A TOOL TO COMPUTE THE EFFECTS OF POPULATION AGING ON ECONOMIC GROWTH.

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MOTIVATION AND PURPOSE

Population aging is one of the most consequential demographic transformations of the twenty-first century. It is driven by the combination of declining fertility and increasing longevity and is unprecedented in both its scale and speed. Nearly all countries are projected to experience a rising share of older individuals in their populations over the coming decades (D. Bloom & Luca, 2016). This demographic shift is expected to generate significant macroeconomic and social effects, including downward pressure on economic growth.

This note introduces a structured framework and an accompanying tool to assess the impact of population aging on economic growth through changes in the size and age composition of the workforce. Consistent with the economic literature, the framework focuses on two primary channels linking demographic change to growth outcomes. Other potential channels; such as changes in savings behavior, are excluded, as empirical evidence suggests that their contribution to the growth effects of population aging is limited and highly context-dependent (H.H. Lee & Shin, 2021; Maestas et al., 2016).

1. **Impact through the relative size of the workforce**. As populations age, the proportion of individuals in age groups with high labor force participation declines. In the absence of offsetting adjustments in participation rates or employment behavior, this leads to a reduction in the number of workers relative to the total

population. This contraction in effective labor supply mechanically lowers output per capita (Amaglobeli & Shi, 2016; D. E. Bloom & Williamson, 1998).

2. **Impact through productivity**. Population aging also reshapes the age distribution within the workforce. An increase in the share of older workers may affect total factor productivity (TFP) growth through age-related changes in health, cognitive flexibility, adaptability to new technologies, entrepreneurial activity, and the accumulation and depreciation of human capital (Börsch-Supan & Weiss, 2023; Feyrer, 2007; Radelet et al., 1997).

Our framework also incorporates capital deepening as a potential mitigating mechanism. As population aging reduces the size of the workforce, and holding savings behavior constant, the capital–labor ratio increases. This rise in capital intensity tends to boost output per worker, thereby partially offsetting the negative impact of a shrinking labor force on output per capita.

Throughout this note, we treat the first channel; the impact operating through the relative size of the workforce, as the baseline, and consider the productivity channel as a pessimistic scenario in which population aging also reduces TFP growth. Demographic dynamics are relatively predictable over medium- to long-term horizons, as workforce size is largely determined by past fertility trends embedded in the population's age structure, rendering changes in the working-age population effectively predetermined (R. Lee, 2011). As a result, the labor supply channel is relatively certain, mechanical, and well identified. By contrast, the impact of aging on productivity remains more uncertain, with mixed empirical evidence, and is therefore treated as a downside scenario rather than part of the baseline (Börsch-Supan & Weiss, 2023).

This tool should be viewed as a first-order approximation to the impact of population aging on economic growth. It isolates a small set of transparent demographic and macroeconomic channels and applies them in a stylized, growth-accounting framework. While this makes the results easy to interpret and compare across countries, it also implies important limitations that should be borne in mind when interpreting the estimates (see the Limitations Section).

ANALYTICAL FRAMEWORK

This tool quantifies the contribution of demographics to growth in GDP per capita across countries and over time. The approach Is based on growth accounting. The analytical foundation is the Solow–Swan growth model expressed through a Cobb-Douglass function, which separates GDP growth into the contributions from capital (K^{α}) and labor ($L^{1-\alpha}$), and total factor productivity (A) (Jones & Vollrath, 2024; Solow, 1956).

$$Y = AK^{\alpha}L^{1-\alpha} \qquad \text{(eq 1.)}$$

We apply a series of transformations to Equation 1 in order to isolate demographic effects on growth:

- Divide by total population (N) to obtain GDP per capita;
- Multiply and divide by the working-age population on the right-hand side (W) to introduce the support ratio explicitly;
- Apply a log-linear growth decomposition to express contributions in growth-rate terms.

$$g_{Y/N} = gA + \alpha g_{K/L} + g_{W/N} + g_{L/W} \qquad \text{(eq. 2)}$$

Where g_x denote the log-growth rate of any variable x.

The contribution from productivity (gA) can be decomposed to separate the effects of demographics on productivity growth ($gAdem$) from all other factors affecting productivity growth ($gAother$).

Specifically:

$$gA = gAdem + gAother \quad \text{(eq. 3)}$$

Introducing eq. 3 and reordering terms we obtain

$$g_{Y/N} = g_{W/N} + g_{L/W} + \alpha g_{K/L} + gAdem + gAother \quad \text{(eq. 4)}$$

Equation 4 decomposes growth in GDP per capita into the following elements:

- $g_{W/N}$, which captures the impact of aging through changes in the relative size of the working age population.
- $g_{L/W}$, which captures changes in labor participation and or employment.
- $\alpha g_{K/L}$, which captures capital deepening, i.e., changes in the ratio of capital per worker.
- $gAdem$, which captures changes in growth in productivity due to changes in demographics.
- $gAother$, which captures changes in growth in productivity unrelated to demographics.

COMPUTING THE CONTRIBUTIONS OF DEMOGRAPHICS TO GROWTH

Our computations for the impact on growth are done by comparing a scenario where population aging takes place ($g^{A}_{Y/N}$) with a theoretical scenario where the age-composition of the population remains constant across time, i.e., population aging does not take place ($g^{NA}_{Y/N}$). Specifically, the effect of aging on growth per capita is measured as:

$$\Delta g_{Y/N} = g^{NA}_{Y/N} - g^{A}_{Y/N} \quad \text{(eq. 5)}$$

We are interested in measuring the contribution of those factors directly affected by demographics: $g_{W/N}$, $gAdem$, $\alpha g_{K/L}$. The share of TFP explained by factors other than demographics ($gAother$) and the growth rate of capital (K) are assumed to be the same under both scenarios.[1]

Extending equation 5 to the three factors affected by demographics, we obtain:

Contribution through the relative size of the workforce

$$\Delta g_{W/N} = g^{NA}_{W/N} - g^{A}_{W/N} = -g^{A}_{W/N} \quad \text{(eq. 6)}$$

Contribution through productivity

$$\Delta gAdem = gAdem^{NA} - gAdem^{A} = -gAdem^{A} \quad \text{(eq. 7)}$$

Contribution through capital deepening[2]

$$\Delta(\alpha g_{K/L}) = \alpha(g^{NA}_{K/L} - g^{A}_{K/L}) = \alpha({g_{W/N}}^{A}) \quad \text{(eq. 8)}$$

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[1] While capital accumulation is in principle endogenous to demographics, since demographic shifts affect growth, saving behavior, and thus the evolution of the capital stock, this note assumes the same growth rate of K across the baseline and counterfactual scenarios. This is a conservative assumption: if adverse demographics also depress capital formation, the true impact of demographic change on capital deepening and output growth would be larger than the estimates reported here. Hence, the estimates presented here should be treated as conservative in this regard.

[2] See detailed steps described in Annex 1.

Data and other computation assumptions

Penn World Table (PWT) data are used to construct all variables for the historical period, with the exception of the decomposition of gA (Feenstra et al., 2015). The PWT series ends in 2019. Beyond this point, population variables are projected forward by indexing them to the United Nations World Population Prospects projections (UN, 2024).

Over the projection horizon, the labor force (L) is assumed to remain constant as a share of the working-age population (W), implying no projected changes in labor force participation or employment rates. K is assumed to grow at the same rates under both, aging and non-aging scenarios. This is a conservative assumption, capital would likely grow slower in an aging scenario, reducing the positive effect of capital deepening on growth in a population aging context.

The impact of aging on growth through productivity ($gDem$) is derived from the empirical estimates of Guénette and Shao (2025), who quantify how changes in the age structure of the working-age population influence economic growth. Their analysis, building on the approach of Feyrer (2007), shows that productivity varies systematically by age group, with middle-aged workers (40–49) contributing the most to total factor productivity. Using cross-country and time-series data, they estimate how shifts in the shares of each age group affect trend productivity growth.

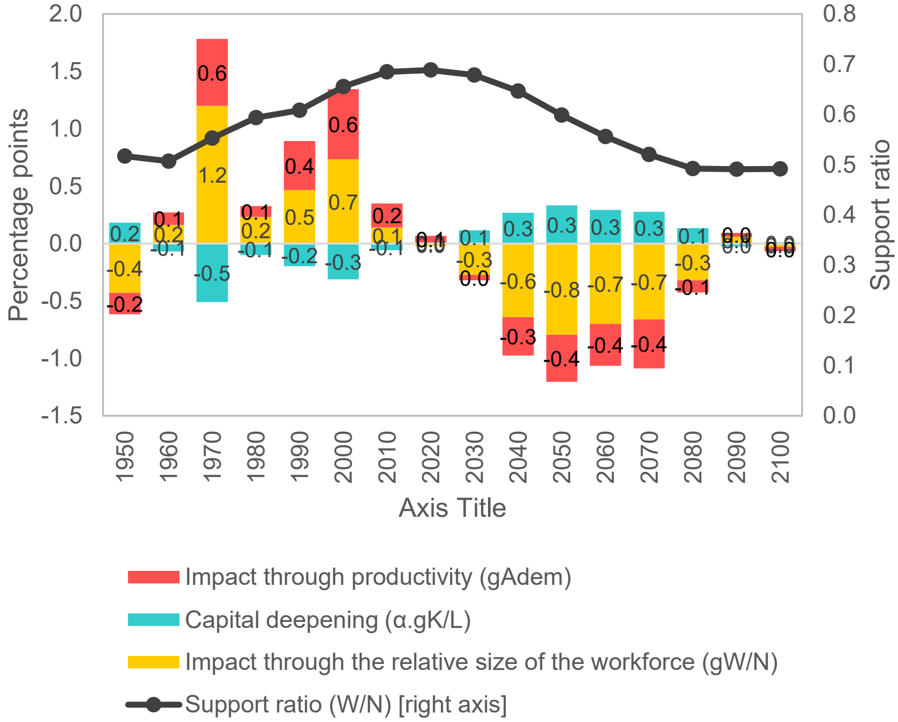
The coefficients estimated by Guénette & Shao (2025) capture the marginal productivity contribution of each cohort. We use their results to compute $gDem$ by weighting projected changes in the age distribution (based on UN population data) with the age-specific productivity elasticities identified in the paper.

RESULTS AVAILABLE THROUGH THE TOOL

Figure 1 illustrates the type of outputs generated by the tool, using Costa Rica as an example. The bars report, by decade, the average contribution of three factors to GDP per capita growth. The line shows the evolution of the support ratio (W/N). In the 1970s, for instance, Costa Rica benefited from strong demographic tailwinds: the contribution of the size of the workforce reached about 1.2 percentage points per year, while the demographic contribution to productivity added roughly 0.6 percentage points. As the support ratio rises and then peaks around the 2020s, the demographic tailwinds disappear. In subsequent decades, these contributions turn negative, indicating that demographics become a headwind to growth. Capital deepening partly offsets, but does not fully neutralize, the projected drag from aging.

Based on the discussion presented in the motivation of this note, we propose interpreting the contribution through the relative size of the workforce as a reference scenario for the future impact of aging on growth, whereas the additional contribution through productivity should be viewed as a pessimistic scenario in which demographic change is also assumed to depress TFP growth.

Figure 1. Results for Costa Rica: average contribution to growth in GDP per capita from factors affected by demographics and average support ratio, by decade.



Source: Author’s calculations.

LIMITATIONS

This tool should be viewed as a first-order approximation to the impact of population aging on economic growth. It is best suited to indicate the likely direction and approximate magnitude of the impact of aging on growth, and to compare the relative importance of different channels across countries, rather than to provide precise point estimates.

The tool isolates a small set of transparent demographic and macroeconomic channels and applies them in a stylized, growth-accounting framework. While this makes the results easy to interpret and compare across countries, it also implies important limitations that should be borne in mind when interpreting the estimates:

- **It abstracts from behavioral responses on the labor side, especially labor-force participation**, which may increase in response to aging and thereby mitigate some of the negative effects on growth. This is intentional, as the objective is to isolate the mechanical impact of demographic change under current participation patterns and to provide a transparent benchmark. In practice, policy reforms and individual responses could raise participation among older workers and women, thereby attenuating the growth effects reported here.
- **It relies on a simple Cobb–Douglas production function with constant factor shares**, which may not capture changes in technology, sectoral structure, or the elasticity of substitution between capital and labor.

- **The demographic impact on productivity is modeled in reduced form** and, in the pessimistic scenario, assumes that aging depresses TFP growth; this is a strong assumption and does not reflect the full range of empirical uncertainty.
- **The analysis is conducted at an aggregate level and does not capture differences across sectors**, regions, or types of workers, nor does it model policy responses (for example, pension or labor-market reforms) that may themselves be triggered by aging.
- **Importantly. the tool is based on a structural, model-driven decomposition rather than an econometric estimation strategy**. It imposes a specific production structure and demographic channels and uses data to quantify them, rather than statistically identifying the causal effect of aging on growth from historical variation. As a result, the estimates are sensitive to the modeling assumptions and should be interpreted as scenario-based projections, not as econometrically identified causal effects.

ANNEX 1. THE EFFECT OF CAPITAL DEEPENING UNDER EXOGENOUS AND ENDOGENOUS ASSUMPTIONS FOR CAPITAL GROWTH

This annex shows that relaxing the assumption of exogenous capital accumulation (allowing saving and investment to respond to slower growth) reduces the buffering effect of capital deepening; thus, the baseline results in the main text should be interpreted as conservative in this regard.

We start with a decomposition of GDP per capita growth shown in equation 2.

$$g_{Y/N} = gA + \alpha g_{K/L} + g_{W/N} + g_{L/W}$$

The effect of aging is measured by comparing growth in GDP per capita ($g_{Y/N}$) in a scenario without aging vs a scenario with aging.

1) **Scenario 1 Aging (A)**: The working-age share declines, so ${g_{W/N}}^{A} < 0$.
2) **Scenario 2 No Aging (NA)**: The working-age share is constant, so ${g_{W/N}}^{NA} = 0$.

Common assumptions across scenarios

- Employment and labor participation rates are constant across scenarios:
  ${g_{L/W}}^{A} = {g_{L/W}}^{NA} = 0$; this assumption entails g_L=g_W

- Population grows at the same rate in both scenarios:
  ${g_N}^{A} = {g_N}^{NA} = g_N$

- To simplify the comparison, we also assume that TFP growth (gA) is identical in both scenarios.

<u>**Comparing non-aging to aging with the same growth rate for K**</u>

Capital growth is exogenous and the same in both scenarios: ${g_K}^{A} = {g_K}^{NA}$.

Capital deepening:

Capital deepening with No Aging minus capital with Aging:

$$\alpha\Delta g_{K/L} = \alpha({g_{K/L}}^{NA} - {g_{K/L}}^{A}) = \alpha({g_K}^{NA} - {g_K}^{A}) - \alpha({g_L}^{NA} - {g_L}^{A})$$

Because ${g_K}^{A} = {g_K}^{NA}$, we get

$$\Delta g_{K/L} = \alpha(-{g_L}^{NA} + {g_L}^{A})$$

As g_L=g_W, we can transform this equation into

$$\Delta g_{K/L} = -{g_L}^{NA} + {g_L}^{A} = -{g_W}^{NA} + {g_W}^{A} + (g_N - g_N) = -{g_{W/N}}^{NA} + {g_{W/N}}^{A} = 0 + {g_{W/N}}^{A}$$

$$\boldsymbol{\alpha\Delta g_{K/L} = \alpha {g_{W/N}}^{A}} \qquad \textbf{(eq. A1)}$$

GDP per capita:

$$\Delta g_{Y/N} = \alpha \cdot \Delta g_{K/L} + \Delta g_{W/N}$$

$-{g_{W/N}}^{NA} = 0$, thus

$$\boldsymbol{\Delta g_{Y/N} = \alpha {g_{W/N}}^{A} - {g_{W/N}}^{A} = (\alpha - 1){g_{W/N}}^{A}} \qquad \textbf{(eq. A2)}$$

Remember that, for an aging country, ${g_{W/N}}^{A}$ is negative. Thus, the growth differential between scenarios NA and A is positive, i.e., countries grow faster in absence of aging.

When capital growth is the same under both scenarios, capital deepening partially offsets the effect of aging on growth per capita but only by a fraction determined by α. The net differential is given by $\boldsymbol{(\alpha - 1){g_{W/N}}^{A}}$

<u>Comparing non aging to aging with different paths for K</u>

Now we assume that capital accumulation responds positively to growth. Since output grows faster in the no-aging scenario, capital growth is higher there: ${g_K}^{NA} > {g_K}^{NA}$.

Capital deepening:

$$\alpha\Delta g_K = \alpha({g_K}^{NA} - {g_K}^{A}) + \alpha({g_L}^{NA} - {g_L}^{A})$$

$$\boldsymbol{\alpha\Delta g_{K/L} = \alpha({g_K}^{NA} - {g_K}^{A}) + \alpha {g_{W/N}}^{A}} \qquad \textbf{(eq. A3)}$$

Compare to eq A1. The only difference is the term $\alpha({g_K}^{NA} - {g_K}^{A})$, which can be assumed to be negative due to weaker investment when aging reduces output growth. Thus, capital deepening is smaller when K is allowed to respond to $g_{Y/N}$.

GDP per capita:

$$\Delta g_{Y/N} = \alpha\Delta g_{K/L} + \Delta g_{W/N}$$

Replacing capital deepening with eq 3 and because ${g_{W/N}}^{NA} = 0$:

$$\boldsymbol{\Delta g_{Y/N} = \alpha({g_K}^{NA} - {g_K}^{A}) + \alpha {g_{W/N}}^{A} - {g_{W/N}}^{A}} \qquad \textbf{(eq. 4)}$$

Compare eq A4 with eq A2. $\alpha({g_K}^{NA} - {g_K}^{A})$ is negative, thus compared with the fixed-K case, the growth gap is larger.

Table 4. Scenario comparison

Channel	Fixed K	Endogenous K (linked to gY)
Support ratio $\Delta g_{W/N}$	**Negative effect:** $-{g_{W/N}}^{A}$	**Same negative effect:** $-{g_{W/N}}^{A}$
Capital deepening $\alpha \Delta g_{K/L}$	**Positive effect mediated by α:** $\alpha {g_{W/N}}^{A}$	**Lower positive effect due to lower capital accumulation:** $\alpha({g_K}^{NA} - {g_K}^{A}) + \alpha {g_{W/N}}^{A}$

Source: Author own work.

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