of $1-\theta_{c,1995}$ across the 17 countries of that regression (0.49), so that it is expressed in units of the whole budget gap, times the share of the gap that the rules in force in 1995 passed on to contributions (Appendix D.4). Column (4) adds to the controls of column (3) the log of real GDP per capita in 1995 (Penn World Table 10.01). Column (5) repeats column (4) with the shift-share replaced by one built from the same 1995 employment shares and the 1980–1995 growth of real value added of the same European industries (EU KLEMS, October 2012 release, summed over the eight countries with data in both windows, leaving out the country itself), so that the shifts predate the window; the predicted wedge change is refitted on it and scaled in the same way. Greece drops from columns (3)–(5) with the house-price control. The lower panel reports the first stage of the wedge change on the instrument with its cluster-robust F, and the reduced form of the outcome on the instrument, which with a single instrument is the Anderson–Rubin test; the p-values in brackets under the reduced form come from the wild cluster bootstrap of Table 2, applied to the reduced form. Standard errors clustered by country are in parentheses; stars as in Table 2.

An obvious placebo test is to repeat the analysis on the retired population the wedge does not tax. Table C.7 in Appendix C conducts this exercise: in every column the coefficient collapses to a small positive and insignificant number, with first stages as strong as in the main table.

Figure 8 summarizes the incidence and its placebo. It extends the cells of Table 3 through the

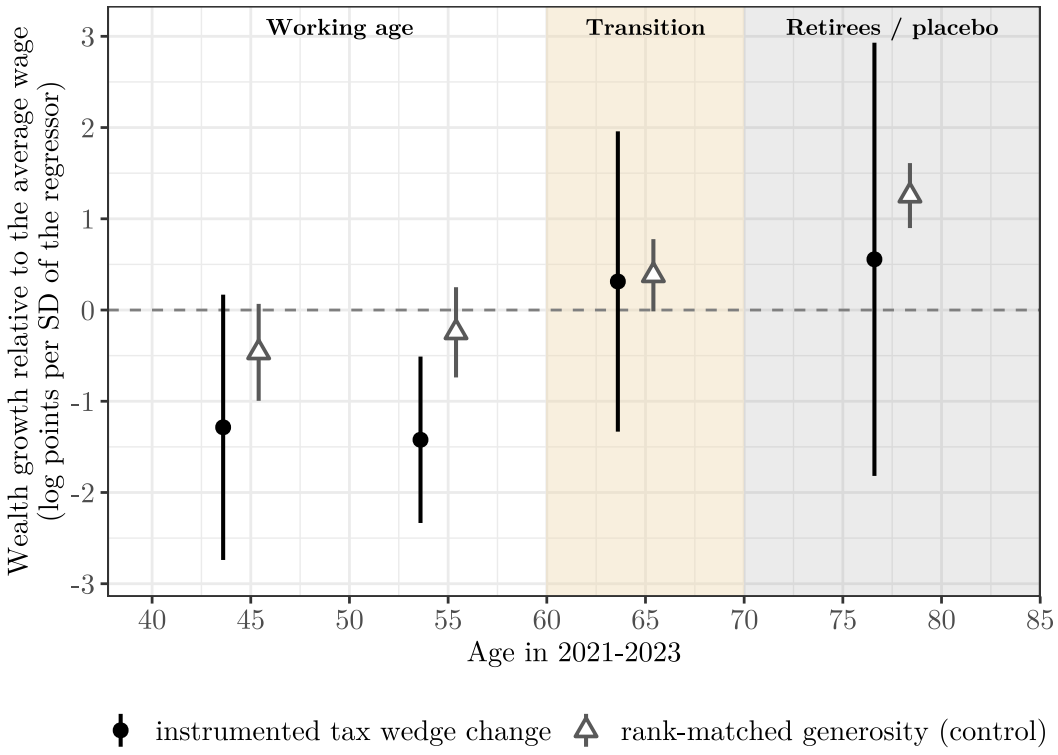


Figure 8: The incidence of the instrumented tax wedge change over the life cycle. This figure repeats the analysis of Table 3, column (3), with the cells extended through the retiree ages (40–44 to 80–85 at the endpoint, the oldest at the survey's age topcode) and every coefficient cut by age group at the endpoint: 40–49 and 50–59 (working age, unshaded), 60–69 (crossing retirement during the window, sand), and 70–85 (retired, gray; its oldest band is the topcode band). Filled circles are the effect of a one between-country standard-deviation increase in the tax wedge change (0.29 log points a year) on the group's annual wealth growth, in log points, instrumented as in Table 3 with the predicted wedge change under the 1995 indexation rule, $\hat{\nu}_c\,(1-\theta_{c,1995})$. Hollow triangles are a sanity check: the coefficient on the rank-matched generosity control ρ_{dc} from the same regression, per standard deviation of the control across these cells (0.14); this control is not instrumented. Bars are 95 percent confidence intervals (asymptotic, with 16 clusters). Because retiree cells have no wage of their own to net out, the outcome for every group is the annualized change in the cell's mean log wealth over the national average wage, cells without earners remain in the sample, and the fixed effects are five-year age band $\times$ income decile; everything else is as in Table 3. The transition group mixes households still working, retired ones, and those that moved from one status to the other during the window.

retiree ages and estimates the specification of column (3) by age group at the endpoint, the 60–69 group covering the cohorts that crossed retirement during the window and the retirees being aged 70–85. A one standard-deviation increase in the wedge change lowers annual wealth growth by 1.3 log points at ages 40–49 and by 1.4 at 50–59. The effect is an insignificant 0.3 for the transition

group and 0.6, with a standard error of 1.2, for the retirees. The coefficient on the rank-matched generosity control from the same regression is the mirror image: small and negative at working ages and 1.3 log points for the retirees, significant at the one percent level. The labor tax weighs on those who pay it and pension generosity benefits those who receive it, as the fiscal channel of the model implies.

One final prediction of the model is that the fiscal channel is mitigated by the inheritance loop. Workers recover part of their taxes through the larger inheritance that higher relative pension benefits allow. If that is true, the results from Tables 2 and 3 are attenuated relative to an alternative specification excluding inherited wealth. To test this prediction, Tables C.5 and C.6 in Appendix C repeat the table with each household's received inheritances — revalued to survey-year prices and capitalized at a two-percent annual real return, excluded from wealth. In line with theory, every burden coefficient rises by a quarter to a third in both the OLS and IV specifications.

5 Conclusion

This paper studies how unfunded pension systems shape the distribution of wealth between overlapping generations when economic growth slows. The growing share of national wealth held by the elderly is now well documented, in Europe as in the United States, with important consequences for the role of inheritance in the fortunes of the next generation. We argue that this shift is not only the outcome of a race between r and g. It also reflects a fiscal choice. When growth slows, a gap opens in the pay-as-you-go budget. Closing that gap by raising contributions rather than by reducing benefits or delaying retirement preserves the resources of retirees, part of which are ultimately bequeathed, while reducing the net wages out of which workers accumulate wealth.

The model makes this mechanism precise. When contribution rates are held fixed, the fiscal channel disappears: the return delivered by the pension system adjusts with economic growth, and pensions do not themselves tilt wealth toward the old. When retirees are partly insulated from the slowdown, by contrast, contribution rates rise and the pension system amplifies the shift in wealth toward older generations. The amplification is stronger when the system is more generous, because a given decline in growth opens a larger funding gap. The source of the slowdown matters as well: unlike a productivity slowdown, a demographic slowdown reduces the number of young

households among whom aggregate wealth is divided, partly offsetting the fiscal force in per-capita terms.

The European evidence is consistent with these predictions. Over 2010–2023, retirees accumulated wealth faster in countries where pensions were more generous and productivity growth slower, while working-age households displayed the opposite pattern. The interaction between generosity and slow growth changes sign around retirement age, as the model predicts. We also find direct evidence for the fiscal mechanism. Countries in which generous pension promises encountered larger slowdowns experienced larger increases in the tax wedge on labor, and those increases predict slower wealth accumulation among workers. Instrumenting the tax wedge with countries' initial industrial composition produces larger estimates, while the effect vanishes among retirees, who are no longer exposed to labor taxation. Finally, removing received inheritances from measured wealth strengthens the estimated burden on workers, consistent with the model's prediction that bequests return part of the transfer to the next generation.

The adjustment parameter θ is therefore not a constant of nature but a political choice, and several large economies are confronting that choice today. In the United States, the 2026 Trustees Report moves the depletion of the OASI trust fund to the fourth quarter of 2032, when scheduled benefits become 78 percent payable, leaving a seventy-five-year shortfall of 4.42 percent of taxable payroll to close.[10] In France, where the elderly are among the wealthiest relative to the working-age population, the 2023 reform raising the minimum retirement age from 62 to 64 was suspended by the 2026 social security budget until after the 2027 presidential election. China began in January 2025 to raise statutory retirement ages over a fifteen-year phase-in, against projections that the urban worker fund would otherwise be exhausted around 2035.[11]

Wen the growth of the payroll slows, either the return promised by the pension system must adjust or a larger burden must be placed on the generations that finance it. In the second case, workers bear lower net wages while retirees preserve resources that become, in part, the inheritances of those same workers. The choice of how to balance a pension system therefore shapes not only who pays for retirement today, but also whether the economic fortunes of the next generation are built increasingly from what they inherit rather than from what they earn.

[10] *2026 Annual Report of the Board of Trustees of the OASI and DI Trust Funds*. The combined OASDI funds are projected to deplete in the third quarter of 2034.

[11] Chinese Academy of Social Sciences, *China Pension Actuarial Report 2019–2050*.

References

Aaron, Henry, "The Social Insurance Paradox," *Canadian Journal of Economics and Political Science*, 1966, *32* (3), 371–374.

Abel, Andrew B., "The Effects of a Baby Boom on Stock Prices and Capital Accumulation in the Presence of Social Security," *Econometrica*, 2003, *71* (2), 551–578.

Alessie, Rob, Viola Angelini, and Peter van Santen, "Pension Wealth and Household Savings in Europe: Evidence from SHARELIFE," *European Economic Review*, 2013, *63*, 308–328.

Alvaredo, Facundo, Bertrand Garbinti, and Thomas Piketty, "On the Share of Inheritance in Aggregate Wealth: Europe and the USA, 1900–2010," *Economica*, 2017, *84* (334), 239–260.

Anderson, Theodore W. and Herman Rubin, "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations," *Annals of Mathematical Statistics*, 1949, *20* (1), 46–63.

Attanasio, Orazio P. and Agar Brugiavini, "Social Security and Households' Saving," *Quarterly Journal of Economics*, 2003, *118* (3), 1075–1119.

Attanasio, Orazio P. and Susann Rohwedder, "Pension Wealth and Household Saving: Evidence from Pension Reforms in the United Kingdom," *American Economic Review*, 2003, *93* (5), 1499–1521.

Attanasio, Orazio, Sagiri Kitao, and Giovanni L. Violante, "Global Demographic Trends and Social Security Reform," *Journal of Monetary Economics*, 2007, *54* (1), 144–198.

Auclert, Adrien, Hannes Malmberg, Frédéric Martenet, and Matthew Rognlie, "Demographics, Wealth, and Global Imbalances in the Twenty-First Century," Working Paper 29161, National Bureau of Economic Research 2025. August 2025 revision.

Auerbach, Alan J. and Ronald D. Lee, "Welfare and Generational Equity in Sustainable Unfunded Pension Systems," *Journal of Public Economics*, 2011, *95* (1), 16–27.

Barro, Robert J., "Are Government Bonds Net Wealth?," *Journal of Political Economy*, 1974, *82* (6), 1095–1117.

Bartik, Timothy J., *Who Benefits from State and Local Economic Development Policies?*, Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 1991.

Bauluz, Luis and Timothy Meyer, "The Wealth of Generations," Working Paper 2024/04, World Inequality Lab January 2024.

Benetton, Matteo, Marianna Kudlyak, and John Mondragon, "Dynastic Home Equity," Working Paper 2022-13, Federal Reserve Bank of San Francisco 2024. December 2024 revision.

Bergeaud, Antonin, Gilbert Cette, and Rémy Lecat, "Productivity Trends in Advanced Countries between 1890 and 2012," *Review of Income and Wealth*, 2016, *62* (3), 420–444.

Bø, Erlend E., Elin Halvorsen, and Thor O. Thoresen, "Heterogeneity of the Carnegie Effect," *Journal of Human Resources*, 2019, *54* (3), 726–759.

Boar, Corina, "Dynastic Precautionary Savings," *Review of Economic Studies*, 2021, *88* (6), 2735–2765.

Boar, Corina and Danial Lashkari, "Occupational Choice and the Intergenerational Mobility of Welfare," Working Paper 29381, National Bureau of Economic Research 2025. May 2025 revision.

Boldrin, Michele and Aldo Rustichini, "Political Equilibria with Social Security," *Review of Economic Dynamics*, 2000, *3* (1), 41–78.

Brock, William A. and Leonard J. Mirman, "Optimal Economic Growth and Uncertainty: The Discounted Case," *Journal of Economic Theory*, 1972, *4* (3), 479–513.

Brown, Jeffrey R., Courtney C. Coile, and Scott J. Weisbenner, "The Effect of Inheritance Receipt on Retirement," *Review of Economics and Statistics*, 2010, *92* (2), 425–434.

Browning, Edgar K., "Why the Social Insurance Budget Is Too Large in a Democracy," *Economic Inquiry*, 1975, *13* (3), 373–388.

Catherine, Sylvain, Max Miller, and Natasha Sarin, "Social Security and Trends in Wealth Inequality," *Journal of Finance*, 2025, *80* (3), 1497–1531.

Catherine, Sylvain, Max Miller, James D. Paron, and Natasha Sarin, "Who Gains When Interest Rates Fall?," Working Paper, University of Pennsylvania 2025.

Cooley, Thomas F. and Jorge Soares, "A Positive Theory of Social Security Based on Reputation," *Journal of Political Economy*, 1999, *107* (1), 135–160.

Diamond, Peter A., "National Debt in a Neoclassical Growth Model," *American Economic Review*, 1965, *55* (5), 1126–1150.

Fagereng, Andreas, Luigi Guiso, Luigi Pistaferri, and Marius A. K. Ring, "Insuring Labor Income Shocks: The Role of the Dynasty," Working Paper 34253, National Bureau of Economic Research 2026. August 2026 revision.

Fagereng, Andreas, Matthieu Gomez, Émilien Gouin-Bonenfant, Martin B. Holm, Benjamin Moll, and Gisle J. Natvik, "Asset-Price Redistribution," *Journal of Political Economy*, 2025, *133* (11), 3494–3549.

Feldstein, Martin, "Social Security, Induced Retirement, and Aggregate Capital Accumulation," *Journal of Political Economy*, 1974, *82* (5), 905–926.

Feldstein, Martin, "Social Security and the Distribution of Wealth," *Journal of the American Statistical Association*, 1976, *71* (356), 800–807.

Galasso, Vincenzo and Paola Profeta, "The Political Economy of Social Security: A Survey," *European Journal of Political Economy*, 2002, *18* (1), 1–29.

Gale, William G., "The Effects of Pensions on Household Wealth: A Reevaluation of Theory and Evidence," *Journal of Political Economy*, 1998, *106* (4), 706–723.

Greenwald, Daniel L., Matteo Leombroni, Hanno Lustig, and Stijn Van Nieuwerburgh, "Financial and Total Wealth Inequality with Declining Interest Rates," Working Paper 28613, National Bureau of Economic Research 2021.

Kopczuk, Wojciech and Joseph P. Lupton, "To Leave or Not to Leave: The Distribution of Bequest Motives," *Review of Economic Studies*, 2007, *74* (1), 207–235.

Kotlikoff, Laurence J. and Lawrence H. Summers, "The Role of Intergenerational Transfers in Aggregate Capital Accumulation," *Journal of Political Economy*, 1981, *89* (4), 706–732.

Krueger, Dirk and Alexander Ludwig, "On the Consequences of Demographic Change for Rates of Return to Capital, and the Distribution of Wealth and Welfare," *Journal of Monetary Economics*, 2007, *54* (1), 49–87.

Lachowska, Marta and Michał Myck, "The Effect of Public Pension Wealth on Saving and Expenditure," *American Economic Journal: Economic Policy*, 2018, *10* (3), 284–308.

Lee, Siha and Kegon Teng Kok Tan, "Bequest Motives and the Social Security Notch," *Review of Economic Dynamics*, 2023, *51*, 888–914.

Mulligan, Casey B. and Xavier Sala i Martin, "Gerontocracy, Retirement, and Social Security," Working Paper 7117, National Bureau of Economic Research 1999.

Musgrave, Richard A., "A Reappraisal of Financing Social Security," in Felicity Skidmore, ed., *Social Security Financing*, Cambridge, MA: MIT Press, 1981, pp. 89–125.

Nardi, Mariacristina De, "Wealth Inequality and Intergenerational Links," *Review of Economic Studies*, 2004, *71* (3), 743–768.

Olea, José Luis Montiel and Carolin Pflueger, "A Robust Test for Weak Instruments," *Journal of Business & Economic Statistics*, 2013, *31* (3), 358–369.

Piketty, Thomas, "On the Long-Run Evolution of Inheritance: France 1820–2050," *Quarterly Journal of Economics*, 2011, *126* (3), 1071–1131.

Sabelhaus, John and Alice Henriques Volz, "Social Security Wealth, Inequality, and Life-Cycle Saving," in Raj Chetty, John N. Friedman, Janet C. Gornick, Barry Johnson, and Arthur Kennickell, eds., *Measuring Distribution and Mobility of Income and Wealth*, Chicago: University of Chicago Press, 2022, chapter 9, pp. 249–285.

Wei, Shang-Jin and Xiaobo Zhang, "The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China," *Journal of Political Economy*, 2011, *119* (3), 511–564.

A Model appendix

A.1 First-order conditions

Attach the multiplier μ_t to (5) and μ^o_{t+1} to (6). Optimality in c^y_t, c^o_{t+1}, and s^y_t gives $\mu_t = (c^y_t)^{-\gamma}$, $\mu^o_{t+1} = \beta\,(c^o_{t+1})^{-\gamma}$, and $\mu_t = (1 + r_{t+1})\,\mu^o_{t+1}$, which is (7). Optimality in s^o_{t+1} trades the old's resources against the warm glow: $\beta\,\varphi\,(s^o_{t+1})^{-\gamma} = \mu^o_{t+1} = \beta\,(c^o_{t+1})^{-\gamma}$, i.e. $s^o_{t+1} = \varphi^{1/\gamma}\,c^o_{t+1}$, which combined with the old's budget (6) is (8); because $\varphi\,u'(s) \to \infty$ as $s \to 0$, the constraint $s^o_{t+1} \geq 0$ never binds and the margin always holds with equality. Earnings being exogenous to the household, the pension enters the budgets only through τ_t and b_{t+1}, both inframarginal.

A.2 The balanced growth path

The old's split. The bequest margin (8) and the old's budget (6) give $c^o_{t+1} = (1 - \Phi)\,j^o_{t+1}$ and $s^o_{t+1} = \Phi\,j^o_{t+1}$, and the split survives aggregation unchanged. With $K_{t+1} = S^y_t$, the old cohort collects the entire payout, $(1 + r_{t+1})\,S^y_t = \Pi_{t+1} = \alpha Y_{t+1}$ by (2), and $N_t\,b_{t+1} = \tau\,W_{t+1}$ on a balanced path, so per unit of the payroll W_{t+1}, $\hat{J}^o = \hat{\Pi} + \tau$, which is (10)–(11).

Existence and uniqueness. Write the equilibrium condition (15) as $f(\Lambda) = 0$ with

$$f(\Lambda) \equiv \left[\frac{\beta(1+g)}{\Lambda}\right]^{1/\gamma} \left[\,1 + \hat{\Pi} - \hat{C}^{\,o} - \Lambda\,\hat{\Pi}\,\right] - \hat{C}^{\,o}\,(1+g), \tag{A.1}$$

where $\hat{C}^{\,o} = (1 - \Phi)(\hat{\Pi} + \tau)$ does not depend on Λ and $1 + \hat{\Pi} = 1/(1 - \alpha)$. On the admissible range $\Lambda \in (0, \bar{\Lambda})$ with $\bar{\Lambda} \equiv (1 + \hat{\Pi} - \hat{C}^{\,o})/\hat{\Pi}$ (which keeps $\hat{C}^{\,y} > 0$) — nonempty for every parameterization, since $\hat{C}^{\,o} = (1 - \Phi)(\hat{\Pi} + \tau) < 1 + \hat{\Pi}$ whenever $\Phi \in (0, 1)$ and $\tau < 1$ — both factors of the first term are positive and strictly decreasing in Λ, so f is strictly decreasing; as $\Lambda \to 0^+$, $f \to +\infty$, and at $\Lambda = \bar{\Lambda}$, $f = -\hat{C}^{\,o}(1 + g) < 0$. A unique root exists. At $\gamma = 1$ the condition is linear in Λ and solves to (16).

Budget consistency. From (13), $\hat{C}^{\,y} + \hat{S}^y = 1 + \hat{\Pi} - \hat{C}^{\,o}$; and the young's budget requires $\hat{C}^{\,y} + \hat{S}^y = (1 - \tau) + \hat{S}^o = 1 - \tau + (\hat{\Pi} + \tau) - \hat{C}^{\,o} = 1 + \hat{\Pi} - \hat{C}^{\,o}$: the system is consistent, with the

young's consumption the residual that clears it.

A.3 Non-neutrality of the pension

Take logarithms of (15),

$$\ln \hat{C}^{o} + \ln(1+g) = \frac{1}{\gamma}\big[\ln\beta + \ln(1+g) - \ln\Lambda\big] + \ln \hat{C}^{y}, \tag{A.2}$$

and differentiate totally, using $d\hat{C}^{o} = (1-\Phi)\,d\tau$, $d\hat{C}^{y} = -(1-\Phi)\,d\tau - \hat{\Pi}\,d\Lambda$, and $\hat{C}^{o} = (1-\Phi)\,(\hat{\Pi}+\tau)$:

$$\frac{d\tau}{\hat{\Pi}+\tau} + d\ln(1+g) = \frac{1}{\gamma}\,d\ln(1+g) - \frac{1}{\gamma}\,d\ln\Lambda - \frac{(1-\Phi)\,d\tau}{\hat{C}^{y}} - \frac{\hat{S}^{y}}{\hat{C}^{y}}\,d\ln\Lambda. \tag{A.3}$$

Collecting terms, with $\Psi \equiv (1-\Phi)\big(1/\hat{C}^{o} + 1/\hat{C}^{y}\big)$ — using $(1-\Phi)/\hat{C}^{o} = 1/(\hat{\Pi}+\tau)$ — and $D \equiv 1 + \gamma\,\hat{S}^{y}/\hat{C}^{y}$,

$$d\ln\Lambda = \frac{(1-\gamma)\,d\ln(1+g) - \gamma\,\Psi\,d\tau}{D}. \tag{A.4}$$

Holding g fixed, $\partial\ln\Lambda/\partial\tau = -\gamma\Psi/D < 0$: by (17), capital intensity and the wage level fall with τ and the interest rate rises. The consumption and estate loadings on τ are immediate from (11). This is where the warm-glow model departs from one with dynastic altruism: there the interest rate is pinned by the dynastic Euler equation and τ appears in no equilibrium condition; here τ appears in the one condition that determines the interest rate.

A.4 Proofs

Proposition 1. By (18), $\ln(s^{o}/s^{y}) = \ln(1+g_n) + \ln\Phi + \ln(\hat{\Pi}+\tau) - \ln\Lambda - \ln\hat{\Pi}$. Every term beyond the cohort factor depends on (g_a, g_n) only through total growth g. Substituting the design rule $d\tau = -(1-\theta)\,\tau\,d\ln(1+g)$ into (A.4) and differentiating those terms gives $-R$ of (26), the difference (21) minus (25). A fall in g_a leaves the cohort factor fixed, so the response of the wealth ratio is R; a fall in g_n moves the cohort factor one for one, so the response is $R-1$, Q.E.D.

Proposition 2. Taking logs of (28), $\ln b_t - \ln[(1-\tau_t)\,w_t] = \ln\rho_t - \ln(1+g_a) - \ln(1-\tau_t)$, and differentiating along the rule (20), $d\ln\rho = \theta\,d\ln(1+g)$ and $-d\ln(1-\tau) = \tau\,d\ln\tau/(1-\tau) =$

$-(1-\theta)\,\tau\,d\ln(1+g)/(1-\tau)$, gives, since $\theta-(1-\theta)\,\tau/(1-\tau)=(\theta-\tau)/(1-\tau)$,

$$d\ln\frac{b_t}{(1-\tau_t)\,w_t}=\frac{(\theta-\tau)\,d\ln(1+g)-(1-\tau)\,d\ln(1+g_a)}{1-\tau}\,. \tag{A.5}$$

The numerator vanishes at $\theta=\theta^*$ with $\theta^*\,d\ln(1+g)=\tau\,d\ln(1+g)+(1-\tau)\,d\ln(1+g_a)=d\ln(1+g_a)+\tau\,d\ln(1+g_n)$, which is (29); substituting $(1-\tau)\,d\ln(1+g_a)=(\theta^*-\tau)\,d\ln(1+g)$ back into the numerator gives $(\theta-\theta^*)\,d\ln(1+g)$. Since $d\ln(1+g)<0$, the ratio rises for $\theta<\theta^*$ and falls for $\theta>\theta^*$. Writing $\sigma\equiv d\ln(1+g_a)/d\ln(1+g)\in[0,1]$ for the productivity share of the slowdown, $\theta^*=\sigma+(1-\sigma)\,\tau$: $\theta^*=1$ at $\sigma=1$ and $\theta^*=\tau$ at $\sigma=0$, Q.E.D.

Proposition 3. By Proposition 1, $d\ln(s^o/s^y)=-R\,d\ln(1+g_a)-(R-1)\,d\ln(1+g_n)=-R\,d\ln(1+g)+d\ln(1+g_n)$, and by (26), $R=(1-\theta)\,\tau\kappa+(1-\gamma)/D$ with $\kappa=1/(\hat{\Pi}+\tau)+\gamma\Psi/D$, which is $\partial\ln(s^o/s^y)/\partial\tau$ at fixed g by (18) and (24); this is (31). (a) Since $d\ln(1+g)<0$ and $\tau\kappa>0$, the fiscal term is zero at $\theta=1$ and positive for $\theta<1$; the design rule (19) is written in total growth, so the term is the same function of (θ,τ) for either composition of the slowdown. (b) By (20) the tax increase is $d\tau=-(1-\theta)\,\tau\,d\ln(1+g)$, proportional to the fall in growth and, at a common initial growth rate g_0, to $\rho=\tau\,(1+g_0)$, and the fiscal term is $\kappa\,d\tau=\tau\kappa\,(1-\theta)\,[-d\ln(1+g)]$, linear in $1-\theta$ with slope $\tau\kappa$ per unit of the fall in growth; the race term and the cohort factor in (31) do not involve θ, so the whole response is affine in $1-\theta$. Since $1-\theta$ is a constant factor, the gradient of the slope is that of $F\equiv(1-\theta)\,\tau\kappa$ at any fixed $\theta<1$. Write $c\equiv\hat{C}^{\,o}$, $y\equiv\hat{C}^{\,y}$, $v\equiv\hat{S}^{y}$, $X\equiv\hat{\Pi}+\tau$, $S\equiv1/(1-\alpha)=c+y+v$, $P\equiv y+\gamma v$, $N\equiv y+\gamma S$, and $a\equiv(1-\theta)\,\tau/X$, so that $D=P/y$. Using $(1-\Phi)/c=1/X$ in (23), $\gamma\Psi/D=\gamma\,(y+c)/(XP)$, hence $\kappa=[P+\gamma(y+c)]/(XP)=N/(XP)$ and $F=aN/P$. Raise (15) to the power γ to write the equilibrium locus as $v\,(c/y)^{\gamma}=\beta\,\hat{\Pi}\,(1+g)^{1-\gamma}$; with S fixed, implicit differentiation at fixed g and $d\ln c=d\tau/X$ gives $dy=y\,(\gamma v-c)\,d\tau/(PX)$ and $dv=-\,[c+y\,(\gamma v-c)/P]\,d\tau/X$, so that $dN=dy$ and $dP=dy+\gamma\,dv$. Differentiating $F=aN/P$ and collecting terms, using $P-(1-\gamma)\,N=\gamma\,(\gamma S-c)$,

$$\frac{XP^3}{\gamma}\,\frac{\partial F}{\partial\tau}=\frac{(1-\theta)\,\hat{\Pi}\,NP^2}{\gamma\,X}+a\,\big[\,cNP+(\gamma S-c)\,y\,(\gamma v-c)\big]. \tag{A.6}$$

The first term is strictly positive for $\theta < 1$. The bracket is nonnegative: if $\gamma S - c$ and $\gamma v - c$ have the same sign its second piece is nonnegative; the only remaining case is $\gamma S > c > \gamma v$, since $S > v$ rules out $\gamma v > c > \gamma S$, and there $(\gamma S - c)\, y\, (c - \gamma v) < cNP$ because each factor on the left is smaller than its counterpart on the right ($\gamma S - c = N - y - c < N$, $y < P$, $c - \gamma v < c$). Hence $\partial F/\partial \tau > 0$ for every $\gamma > 0$, $\Phi \in (0, 1)$, and $\tau \in (0, 1)$, and at a common initial growth rate $\partial F/\partial \rho = (1 + g_0)^{-1}\, \partial F/\partial \tau > 0$, Q.E.D.

Corollary 1. In the notation of the proof of Proposition 3, $R = aN/P + (1 - \gamma)\, y/P$ by (26), and the demographic response $R - 1$ shares its gradient. From dy and dP there, $\partial(y/P)/\partial \tau = \gamma\, y\, v\, (\gamma S - c)/(XP^3)$, so adding the race term to (A.6) gives the identity

$$\frac{XP^3}{\gamma}\frac{\partial R}{\partial \tau} = \frac{(1-\theta)\,\hat{\Pi}\,NP^2}{\gamma\, X} + a\, cNP + (\gamma S - c)\, y\, \big[a(\gamma v - c) - (\gamma - 1)\, v\big]. \tag{A.7}$$

Note $\gamma S - c > 0$ under the first assumption: $\tau < 1$ gives $X < S$, so $c = (1 - \Phi)X < (1 - \Phi)S \leq \gamma S$. Three cases.

Fixed contribution rate ($\theta = 1$, $a = 0$). Identity (A.7) reduces to $\partial R/\partial \tau = \gamma(1 - \gamma)\, vy\, (\gamma S - c)/(XP^3)$, whose sign is that of $1 - \gamma$; and $R = (1 - \gamma)y/P$ is positive exactly when $\gamma < 1$. Premise and conclusion hold together.

Case $\gamma \leq 1$, $\theta < 1$. The bracket of (A.7) is $a(\gamma v - c) + (1 - \gamma)v$, whose second piece is nonnegative. If its first piece is negative ($c > \gamma v$), it is dominated by the middle term of (A.7): $(\gamma S - c)\, y\, (c - \gamma v) \leq NPc$, because each factor on the left is smaller than its counterpart on the right ($\gamma S - c = N - y - c < N$, $y < P$, $c - \gamma v < c$). The first term of (A.7) is strictly positive, so $\partial R/\partial \tau > 0$ — without using the premise.

Case $\gamma > 1$, $\theta < 1$. The premise is used once: $R > 0$ means $\gamma - 1 < aN/y$, so the bracket obeys

$$a(\gamma v - c) - (\gamma - 1)\, v > a\, \frac{(\gamma v - c)\, y - Nv}{y} = -\, a\, \frac{(v + c)\, P}{y}, \tag{A.8}$$

using $(\gamma v - c)\, y - Nv = -(v + c)\, P$. Substituting into (A.7) and using $cN - (\gamma S - c)(v + c) = S\, (c - \gamma v)$,

$$\frac{XP^3}{\gamma}\frac{\partial R}{\partial \tau} > \frac{(1-\theta)\,\hat{\Pi}\,NP^2}{\gamma X} + a\, P\, S\, (c - \gamma v). \tag{A.9}$$

If $c \geq \gamma v$, both terms are nonnegative and the first is strictly positive. Otherwise it suffices that $\hat{\Pi}\, NP \geq \gamma\, \tau\, S\,(\gamma v - c)$, which follows from $N > \gamma S$, $P > \gamma v$, and $\tau \leq \hat{\Pi}$: $\hat{\Pi} NP > \hat{\Pi}\gamma^2 Sv \geq \gamma^2 \tau Sv \geq \gamma \tau S(\gamma v - c)$. Finally, at a common initial growth rate $\partial R/\partial \rho = (1 + g_0)^{-1}\, \partial R/\partial \tau$, which carries the sign to (32), Q.E.D.

Proposition 4. By Proposition 1 the productivity condition is $R > 0$, which rearranges to (33), and the demographic condition is $R > 1$. At $\theta = 1$ the fiscal terms vanish and $R = (1 - \gamma)/D$: positive if and only if $\gamma < 1$ — globally, because nothing but γ and the sign-definite object $D > 0$ remains — and always below one, since $\gamma > 0$ gives $1 - \gamma < 1 \leq D$, Q.E.D.

A.5 The response of relative wealth across the parameter space

Figure A.1 maps the balanced-path response R of (26) in the plane of the intertemporal elasticity of substitution $1/\gamma$ and the bequest share Φ, one panel per generosity level, holding every other parameter at its calibrated value from Section 2.4.1. It displays only the region $\gamma > 1$, since a slowdown unambiguously tilts wealth toward the elderly when $\gamma \leq 1$. Red areas represent calibrations in which a productivity slowdown tilts wealth toward the elderly ($R > 0$), and the region where $R > 1$ those in which even a demographic slowdown does. Blue areas ($R < 0$) represent situations in which the return r falls sufficiently more than g for the relative wealth of the elderly to decline, which is more likely when the intertemporal elasticity of substitution is particularly low and the pension system small.

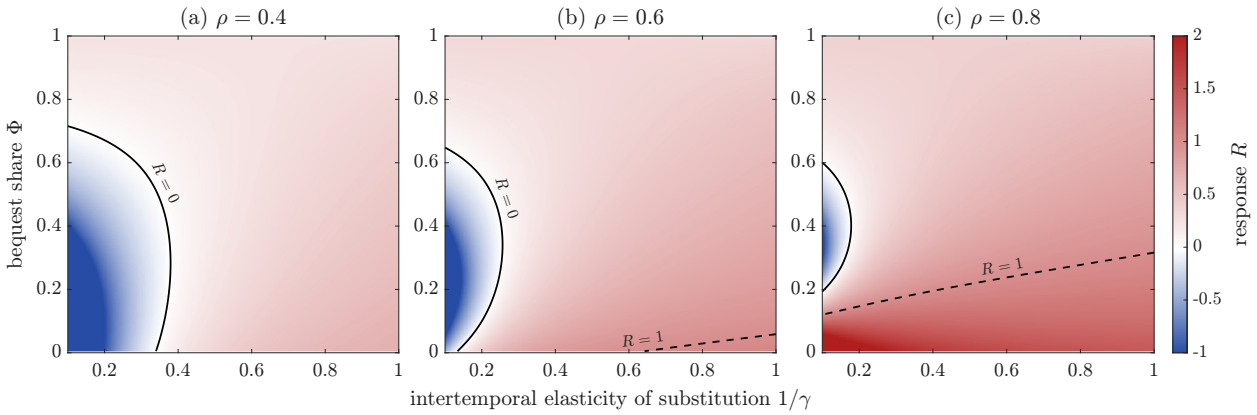


Figure A.1: The response of relative wealth to a slowdown. The balanced-path response R (26) — the response of the wealth ratio s^o/s^y to a productivity slowdown; a demographic slowdown's is $R - 1$ (27) — in the plane of the intertemporal elasticity of substitution $1/\gamma$ and the bequest share Φ, under the fixed-replacement-rate rule ($\theta = 0$), one panel per replacement rate $\rho \in \{0.4,\ 0.6,\ 0.8\}$, with all other parameters at their calibrated values (Section 2.4.1).

A.6 The transition

Two observations organize the computation. First, the warm-glow margin is contemporaneous — the old settle it after returns are realized — so $s^o_t = \Phi\, j^o_t$ holds at every date, surprises included, and factor shares give

$$c^o_t = \omega_t\, Y_t, \qquad \omega_t \equiv (1-\Phi)\left[\alpha + (1-\alpha)\,\tau_t\right], \tag{A.10}$$

with τ_t from the design rule $\tau_t = \rho_0\,(1+g_0)^{-\theta}\,(w_t/w_{t-1})^{\theta-1}$, which reduces to $\tau_t = \rho\, w_{t-1}/w_t$ under a fixed replacement rate ($\theta = 0$), to $\tau_t = \tau$ under a fixed contribution rate ($\theta = 1$), and to (19) across balanced paths. Second, the contribution rate enters (A.10) directly, so the real path is design-dependent and each design must be solved separately. The detrended system depends on growth only through the total factors W_{t+1}/W_t, so the demographic experiment of Section 2.4 is solved by the same code run at the total growth factors, with the cohort factor $1 + g_n$ multiplied into the wealth ratio afterward; the notation below normalizes the cohort size to one. The system per design is, in detrended form $\hat{k}_t \equiv K_t/A_t$:

$$c^y_t = Y_t - c^o_t - K_{t+1}, \qquad (c^y_t)^{-\gamma} = \beta\,(1+r_{t+1})\,(c^o_{t+1})^{-\gamma}, \qquad 1 + r_{t+1} = \alpha\,\hat{k}^{\alpha-1}_{t+1}, \tag{A.11}$$

a second-order difference equation in $\hat{k}_t$ with boundary conditions $\hat{k}_1 = \tilde{k}_0\,(1+g_0)/(1+g_1)$ — generation 0's saving, chosen on the old path, deflated by the new productivity level — and convergence to the new balanced value from Section 1.2, solved by Newton's method on the detrended capital path over a long horizon (`simulate_wg`). Under a fixed replacement rate, τ_t depends on the current wage and hence on $\hat{k}_t$, which the solver handles inside the same system.

At $\gamma = 1$ under a fixed contribution rate, ω is constant and the Euler equation delivers a constant investment rate: substituting $c^o_{t+1} = \omega Y_{t+1}$ and $1 + r_{t+1} = \alpha Y_{t+1}/K_{t+1}$ into the Euler equation gives $c^y_t = \omega K_{t+1}/(\alpha\beta)$, and the resource constraint then yields

$$K_{t+1} = \frac{1-\omega}{1+\omega/(\alpha\beta)}\,Y_t, \tag{A.12}$$

the warm-glow counterpart of the Brock and Mirman (1972) saving rule, valid date by date, surprises included — the closed-form check on the numerical solver.

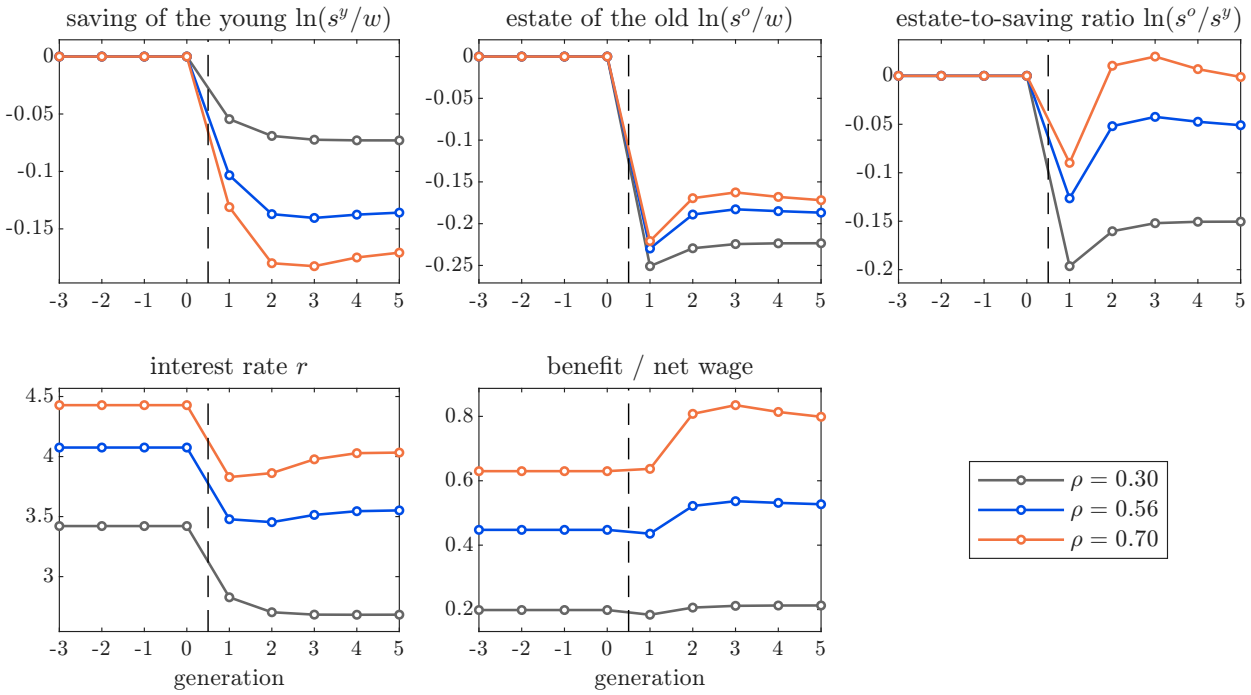


Figure A.2: Transitions after a demographic slowdown. The total fertility rate falls unexpectedly and permanently from 2 to 1.5 between generations 0 and 1 (dashed line): the cohort factor $1 + g_n$ drops from 1 to 0.75 and total growth from 2 to 1.03 percent a year, while productivity growth is unchanged at 2 percent; fixed-replacement-rate rule ($\theta = 0$), replacement rates $\rho \in \{0.3, 0.56, 0.7\}$. The five plots are those of Figure 2: the first two show the saving of a young household s^y and the estate of an old household s^o, both relative to the wage per worker w, and the third their ratio, all three in logs and normalized to zero on the initial balanced path (generations -3 to 0); the estate relative to the wage per worker includes the cohort factor $1 + g_n = 0.75$ from generation 1 on, as each old cohort is then larger than the working one.

B Data appendix

Table B.3 lists the variables used in the paper, with their source codes: the HFCS User Database variables and the external country-level series. Table B.1 details the country coverage of each survey wave, and Table B.2 the observation counts by country and wave.

The productivity slowdown. The growth regressor of Section 4.2 measures the slowdown over the 1991–2019 window that the HFCS cohorts lived through. Figure B.1 places that window in its long-run context. Panel A plots the log of GDP per hour worked since 1950 for the sixteen European countries of the Long-Term Productivity Database of Bergeaud et al. (2016); because

Table B.1: Country coverage of the HFCS, by survey wave. A checkmark marks participation in the wave. Malta participates in every wave but is excluded from all analyses because age is not released in its User Database extract; the bottom row counts the countries entering the analysis sample.

	2010	2014	2017	2021	2023
AT, BE, CY, DE, ES, FI, FR, GR, IT, LU, NL, PT, SI, SK	✓	✓	✓	✓	✓
MT (excluded: age not released)	✓	✓	✓	✓	✓
EE, HU, LV		✓	✓	✓	✓
PL		✓	✓		
HR, LT			✓	✓	✓
CZ				✓	✓
Countries in the analysis sample	14	18	20	20	20

the vertical axis is in logs, the slope of each line is that country's productivity growth rate. Panel B plots that growth rate directly, as the annualized growth over the past five years. Three features matter for the paper. First, the slowdown is common: the unweighted mean growth rate falls from 4.6 percent a year over 1950–1975 to 2.3 percent over 1975–2000 and 0.9 percent over 2000–2024, and no country in the sample grows faster after 2000 than before 1975. Second, the catch-up that compressed the cross-country spread ends with it: the lines fan in until the 1990s and run roughly parallel thereafter, so the countries that entered the slowdown poorer have stayed poorer. Third, the slowdown has been deepest where pensions are most generous: the three slowest-growing countries since 2000 are Italy (0.04 percent a year, essentially no productivity growth in a quarter century), Greece (0.10) and France (0.59), all in the upper part of the pension-to-salary distribution, against 1.0 to 1.2 percent in Denmark, Sweden and Switzerland. This is the joint variation in generosity and growth that the interaction of Section 4.2 exploits.

Table B.2: Number of observations by country and wave. Person-rows in the analysis population: household heads and spouses/partners with non-missing age, counted for a single implicate. Malta participates in the HFCS but its User Database extract does not release age, so none of its observations enter the analysis sample.

	2010	2014	2017	2021	2023	Total
Austria	3,641	4,512	4,709	3,415	4,163	20,440
Belgium	3,704	3,564	3,654	3,367	3,226	17,515
Croatia	–	–	2,202	2,118	2,308	6,628
Cyprus	2,229	2,288	2,312	2,337	2,172	11,338
Czechia	–	–	–	4,863	4,917	9,780
Estonia	–	3,687	4,282	3,525	4,029	15,523
Finland	18,113	18,233	16,892	15,576	14,562	83,376
France	24,332	19,577	22,197	16,584	19,369	102,059
Germany	5,981	7,546	8,375	6,832	6,631	35,365
Greece	4,797	4,920	4,860	5,243	5,770	25,590
Hungary	–	9,624	9,409	9,093	10,544	38,670
Italy	12,994	12,891	11,414	10,340	15,821	63,460
Latvia	–	1,820	1,914	1,807	1,857	7,398
Lithuania	–	–	2,428	2,400	2,347	7,175
Luxembourg	1,580	2,688	2,673	3,328	6,082	16,351
Malta	–	–	–	–	–	–
Netherlands	2,210	2,122	3,963	4,133	3,910	16,338
Poland	–	5,559	9,463	–	–	15,022
Portugal	7,279	10,527	9,873	10,313	8,641	46,633
Slovakia	3,242	3,403	3,499	3,362	3,502	17,008
Slovenia	578	4,296	3,322	3,284	3,289	14,769
Spain	10,249	10,204	10,743	10,461	10,490	52,147
Total	100,929	127,461	138,184	122,381	133,630	622,585

Table B.3: Variables and data sources.

Code	Description
Household level	
DN3001	Net wealth: total assets net of total liabilities (UDB-derived)
DH0001	Number of household members
HW0010	Household weight
HH0401–HH0403	Value of up to three substantial gifts or inheritances received, at the time of receipt
HH0201–HH0203	Year in which each gift or inheritance was received
Person level	
RA0300	Age
RA0100	Relationship to the reference person (1 = reference person, 2 = spouse or partner)
PA0100	Marital status (the widow convention of Section 3.4)
PE0600	Hours worked per week in the main job (the ten-hour floor of the earnings deciles, Table 1)
PG0110	Gross employee income
PG0310	Gross public pension income
PG0410	Gross occupational and private pension income
External country-level series	
ITR on labour	Implicit tax rate on labour: taxes and social contributions on employed labor over total compensation of employees, 1995 and 2019 (European Commission, DG TAXUD, Data on Taxation Trends, dataset tax_itr, release of 30 March 2026)
ilc_pnp3	Aggregate replacement ratio, 2023 (Eurostat; calibration of ρ)
rgdpna; SP.POP.1564.TO	Real GDP per working-age adult (15–64), 1991–2019 (Penn World Table 10.01; World Bank WDI)
prc_hicp_ainr	HICP, all-items annual average index, from 1996 (Eurostat)
prc_hpi_a	House price index, total dwellings, annual average, from 2005–2010 depending on the country; not reported by Greece (Eurostat)
FP.CPI.TOTL	Consumer price index, pre-1996 back-splice of the HICP (World Bank WDI)
nama_10_gdp; nama_10_pe	Nominal average wage per employee, index 1996 = 1: compensation of employees (D1, national currency) per employee (domestic concept), 1995–2025 (Eurostat, release of 3 September 2026; the restatement of pensions, equation (35))
Indexation rules	Statutory rule for pensions in payment, by country and year, 1997–2025: wage and price shares, freezes and fixed adjustments (OECD, *Pensions at a Glance*; European Commission, Ageing Reports; national sources); the uprating index of equation (35)
Earnings-base rules	Length and type of the earnings base of each public scheme (last N years, best N, whole career, points, final salary, flat) and the index revaluing it (prices, wages, mixes), by award year (same sources; Appendix D.3); the correction $\mathscr{C}$ of equation (35)
HWCDW; ZCPIN	Nominal compensation per employee and national consumer price index, 1960–2025 (AMECO, June 2026 vintage): growth rates extending the wage and price series back before 1995 for the earnings-base correction
$\theta^{\text{rule}}_{a,0}$, $\theta^{\text{rule}}_{a,1}$	Wage share in the revaluation of the earnings base at award, and mean wage share of the indexation of pensions in payment over 2010–2022, by country (same sources; Appendix D)
Labor productivity	GDP per hour worked, US$ 2020 PPP, 1950–2024 (Long-Term Productivity Database v2.7, Bergeaud et al., 2016)

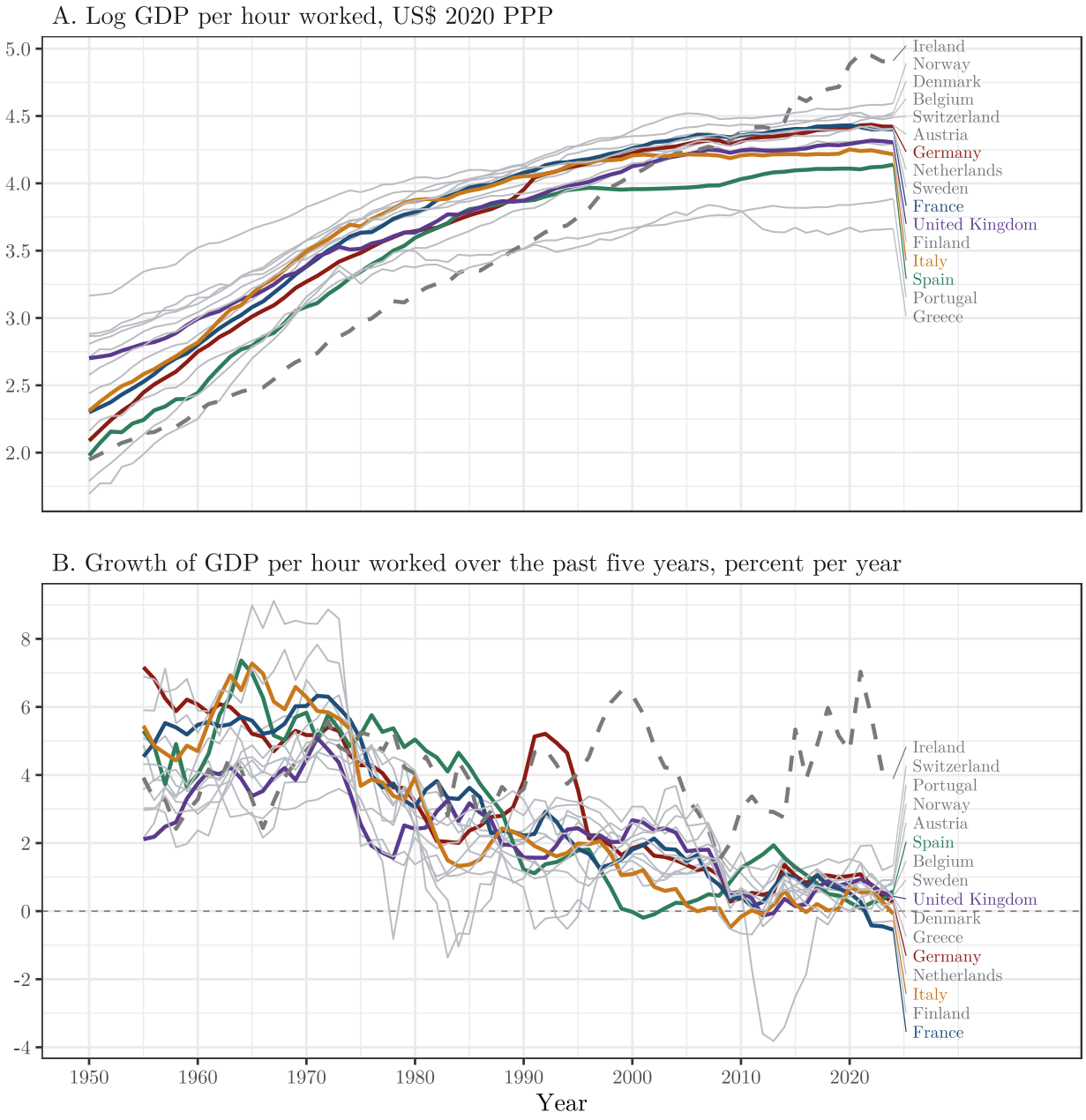


Figure B.1: Labor productivity in Europe, 1950–2024. Panel A plots log GDP per hour worked, in US$ at 2020 purchasing power parity, for the sixteen European countries of the Long-Term Productivity Database v2.7 (Bergeaud et al., 2016); the slope of a line is the country's annual productivity growth rate. Panel B plots that growth rate directly: the annualized log change of GDP per hour worked over the past five years, in percent per year, so that the value at year t is the average growth rate between $t - 5$ and t; the dashed line marks zero. In both panels the five largest economies are drawn in color and the others in gray; Ireland is dashed because its post-2015 level break reflects the redomiciling of multinational intangible assets rather than a change in Irish production, and the same break drives the swings of its growth rate in Panel B.

C Additional empirical results

Table C.1 repeats the estimation of Table 1 with the survey mean employee wage in place of the country's average wealth as the scale: the outcome is the annual change in the group's mean log wage-scaled wealth — net wealth per partner over the economy's average wage — between the pooled baseline and the pooled endpoint. The population-weighted estimates barely move, because the outcome compares income groups inside a country and the choice of national scale shifts a country's groups alike: the level effect is 0.08 to 0.10 against 0.11 to 0.13 in the main text, the interaction -10.8 to -15.2 against -12.2 to -17.4, with bootstrap p-values between 0.01 and 0.04, and the gradient of a one-standard-deviation increase in the replacement rate is 1.9 to 2.3 log points at one percent growth and 0.7 to 0.9 at two percent, against 2.4 to 3.0 and 1.1 to 1.2 in the main text. The house-price control is small and insignificant on either scale.

The resolution of the income ranking matters for the interaction more than for the level effect: coarser income groups average over the part of the distribution where the gradient is steepest, which is why the main text uses deciles throughout: the same partition defines the cells and the generosity measure in Table 1 and in Figure 5, so that the two report the same object at different levels of aggregation.

Table C.2 probes the role of the euro-area crisis countries in Table 1 in two ways. Columns (1) to (3) add to columns (2) to (4) of that table an indicator for the crisis countries, Greece, Italy, Spain, Portugal and Cyprus; since Greece is not in the estimation sample, the indicator compares Italy, Spain, Portugal and Cyprus with the remaining countries. Column (4) drops Italy, Spain and Portugal from the construction altogether and re-estimates column (3) of Table 1 on the thirteen remaining countries and 390 cells. The indicator, whose coefficient is not reported, is small and insignificant in every column, between -0.005 and -0.004, and leaves the coefficients of interest where they are: the interaction is -12.4 to -17.1 with the indicator against -12.2 to -17.4 in Table 1, with bootstrap p values between 0.01 and 0.02, and the level effect and the gradient at one percent growth keep their size and their significance. Excluding the three countries leaves the interaction at -12.3, against -15.8 in column (3) of Table 1, with a larger standard error and a bootstrap p value of 0.10; the level effect and the gradient at one percent growth, 2.5 log points per standard deviation against 2.9, keep their significance. The association is therefore not driven by

the post-crisis trajectories of the southern euro area.

Table C.3 reports the coefficients behind Figure 5: for each endpoint age group, the generosity main effect, the growth main effect, their interaction, the house-price control and the Eastern-bloc indicator, together with the generosity gradients at 1 and 2 percent growth and the population-weighted average that the figure subtracts from them.

Table C.4 reports the coefficients behind Figure 4, in the layout of Table C.3.

Table C.5 repeats Table 2 with received inheritances excluded from the wealth of the working-age cohorts. Each household's reported gifts and inheritances are revalued to survey-year prices and capitalized at a two-percent annual real return from the year of receipt, and the total is subtracted from net wealth before the split between partners; the cell count falls by one in every column, but the netting roughly doubles the number of households with non-positive wealth, which leave the sample as in Table 2. Because the generous slow-growth countries are also those where working-age households receive the most (Figure 1, Panel B), the inflow works against the incidence the table measures, and excluding it strengthens every burden coefficient: the realized measure rises from 6.0 to 8.1 log points in column (1), with a bootstrap p value of 0.04 in both, and the pension-predicted measure rises from 3.9 to 5.3 ($p = 0.002$ and 0.003).

Table C.6 applies the same exclusion to the instrumented estimates of Table 3. The pattern is the least-squares one: every instrumented wedge coefficient rises by about a quarter, to 12.9–15.4 log points in columns (1)–(4) and to 10.7 in column (5), the first stages are unchanged, and the wild-bootstrap p values of the reduced form are 0.05 in the baseline columns, 0.12 and 0.01 with the house-price and development controls, and 0.04 with the pre-window shifts.

Table C.7 runs the placebo of Section 4.4 on the population the tax wedge does not tax. It repeats the five columns of Table 3 on the country $\times$ five-year cohort $\times$ income-decile cells of retirees aged 70 to 85 at the endpoint. Because retiree cells have no wage of their own to net out, the outcome is the annualized change in the cell's mean log wealth over the national average wage, without the netting of Table 3, and cells without earners remain in the sample. The instruments are those of the main table, with the zero stage estimated on the working-age cells. In every column the instrumented wedge coefficient is small, positive and insignificant, between 1.2 and 3.8 log points with standard errors of 2.8 to 4.4, while the first stages are as strong as in the main table, with F between 42 and 49 in columns (1)–(3), so the null is not a loss of power, and in each column

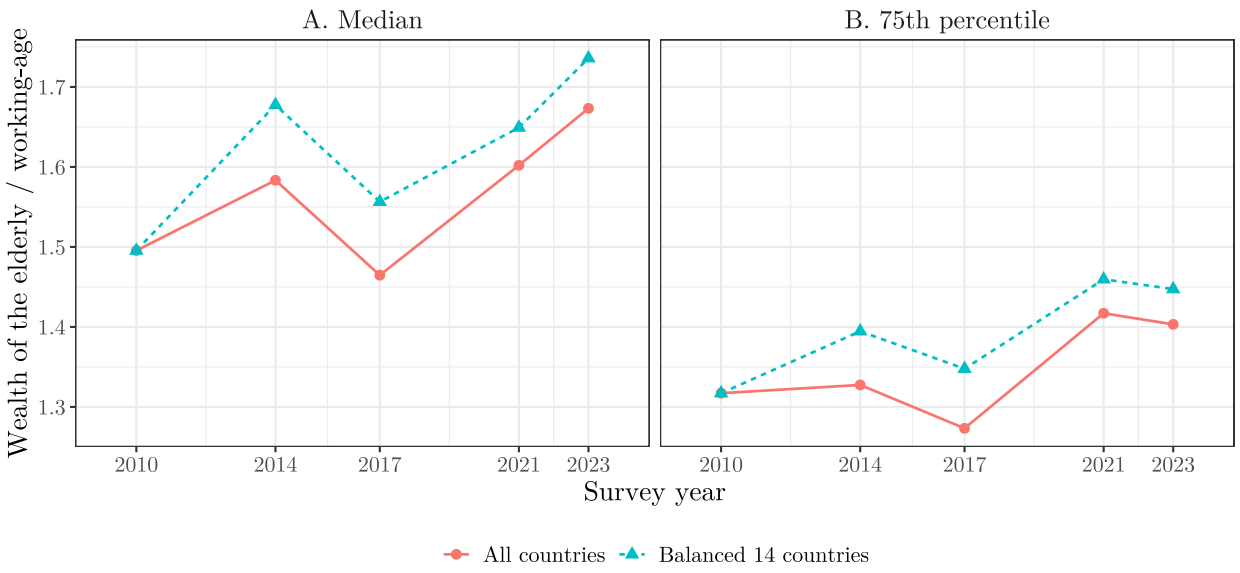


Figure C.1: The relative wealth of the elderly in Europe, 2010–2023. This figure plots, by survey wave, the population-weighted mean across HFCS countries of the ratio of the per-adult net wealth of individuals aged 70–85 to that of the working-age population (ages 26–59). Panel A uses the ratio of medians and Panel B the ratio of 75th percentiles. Country population is measured as the survey sum of the household weight times household size. In each panel, the solid line uses every country surveyed in each wave, from 14 in 2010 to 20 as the survey expands to Central and Eastern Europe, whereas the dashed line holds the country set fixed at the 14 countries of the 2010 wave.

the confidence interval excludes the working-age estimate. The bootstrap p values of the reduced form are 0.6 or above. The initial replacement rate, in the columns that control for it, is positive and significant: where pensions are generous, retirees' wealth grew faster relative to wages, the other side of the incidence that Section 4.2 documents.

The rise in the relative wealth of the elderly documented in the Introduction is not an artifact of the survey's expanding country coverage. Figure C.1 plots the series for every country surveyed in each wave alongside the series computed on the fixed set of the 14 first-wave countries: the balanced series rises by *more* (from 1.50 to 1.74, against 1.50 to 1.67 for the full set) — the countries that join after 2010 have relatively poorer elderly, so the expansion dampens the all-countries series rather than driving it.

Pension generosity by country. Figure C.2 isolates the effect of the restatement of equation (35) on measured generosity. For the seventeen countries of the rank-matched sample, it plots the aver-

age pension of recipients aged 70–85 relative to the average gross employee income of employees aged 26–59, in the pooled 2021 and 2023 waves, as paid and restated to its value at award relative to own earnings, expressed at reference-year wage levels. The population and the denominator are the same in both bars, so the gap between them is the restatement alone. The restatement raises the measured benefit where pensions in payment were indexed to prices while real wages grew, and where the earnings base was revalued with prices: by 15 points in Latvia, by 13 in Slovakia and Belgium, by 12 in Portugal, by 8 in Spain and France, by 6 in Hungary and by 3 to 4 points in Estonia, Finland and Slovenia. In Belgium the whole change is the earnings-base correction, the 45-year career average being revalued with prices; in Slovakia, Portugal, Spain, France and Finland the correction contributes 2 to 4 points of the change. It moves the measure by less than three points in the wage-indexed systems of the Netherlands, Luxembourg and Germany and in Austria and Cyprus. It lowers it where pensions in payment gained on wages or the earnings base was revalued above them, by 7 points in Italy and by 12 in Greece, where nominal wages fell by more than the frozen and cut pensions over the period.

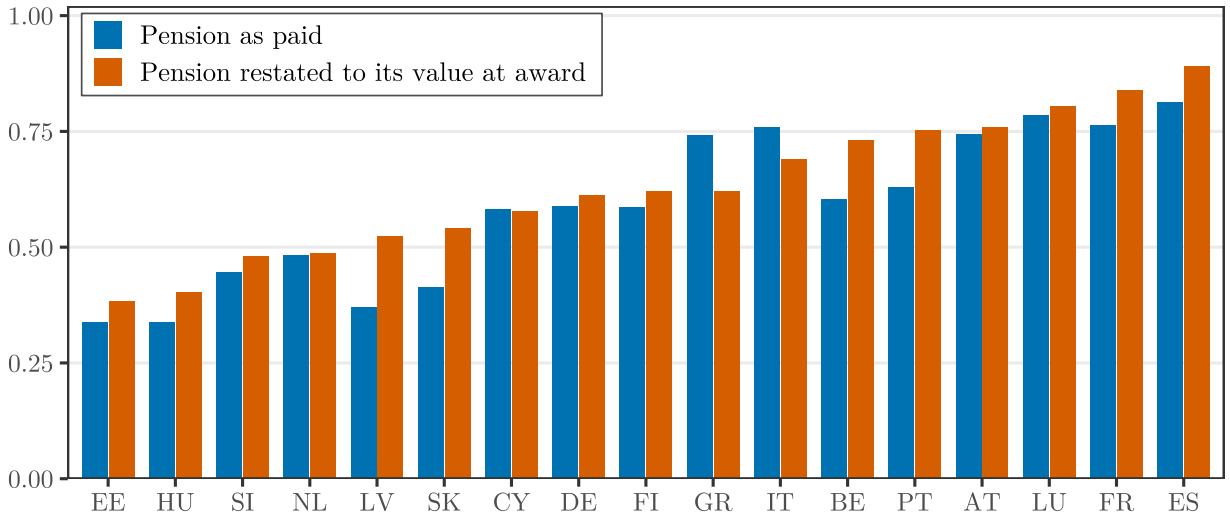


Figure C.2: Pension generosity by country: pensions as paid and restated to their value at award. For each country, the first bar plots the weighted mean pension of recipients aged 70–85 (public pensions only for the Netherlands) over the weighted mean gross employee income of employees aged 26–59, in the pooled 2021 and 2023 waves and the five implicates. The second bar plots the same ratio with each pension restated to its value at award relative to the retiree's own earnings and expressed at reference-year wage levels, equation (35) with its earnings-base correction, the year the retiree turned 63 serving as the award year; the denominator is unchanged, so the gap between the bars is the restatement alone. Countries are ordered by the restated ratio. Source: HFCS waves 2021 and 2023; the restatement uses the uprating and wage indexes and the earnings-base correction of Section 3.

Table C.1: The initial replacement rate, growth, and the within-cohort change since 2010–2014 in the wage-scaled wealth of the elderly (aged 70–85 in 2021/2023)

	(1)	(2)	(3)	(4)	(5)
Rank-matched pension/earnings	-13.118**	-10.795***	-13.393**	-15.219**	-26.692*
$\times (1-\theta_a^{\text{rule}}) \log(1+g_a)$	(5.352)	(3.234)	(5.260)	(6.302)	(14.156)
	[0.038]	[0.020]	[0.026]	[0.015]	[0.134]
Rank-matched pension/earnings					6.088
$\times \log(1+g_a)$, unweighted					(6.332)
					[0.335]
Rank-matched pension/earnings	0.095***	0.083***	0.099***	0.098***	0.088***
	(0.012)	(0.014)	(0.012)	(0.009)	(0.013)
	[0.030]	[0.025]	[0.028]	[0.002]	[0.011]
$\log(1+g_a)$ (centered)	1.264***	0.935	0.797	1.260	1.416
	(0.429)	(0.709)	(0.609)	(0.838)	(0.943)
	[0.238]	[0.204]	[0.173]	[0.174]	[0.156]
Real house-price growth		0.076	0.118	0.087	0.069
		(0.134)	(0.131)	(0.134)	(0.141)
		[0.615]	[0.467]	[0.564]	[0.663]
Effect of a one SD increase in pension generosity:					
at 1% productivity growth	0.022***	0.019***	0.023***	0.023***	0.022***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
	[0.021]	[0.017]	[0.020]	[0.006]	[0.005]
at 2% productivity growth	0.008**	0.007**	0.009**	0.007	0.004
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
	[0.130]	[0.141]	[0.098]	[0.297]	[0.460]
R^2	0.361	0.132	0.364	0.366	0.367
Countries	16	16	16	16	16
House-price control	No	Yes	Yes	Yes	Yes
Soviet-bloc dummy	No	No	No	Yes	Yes
Decile×cohort FE	Yes	No	Yes	Yes	Yes

Notes: This table repeats Table 1 with the survey mean employee wage in place of the country's average wealth as the scale, so the dependent variable is the annualized change in the cell's mean log wealth-to-wage ratio. The columns follow the layout of Table 1: the generosity regressor is the initial replacement rate in every column and the interaction is multiplied by $1-\theta_a^{\text{rule}}$; column (1) includes decile $\times$ cohort effects only, column (2) cohort effects and the house-price control, column (3) both, and column (4) adds an indicator for the former Eastern-bloc countries. The sample, the replacement rates at award, the θ weighting of the interaction, the house-price control, the centering, the winsorization, the population weights and the combination of the five implicates by Rubin's rules are those of Table 1. Standard errors clustered by country are in parentheses; in brackets, p-values from a wild cluster bootstrap by country. $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

Table C.2: The initial replacement rate, growth, and the within-cohort change since 2010–2014 in the wealth of the elderly: the euro-area crisis countries

	All countries			Excluding IT, ES, PT
	(1)	(2)	(3)	(4)
Rank-matched pension/earnings	-12.440***	-15.960***	-17.056***	-12.283*
$\times\ (1-\theta_a^{\text{rule}})\ \log(1+g_a)$	(4.522)	(5.022)	(5.845)	(6.271)
	[0.019]	[0.023]	[0.015]	[0.100]
Rank-matched pension/earnings	0.105***	0.126***	0.126***	0.101***
	(0.028)	(0.019)	(0.019)	(0.030)
	[0.017]	[0.005]	[0.005]	[0.008]
$\log(1+g_a)$ (centered)	0.669	0.507	0.824	-0.048
	(0.769)	(0.649)	(1.158)	(0.520)
	[0.601]	[0.549]	[0.733]	[0.923]
Effect of a one SD increase in pension generosity:				
at 1% productivity growth	0.024***	0.029***	0.029***	0.025***
	(0.006)	(0.004)	(0.005)	(0.007)
	[0.005]	[0.011]	[0.011]	[0.028]
at 2% productivity growth	0.010**	0.012***	0.011**	0.015**
	(0.005)	(0.004)	(0.005)	(0.006)
	[0.136]	[0.103]	[0.153]	[0.119]
R^2	0.178	0.406	0.407	0.422
Countries	16	16	16	13
House-price control	Yes	Yes	Yes	Yes
Euro-crisis dummy	Yes	Yes	Yes	No
Soviet-bloc dummy	No	No	Yes	No
Decile×cohort FE	No	Yes	Yes	Yes

Notes: Columns (1)–(3) are columns (2)–(4) of Table 1 with an indicator equal to one for the euro-area crisis countries (Greece, Italy, Spain, Portugal and Cyprus) added to each, entered uncentered; Greece is not in the estimation sample, so the indicator identifies Italy, Spain, Portugal and Cyprus. Its coefficient is not reported: it lies between -0.005 and -0.004, with bootstrap p-values above 0.5. Column (4) is column (3) of Table 1 with Italy, Spain and Portugal excluded from the construction altogether: the income ranks, the wealth scale, the winsorization and the centering means are computed without them, leaving thirteen countries and 390 cells. The real house-price growth control enters every column and the indicator for the former Soviet-bloc countries column (3); neither coefficient is reported. All other conventions, the cells, the initial replacement rate, the θ weighting of the interaction, the centering, the winsorization, the population weights, the fixed effects, the clustering and the combination of the five implicates by Rubin's rules, are those of Table 1, as is the bottom panel. Standard errors clustered by country are in parentheses; p-values from a wild cluster bootstrap by country (999 replications), combined across implicates by the Licht–Rubin method, are in brackets. Stars reflect the asymptotic t statistics: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

Table C.3: The by-age regression behind Figure 5: full coefficient estimates

Age group	Own-earnings replacement rate at age 63		$\log(1+g_a)$		Interaction $\times(1-\theta_a^{\text{rule}})$		Real HP growth		Soviet bloc		Slope at 1%		Slope at 2%	
40–49	-0.00	(0.03)	-2.69	(1.72)	6.26	(7.45)	0.29	(0.23)	0.01	(0.03)	-0.01	(0.04)	0.02	(0.04)
50–59	0.01	(0.03)	-3.33*	(1.84)	7.93	(7.42)	0.54*	(0.28)	0.03	(0.03)	-0.00	(0.04)	0.04	(0.04)
60–69	0.06***	(0.02)	0.35	(0.88)	0.44	(5.67)	0.01	(0.16)	0.00	(0.02)	0.06**	(0.03)	0.06**	(0.02)
70–85	0.12***	(0.02)	0.98	(0.89)	-15.75***	(5.26)	0.10	(0.13)	-0.01	(0.01)	0.16***	(0.02)	0.06**	(0.03)
Weighted mean											0.05**	(0.02)	0.05**	(0.02)
Cells	1431 (318, 318, 318, 477 by age group)													
Countries	16													
SD of the ratio	0.188													

Notes: Full coefficients of the cell-level regression plotted in Figure 5. The cells are country $\times$ five-year endpoint age band (80–85 at the survey's age topcode) $\times$ income decile; the outcome is the change in a cell's mean log wealth-scaled wealth between the pooled 2010/2014 baseline and the pooled 2021/2023 endpoint, divided by the number of years between the weighted mean survey dates. All regressors, including the house-price control and the indicator for the former Eastern-bloc countries, are interacted with the four age groups of the figure, and the fixed effects are five-year age band$\times$income decile. The cell change is winsorized at the 1st and 99th percentiles across cells within implicate, as in Table 1. The slope columns evaluate the generosity gradient at 1 and 2 percent annual growth, and the last row their population-weighted average across the four age groups; the figure plots, for each age group, the slope minus that average, multiplied by 0.188, the standard deviation of the initial replacement rate across cells. The interaction column is the coefficient on the product of the centered replacement rate, centered growth and $1-\theta_a^{\text{rule}}$, as in Table 1, and the slopes are evaluated at the cell-weighted mean of the weight. All other conventions and sample restrictions are those of Figure 5. Standard errors clustered by country are in parentheses. $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

Table C.4: The regression behind Figure 4: full coefficient estimates

Age group	Own-earnings replacement rate at age 63		$\log(1+g_a)$		Interaction $\times(1-\theta_a^{\text{rule}})$		Real HP growth		Soviet bloc		Slope at 1%		Slope at 2%	
30–39	-0.04**	(0.02)	-2.90**	(1.24)	9.16**	(4.17)	0.08	(0.15)	0.04**	(0.02)	-0.06**	(0.02)	-0.01	(0.02)
40–49	-0.02	(0.02)	-2.05**	(0.81)	3.59	(5.23)	0.41***	(0.14)	0.03**	(0.01)	-0.03	(0.03)	-0.01	(0.02)
50–59	-0.02	(0.02)	-2.31	(1.62)	13.62**	(5.77)	0.61**	(0.27)	0.04	(0.02)	-0.05**	(0.03)	0.03	(0.03)
60–69	0.00	(0.02)	-0.76	(0.84)	5.11	(9.94)	0.54***	(0.15)	0.00	(0.02)	-0.01	(0.04)	0.02	(0.04)
70–79	0.09***	(0.01)	-0.87	(0.86)	-6.32	(4.56)	0.25*	(0.14)	0.03***	(0.01)	0.10***	(0.02)	0.07***	(0.02)
80–85	0.09***	(0.03)	1.56	(1.77)	-14.85*	(8.35)	-0.17	(0.24)	-0.00	(0.03)	0.12***	(0.04)	0.04	(0.04)
Weighted mean											-0.00	(0.01)	0.02*	(0.01)
Cells	1749 (318, 318, 318, 318, 318, 159 by age group)													
Countries	16													
SD of the ratio	0.188													

Notes: Full coefficients of the cell-level regression plotted in Figure 4. The cells are country $\times$ five-year age band (80–85 at the survey's age topcode) $\times$ income decile, with the same age band at both ends; the outcome is the change in a cell's mean log wage-scaled wealth, net wealth per partner over the survey mean employee wage, between the pooled 2010/2014 baseline and the pooled 2021/2023 endpoint, divided by the number of years between the weighted mean survey dates. All regressors, including the house-price control and the indicator for the former Eastern-bloc countries, are interacted with the six ten-year age groups of the figure, and the fixed effects are five-year age band$\times$income decile. The cell change is winsorized at the 1st and 99th percentiles across cells within implicate, as in Table 1. The slope columns evaluate the generosity gradient at 1 and 2 percent annual growth, and the last row their population-weighted average across the six age groups; the figure plots, for each age group, the slope itself, without demeaning, multiplied by 0.188, the standard deviation of the initial replacement rate across cells. The interaction column is the coefficient on the product of the centered replacement rate, centered growth and $1-\theta_a^{\text{rule}}$, as in Table 1, and the slopes are evaluated at the cell-weighted mean of the weight. All other conventions and sample restrictions are those of Figure 4. Standard errors clustered by country are in parentheses. $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

Table C.5: The fiscal adjustment in tax-wedge units: wealth excluding received inheritances

	(1)	(2)	(3)	(4)	(5)	(6)
Tax wedge change ν^{real}	-8.106***	-8.066***	-7.353**			
	(2.727)	(2.564)	(2.966)			
	[0.036]	[0.039]	[0.119]			
Tax wedge change ν^{pred}, pension-predicted				-5.336***	-5.287***	-6.132**
				(1.664)	(1.569)	(2.486)
				[0.003]	[0.022]	[0.201]
$\log(1+g_a)$ (centered)	-4.337***	-4.453***	-5.092***	-2.217**	-2.292**	-2.713**
	(1.636)	(1.529)	(1.855)	(1.011)	(0.975)	(1.337)
	[0.035]	[0.051]	[0.026]	[0.178]	[0.210]	[0.173]
Replacement rate at award		-0.021	-0.013		-0.015	-0.003
		(0.027)	(0.029)		(0.025)	(0.027)
		[0.489]	[0.721]		[0.601]	[0.931]
Real house-price growth			0.214			0.118
			(0.177)			(0.252)
			[0.298]			[0.862]
Soviet bloc	0.035*	0.033*	0.036*	0.013	0.011	0.011
	(0.019)	(0.017)	(0.019)	(0.015)	(0.014)	(0.015)
	[0.201]	[0.157]	[0.164]	[0.471]	[0.486]	[0.503]
Cohort×decile FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.376	0.378	0.389	0.384	0.385	0.398
Cells	568	568	544	568	568	544
Countries	17	17	16	17	17	16

Notes: Cells, regressors and all estimation conventions are those of Table 2, with one change to the dependent variable: each household's received gifts and inheritances, as reported in the HFCS inheritance module, are revalued to survey-year prices with the national HICP and capitalized at a two-percent annual real return from the year of receipt (undated transfers enter at face value), and the total is subtracted from net wealth before the split between partners. Finland never fielded the inheritance module, Italy fielded it only in 2014, and Luxembourg did not field it in 2021, so those observations enter as in Table 2; every other country–wave, the 2010 wave included, is netted. Standard errors clustered by country are in parentheses. The p-values in brackets come from a wild cluster bootstrap at the country level (null imposed, Rademacher weights, 999 replications), computed within each implicate and combined across implicates by the Licht–Rubin method. Stars reflect the asymptotic t statistics: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.6: Instrumenting the tax wedge change: wealth excluding received inheritances

	Instrument: $\hat{\nu}_c\,(1-\theta_{c,1995})$, 1995–2019 shifts				1980–95 shifts
	(1)	(2)	(3)	(4)	(5)
Tax wedge change ν^{real}	-13.260***	-12.902***	-13.675***	-15.415***	-10.658***
	(2.716)	(2.534)	(3.560)	(5.184)	(2.844)
$\log(1+g_a)$ (centered)	-6.984***	-6.924***	-7.095***	-7.804**	-6.006***
	(1.732)	(1.623)	(1.779)	(3.421)	(2.167)
Replacement rate at award		-0.019	-0.013	-0.021	-0.007
		(0.026)	(0.030)	(0.043)	(0.034)
Real house-price growth			0.033	-0.006	0.110
			(0.333)	(0.322)	(0.230)
Soviet bloc	0.055***	0.052**	0.052**	0.048	0.052**
	(0.021)	(0.022)	(0.022)	(0.030)	(0.025)
Log GDP per capita, 1995				-0.013	0.011
				(0.045)	(0.029)
First stage	0.254***	0.262***	0.223***	0.266***	0.372***
	(0.038)	(0.037)	(0.038)	(0.081)	(0.077)
First-stage F	44.4	49.2	34.3	10.7	23.4
Reduced form	-3.368***	-3.377***	-3.056***	-4.094***	-3.966***
	(0.534)	(0.550)	(0.492)	(0.666)	(0.970)
	[0.049]	[0.049]	[0.119]	[0.009]	[0.038]
Cohort×decile FE	Yes	Yes	Yes	Yes	Yes
Cells	568	568	544	544	544
Countries	17	17	16	16	16

Notes: The five columns of Table 3 with the dependent variable of Table C.5: each household's received inheritances, revalued to survey-year prices and capitalized at a two-percent annual real return as described there, are excluded from net wealth before the split between partners. Instruments, controls, samples and the reporting of the lower panel are those of Table 3. Standard errors clustered by country are in parentheses; stars as in Table 2.

Table C.7: Placebo: instrumenting the tax wedge change on the retiree population

	Instrument: $\hat{\nu}_c\,(1-\theta_{c,1995})$, 1995–2019 shifts				1980–95 shifts
	(1)	(2)	(3)	(4)	(5)
Tax wedge change ν^{real}	3.762	2.552	1.963	3.567	1.242
	(3.775)	(2.781)	(4.152)	(4.431)	(3.500)
$\log(1+g_a)$ (centered)	3.109	2.787	2.093	2.893	1.781
	(2.598)	(1.791)	(1.839)	(2.531)	(2.181)
Replacement rate at award		0.082***	0.092***	0.099***	0.091***
		(0.017)	(0.014)	(0.023)	(0.020)
Real house-price growth			0.149	0.169	0.137
			(0.208)	(0.210)	(0.171)
Soviet bloc	-0.023	-0.008	-0.004	-0.001	-0.003
	(0.029)	(0.022)	(0.020)	(0.024)	(0.022)
Log GDP per capita, 1995				0.012	-0.001
				(0.032)	(0.027)
Tax wedge change ν^{real}, OLS	0.658	1.066	-0.522	-1.569	-1.569
	(2.806)	(2.261)	(2.314)	(1.653)	(1.653)
First stage	0.254***	0.261***	0.237***	0.244***	0.339***
	(0.038)	(0.037)	(0.037)	(0.090)	(0.087)
First-stage F	46.0	48.5	41.6	7.4	15.2
Reduced form	0.957	0.665	0.465	0.871	0.420
	(0.895)	(0.702)	(0.939)	(1.040)	(1.172)
	[0.629]	[0.613]	[0.692]	[0.595]	[0.793]
Cohort×decile FE	Yes	Yes	Yes	Yes	Yes
Cells	510	507	477	477	477
Countries	17	17	16	16	16

Notes: The five columns of Table 3 estimated on the cells of retirees aged 70–85 at the endpoint (cohorts 70–74, 75–79 and 80–85 at the survey's age topcode), built exactly as the working-age cells. The dependent variable is the annualized change between the two ends in the cell's mean log net wealth per partner over the national average wage; unlike Table 3 it is not netted of the cell's own wage growth, which does not exist for retiree cells, and cells without an employed member remain in the sample. The change is winsorized at the 1st and 99th percentiles across these cells within implicate. The endogenous regressor, the instruments (the predicted wedge change under the 1995 indexation rule of Table 3, from the 1995–2019 shifts in columns (1)–(4) and the pre-1995 shifts in column (5), with the zero stage estimated on the working-age cells), the controls, the cohort × decile fixed effects, the population weights, the clustering by country and the combination of the five implicates by Rubin's rules are unchanged. The lower panel reports the least-squares coefficient on the same sample, the first stage with its cluster-robust F, and the reduced form, which with a single instrument is the Anderson–Rubin test; the p-values in brackets under the reduced form come from a wild cluster bootstrap at the country level (null imposed, Rademacher weights, 999 replications), computed within each implicate and combined across implicates by the Licht–Rubin method. Greece drops from columns (3)–(5) with the house-price control. Standard errors clustered by country are in parentheses. Stars reflect the asymptotic t statistics: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

D Indexation rules by country

The indexation parameter θ of the model is the elasticity of benefits to growth, whatever brings the adjustment about. This appendix documents its partial counterpart θ_a^{rule}, the elasticity of benefits to productivity growth implied by the statutory indexation rules (Section 3): the subscript a records that the rules tie benefits to wages or to prices and so make them respond to the growth of output per worker, not to the demographic component of growth, and the superscript that the discretionary adjustments made outside the rules are not captured, the rule-based part standing as a proxy for the whole. The rules act at two stages. The first is the computation of a new pension: $\theta_{a,0}^{\text{rule}}$ is the share of wage growth that enters the benefit through the revaluation of the past earnings on which it is based, one when those earnings are brought to the year of award with wage growth, or recorded as a fraction of the average wage, or credited in a notional account at a wage-type rate, and zero when they are brought forward with prices only. The second is the indexation of pensions in payment: $\theta_{a,1}^{\text{rule}}$ is the share of nominal wage growth that the indexation rule passed on to pensions already in payment, averaged over the years 2010 to 2022, the period over which wealth changes are measured, a pure price rule counting as zero for the year, a pure wage rule as one, a rule mixing the two as its wage weight, and a year in which the rule was suspended and no increase granted as zero. Both components cover every public pay-as-you-go scheme that pays a significant share of the pensions of the sample cohorts, the main scheme of private-sector employees, the separate schemes of civil servants and the self-employed and the mandatory complementary schemes where they exist, each weighted by its share of that expenditure; when the rule changed within the careers of the cohorts, the value is the average over the award years. The two components are combined with weights 0.53 and 0.47, $\theta_a^{\text{rule}} = 0.53\,\theta_{a,0}^{\text{rule}} + 0.47\,\theta_{a,1}^{\text{rule}}$, the weights that the pension bill of the system implies at a horizon of thirty years, the generation length of the model, for a forty-year career and a twenty-five-year retirement (Section 3). Table D.1 lists the three parameters, plotted in Figure 3 of Section 3; the rest of this appendix states, for each country, the rule behind each estimate. The rules described for the first benefit are those that applied to the cohorts of the sample, born between 1936 and 1953, who reached the award age of 63 between 1999 and 2016. The parameters were reconstructed from public sources following a written brief, from the OECD's *Pensions at a Glance* country profiles, the European Commission's Ageing Reports, the

MISSOC comparative tables, the US Social Security Administration's *Social Security Programs Throughout the World* and the legislation and publications of the national pension institutions; the brief is reproduced in Appendix E; the year-by-year rule table and the source log are part of the replication files.

D.1 The first benefit

Austria ($\theta^{\text{rule}}_{a,0} = 0.72$). Claimants born before 1955 retired under the old ASVG rules: 1.78 percent (2 percent before 2004) of the assessment base per insurance year, the base being the best 15 contribution years for awards to 2003, extended by one year per award year from 2004 towards 40 years in 2028, so 28 years for a 2016 award (section 238 ASVG). Past contribution bases are revalued with the Aufwertungsfaktoren, which by section 108(4) ASVG are the cumulated pension adjustment factors; those followed net wages under the 1993 Nettoanpassung until 2003 and consumer prices since 2004 (section 108f ASVG). The wage-type share of the revaluation years is 0.88 to 0.93 for awards up to 2004 and falls to 0.32 for 2016, mean 0.69. Civil servants (22 percent of spending) kept a final-salary base with a loss cap, approximated at 0.82. $\theta^{\text{rule}}_{a,0} = 0.78 \times 0.69 + 0.22 \times 0.82 = 0.72$.

Belgium ($\theta^{\text{rule}}_{a,0} = 0$). Wage earners (and the self-employed, same mechanics) receive 60 percent, or 75 percent for a household, of the average wage of a 45-year career, each year's wage taken up to a ceiling and revalued to the year of award with the consumer price index, with a small coefficient for the oldest years. Wage growth does not enter the base through revaluation: 0. Civil servants, about a third of public pension spending, receive 1/60 of the reference salary per year of service, the average salary of the last five years for those born before 1962, expressed in scale amounts at the base pivot index and re-indexed to prices at award; pay-scale increases reach the pension only later, through the perequation. Both regimes are price-type, with lags of about three and twenty-three years: $\theta^{\text{rule}}_{a,0} = 0.67 \times 0 + 0.33 \times 0 = 0.00$.

Cyprus ($\theta^{\text{rule}}_{a,0} = 1$). The General Social Insurance Scheme (Social Insurance Law 59(I)/2010) records each year's insurable earnings as insurance points, the earnings divided by the basic insurable earnings of the year. At award the basic pension is 60 percent (up to 100 percent with depen-

Table D.1: The indexation parameter by country. $\theta^{\text{rule}}_{a,0}$: share of wage growth in the revaluation of the earnings base when a new pension is computed. $\theta^{\text{rule}}_{a,1}$: share of nominal wage growth passed on to pensions in payment, mean of the yearly rule over 2010–2022. $\theta^{\text{rule}}_{a} = 0.53\,\theta^{\text{rule}}_{a,0} + 0.47\,\theta^{\text{rule}}_{a,1}$. Public pay-as-you-go schemes weighted by their share of the pensions of the sample cohorts. The measure is the rule-based elasticity of benefits to productivity growth, a partial counterpart of the model's θ. Greece is outside the estimation sample of the regressions.

	$\theta^{\text{rule}}_{a,0}$	$\theta^{\text{rule}}_{a,1}$	θ^{rule}_{a}
Austria	0.72	0	0.38
Belgium	0	0.33	0.16
Cyprus	1	0.33	0.69
Estonia	0.53	0.68	0.6
Finland	0.55	0.2	0.39
France	0.26	0	0.14
Germany	1	0.87	0.94
Greece	0.35	0	0.19
Hungary	1	0	0.53
Italy	0.2	0	0.1
Latvia	1	0.31	0.68
Luxembourg	1	0.85	0.93
Netherlands	1	1	1
Portugal	0.34	0.02	0.19
Slovakia	0.72	0.19	0.47
Slovenia	1	0.24	0.64
Spain	0	0	0

dants) of the weekly value of the average basic points and the supplementary pension 1.5 percent of the weekly value of all supplementary points, both valued at the basic insurable earnings of the award year, an amount adjusted each year to the growth of average insurable earnings. The base is the whole career and the revaluation wage-type: 1. The Government Employees Pension Scheme, about 28 percent of public pension spending, paid pensions on the final salary for service before 2013: 1. The freeze of the basic insurable earnings in 2013 to 2017 lowered pensions awarded then but did not change the rule. $\theta^{\text{rule}}_{a,0} = 1.00$.

Estonia ($\theta^{\text{rule}}_{a,0} = 0.53$). The Estonian state pension is the sum of a flat base amount, one point per year of pensionable service before 1999 and, from 1999, annual insurance coefficients equal to the social tax paid for the person relative to the average, all multiplied at award by the year value. The year value and the base amount are raised each 1 April by the pension index, so past points

are revalued through the growth of the year value: half consumer prices and half the growth of the pension-insurance part of social tax from 2002 to 2007, 20 percent prices and 80 percent social tax revenue since 2008, a wage-type series. Before 2002 the values were set with the budget, coded as half wage-type. Averaged over a forty-year base and the award years 1999 to 2016, the wage share is 0.50 up to 2008 and 0.61 for 2016: $\theta_{a,0}^{\text{rule}} = 0.53$.

Finland ($\theta_{a,0}^{\text{rule}} = 0.55$). Finnish earnings-related pensions, private (TyEL) and public (Keva, state), use the same indexes. For pensions starting up to 2004 the pensionable wage of each employment was the average of its last ten years' earnings, revalued with the TEL half-way index, half wages and half prices. The 2005 reform moved to lifetime earnings: earnings from 2005 are revalued to the year the pension starts with the wage coefficient, 80 percent wages and 20 percent prices, and rights accrued before 2005 are computed under the old rules at the end of 2004 and carried forward with the same coefficient (Employees Pensions Act, sections 96 to 100). The revaluation chain is half wage-type for years to 2004 and 0.8 for years from 2005; averaged over a forty-year base and the award years 1999 to 2016 this gives 0.50 for awards to 2005 and 0.64 for 2016: $\theta_{a,0}^{\text{rule}} = 0.55$.

France ($\theta_{a,0}^{\text{rule}} = 0.26$). The general-regime pension is 50 percent of the average annual wage of the best years of the career; the number of best years rose by one per birth cohort from 10 for those born before 1934 to 25 for those born in 1948 or later, so 13 to 25 years for the cohorts born 1936 to 1953. Since 1987 and the Balladur reform of 1993 the wages in the account are revalued to the year of award with the same price coefficients as pensions in payment: 0. Agirc and Arrco convert contributions into points at a purchase price indexed to wages and pay them at a point value indexed to prices, a price-type valuation: 0. Civil servants and the special regimes receive 75 percent of the index salary of the last six months, equivalent to full revaluation: 1. With outlay shares 0.46, 0.28 and 0.26: $\theta_{a,0}^{\text{rule}} = 0.26$.

Germany ($\theta_{a,0}^{\text{rule}} = 1$). In the statutory pension insurance (GRV) each year of contributions is recorded as earnings points, the ratio of the individual's insured earnings to the average earnings of all insured persons in that year (section 63 SGB VI). At award the points of the whole career are summed and multiplied by the current pension value, which is the same for new and existing

pensioners and moves with wages, so past earnings are in effect revalued with average wages: 1. Earnings in the new Laender were scaled up and valued at the eastern pension value, which does not change the type of revaluation. Civil servants, judges and soldiers (about 15 percent of public pension spending) receive up to 71.75 percent of the pensionable pay of their final post held for at least two years (section 5 BeamtVG), equivalent to full revaluation: 1. $\theta_{a,0}^{\text{rule}} = 1.00$.

Greece ($\theta_{a,0}^{\text{rule}} = 0.35$). Nearly all Greeks born 1936 to 1953 retired under the rules preceding the 2016 reform. In IKA-ETAM, the fund of private-sector employees, the pension was a replacement rate fixed by insurance class, 70 to 80 percent for a full 35-year career of a person insured before 1993, applied to the average earnings of the last five years before retirement, and those earnings were brought forward with the percentage increases granted to pensions under the national incomes policy, which tracked prices rather than wages: 0. Self-employed funds (OAEE) used notional class incomes and the farmers' fund (OGA) a largely flat pension, both price-type: 0. Civil servants and the military (about 22 percent of spending) and the funds of public enterprises and banks (about 13 percent) received pensions computed on the final salary: 1. Laws 3863/2010 and 4387/2016 introduced price-revalued career averages for later service. $\theta_{a,0}^{\text{rule}} = 0.22 + 0.13 = 0.35$.

Hungary ($\theta_{a,0}^{\text{rule}} = 1$). The Hungarian social insurance pension (Act LXXXI of 1997) is a percentage fixed by years of service, 33 percent for ten years rising to 80 percent for forty, of the average monthly earnings from 1 January 1988 to retirement, so the base covers between eleven and twenty-eight years for pensions awarded from 1999 to 2016. Earnings are taken net of contributions and tax, and each year's net earnings are multiplied by the growth of the national net average wage up to the year preceding retirement, bringing earlier years to the same national average wage level, as the State Treasury puts it; until 2007 the valorisation stopped two years before retirement and the last two years entered unvalorised, and full valorisation applies since 2008 (OECD Pensions at a Glance 2011 to 2015). Net wages are a wage-type series, so the revaluation passes wage growth on in full: $\theta_{a,0}^{\text{rule}} = 1.00$.

Italy ($\theta_{a,0}^{\text{rule}} = 0.2$). Almost everyone born 1936 to 1953 had eighteen years of contributions by the end of 1995 and retired under the earnings-related (retributivo) formula kept by Law 335/1995: 2 percent per year of the pensionable earnings, computed for private employees as the average of the

last five years for service to 1992 (quota A) and of the last ten years for later service (quota B), each year's earnings revalued with the cost-of-living index plus one percentage point. Prices plus a fixed real increment pass no wage growth through: 0; self-employed likewise: 0. Public employees (29 percent of the bill) received quota A on the final salary, equivalent to full revaluation and covering about 62 percent of their pensions, and quota B on the last ten years. The small mixed pro-rata group has a GDP-revalued notional part. $\theta^{\text{rule}}_{a,0} = 0.52 \times 0.03 + 0.29 \times 0.62 = 0.20$.

Latvia ($\theta^{\text{rule}}_{a,0} = 1$). Latvia's first pillar is a notional defined contribution scheme in force since 1996 (Law on State Pensions). The old-age pension equals the notional capital at retirement divided by the projected number of years in retirement (the G-value). The capital is the sum of the contributions recorded since 1996 and, for the years worked before 1996 when no individual records existed, an initial capital computed from the person's average contribution wage in 1996 to 1999 (the national average for long careers with low recorded income) multiplied by the years of service; the whole capital is revalued every year with the index of the insurance contribution wage sum, the growth of the total wage base on which contributions were paid. The base is the whole career and its revaluation wage-type: $\theta^{\text{rule}}_{a,0} = 1.00$. The cohorts born 1936 to 1953 retired mostly between 1996 and 2016 under these rules.

Luxembourg ($\theta^{\text{rule}}_{a,0} = 1$). The Luxembourg general pension has a flat part, depending on the years of insurance, and a proportional part equal to 1.85 percent (falling slowly from 2013) of the contributory income of every year of the career (Code de la securite sociale, articles 214 to 225). Each year's income is entered at the price and real-wage level of the base year 1984, through the cost-of-living index and the facteur de revalorisation, which article 220 defines as the relation between the average gross wage level of each calendar year and that of 1984; at award the pension is multiplied by the current cost-of-living index and by the revaluation factor of the fourth year before the pension starts. Past earnings are thus revalued with nominal wages: 1. Civil servants appointed before 1999, about a fifth of spending, receive a fraction of the final salary under the special transitional regime: 1. $\theta^{\text{rule}}_{a,0} = 1.00$.

Netherlands ($\theta^{\text{rule}}_{a,0} = 1$). The Dutch state pension (AOW, Algemene Ouderdomswet 1957) is a flat-rate benefit for residents, built up at 2 percent per year of residence between the ages of 15

(later 17) and the pension age, with no earnings record. Its amount is fixed by law as a percentage of the net statutory minimum wage, 70 percent for a single person and 50 percent for each member of a couple (AOW Act, articles 9 and 9a), and the minimum wage is adjusted every 1 January and 1 July to the average increase of collectively agreed wages (Wet minimumloon en minimumvakantiebijslag, article 14, and the Wet koppeling met afwijkingsmogelijkheid of 1992). A newly awarded AOW pension therefore stands at the current wage-linked amount whatever the year of award, a flat-rate benefit linked to wages: $\theta_{a,0}^{\text{rule}} = 1.00$. The funded occupational pillar is out of scope by convention.

Portugal ($\theta_{a,0}^{\text{rule}} = 0.34$). General-regime pensions awarded to people enrolled before 2002, are a weighted average of two formulas. The old formula gives 2 percent per year of the average of the best 10 of the last 15 years' earnings, each year revalued with the consumer price index excluding housing: 0. The new formula uses the whole career with earnings revalued by an index weighting the same price index at 75 percent and the earnings reported to Social Security at 25 percent, and applies pro rata only to the years from 2002 or 2007, worth about 0.25 on a tenth of a 2016 base: about 0.02 on average. Civil servants of the CGA, roughly 35 percent of spending, had 80 percent of the last salary for service until 2005 and general-regime rules afterwards, about 0.93. $\theta_{a,0}^{\text{rule}} = 0.65 \times 0.02 + 0.35 \times 0.93 = 0.34$.

Slovakia ($\theta_{a,0}^{\text{rule}} = 0.72$). Since the 2004 reform (Act 461/2003 on social insurance) the Slovak old-age pension equals the years of insurance times the average personal wage point, the ratio of the person's assessment base to the national average wage for each year from 1984, times the current pension value. The value was fixed in 2004, and it is raised every year with the growth of the average wage, by government decree until 2014, automatically from 2015 and at 95 percent of wage growth since 2023. Points valued at a wage-indexed value are a wage-type revaluation over the recorded career: 1. Pensions awarded from 1999 to 2003 under the previous Act 100/1988 were computed on the nominal average of the best five of the last ten years, reduced by brackets and never revalued: 0. Five of eighteen award years fall under the old act: $\theta_{a,0}^{\text{rule}} = 13/18 = 0.72$.

Slovenia ($\theta_{a,0}^{\text{rule}} = 1$). Under the Pension and Disability Insurance Act of 1999 (ZPIZ-1), which governed awards from 2000 to 2012, the pension rating base was the average monthly wage of

the most favourable consecutive years since 1970, the number of years rising from 10 in 2000 by one a year to 18 in 2008; ZPIZ-2, in force from 2013, lengthened the window by one year a year from 19 to 24 years in 2018, so 22 years for a 2016 award. Each year's wage is multiplied by a valorisation coefficient that brings it to the average wage level of the year before retirement; the coefficients were also set to keep pensions of new and earlier retirees aligned, a level factor that lowered the base without changing its link to wages. The revaluation is wage-type: $\theta_{a,0}^{\text{rule}} = 1.00$. Awards before 2000 used the best 10 years with the same valorisation.

Spain ($\theta_{a,0}^{\text{rule}} = 0$). The General Regime retirement pension (and the self-employed scheme RETA, same formula) is a percentage of the regulatory base, which for awards up to 2012 was the sum of the contribution bases of the last 15 years divided by 210; Law 27/2011 lengthens the window by one year per year from 2013 to 25 years in 2022, so 19 years for a 2016 award. The bases of the 24 months before retirement enter at their nominal value and all earlier bases are revalued with the consumer price index (LGSS article 209): price-type, 0. Civil servants under Clases Pasivas, about 11 percent of public pension spending, receive a percentage by years of service of a flat haber regulador set for their corps group in each budget law and updated like pensions, again price-type: 0. $\theta_{a,0}^{\text{rule}} = 0.89 \times 0 + 0.11 \times 0 = 0.00$.

D.2 Pensions in payment

Austria ($\theta_{a,1}^{\text{rule}} = 0$). Since 2004 pensions in payment are multiplied each January by an adjustment factor set by decree on the Richtwert, the average consumer price increase from August to July (sections 108f and 108h ASVG, Pensionsharmonisierungsgesetz 2004); from 1993 to 2003 the net-wage adjustment applied instead, and in 1997 no adjustment was granted. Within 2010 to 2022 the price rule was applied every year, though seldom uniformly: pensions above 2,000 to 2,466 euros received fixed amounts or nothing in 2010 and 2011, the Stabilitaetsgesetz 2012 cut the increase to the Richtwert minus 1.0 and 0.8 points in 2013 and 2014, and social staggering gave small pensions more than inflation from 2018 to 2022. Civil-service pensions have followed the same factor since 1998. None of these variations contains a wage element: thirteen years at zero, $\theta_{a,1}^{\text{rule}} = 0.00$.

Belgium ($\theta^{\text{rule}}_{a,1} = 0.33$). Employee and self-employed pensions are indexed to the smoothed health index, consumer prices excluding tobacco, alcohol and motor fuels: whenever the index passes a pivot value, pensions rise 2 percent the following month (law of 2 August 1971). Between 2010 and 2022 this happened in September 2010, May 2011, twice in 2012, June 2016, June 2017, September 2018, March 2020, September 2021 and six times in 2022; in 2015 the government skipped one step (index jump). The biennial welfare envelope of the 2005 Generation Pact added real increases of 1 to 2.25 percent for particular pension vintages, recorded separately. Civil-service pensions receive in addition a biennial perequation equal to the rise of the pay scales of active civil servants in their basket (law of 25 April 2007), a wage-scale index coded 1 although small since 2013. With weights 0.67 and 0.33: thirteen years at 0.33, $\theta^{\text{rule}}_{a,1} = 0.33$.

Cyprus ($\theta^{\text{rule}}_{a,1} = 0.33$). The basic part of a social insurance pension is raised each January by the increase in the basic insurable earnings, which follow average insurable earnings, and the supplementary part by the consumer price index; the two parts weigh 0.6 and 0.4 for these cohorts. Government employees' pensions followed civil-service pay and the cost-of-living allowance until 2012, were switched to prices by Law 216(I)/2012 and since 2018 rise by half the cost-of-living rate. Under the adjustment programme all social insurance pensions were frozen from 2013 to 2016, the basic insurable earnings stayed unchanged through 2017, and public-sector pensions were frozen from 2013 to 2017. The wage element is thus 0.6 for the social insurance scheme in 2010 to 2012 and 2018 to 2022, 1 for the government scheme in 2010 to 2012, zero otherwise. With weights 0.72 and 0.28: $\theta^{\text{rule}}_{a,1} = 0.33$.

Estonia ($\theta^{\text{rule}}_{a,1} = 0.68$). Pensions in payment are raised every 1 April by the pension index, since 2008 the sum of 80 percent of the growth of the pension-insurance part of social tax revenue and 20 percent of the change in consumer prices (State Pension Insurance Act, section 26), the base amount receiving 1.1 and the year value 0.9 of the increment; an index below one is not applied. The social tax base is a wage-type series, so the rule passes 0.8 of wage growth on. In 2009 the government cut the index to a flat 5 percent, and in 2010 and 2011 the index fell below one, so pensions were unchanged. From 2012 to 2022 the index was applied every year, with extraordinary additions to the base amount in 2020 and 2021 that are not indexation. Two years at zero and eleven

at 0.8: $\theta_{a,1}^{\text{rule}} = 0.68$.

Finland ($\theta_{a,1}^{\text{rule}} = 0.2$). All earnings-related pensions in payment are raised every 1 January by the earnings-related pension index, which combines the change in consumer prices with a weight of 80 percent and the change in the wage earners' earnings level with a weight of 20 percent, measured from the third quarter of the year before last to the third quarter of the previous year (Employees Pensions Act, section 98; before 2005 the same 20/80 pensioner's index applied to pensions of persons aged 65 and over). The index was applied in every year from 2010 to 2022; in 2016 the formula gave about zero because prices had fallen, an outcome of the rule and not a freeze. National and guarantee pensions follow a cost-of-living index, cut in 2017 and frozen in 2018 and 2019, but fall below the 10 percent threshold and are folded in. Thirteen years at 0.2: $\theta_{a,1}^{\text{rule}} = 0.20$.

France ($\theta_{a,1}^{\text{rule}} = 0$). Basic pensions are revalued once a year on consumer prices excluding tobacco (Code de la securite sociale, article L161-25): until 2015 on forecast inflation, since October 2016 on the average index of the last twelve months, with the date moved to April in 2009, to October in 2014 and back to January from 2019. Within 2010 to 2022 the rule gave zero in October 2014 and 2016, no revaluation fell in calendar 2018, the finance laws set 0.3 percent in 2019 and, above 2,000 euros, in 2020, and an exceptional 4 percent was paid in July 2022. Civil-service and special-regime pensions follow the same coefficients since the law of 21 August 2003. Agirc-Arrco applied prices minus one point in 2013, froze its point value from 2014 to 2017 and in 2020, and gave about one percent in 2018, 2019 and 2021. No wage element: $\theta_{a,1}^{\text{rule}} = 0.00$.

Germany ($\theta_{a,1}^{\text{rule}} = 0.87$). The current pension value is adjusted every 1 July by the growth of gross wages per employee of the year before last, multiplied by a contribution factor and, since 2005, a sustainability factor reflecting the ratio of pensioners to contributors (section 68 SGB VI); these factors scale the increase but do not depend on wage growth, so the rule passes wage growth on with an elasticity of one. The protection clause of section 68a forbids a fall in the value: in 2010 (formula result minus 2.1 percent) and 2021 (minus 3.25 percent) no increase was paid, the suppressed reductions being recouped by halving the increases of 2011 to 2013 and cutting the 2022 increase to 5.35 percent. Civil-service pensions rise whenever active pay rises (section 70

BeamtVG). Eleven formula years and two zero years for the GRV (weight 0.85), thirteen wage years for civil servants (0.15): $\theta_{a,1}^{\text{rule}} = 0.87$.

Greece ($\theta_{a,1}^{\text{rule}} = 0$). Before 2010 Greek pensions were raised each year by ministerial decision under the national incomes policy, close to consumer prices for the social insurance funds and in step with civil-service pay for state pensions. From 2010 the adjustment programmes froze all pensions in payment in nominal terms and cut them repeatedly (laws 3845/2010, 3863/2010, 3986/2011, 4024/2011, 4051/2012 and 4093/2012); Law 4387/2016 recalculated pensions, kept the freeze and set a new rule, half the change in GDP plus half the change in prices with the price change as a ceiling, whose first application was deferred to 2023 by Law 4472/2017. Increases of 7.75 percent in January 2023, 3.0 percent in 2024 and 2.4 percent in 2025 followed, and pensioners with a personal difference from the recalculation received them only once it was absorbed. Between 2010 and 2022 no pension was indexed: thirteen years at zero, $\theta_{a,1}^{\text{rule}} = 0.00$.

Hungary ($\theta_{a,1}^{\text{rule}} = 0$). Until 2000 Hungarian pensions were raised each January by the planned growth of net wages, and from 2001 to 2009 by the Swiss formula of section 62 of Act LXXXI of 1997, half the planned growth of net average wages and half the planned rise in consumer prices, corrected when actual values exceeded the plan. A 2009 amendment made the wage share depend on GDP growth, from nothing below 3 percent to half above 5 percent; growth stayed below 3 percent, so the increases of 2010 (about 4 percent) and 2011 (4.3 percent) followed prices only. Since 2012 (Act CLXVII of 2011) the January increase equals the planned consumer price index, with a November correction when actual inflation is higher, as in 2017, 2019, 2021 and 2022; the pension premium and the 13th-month pension are not indexation. No wage element in 2010 to 2022: $\theta_{a,1}^{\text{rule}} = 0.00$.

Italy ($\theta_{a,1}^{\text{rule}} = 0$). Italian pensions in payment are raised each January by the ISTAT cost-of-living index of the previous year (perequazione automatica, Law 160/1975), the indexation to real wages having been abolished by Decree 503/1992. The pass-through falls with the size of the pension: by brackets under Law 388/2000, 100 percent up to three times the minimum pension, 90 percent to five times and 75 percent above; Decree-Law 201/2011 suspended indexation in 2012 and 2013 for pensions above three times the minimum, whole-pension rates of 100 down to 40 or 45 percent

applied under Law 147/2013 in 2014 to 2018 and Law 145/2018 in 2019 to 2021, Law 234/2021 restored the brackets in 2022, and rates of 100 down to 32 percent applied in 2023 and 2024. The index was at or below zero in 2016, 2017 and 2021. Public employees follow the same rules. No wage element: $\theta_{a,1}^{\text{rule}} = 0.00$.

Latvia ($\theta_{a,1}^{\text{rule}} = 0.31$). Pensions in payment are indexed on 1 October by a coefficient combining the consumer price index with a share of the real growth of the insurance contribution wage sum, applied to the pension up to a ceiling. The share was 25 percent from 2014 to 2016 and 50 percent from 2017; since October 2018 it rises with the insurance record, 60 percent for 30 to 39 years, 70 percent for 40 years and 80 percent (from 2019) for 45 years, about 0.65 on average; the ceiling was 285 euros in 2014 and half the average contribution wage from 2015, so about 0.9 of the bill was indexed. Indexation was suspended from 2009 to 2012 and resumed in September 2013 with a legislated 4 percent. Wage-type pass-through: zero in 2010 to 2013, 0.225 in 2014 to 2016, 0.45 in 2017 and 0.58 in 2018 to 2022: $\theta_{a,1}^{\text{rule}} = 0.31$.

Luxembourg ($\theta_{a,1}^{\text{rule}} = 0.85$). Pensions in payment are adapted to the cost of living, by 2.5 percent whenever the six-month average of the consumer price index has moved 2.5 percent from the last adjustment (article 224 CSS), and adjusted to the real evolution of wages: by biennial adjustment laws before 2013 and, since the reform of 21 December 2012, every 1 January by a reajustement factor equal to the real wage change two years earlier times a moderator (article 225bis), which is 1 while the pure pay-as-you-go premium stays below the 24 percent contribution rate. Prices plus real wages amount to nominal wage indexation. The law of 20 December 2013 set the moderator to 0 for 2014 and 2015, leaving only the price tranches; the reajustement then resumed at 0.5, 0.9, 0.3, 0.5, 1.5, 1.3 and 1.1 percent from 2016 to 2022. Eleven years at one and two at zero: $\theta_{a,1}^{\text{rule}} = 0.85$.

Netherlands ($\theta_{a,1}^{\text{rule}} = 1$). AOW pensions in payment move with the statutory minimum wage, which by article 14 of the Wet minimumloon is raised on 1 January and 1 July by the contract-wage increase forecast by the Central Planning Bureau, with a correction for the previous forecast; the government may deviate under the Wet koppeling met afwijkingsmogelijkheid when the ratio of benefit recipients to workers deteriorates. It did so in 2004 and 2005, when the minimum wage

and the coupled benefits were frozen at a zero line, and it added an extraordinary 8.05 percent to the minimum wage on 1 January 2023, which raised the AOW by 10.15 percent including the regular indexation. In every year from 2010 to 2022 the coupling was applied in both half-years, so the AOW passed contract-wage growth on in full: thirteen years at one, $\theta_{a,1}^{\mathrm{rule}} = 1.00$.

Portugal ($\theta_{a,1}^{\mathrm{rule}} = 0.02$). Since 2008 pensions are updated each January under Law 53-B/2006 by brackets of the social support index (IAS): when the two-year average of real GDP growth is below 2 percent, pensions up to 1.5 IAS receive the consumer price index excluding housing and larger pensions the index minus 0.5 or 0.75 point; with growth between 2 and 3 percent the first bracket receives prices plus 20 percent of GDP growth. Updates were suspended for all but minimum pensions from 2011 to 2015; the formula applied in 2016 and 2017 to the first bracket only, the GDP term applied in 2018, 2019 and 2020, the price branch in 2021 and 2022, and in 2023 the government paid about half the formula after a lump sum. GDP growth is the only wage-type element, worth 0.11 to 0.16 of the bill in 2018 to 2020: $\theta_{a,1}^{\mathrm{rule}} = 0.03$.

Slovakia ($\theta_{a,1}^{\mathrm{rule}} = 0.19$). From 2004 to 2012 Slovak pensions were raised every 1 July by the average of the growth of the average wage and of consumer prices (Act 461/2003, section 82), a Swiss formula with a wage weight of one half: 3.05 percent in 2010, 1.8 in 2011 and 3.3 in 2012. Act 252/2012 moved the date to January and phased the wage weight out: the increases of 2013 to 2016 were fixed sums equal to a mixed rate of 40, 30, 20 and 10 percent wage growth and the rest consumer prices, so the aggregate bill still moved with those weights. From 2017 pensions follow the inflation of pensioner households, with a minimum of 2 percent of the average pension until 2021, then pensioner inflation alone, 11.8 and 10.6 percent in 2023. Three years at 0.5, then 0.4, 0.3, 0.2 and 0.1, six years at zero: $\theta_{a,1}^{\mathrm{rule}} = 0.19$.

Slovenia ($\theta_{a,1}^{\mathrm{rule}} = 0.24$). Slovenian pensions were adjusted to the growth of average wages twice a year under ZPIZ-1 (article 150a), a wage rule that crisis legislation curtailed: the 2009 intervention act paid half of the wage adjustment in 2010, the ZIU and ZDIU acts a quarter in 2011, and the Fiscal Balance Act of 2012 none. ZPIZ-2 (article 105) prescribes since 2013 a February adjustment of 60 percent of the previous year's growth of the average gross wage plus 40 percent of consumer price growth, but the budget implementation acts replaced it with fixed increases of 0.1 percent in

2013, nothing in 2014 and 2015, 0.7 percent in 2016, 1.15 percent in 2017 and 2.2 percent in 2018; the formula was applied from 2019 to 2022, extraordinary increases recorded separately. Years at 0.5 and 0.25 in 2010 and 2011, seven zero years and four at 0.6: $\theta_{a,1}^{\text{rule}} = 0.24$.

Spain ($\theta_{a,1}^{\text{rule}} = 0$). Until 2010 Spanish pensions were raised each January by the forecast consumer price index, with a lump-sum compensation whenever the November-to-November index exceeded the forecast (Law 24/1997). Royal Decree-Law 8/2010 cancelled the compensation of the 2010 deviation and froze all but minimum pensions in 2011; in 2012 the 1 percent granted was not topped up for a 2.9 percent inflation (RDL 28/2012), and in 2013 pensions rose 1 percent (2 percent below 1,000 euros). Law 23/2013 replaced price indexation by a revaluation index tied to the system's balance with a floor of 0.25 percent, the increase actually paid from 2014 to 2017. The 2018 budget raised that year to 1.6 percent, RDL 28/2018 gave 1.6 percent plus the deviation in 2019, 0.9 percent followed in 2020 and 2021, and Law 21/2021 restored CPI indexation from 2022; Clases Pasivas followed. No year has a wage element: $\theta_{a,1}^{\text{rule}} = 0.00$.

D.3 The earnings-base correction

The last factor of equation (35) restates the benefit at award from the average wage of the award year to the retiree's own earnings revalued with wages. For each public scheme it is the inverse of the mean, over the years of the scheme's earnings base, of the revaluation of each year's earnings relative to wage growth to the award year; a country's factor is the expenditure-weighted mean over its schemes, with the shares of Table D.1. The base years are the last N years before the award for a base of the last N years and for a whole career, which counts 45 years; a best-N base keeps the N years of the last 45 with the highest revalued earnings. Table D.2 lists the rules by scheme, with the award-year dependence of the base lengths, and Table D.3 the resulting factors. The wage and price series are those of the uprating index, extended back to 1954 with the growth rates of AMECO's nominal compensation per employee and national consumer price index; years before the first AMECO observation carry the mean growth of its first five years. A points scheme whose points are the ratio of own to average earnings and are valued at award, such as the German, Cypriot and Estonian schemes and the French Agirc-Arrco, has no earnings-base lag, and its exposure to growth enters only through $\theta_{a,0}^{\text{rule}}$.

Table D.2: The earnings base and its revaluation, by scheme

AT	ASVG old law (0.78): best N years, $N = 15$ to 2003 and $15 + (s - 2003)$ after (28 in 2016), revalued with the cumulated adjustment factors, net wages to 2003 and prices from 2004; civil servants (0.22): final salary.
BE	Wage earners and self-employed (0.67): 45-year career average revalued with prices; civil servants (0.33): last 5 years at the base index, re-indexed to prices.
CY, DE, EE, LV, SI	Points valued at award (Cyprus GSIS, German GRV, Estonian coefficients), notional capital indexed with the contribution wage sum (Latvia), wages valorised to the year before award (Slovenia); final salaries (Cyprus GEPS, German civil servants): no correction.
ES	General regime and RETA (0.89): last N years, $N = 15$ to 2012 and $15 + (s - 2012)$ after (19 in 2016, 25 in 2022), revalued with the CPI to two years before award, the last 24 months nominal; Clases Pasivas (0.11): flat by corps.
FI	Earnings-related schemes (0.92): awards to 2004 on the last 10 years with the half-way index (half wages, half prices); awards from 2005: rights accrued to 2004, a share $(2044 - s)/40$ of the pension, on the last 10 years to 2004 with the half-way index and carried to s with the wage coefficient (80 percent wages, 20 percent prices), earnings from 2005 revalued with the wage coefficient; national pension (0.08): flat.
FR	CNAV and aligned regimes (0.46): best N years, $N = \min(25,\ 13 + (s - 1999))$, coefficients following wages to 1986 and prices from 1987; Agirc-Arrco (0.28): points bought at a wage-indexed purchase price, no correction; civil service and special regimes (0.26): last six months, no correction.
GR	IKA-ETAM (0.45): last 5 years revalued with the increases granted to pensions, the uprating index from 1996 and prices before; civil servants and military (0.22) and public enterprises and banks (0.13): final salary; OAEE (0.10) notional classes and OGA (0.10) flat: no correction.
HU	Net earnings from 1988 valorised with net wages to the year before award: no correction, except the last two years unvalorised for awards to 2007.
IT	Private employees (0.52): quota A, service to 1992 (share $(2032 - s)/40$), on the last 5 years and quota B on the last 10, revalued with the cost-of-living index plus one point; public employees (0.29): quota A on the final salary (0.62 of the pension) and quota B on the last 10 years; self-employed (0.19): last 10 years, cost-of-living index plus one point.
LU, NL	Career wages revalued to current wage and price levels (Luxembourg; civil servants on final salary), flat AOW (Netherlands): no correction.
PT	General regime (0.65): old formula on the best 10 of the last 15 years revalued with prices, blended with the career-average formula (75 percent prices, 25 percent wages) at weight $(s - 2006)/40$ from 2008 and $(s - 2001)/40$ for 2003–2007; CGA (0.35): final salary for service to 2005 (0.93 of the pension), career average after.
SK	Awards to 2003 (Act 100/1988): best 5 of the last 10 years, unrevalued; awards from 2004: points valued at the current pension value, no correction.

Notes: s is the award year, taken as the year the retiree turned 63. Scheme weights in parentheses are the expenditure shares of Appendix D. Sources: the reconstruction of Appendix D, the OECD *Pensions at a Glance* country profiles and national legislation.

Table D.3: The earnings-base correction $\mathscr{C}_{c,s}$ by country and award year

	1999	2003	2007	2011	2016	Lag, 2007
AT	1.000	1.000	1.016	1.006	1.026	4.1
BE	1.381	1.318	1.252	1.173	1.117	16.4
ES	1.112	1.074	1.048	1.058	0.984	7.1
FI	1.043	1.028	1.038	1.038	1.033	2.7
FR	1.017	1.030	1.043	1.046	1.046	5.1
GR	1.035	1.035	1.018	0.982	0.951	1.4
HU	1.013	1.007	1.003	1.000	1.000	0.0
IT	0.969	0.963	0.970	0.950	0.945	3.3
PT	1.125	1.064	1.048	1.012	0.993	4.8
SK	1.328	1.258	1.000	1.000	1.000	0.0
CY, DE, EE, LU, LV, NL, SI	1.000	1.000	1.000	1.000	1.000	0.0

Notes: The factor by which the benefit at award over the average wage of the award year is multiplied to obtain the benefit over the retiree's own earnings revalued with wages, for awards in the stated years. The last column is the number of years of wage revaluation missing from the earnings base for a 2007 award, the scheme-weighted mean lag of the base times one minus the wage share of its revaluation index. Belgium's factor falls over award years as real wage growth slowed; Italy's is below one because the revaluation of the base at the cost-of-living index plus one point exceeded real wage growth; the Greek and Spanish factors fall below one for the latest awards because nominal wages fell over their base years. The weighted mean over the retirees of the estimation sample, awarded between 1999 and 2016, is 1.014.

D.4 The indexation parameter in 1995

The instrument of Section 4.4 scales the predicted wedge change by $1 - \theta_{c,1995}$, the share of a pension budget gap that contributions absorbed under the rules in force in 1995, the start of the window over which the wedge change is measured. The parameter is built as θ_a^{rule} above, with the same two stages and the same weights, $\theta_{c,1995} = 0.53\,\theta^0_{c,1995} + 0.47\,\theta^1_{c,1995}$, from the statutes and uprating decisions of 1995 rather than those of the 2010s: the award stage codes the revaluation of the earnings base of a pension awarded in 1995, and the payment stage the uprating granted in 1995 to pensions already in payment, each weighted by expenditure over the public schemes. Table D.4 reports the two stages, the grade of the evidence behind each, the earnings base in force, and the 2010s parameter for comparison. Five countries, Austria, Estonia, Hungary, Luxembourg and Slovenia, indexed both stages fully to wages in 1995 and carry a parameter of one, so the instrument is zero for them. The largest changes since are the moves away from wage indexation in those countries and in France, and the Dutch move toward it. The brief under which the parameters were reconstructed is reproduced in Appendix E.

Table D.4: The indexation parameter under the rules in force in 1995

	Award stage		In payment			Earnings base		
Country	$\theta^0_{c,1995}$	Grade	$\theta^1_{c,1995}$	Grade	$\theta_{c,1995}$	Type	Years	θ^{rule}_a
Austria	1.00	B	1.00	B	1.00	last N	9	0.38
Belgium	0.34	C	0.34	B	0.34	whole career	43	0.16
Cyprus	1.00	A	0.65	C	0.84	whole career	22	0.69
Germany	0.99	B	0.99	B	0.99	whole career	33	0.94
Estonia	1.00	C	1.00	C	1.00	flat	0	0.60
Spain	0.00	B	0.00	B	0.00	last N	7	0.00
Finland	0.37	B	0.37	A	0.37	whole career	3	0.39
France	0.53	C	0.29	C	0.42	best N	11	0.14
Greece	0.30	B	0.00	C	0.16	last N	7	0.19
Hungary	1.00	B	1.00	C	1.00	last N	7	0.53
Italy	0.28	C	0.00	B	0.15	last N	4	0.10
Luxembourg	1.00	B	1.00	B	1.00	whole career	31	0.93
Latvia	1.00	A	0.00	C	0.53	flat	0	0.68
Netherlands	1.00	A	0.00	B	0.53	flat	0	1.00
Portugal	0.31	B	0.26	B	0.29	best N	7	0.19
Slovenia	1.00	A	1.00	A	1.00	best N	10	0.64
Slovakia	0.00	B	1.00	C	0.47	best N	5	0.47

Notes: The award-stage parameter $\theta^0_{c,1995}$ is the share of wage growth passing into a pension awarded in 1995 through the revaluation of its earnings base, the payment-stage parameter $\theta^1_{c,1995}$ the share passed on by the uprating granted in 1995 to pensions in payment, each an expenditure-weighted mean over the public schemes, and $\theta_{c,1995}$ their combination with the weights of Section 3.3. Grades: A, statutory text found and the 1995 application confirmed; B, rule confirmed and its application partly inferred; C, approximation from secondary sources or a discretionary practice read from outcomes. Earnings base: the type and length in years of the base of a pension awarded in 1995; flat denotes a benefit without an individual earnings base. The last column is θ^{rule}_a of Table D.1, the parameter of the 2010s used in Sections 4.2 and 4.3 and in Figure 7. Source: the reconstruction of 9 September 2026 under the brief of Appendix E.

E The reconstruction brief

This appendix reproduces the brief under which the indexation parameters of Appendix D were reconstructed, the Markdown file `THETA_CONSTRUCTION.md` of the replication files dated 6 September 2026, exactly as written. The brief was written to be executed without access to any other part of the project, so it restates definitions given elsewhere in the paper, and its section numbers are its own.

```
# Reconstructing the rule-based indexation parameter of European pension
    ↪ systems

Self-contained brief for an analyst or an AI agent with web access.
    ↪ Everything needed to redo the work is in this file; no other file of
    ↪ the project is required or should be consulted, before, during or
    ↪ after the work. Write all deliverables to a new folder named `
    ↪ theta_rederivation_YYYY-MM-DD` next to this file, and keep a running
    ↪ log of the sources consulted from the first search onward.

## 1. Purpose

A pension system passes wage growth on to benefits at two points: when a new
    ↪  pension is computed, through the revaluation of the past earnings on
    ↪ which it is based, and after retirement, through the indexation of
    ↪ pensions in payment. The parameter to reconstruct summarizes the share
    ↪  of wage growth that the statutory rules pass on at each point, for
    ↪ seventeen European countries. It is written

    theta_a = omega_0 * theta_a0 + (1 - omega_0) * theta_a1,      omega_0 =
    ↪ 0.53

where `theta_a0` is the award-stage component, `theta_a1` the payment-stage
    ↪ component, and the weights are fixed (Section 3.4). Deliverables:
    ↪ three CSV files, one explanation file and a source log (Section 7).

Countries (ISO codes used throughout): AT Austria, BE Belgium, CY Cyprus, DE
    ↪  Germany, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HU
    ↪ Hungary, IT Italy, LU Luxembourg, LV Latvia, NL Netherlands, PT
    ↪ Portugal, SI Slovenia, SK Slovakia.

Population the parameter describes: people born between 1936 and 1953 who
    ↪ reached the award age of 63 between 1999 and 2016 (some claimed
    ↪ earlier under early-retirement provisions) and drew it over 2010 to
    ↪ 2022. The award-stage component must therefore describe the benefit
    ↪ formula that applied to those claimants, including transitional
    ↪ regimes, not the formula that applies to new entrants today. The
    ↪ payment-stage component covers the calendar years 2010 to 2022.

## 2. Which schemes to code

The parameter describes the public pension bill of the sample cohorts, so it
    ↪  covers every public, pay-as-you-go scheme that pays a significant
```

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    ↪ share of their pensions: the main scheme of private-sector employees,
    ↪ the schemes of civil servants and the self-employed where they are
    ↪ separate, and mandatory complementary schemes run on a pay-as-you-go
    ↪ basis. Funded occupational and private pensions are out of scope, and
    ↪ so are survivor and disability pensions and minimum-pension or means-
    ↪ tested supplements, unless they follow the same revaluation and
    ↪ indexation rules as the old-age pension of the scheme. A scheme is
    ↪ significant when it pays at least 10 percent of the public pension
    ↪ expenditure going to the birth cohorts 1936 to 1953; smaller schemes
    ↪ are folded into the closest significant one and mentioned in the
    ↪ explanation. The table gives the main scheme and the other schemes to
    ↪ check for each country; it is a starting point, not a closed list.

| Country | Main scheme | Other public schemes to check |
|---|---|---|
| AT | ASVG employee pension (assessment base and yearly adjustment) | Civil
    ↪ -service pensions (Beamte), self-employed and farmers' schemes |
| BE | Employee pension (salaried workers' scheme) | Civil-service pensions
    ↪ (final-salary based, perequation), self-employed scheme |
| CY | Social Insurance Scheme (basic and supplementary parts together) |
    ↪ Government employees' pension scheme |
| DE | Statutory pension insurance (GRV), points system, West pension value
    ↪ | Civil-service pensions (Beamtenversorgung, final salary adjusted
    ↪ with civil-service pay) |
| EE | State pension insurance (first pillar), insurance component | Special
    ↪  pensions of public officials (small) |
| ES | General Regime contributory retirement pension | Clases Pasivas (
    ↪ civil servants), self-employed (RETA) |
| FI | Earnings-related pension of private-sector employees (TyEL and
    ↪ predecessors) | Public-sector earnings-related pensions (Keva),
    ↪ national pension (KEL index) |
| FR | General regime basic pension (CNAV) | AGIRC-ARRCO mandatory
    ↪ complementary points (purchase price and point value have their own
    ↪ indexation), civil-service pensions (last six months' salary), special
    ↪  regimes |
| GR | Main IKA/EFKA employee pension | Public-sector and special funds
    ↪ merged into EFKA |
| HU | Social insurance old-age pension | None separate of note |
| IT | INPS employee pension (FPLD) under the regime applicable to the
    ↪ cohorts | Public-sector pensions (former INPDAP), self-employed funds;
    ↪  the mixed pro-rata regime within FPLD |
| LU | General contributory scheme (CNAP) | Special transitional scheme of
    ↪ civil servants |
| LV | First-pillar notional defined contribution pension | None separate of
    ↪  note |
| NL | AOW state pension only (the funded occupational pillar is out of
    ↪ scope by convention) | None |
| PT | General social security regime old-age pension | Caixa Geral de
    ↪ Aposentacoes (civil servants) |
| SI | ZPIZ old-age pension | None separate of note |
| SK | Old-age pension of the Social Insurance Agency (first pillar) | Armed
    ↪  forces and police schemes (small) |

## 3. Definitions and coding rules
```

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Throughout, "wages" means the nominal average wage per employee of the
   ↪ economy; the reference series is compensation of employees over the
   ↪ number of employees from the national accounts (Eurostat `nama_10_gdp
   ↪ `, item D1, over `nama_10_pe`, item SAL_DC), and the reference price
   ↪ series is the all-items HICP annual average (Eurostat `prc_hicp_aind`)
   ↪ . An index that tracks gross or net wages, the wage bill, the
   ↪ contribution base, social-tax revenue, or nominal GDP is treated as a
   ↪ wage-type index (its growth tracks wages over the long run); an index
   ↪ of consumer prices, of the cost of living, of pensioners' prices or a
   ↪ "health index" is a price-type index. Where a rule uses a wage or
   ↪ price concept other than the reference series (net wages, a pensioner
   ↪ price index, wages of a sector), code it as the corresponding type and
   ↪  note the difference; the reference series are what the uprating index
   ↪  will be computed with.

### 3.1 Award-stage component, theta_a0

`theta_a0` is the share of wage growth that enters a new pension through the
   ↪  revaluation of the earnings on which it is computed, for the
   ↪ claimants of 1999 to 2016.

| Rule for bringing past earnings to the year of award | theta_a0 |
|---|---|
| Earnings revalued with wage growth, or recorded as a fraction of the year'
   ↪ s average wage (points), or credited in a notional account at a wage-
   ↪ type rate | 1 |
| Earnings revalued with prices only, or with prices plus a fixed real
   ↪ increment (for example "cost of living plus one percent") | 0 |
| Mixed index with fixed weights (for example 80 percent wages, 20 percent
   ↪ prices) | the wage weight |
| Flat-rate benefit with no earnings base, linked to the minimum wage or to
   ↪ wages | 1 |
| Flat-rate benefit linked to prices | 0 |

Also record `base_years`, the number of years of earnings that enter the
   ↪ base, and `base_type`, one of whole career, last N years, best N years
   ↪ , flat rate (with `base_years` equal to 0). Together they say how far
   ↪ the base lags the wage at award, and so how exposed the award stage is
   ↪  to the revaluation rule: a whole career or the last N years lag by
   ↪ about (N+1)/2 years, a best-N base by less since the best years fall
   ↪ late in a career, a flat-rate benefit not at all.

**Early retirement.** Code the regime at the ages at which the cohorts
   ↪ actually claimed, which in several countries were 57 to 62 rather than
   ↪  63 (seniority pensions in Italy, long-insurance rules in Austria, pre
   ↪ -reform ages in Slovenia and Hungary). Where an early-retirement route
   ↪  had its own formula or revaluation, treat it as a regime of its own
   ↪ under the weighting rule below.

**Several regimes.** When the pensions of the sample cohorts were computed
   ↪ under more than one rule, because coexisting schemes have different
   ↪ formulas or because a reform created transitional regimes within a
   ↪ scheme, do not pick one. Score each significant regime with the table
```

```
    ↪ above and take the average weighted by each regime's share of the
    ↪ public pension expenditure paid to the birth cohorts 1936 to 1953:

     theta_a0 = sum over regimes k of  w_k * theta_a0(k),   sum of w_k = 1

Weights, in order of preference:

1. the number of pensions in payment times the average pension, by regime,
    ↪ for those birth cohorts, from the pension institution's statistics (
    ↪ for example the Italian INPS observatory by regime, the German DRV
    ↪ time series, the French DREES pensioner panel);
2. expenditure shares by scheme for all pensioners, from Eurostat's ESSPROS
    ↪ scheme-level data, the Ageing Report country fiches or the
    ↪ institutions' accounts, adjusted for the cohorts when a transition
    ↪ rule makes a regime cohort-specific (the share of claimants on either
    ↪ side of a contribution-record or age cutoff);
3. claimant shares inferred from the transition rule and the cohorts'
    ↪ typical contribution histories.

Regimes below the 10 percent threshold are folded into the closest
    ↪ significant regime. Report the regimes, their wage shares, their
    ↪ weights and the source of the weights in the explanation and in the `
    ↪ regimes` column of the CSV, and grade the weights with the same A to C
    ↪  scale as the estimates.

### 3.2 Payment-stage component, theta_a1

For each country and each calendar year 2010 to 2022, determine the rule
    ↪ under which pensions in payment were actually raised that year and
    ↪ code the share of nominal wage growth it passed on, `omega_w`:

| Rule actually applied in the year | omega_w |
|---|---|
| Wage indexation | 1 |
| Price indexation, in full or partial (degressive by pension size, capped)
    ↪ | 0 |
| Mixed indexation with fixed weights, "Swiss" formula included | the wage
    ↪ weight |
| "Prices plus x percent of real wage growth" | x |
| Freeze, suspension, or index below one not applied | 0 |
| Fixed nominal increase granted instead of indexation (for example 0.25
    ↪ percent) | 0 |
| Formula whose base is wage growth, dampened by level factors that do not
    ↪ depend on wage growth (Germany's contribution and sustainability
    ↪ factors) | 1 |
| Conditional rule (indexation depends on GDP growth, on the system's
    ↪ balance, or similar) | code the branch that actually applied in that
    ↪ year |

`theta_a1` is the arithmetic mean of `omega_w` over the thirteen years 2010
    ↪ to 2022. When a significant scheme indexes its pensions in payment
    ↪ under a different rule from the main scheme (a complementary scheme
    ↪ whose point value follows its own rule, a civil-service scheme
    ↪ adjusted with civil-service pay), compute `omega_w` for each scheme
```

```
    ↪ and average them with the expenditure weights of Section 3.1, year by
    ↪ year, before taking the mean over the window. The component is an
    ↪ elasticity, not a level: it records how a pension in payment would
    ↪ have responded to a change in wage growth under the rule of the year,
    ↪ not how much pensions actually gained or lost on wages. Explicit cuts
    ↪ of pensions, lump sums, thirteenth-month payments, pension premiums
    ↪ and targeted increases of small pensions are not indexation and
    ↪ receive no weight; note them in the explanation.

### 3.3 The rule table behind the uprating index

The same research yields, at no extra cost, the inputs of a second object
    ↪ used elsewhere, the cumulative statutory uprating of pensions in
    ↪ payment. For every country and year from 1997 to 2025 record,
    ↪ alongside `omega_w`:

- `omega_p`: the share of price inflation passed on (1 under a price rule,
    ↪ the price weight under a mixed rule, 0 in a freeze; under a degressive
    ↪  schedule by pension size, the pass-through averaged over pension
    ↪ bands with expenditure weights, or a stated approximation graded C
    ↪ when band data are missing);
- `fixed_nom`: a fixed nominal increase granted instead of indexation, as a
    ↪ decimal (0.0025 for 0.25 percent), otherwise 0;
- `fixed_real`: a fixed real increase granted on top of price indexation, as
    ↪  a decimal, otherwise 0;
- for Germany, the actual July adjustment of the pension value (West), as a
    ↪ decimal, in `fixed_nom`, with `omega_w = omega_p = 0`;
- a one-line note naming the rule and its legal basis;
- where the payment-stage rule is a weighted average over schemes, one row
    ↪ per scheme with its `scheme` label and `weight`, so that the index can
    ↪  be rebuilt scheme by scheme or from the weighted parameters (Section
    ↪ 7).

Under these conventions the yearly uprating factor is `(1 + wage growth)^
    ↪ omega_w * (1 + inflation)^omega_p * (1 + fixed_nom) * (1 + fixed_real)
    ↪ `. Years before 2010 and after 2022 do not enter `theta_a1` but are
    ↪ needed for the index; where a rule before 2004 or so was discretionary
    ↪ , code the closest statutory description and flag the uncertainty.

Timing conventions: a row describes the increase paid in that calendar year,
    ↪  whatever the month (Germany in July, Estonia in April, France in
    ↪ October in some years) and whatever the reference period of the index
    ↪ it applies (the previous year's inflation, a forecast with a later
    ↪ catch-up); two increases paid in the same year are compounded into one
    ↪  row; a catch-up payment for an earlier year's shortfall is recorded
    ↪ in the year it is paid, in `fixed_nom`, with a note.

### 3.4 Combination

`theta_a = 0.53 * theta_a0 + 0.47 * theta_a1`. The weights are given, not to
    ↪  be re-derived: they are the exposures of an aggregate pension bill to
    ↪  the two stages thirty years after a permanent growth slowdown, for
    ↪ one-year cohorts with a forty-year career and a twenty-five-year
    ↪ retirement (13.5 years through the earnings base against 12 years in
```

```
    ↪ payment).

## 4. Sources

Use at least two independent sources per component and country; prefer the
    ↪ legal text or the pension institution's own publication for the yearly
    ↪  application. Record every source with title, publisher, year, URL and
    ↪  access date in the source log.

Comparative sources, in the order in which they are useful:

1. OECD, *Pensions at a Glance*, editions 2011, 2013, 2015, 2017, 2019, 2021
    ↪  and 2023, country profiles. Each profile gives the benefit formula,
    ↪ the revaluation of past earnings (the OECD calls it "valorisation")
    ↪ and the indexation of pensions in payment, plus the reforms enacted
    ↪ since the previous edition. The 2011 to 2015 editions describe the
    ↪ rules the sample cohorts retired under.
2. European Commission and Economic Policy Committee, *Ageing Report*,
    ↪ editions 2012, 2015, 2018, 2021 and 2024, country fiches and the "
    ↪ underlying assumptions" volume. The fiches state the legislated
    ↪ indexation and valorisation rules and list recent reforms, including
    ↪ temporary freezes.
3. MISSOC, comparative tables on social protection, table VI (old age), row
    ↪ on the adjustment of pensions, two releases a year since 2011. The
    ↪ most direct source for the rule in force in a given year.
4. US Social Security Administration and ISSA, *Social Security Programs
    ↪ Throughout the World: Europe*, editions 2010, 2012, 2014, 2016 and
    ↪ 2018, "benefit adjustment" paragraphs.
5. ECB Occasional Paper 299 (2022) on pension systems and indexation in the
    ↪ euro area, for the classification of indexation rules.
6. IMF and European Commission programme documents for the countries under
    ↪ adjustment programmes (GR, CY, PT, LV), which date freezes and
    ↪ suspensions.

National sources for the yearly application: Deutsche Rentenversicherung (
    ↪ history of the aktueller Rentenwert and its July adjustments); INPS
    ↪ and the Ministry of Economy decrees on perequazione (Italy); Seguridad
    ↪  Social and the annual revaluation laws, including Law 23/2013 on the
    ↪ revaluation index (Spain); the social security financing laws and CNAV
    ↪  circulars on revalorisation dates (France); the Austrian
    ↪ Pensionsanpassung decrees and the ASVG revaluation factors; the
    ↪ Belgian health index and the biennial welfare envelope decisions; SVB
    ↪ and the statutory minimum wage adjustments, including the 2004 to 2005
    ↪  freeze (Netherlands); CNAP and the indexation and réajustement laws (
    ↪ Luxembourg); Finnish Centre for Pensions on the earnings-related
    ↪ pension index and the wage coefficient (palkkakerroin); Estonian
    ↪ Social Insurance Board on the pension index; Latvian State Social
    ↪ Insurance Agency indexation notices; ZPIZ annual adjustment decisions
    ↪ (Slovenia); Sociálna poisťovňa valorisation notices (Slovakia); the
    ↪ Hungarian State Treasury pension increase notices; e-EFKA and Laws
    ↪ 3863/2010 and 4387/2016 (Greece); the Cypriot Social Insurance
    ↪ Services annual increase announcements; the Portuguese annual pension
    ↪ updating orders (portarias).
```

```
## 5. Procedure

1. **Schemes.** For each country, establish which schemes pass the 10
   ↪ percent criterion of Section 2, and for each of them note the reforms
   ↪ of 1990 to 2016 that changed its formula or its indexation. Identify
   ↪ the transitional regimes and which of them governed claimants of 1999
   ↪ to 2016.
2. **Award stage.** Establish, for those claimants, how past earnings were
   ↪ brought to the year of award, the length of the earnings base and,
   ↪ where relevant, the accrual formula; code `theta_a0` and `base_years`
   ↪ with the table of Section 3.1. Write the explanation (Section 6).
3. **Payment stage, rule table.** For each year 1997 to 2025 fill the row of
   ↪  Section 3.3, from the statutory rule and from what was actually
   ↪ granted that year (freezes, suspensions, fixed increases, one-off
   ↪ measures). The 2010 to 2022 rows must rest on a dated source each.
4. **Payment stage, component.** Compute `theta_a1` as the mean of `omega_w`
   ↪  over 2010 to 2022. State the exceptions explicitly in the note (
   ↪ Germany's elasticity of one is the expected case of the formula rule).
5. **Combination.** Compute `theta_a` with the weights of Section 3.4 and
   ↪ round the three parameters to two decimals in the table, keeping four
   ↪ decimals in the CSV.
6. **Explanations.** One paragraph per country and stage (Section 6).
7. **Checks.** A pure wage-indexed system has both components at one, a pure
   ↪  price-indexed system both at zero; a country with a freeze in the
   ↪ window has `theta_a1` below the wage weight of its rule; the payment-
   ↪ stage table must reflect the suspensions, freezes and fixed nominal
   ↪ increases that several countries applied during and after the euro-
   ↪ area crisis, in particular those under adjustment programmes, so a
   ↪ table with no zero or fixed-increase year in that period for such a
   ↪ country needs a source that confirms uninterrupted indexation. Grade
   ↪ each estimate A (statutory text found and yearly application confirmed
   ↪ ), B (rule confirmed, yearly application partly inferred), C (
   ↪ approximation from secondary sources).

## 6. Explanation paragraphs

For each country, one paragraph for the award stage and one for the payment
   ↪ stage, 60 to 150 words each, in plain prose, containing: the rule (
   ↪ what is indexed to what, with weights), its legal basis and dates, the
   ↪  transitional or exceptional years within the relevant window, and the
   ↪  last sentence stating the number and how it follows from the rule ("
   ↪ nine years at 0.5 and four years at zero: theta_a1 = 0.35"). No
   ↪ project-specific vocabulary; a reader with no access to anything else
   ↪ must be able to follow.

## 7. Deliverables and formats

- `pension_theta.csv`, one row per country, header exactly `country,
   ↪ theta_val,theta_pay,base_years,base_type,regimes,confidence_val,
   ↪ confidence_pay,note`, where `theta_val` is `theta_a0`, `theta_pay` is
   ↪ `theta_a1`, `base_type` one of `whole career`, `last N`, `best N`, `
   ↪ flat`, `regimes` the list of regimes entering the averages with their
   ↪ wage shares and weights (for example `FPLD-DB 0 w0.92; FPLD-mixed 0.45
   ↪  w0.08`), the confidence grades A to C, and the note one line per
```

```
    ↪ country.
- `pension_uprating_rules.csv`, one row per country, scheme and year 1997 to
    ↪  2025, header exactly `country,scheme,weight,year,omega_w,omega_p,
    ↪ fixed_nom,fixed_real,note`, with `scheme` equal to `main` and `weight`
    ↪  equal to 1 where a single scheme is coded.
- `pension_uprating_rules_country.csv`, the same table collapsed to one row
    ↪ per country and year with the expenditure-weighted `omega_w`, `omega_p
    ↪ `, `fixed_nom` and `fixed_real`, header exactly `country,year,omega_w,
    ↪ omega_p,fixed_nom,fixed_real,note`; this is the file the uprating
    ↪ index is built from.
- `theta_explanations.md`, the paragraphs of Section 6, grouped by stage,
    ↪ countries in alphabetical order of their English names.
- `theta_sources.md`, the source log, with the open questions and the points
    ↪  on which the sources disagree.
```

The parameters of Appendix D.4, under the rules in force in 1995, were reconstructed under the companion brief `THETA_CONSTRUCTION_1995.md`, dated 9 September 2026, reproduced below in the same way.

```
# Reconstructing the rule-based indexation parameter of European pension
    ↪ systems as it stood in 1995

Self-contained brief for an analyst or an AI agent with web access.
    ↪ Everything needed to redo the work is in this file; no other file of
    ↪ the project is required or should be consulted, before, during or
    ↪ after the work. Write all deliverables to a new folder named `
    ↪ theta_1995_YYYY-MM-DD` next to this file, and keep a running log of
    ↪ the sources consulted from the first search onward.

## 1. Purpose

A pension system passes wage growth on to benefits at two points: when a new
    ↪  pension is computed, through the revaluation of the past earnings on
    ↪ which it is based, and after retirement, through the indexation of
    ↪ pensions in payment. The parameter to reconstruct summarizes the share
    ↪  of wage growth that the statutory rules pass on at each point, for
    ↪ seventeen European countries, **as those rules stood in 1995**. It is
    ↪ written

    theta_a^1995 = omega_0 * theta_a0^1995 + (1 - omega_0) * theta_a1^1995,
    ↪      omega_0 = 0.53

where `theta_a0^1995` is the award-stage component, `theta_a1^1995` the
    ↪ payment-stage component, and the weights are fixed (Section 3.4).
    ↪ Deliverables: four CSV files, one explanation file and a source log (
    ↪ Section 7).

Countries (ISO codes used throughout): AT Austria, BE Belgium, CY Cyprus, DE
    ↪  Germany, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HU
    ↪ Hungary, IT Italy, LU Luxembourg, LV Latvia, NL Netherlands, PT
    ↪ Portugal, SI Slovenia, SK Slovakia.

**The date is the whole point.** This is a snapshot of the law as it stood
```

```
   ↪ in 1995, not a description of the rules that governed any later cohort
   ↪  of retirees. Two consequences run through every section. First, a
   ↪ reform enacted after 1995 is out of scope no matter how well known it
   ↪ is: the Spanish base period of fifteen years (1997), the Italian
   ↪ notional accounts (Law 335 of August 1995, applying to awards from 1
   ↪ January 1996), the Latvian notional accounts (1996), the Estonian
   ↪ pension insurance act (1998), the Slovak point system (2004), the
   ↪ Finnish wage coefficient (2005), the German sustainability factor
   ↪ (2004), the Portuguese and Slovenian formula reforms, the Greek and
   ↪ Cypriot programme-era measures. Second, a reform enacted before or
   ↪ during 1995 but phased in gradually is in scope only to the extent of
   ↪ the phase-in reached in 1995: the French base period was moving from
   ↪ the best ten years to the best twenty-five under the 1993 decree and
   ↪ had reached about eleven years for the claimants of 1995; the Italian
   ↪ 1992 Amato reform had lengthened the reference period on a pro-rata
   ↪ basis, more for younger workers than for those claiming in 1995. Code
   ↪ the phase-in position of 1995, not its endpoint.

**Award stage, whose pension?** `theta_a0^1995` describes the benefit
   ↪ formula that governed a person **claiming an old-age pension in 1995**
   ↪  --- someone born around 1930 to 1935, retiring at the age the system
   ↪ then made normal, under the transitional rules as they then applied.
   ↪ Where a country ran several coexisting regimes in 1995, or where a pre
   ↪ -1995 reform had created transitional cohorts inside a scheme, weight
   ↪ them as Section 3.1 prescribes.

**Payment stage, which year?** `theta_a1^1995` is the share of wage growth
   ↪ passed on by the rule governing the uprating of **pensions already in
   ↪ payment in 1995**. Two numbers are wanted, both reported:

- `theta_a1^1995` (**primary**): the rule as it stood in 1995 --- the
   ↪ uprating granted in 1995 under the statute then in force. This is the
   ↪ snapshot, and it is what the parameter is.
- `theta_a1_win^1995` (**secondary**): the mean of the same pass-through
   ↪ over the five years 1991 to 1995, so that a one-off freeze or a one-
   ↪ off catch-up in 1995 itself does not decide the number on its own.
   ↪ Where a system did not exist in a form that paid indexed pensions over
   ↪  part of that window --- the Baltic and central European countries
   ↪ rebuilt their pension laws between 1990 and 1993 --- average over the
   ↪ years the system did exist, state which years those are, and grade the
   ↪  value accordingly.

Report both; they are separate columns of the same file. The primary is the
   ↪ one the parameter is built from.

## 2. Which schemes to code

The parameter describes the public pension bill of 1995, so it covers every
   ↪ public, pay-as-you-go scheme that paid a significant share of the
   ↪ pensions in payment that year: the main scheme of private-sector
   ↪ employees, the schemes of civil servants and the self-employed where
   ↪ they were separate, and mandatory complementary schemes run on a pay-
   ↪ as-you-go basis. Funded occupational and private pensions are out of
   ↪ scope, and so are survivor and disability pensions and minimum-pension
```

```
   ↪  or means-tested supplements, unless they followed the same
   ↪ revaluation and indexation rules as the old-age pension of the scheme.
   ↪  A scheme is significant when it paid at least 10 percent of public
   ↪ pension expenditure in 1995; smaller schemes are folded into the
   ↪ closest significant one and mentioned in the explanation. The table
   ↪ gives the main scheme and the other schemes to check for each country,
   ↪  **as they stood in 1995**; it is a starting point, not a closed list.

| Country | Main scheme in 1995 | Other public schemes to check |
|---|---|---|
| AT | ASVG employee pension (Bemessungsgrundlage revalued with the
   ↪ Aufwertungszahl; yearly Pensionsanpassung) | Civil-service pensions (
   ↪ Beamte, final salary, adjusted with civil-service pay), GSVG self-
   ↪ employed and BSVG farmers |
| BE | Employee pension of the salaried workers' scheme (career average,
   ↪ Royal Decree 50 of 1967 as amended) | Civil-service pensions (final-
   ↪ salary based, perequation to civil-service pay), self-employed scheme
   ↪ |
| CY | Social Insurance Scheme under the 1980 law as amended (basic part on
   ↪ insurable points, supplementary part on earnings above the basic
   ↪ ceiling) | Government employees' pension scheme |
| DE | Statutory pension insurance (SGB VI in force since 1992: points, net-
   ↪ wage revaluation and net-wage adjustment), West pension value |
   ↪ Beamtenversorgung (final salary, adjusted with civil-service pay); the
   ↪  separate East pension value and the Rentenueberleitungsgesetz
   ↪ transition |
| EE | State pension under the 1993 State Allowances Act (largely flat
   ↪ national pension plus length-of-service supplements; ad hoc increases)
   ↪  | Special pensions of public officials (small) |
| ES | General Regime contributory retirement pension under Law 26/1985 (
   ↪ base of the last eight years, CPI revaluation except the last two) |
   ↪ Clases Pasivas (civil servants), RETA self-employed |
| FI | Private-sector earnings-related pension (TEL and the sectoral acts;
   ↪ base computed employment by employment, TEL index) | Public-sector
   ↪ earnings-related pensions (VEL, KVTEL), national pension (KEL) |
| FR | General regime basic pension (CNAV) under the 1993 decree in its 1995
   ↪  phase-in position | ARRCO and AGIRC mandatory complementary points (
   ↪ purchase price and point value have their own rules), civil-service
   ↪ pensions (last six months' salary), special regimes |
| GR | Main IKA employee pension (final-period earnings, incomes-policy
   ↪ increases) | Public-sector pensions (Dimosio), OGA farmers, OAEE/TEVE
   ↪ self-employed, the auxiliary funds and the bank and public-enterprise
   ↪ funds |
| HU | Social insurance old-age pension under Act II of 1975 as amended (net
   ↪  earnings since 1988, degressive benefit brackets, net-wage indexation
   ↪  since 1992) | None separate of note |
| IT | INPS employee pension FPLD under the retributivo formula as amended
   ↪ by the 1992 Amato reform | Public-sector pensions (INPDAP, created
   ↪ 1994), self-employed funds, the substitute and exclusive funds |
| LU | General contributory scheme (career wages revalued to a fixed real
   ↪ base, cost-of-living indexation plus periodic readjustment) | Special
   ↪ transitional scheme of civil servants |
| LV | State pension under the 1990/1991 Law on State Pensions as amended,
   ↪ before the notional accounts of 1996 | None separate of note |
```

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| NL | AOW state pension only (the funded occupational pillar is out of
   ↪ scope by convention); the WKA linkage to contract wages and its
   ↪ suspension | None |
| PT | General social security regime old-age pension under Decree-Law
   ↪ 329/93 (best ten of the last fifteen years, CPI revaluation) | Caixa
   ↪ Geral de Aposentacoes (civil servants, final salary) |
| SI | ZPIZ old-age pension under the 1992 law (best consecutive ten years,
   ↪ wage valorisation, wage indexation) | None separate of note |
| SK | Old-age pension under Act 100/1988 as taken over by independent
   ↪ Slovakia (best five of the last ten years, unrevalued nominal earnings
   ↪ , degressive reduction brackets); Social Insurance Agency from 1995 |
   ↪ Armed forces and police schemes (small) |

## 3. Definitions and coding rules

Throughout, "wages" means the nominal average wage per employee of the
   ↪ economy; the reference series is compensation of employees over the
   ↪ number of employees from the national accounts, and the reference
   ↪ price series is the all-items consumer price index (for the years at
   ↪ issue, the national CPI, since the harmonized index begins in 1996).
   ↪ An index that tracks gross or net wages, the wage bill, the
   ↪ contribution base, social-tax revenue, or nominal GDP is treated as a
   ↪ wage-type index (its growth tracks wages over the long run); an index
   ↪ of consumer prices, of the cost of living, of pensioners' prices or a
   ↪ "health index" is a price-type index. Where a rule used a wage or
   ↪ price concept other than the reference series (net wages, a pensioner
   ↪ price index, wages of a sector, the minimum wage), code it as the
   ↪ corresponding type and note the difference.

**Discretion.** In 1995 a larger share of these systems adjusted pensions by
   ↪  decision rather than by formula than is true today, especially in the
   ↪  countries that had rebuilt their pension law after 1990 and in the
   ↪ countries whose adjustment was set in an annual budget or incomes-
   ↪ policy law. Code the statutory rule where one existed and was applied.
   ↪  Where the adjustment was discretionary, code the type of index the
   ↪ decision actually tracked, stated as a wage share, say so in the note,
   ↪  and grade the value C. Do not code a discretionary adjustment as zero
   ↪  merely because no formula existed: a discretionary increase that
   ↪ repeatedly matched wage growth is a wage-type adjustment for this
   ↪ purpose, and one that repeatedly matched prices is a price-type one.

### 3.1 Award-stage component, theta_a0^1995

`theta_a0^1995` is the share of wage growth that entered a new pension
   ↪ through the revaluation of the earnings on which it was computed, for
   ↪ a claimant of 1995.

| Rule for bringing past earnings to the year of award | theta_a0 |
|---|---|
| Earnings revalued with wage growth, or recorded as a fraction of the year'
   ↪ s average wage (points), or credited in a notional account at a wage-
   ↪ type rate | 1 |
| Earnings revalued with prices only, or with prices plus a fixed real
   ↪ increment (for example "cost of living plus one percent") | 0 |
```

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| Mixed index with fixed weights (for example 80 percent wages, 20 percent
   ↪ prices) | the wage weight |
| Earnings entering in nominal terms with no revaluation at all | 0 |
| Benefit computed on a final salary or on the last months' salary, with no
   ↪ revaluation because there is nothing to revalue | 1 |
| Flat-rate benefit with no earnings base, linked to the minimum wage or to
   ↪ wages | 1 |
| Flat-rate benefit linked to prices, or set in nominal amounts by decision
   ↪ | 0 for prices; for nominal amounts, the type the decisions tracked,
   ↪ graded C |

Two of these lines matter more in 1995 than they do later and are easy to
   ↪ get wrong. A benefit computed on a **final salary** is fully exposed
   ↪ to the wage at award and takes 1, and several countries still computed
   ↪  civil-service and some public-enterprise pensions that way. A base of
   ↪  **unrevalued nominal earnings** --- the rule Act 100/1988 still
   ↪ imposed in Slovakia, and a feature of several transition-country laws
   ↪ before their reforms --- takes 0, and the mean lag of the base is then
   ↪  the whole distance between the earnings years and the award.

Also record `base_years`, the number of years of earnings that entered the
   ↪ base in 1995, and `base_type`, one of whole career, last N years, best
   ↪  N years, final salary, flat rate (with `base_years` equal to 0 for
   ↪ the last two). Together they say how far the base lagged the wage at
   ↪ award, and so how exposed the award stage was to the revaluation rule:
   ↪  a whole career or the last N years lag by about (N+1)/2 years, a best
   ↪ -N base by less since the best years fall late in a career, a final-
   ↪ salary or flat-rate benefit not at all. Report the implied mean lag in
   ↪  `lag_years`.

**Early retirement.** Code the regime at the ages at which people actually
   ↪ claimed in 1995, which in several countries were well below the
   ↪ statutory age: the early-retirement and seniority routes of Italy and
   ↪ Austria, the pre-reform ages of Slovenia and Hungary, the disability
   ↪ and long-service routes that carried a large share of exits in the
   ↪ transition countries, and the special ages of arduous occupations.
   ↪ Where such a route had its own formula or revaluation, treat it as a
   ↪ regime of its own under the weighting rule below.

**Several regimes.** When the pensions awarded in 1995 were computed under
   ↪ more than one rule, because coexisting schemes had different formulas
   ↪ or because a pre-1995 reform had created transitional regimes within a
   ↪  scheme, do not pick one. Score each significant regime with the table
   ↪  above and take the average weighted by each regime's share of the
   ↪ public pension expenditure of 1995:

    theta_a0^1995 = sum over regimes k of  w_k * theta_a0(k),   sum of w_k =
   ↪  1

Weights, in order of preference:

1. the number of pensions in payment times the average pension, by regime,
   ↪ from the pension institution's statistics for the mid-1990s (the INPS
   ↪ and INPDAP yearbooks, the VDR statistics for Germany, the French SESI
```

```
   ↪ and DREES series, the Hauptverband der oesterreichischen
   ↪ Sozialversicherungstraeger handbook);
2. expenditure shares by scheme from the social protection accounts of the
   ↪ mid-1990s (Eurostat ESSPROS from 1990 for the then-members, the OECD
   ↪ Social Expenditure Database, national social budget publications) or
   ↪ the institutions' accounts, adjusted when a transition rule makes a
   ↪ regime cohort-specific;
3. claimant shares inferred from the transition rule and typical
   ↪ contribution histories.

Where a mid-1990s weight cannot be found, a later weight may be used as an
   ↪ approximation, but say so and grade it C: scheme shares moved over the
   ↪  following decades, in some countries a great deal. Regimes below the
   ↪ 10 percent threshold are folded into the closest significant regime.
   ↪ Report the regimes, their wage shares, their weights and the source of
   ↪  the weights in the explanation and in the `regimes` column of the CSV
   ↪ , and grade the weights with the same A to C scale as the estimates.

### 3.2 Payment-stage component, theta_a1^1995

For each country and each calendar year 1990 to 1996, determine the rule
   ↪ under which pensions in payment were actually raised that year and
   ↪ code the share of nominal wage growth it passed on, `omega_w`:

| Rule actually applied in the year | omega_w |
|---|---|
| Wage indexation, gross or net | 1 |
| Price indexation, in full or partial (degressive by pension size, capped)
   ↪ | 0 |
| Mixed indexation with fixed weights, "Swiss" formula included | the wage
   ↪ weight |
| "Prices plus x percent of real wage growth" | x |
| Freeze, suspension, or a statutory index not applied | 0 |
| Fixed nominal increase granted instead of indexation | 0 |
| Formula whose base is wage growth, dampened by factors that do not depend
   ↪ on wage growth | 1 |
| Conditional rule (indexation depends on GDP growth, on the system's
   ↪ balance, or similar) | code the branch that actually applied in that
   ↪ year |
| Discretionary adjustment that tracked wages | 1, graded C |
| Discretionary adjustment that tracked prices | 0, graded C |
| Discretionary adjustment that tracked neither, or a nominal amount set by
   ↪ decision | the wage share implied by what the decisions actually
   ↪ followed over 1991 to 1995, graded C |

`theta_a1^1995` is the value of `omega_w` in 1995. `theta_a1_win^1995` is
   ↪ the arithmetic mean of `omega_w` over 1991 to 1995, restricted to the
   ↪ years in which the system paid indexable pensions under a law of its
   ↪ own, with those years named in the note. When a significant scheme
   ↪ indexed its pensions in payment under a different rule from the main
   ↪ scheme (a complementary scheme whose point value followed its own rule
   ↪ , a civil-service scheme adjusted with civil-service pay), compute `
   ↪ omega_w` for each scheme and average them with the expenditure weights
   ↪  of Section 3.1, year by year, before taking the value or the mean.
```

```
    ↪ The component is an elasticity, not a level: it records how a pension
    ↪ in payment would have responded to a change in wage growth under the
    ↪ rule of the year, not how much pensions actually gained or lost on
    ↪ wages. Explicit cuts of pensions, lump sums, thirteenth-month payments
    ↪ , and targeted increases of small pensions are not indexation and
    ↪ receive no weight; note them in the explanation.

The early 1990s were a period of high inflation and fiscal strain in several
    ↪  of these countries, and adjustments were often granted more than once
    ↪  a year, sometimes with a lag or a partial catch-up, and sometimes as
    ↪ flat amounts rather than percentages. A flat amount granted to every
    ↪ pensioner is not indexation of the pension to any index and takes `
    ↪ omega_w = 0` with a note; a percentage increase takes the type of the
    ↪ index it followed.

### 3.3 The rule table behind the uprating index

The same research yields, at no extra cost, the inputs of a second object,
    ↪ the cumulative statutory uprating of pensions in payment over the
    ↪ early-to-mid 1990s. For every country and year from 1990 to 1996
    ↪ record, alongside `omega_w`:

- `omega_p`: the share of price inflation passed on (1 under a price rule,
    ↪ the price weight under a mixed rule, 0 in a freeze; under a degressive
    ↪  schedule by pension size, the pass-through averaged over pension
    ↪ bands with expenditure weights, or a stated approximation graded C
    ↪ when band data are missing);
- `fixed_nom`: a fixed nominal increase granted instead of indexation, as a
    ↪ decimal (0.0025 for 0.25 percent), otherwise 0;
- `fixed_real`: a fixed real increase granted on top of price indexation, as
    ↪  a decimal, otherwise 0;
- for Germany, the actual adjustment of the pension value (West), as a
    ↪ decimal, in `fixed_nom`, with `omega_w = omega_p = 0`, and the East
    ↪ pension value in a scheme row of its own;
- a one-line note naming the rule and its legal basis;
- where the payment-stage rule is a weighted average over schemes, one row
    ↪ per scheme with its `scheme` label and `weight`, so that the index can
    ↪  be rebuilt scheme by scheme or from the weighted parameters (Section
    ↪ 7).

Under these conventions the yearly uprating factor is `(1 + wage growth)^
    ↪ omega_w * (1 + inflation)^omega_p * (1 + fixed_nom) * (1 + fixed_real)
    ↪ `.

Timing conventions: a row describes the increase paid in that calendar year,
    ↪  whatever the month and whatever the reference period of the index it
    ↪ applies; two or more increases paid in the same year are compounded
    ↪ into one row; a catch-up payment for an earlier year's shortfall is
    ↪ recorded in the year it is paid, in `fixed_nom`, with a note. Where a
    ↪ country's pension law was replaced during the window (Slovenia in
    ↪ 1992, the Baltic laws of 1990 to 1993, the Slovak succession of 1993),
    ↪  the rows before the new law describe the predecessor regime and say
    ↪ so in the note.
```

```
### 3.4 Combination

`theta_a^1995 = 0.53 * theta_a0^1995 + 0.47 * theta_a1^1995`, and the same
   ↪ combination with `theta_a1_win^1995` gives `theta_a_win^1995`. The
   ↪ weights are given, not to be re-derived: they are the exposures of an
   ↪ aggregate pension bill to the two stages thirty years after a
   ↪ permanent growth slowdown, for one-year cohorts with a forty-year
   ↪ career and a twenty-five-year retirement (13.5 years through the
   ↪ earnings base against 12 years in payment).

## 4. Sources

Use at least two independent sources per component and country; prefer the
   ↪ legal text or the pension institution's own publication for the yearly
   ↪  application. Record every source with title, publisher, year, URL and
   ↪  access date in the source log.

Sources for the mid-1990s are thinner on the web than sources for the 2010s,
   ↪  and the comparative series that cover the period best are the older
   ↪ ones. In rough order of usefulness:

1. US Social Security Administration, *Social Security Programs Throughout
   ↪ the World*, editions 1993, 1995, 1997 and 1999. These are the single
   ↪ most reliable snapshot of the rules of the period, country by country,
   ↪  with the benefit formula, the reference period and the adjustment
   ↪ provision stated for the year of the edition. The 1995 and 1997
   ↪ editions bracket the date exactly. They are available from the SSA's
   ↪ own archive.
2. MISSOC, comparative tables on social protection, editions from 1990
   ↪ onward, table on old age and the row on the adjustment of pensions.
   ↪ The mid-1990s editions are the direct source for the rule in force in
   ↪ a given year in the then-members of the Union.
3. OECD, *Pensions at a Glance*, first edition 2005 and the 2007, 2009 and
   ↪ 2011 editions, whose country profiles describe the reforms of the
   ↪ preceding fifteen years and therefore date what changed after 1995;
   ↪ and the OECD's older reform monographs (*Reforming Public Pensions*,
   ↪ 1988; *Ageing in OECD Countries*, 1996; the *Economic Surveys* of the
   ↪ mid-1990s, whose pension chapters describe the system in force).
4. European Commission, *Social Protection in Europe* reports (1993, 1995,
   ↪ 1997) and the historical annexes of the *Ageing Report* series; the
   ↪ Economic Policy Committee's 1997 and 2001 reports on the budgetary
   ↪ implications of ageing, which describe the pre-reform systems.
5. World Bank and IMF work on the transition countries: *Averting the Old
   ↪ Age Crisis* (1994), the country studies and Staff Country Reports of
   ↪ the mid-1990s for Estonia, Latvia, Hungary, Slovakia and Slovenia,
   ↪ which document the pension laws of 1990 to 1995 and the ad hoc
   ↪ indexation practice of those years.
6. The academic literature on the pre-reform systems: the country chapters
   ↪ of Gruber and Wise, *Social Security and Retirement around the World*
   ↪ (1999) and *Social Security Programs and Retirement around the World*
   ↪ (2004), whose institutional appendices describe the rules of the 1990s
   ↪  in detail for Belgium, France, Germany, Italy, the Netherlands and
   ↪ Spain; Franco on Italy; Blanchet and Pele on France; Boersch-Supan and
   ↪  Schnabel on Germany; Boldrin, Jimenez-Martin and Peracchi on Spain;
```

```
    ↪ Palacios and Rocha on the transition countries.

National sources for the yearly application: Deutsche Rentenversicherung and
    ↪  its predecessor VDR for the history of the aktueller Rentenwert West
    ↪ and Ost and the net-wage adjustment of the 1992 law; INPS and the
    ↪ Italian budget laws for the perequazione automatica of the early 1990s
    ↪  and the 1992 Amato provisions; the Spanish Boletin Oficial del Estado
    ↪  for the annual revaluation provisions of the Ley de Presupuestos; the
    ↪  French decrees on the revalorisation of pensions and the ARRCO and
    ↪ AGIRC circulars; the Austrian Pensionsanpassung decrees and the ASVG
    ↪ Aufwertungszahlen; the Belgian health index (introduced 1994) and the
    ↪ perequation of public-sector pensions; the Dutch WKA and the years in
    ↪ which the linkage was suspended; the Luxembourg cost-of-living and
    ↪ readjustment laws; the Finnish TEL index and its split between wages
    ↪ and prices, and the separate index for pensioners aged 65 and over
    ↪ introduced in 1996; the Hungarian pension increase acts and the net-
    ↪ wage indexation introduced in 1992; the Slovenian ZPIZ 1992 wage
    ↪ indexation; the Slovak government valorisation decrees under Act
    ↪ 100/1988; the Latvian and Estonian pension increase decisions of 1991
    ↪ to 1995; the Greek incomes-policy pension increases; the Cypriot
    ↪ Social Insurance Services annual increases; the Portuguese annual
    ↪ updating portarias.

## 5. Procedure

1. **Schemes.** For each country, establish which schemes passed the 10
    ↪ percent criterion in 1995, and for each of them state the law in force
    ↪  in 1995 and the date of the last reform that had changed its formula
    ↪ or its indexation before that date. Identify the transitional regimes
    ↪ created by pre-1995 reforms and their phase-in position in 1995.
2. **Award stage.** Establish, for a claimant of 1995, how past earnings
    ↪ were brought to the year of award, the length of the earnings base and
    ↪ , where relevant, the accrual formula; code `theta_a0^1995`, `
    ↪ base_type`, `base_years` and `lag_years` with the table of Section
    ↪ 3.1. Write the explanation (Section 6).
3. **Payment stage, rule table.** For each year 1990 to 1996 fill the row of
    ↪  Section 3.3, from the statutory rule and from what was actually
    ↪ granted that year (freezes, suspensions, flat amounts, multiple
    ↪ increases, one-off measures).
4. **Payment stage, components.** Take `theta_a1^1995` from the 1995 row and
    ↪  compute `theta_a1_win^1995` as the mean of `omega_w` over the
    ↪ available years of 1991 to 1995, naming those years.
5. **Combination.** Compute `theta_a^1995` and `theta_a_win^1995` with the
    ↪ weights of Section 3.4 and round to two decimals in the table, keeping
    ↪  four decimals in the CSV.
6. **Explanations.** One paragraph per country and stage (Section 6).
7. **Checks.** A pure wage-indexed system has both components at one, a pure
    ↪  price-indexed system both at zero. Four checks are specific to this
    ↪ date and each failure needs a source that confirms it rather than a
    ↪ shrug. (a) A country whose award formula in 1995 was a **final salary
    ↪ ** must not carry an award value below one for that regime. (b) A
    ↪ country whose earnings base entered in **nominal unrevalued** terms
    ↪ must carry an award value of zero for that regime and a long lag. (c)
    ↪ The **transition countries** must show the discontinuity of their own
```

```
    ↪ pension laws inside the 1991 to 1995 window, and a window mean
    ↪ computed over years in which no such law existed is an error, not an
    ↪ approximation. (d) The values must differ from the rules of the 2010s
    ↪ wherever a post-1995 reform changed the rule, and a country whose 1995
    ↪  value equals its 2010s value needs a positive statement that no
    ↪ relevant reform intervened. Grade each estimate A (statutory text
    ↪ found and yearly application confirmed), B (rule confirmed, yearly
    ↪ application partly inferred), C (approximation from secondary sources
    ↪ or a discretionary practice read from outcomes).

## 6. Explanation paragraphs

For each country, one paragraph for the award stage and one for the payment
    ↪ stage, 60 to 150 words each, in plain prose, containing: the rule in
    ↪ force in 1995 (what is indexed to what, with weights), its legal basis
    ↪  and dates, the phase-in position of any pre-1995 reform, the
    ↪ exceptional years within the 1991 to 1995 window, and the last
    ↪ sentence stating the number and how it follows from the rule ("wage
    ↪ indexation in 1995, and in four of the five years 1991 to 1995:
    ↪ theta_a1 = 1, window 0.8"). Each award paragraph must also name the
    ↪ first post-1995 reform that changed the rule, in one clause, so that a
    ↪  reader can see what the snapshot deliberately excludes. No project-
    ↪ specific vocabulary; a reader with no access to anything else must be
    ↪ able to follow.

## 7. Deliverables and formats

- `pension_theta_1995.csv`, one row per country, header exactly `country,
    ↪ theta_val,theta_pay,theta_pay_window,window_years,base_years,base_type
    ↪ ,lag_years,regimes,confidence_val,confidence_pay,note`, where `
    ↪ theta_val` is `theta_a0^1995`, `theta_pay` is `theta_a1^1995`, `
    ↪ theta_pay_window` is `theta_a1_win^1995`, `window_years` the years
    ↪ actually averaged (for example `1991-1995` or `1993-1995`), `base_type
    ↪ ` one of `whole career`, `last N`, `best N`, `final salary`, `flat`, `
    ↪ regimes` the list of regimes entering the averages with their wage
    ↪ shares and weights (for example `FPLD retributivo 0 w0.62; INPDAP
    ↪ final salary 1 w0.24; self-employed 0 w0.14`), the confidence grades A
    ↪  to C, and the note one line per country.
- `pension_uprating_rules_1995.csv`, one row per country, scheme and year
    ↪ 1990 to 1996, header exactly `country,scheme,weight,year,omega_w,
    ↪ omega_p,fixed_nom,fixed_real,note`, with `scheme` equal to `main` and
    ↪ `weight` equal to 1 where a single scheme is coded.
- `pension_uprating_rules_country_1995.csv`, the same table collapsed to one
    ↪  row per country and year with the expenditure-weighted `omega_w`, `
    ↪ omega_p`, `fixed_nom` and `fixed_real`, header exactly `country,year,
    ↪ omega_w,omega_p,fixed_nom,fixed_real,note`.
- `pension_theta_1995_pipeline.csv`, the parameters in the column order the
    ↪ project's estimation code already reads, header exactly `country,
    ↪ theta_pay,theta_val,lag_years,years_in_payment,exposure_years,exposure
    ↪ ,theta,note`, with `years_in_payment` equal to 13.5, `exposure_years`
    ↪ equal to `lag_years * (1 - theta_val) + years_in_payment * (1 -
    ↪ theta_pay)`, `exposure` equal to `exposure_years / years_in_payment`,
    ↪ and `theta` equal to `theta_pay`, following the convention of the file
    ↪  it mirrors.
```

```
- 'theta_1995_explanations.md', the paragraphs of Section 6, grouped by
    ↪ stage, countries in alphabetical order of their English names.
- 'theta_1995_sources.md', the source log, with the open questions and the
    ↪ points on which the sources disagree.
- 'SUMMARY.md', a short reader's guide: the table of the parameters by
    ↪ country with grades, the countries whose weights had to be
    ↪ approximated, the open questions, and the checks of Section 5.7 with
    ↪ their outcomes.
```