# Aging and Productivity Growth

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## Introduction

The global demographic landscape is undergoing a profound transformation as populations age at an unprecedented rate. This demographic shift has profound implications for various facets of human society. As the world's population becomes older, understanding the mechanisms through which it influences productivity, and therefore economic growth, the becomes increasingly vital for policymakers, economists, and society as a whole.

Aging demographics are not confined to a single region or nation; rather, they constitute a global phenomenon. Fertility rates, the number of children expected per woman, initially dropped below the maintenance rate (zero population growth) in the Western World. Latin America, Eastern and Southern Asia have since followed suit. High fertility rates persist in Africa and the Middle East, albeit in decline. (See Figure 1)

Low fertility rates, in conjunction with advancements in health care, have in turn dramatically risen the share of elderly citizens, This shift poses multifaceted challenges, including those related to labor markets, social welfare systems, and productivity. The interplay of these elements raises significant questions about the sustainability of economic growth in the long term.

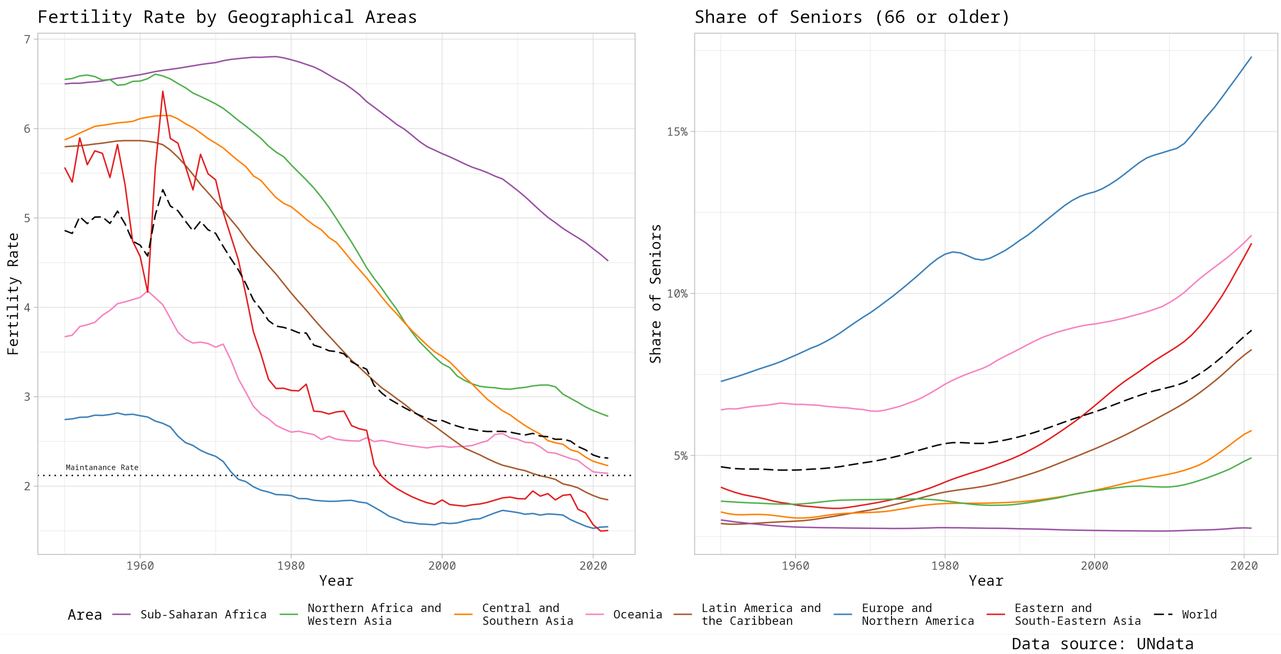


Figure 1: Demographic Trend

This study aims to understand the possible effect that this aging process may have on productivity growth and therefore general economic growth. I show that a decline in Total Factor Productivity (TFP) growth is correlated with higher share of elderly population and by using Micro Data on Innovation from the PINTEC survey in Brazil I am able to show that firms that employ younger employees are more capable on innovation.

The idea that demographic aging will impact economic growth, often called Secular Stagnation, is an old one, being first popularized by economist Alvin Hansen in his (1939), and that is frequently brought to the front of economic discourse in times of slow economic growth. The idea has, indeed, been rekindled recently in works such as (Gordon 2016).

The impact of aging on productivity, in particular, is a matter of some debate: Feyrer (2007) uses data from the International Labour Organization (ILO) and Penn World Table (PWT) to present evidence that higher productivity is correlated with higher share of the population in the 40's age group. Skirbekk (2008) uses data from the US Department of Labor to estimate that a worker general productivity peaks at its 40's. However, Acemoglu and Restrepro (2017) using newer PWT data fail to see a strong correlation between productivity growth and aging, arguing that the demographics transition creates incentives for technological investment in Automation which is able to offset any other negative productivity effects, an idea that is further developed in (Acemoglu and Restrepo 2022).

**Question Acemoglu results?**

The second section of my paper focus on innovation survey, the literature on innovation's structural models using micro data is still a growing one. Akcigit, Hanley and Stantcheva (2022) use a mechanism design approach to solve for the optimal design of innovation policy using a quality-ladder model with asymmetric information on firm types. Akcigit and Kerr (2018) applies a similar model do US Census of Manufacturing data, Akcigit, Hanley and Serrano-Velarde (2021) applies a similar model to French Data. Utilization of the Brazilian Innovation Survey is rare, but an example of it utilization can be found at the work of Bastos and Britto (Bastos and Britto 2017) where it is presented evidence that cooperation between firms and universities improves innovation.

In the next section I present evidence from macroeconomic trends, in section 3 I present the data used on the remainder of the paper, section 4 discuss the model used, section 5 presents the results and the last section summaries the conclusion.

# Evidence from Macroeconomic Data

To motivate this analysis, I start by looking for evidence in the macroeconomic data provided by Penn World Table version 10, PWT has collected data from the national accounts of most of the countries in the world for some decades now [1]. This is used in conjunction with national demographic data provided by UN Data[2].

## Measuring Productivity

Total Factor Productivity, henceforth called TFP or simply productivity, is not directly observed and has to be calculated as a residual, there is an available variable for productivity PWT, however, in that data set productivity is measured as a cross section comparison variable where the US productivity is set to one and all countries are compared to it, which is not ideal for case.

Being a residual the TFP is dependent on the assumption made for the production function, an important assumption for our purposes is the how to define the factor elasticity, two different but commonly used methods in the literature is to set capital elasticity to be 0.3 [3], or to use share of labor income to estimate labor elasticity. Also, to show that the results is not a simple consequence of the assumptions made to calculate the TFP I also run the model against growth of GDP per capita.

The choice of method have implications for our results, as societies age there are incentives to transition from a labor intensive production technology to a more capital intensive one, and indeed according to

[1] (Feenstra, Inklaar, and Timmer 2015) provides a comprehensive description of the dataset

[2] See: (United Nations and Social Affairs 2022)

[3] See: (Hall and Jones 1996)

PWT data, labor income share for Japan have fallen from 62% 1960 to 56% in 2019, a trend that was followed by many other countries.

The exact procedures to calculate these productivity variables are detailed in the annexes.

### Measuring Aging

To measure aging I calculate the share of population in three different groups:

1. Those who are younger than 35 (Young Population)
2. Those between 35 and 64 (Mature Population)
3. Those to are older than 65 (Old Population)

The cutoff at 65 is chosen due to it been a common retirement age world world, the cutoff at 35 is used because there evidence from productivity literature suggest that labor productivity peaks around age 40 [4], by using this cutoff we are able to control for the effects that having a population that is too young may have on productivity. This structure also have the benefit to better dialogue with the results in the next section. Finally, for robustness we also run our models using average population age.

### Model

We run the following Fixed Effects Regression:

$$TFP_i^t = \beta_0 + \mu_i + \nu_t + \beta_1 Demographics_i^t + \epsilon_i^t \tag{1}$$

where $TFP$ and $Demographics$ are as previously discussed. $\mu_i$ and $nu_t$ are country-specific and time-specific fixed effects, $\epsilon_i^t$ are the residuals and $\beta$ are the coefficient of interest.

Random effects models were considered for both country and time specific effects but ultimately rejected for presenting worse scores in Akaike and Bayes Information Criteria, and in the case of country specific effects for not being able to fit the data well, that is, it fails Hausman's consistency test when compared to the fixed effect model.

To mitigate the problem of serial correlation, the available date is aggregated in 5 years long time chunks, instead of the usual 1 year long time chunk used in the ordinary data set. This, however, does not meaningfully affects the results.

### Results

Table 1 presenting the results, showing a clear and strong correlation independent of the metric used. Interestingly there is no significant different between the model that allow labor elasticity to decrease as labor share decrease and the model with fixed elasticity, presenting some evidence that the Automation effect generating by an aging population is not strong enough to overcome the effect aging have on productivity.

The results are in line with some of the literature, such as Feyrer (2007), but disagrees sharply with the one recently found in (Acemoglu and Restrepo 2017), in that work the difference between (log) GDP per capita in 2015 and the one in 1990 is regressed against the degree of aging observed in the same period, resulting in a positive correlation that is robust to a series of controls and alternative specifications.

[4] For example, see: (Skirbekk 2008)

Table 1:

| | TFP Growth Rate | | | | |
|---|---|---|---|---|---|
| | Fixed Elasticity | | Variable Elasticity | | GDP Per Capita |
| | (1) | (2) | (3) | (4) | (5) |
| Average Age | $-0.008^{***}$ | | $-0.008^{***}$ | | |
| | (0.002) | | (0.002) | | |
| Young Population Share | | 0.032 | | 0.148 | 0.016 |
| | | (0.122) | | (0.120) | (0.151) |
| Old Population Share | | $-0.817^{***}$ | | $-0.648^{***}$ | $-1.099^{***}$ |
| | | (0.248) | | (0.245) | (0.312) |
| Observations | 1,145 | 1,145 | 1,145 | 1,145 | 1,723 |
| $R^2$ | 0.375 | 0.379 | 0.368 | 0.370 | 0.315 |
| *Note:* | | | | | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

I believe the discrepancy in our results are coming from the fact that many of underlining mechanisms driving the current trend of demographic aging, such a greater societal focus on work in prejudice of families (specially among women) and the transition of population from rural to urban spaces (specially in developing countries), are also driving higher economic growth in the present. Therefore, this is the effect that Acemoglu's models are likely capturing, the fact that countries with higher degrees of aging also have institutions that are more conducive to GDP per capita growth.

**Other Robustness tests ?**

By using a fixed effects model on a longer panel, therefore controlling for country specific effects, I believe we are better controlling for these effects and seeing the true effect aging is having on productivity. However, to establish that is indeed the case we turn to innovation micro data.

## Innovation

The theory is as society age innovation drive decreases, evidence from psychological studies [5] points to a decrease in the "openness to experience" as people age, as people as less inclined to purse newer experience and as society is increasingly concern with the worries of the retired, the investment and the drive to innovate decreases.

[5] See: (Schwaba et al. 2018)

## Data

## Model

## Results

## Appendix

$$Y = A(aK^{\rho}+(1-a)L^{\rho})^{1/\rho} \ln(Y) \approx \ln(A)+a\ln(K)+(1-a)\ln(L)-\frac{\rho a(1-a)}{2}(\ln(K)-\ln(L))^2 Y_t = r_t(K_t, L_t) \tag{2}$$

$$\Delta TFP_t^1 = \frac{r_t(K_t, L_t)}{r_{t-1}(K_t, L_t)} \tag{3}$$

$$\Delta TFP_t^2 = \frac{r_t(K_{t-1}, L_{t-1})}{r_{t-1}(K_{t-1}, L_{t-1})} \tag{4}$$

$$\begin{aligned}\ln(\Delta TFP_t) &= \ln((\Delta TFP_t^1 \Delta TFP_t^2)^{\frac{1}{2}}) \\ &= \frac{1}{2}(\ln(r_t(K_t, L_t)) + \ln(r_t(K_{t-1}, L_{t-1}))- \\ &\quad \ln(r_{t-1}(K_t, L_t)) - \ln(r_{t-1}(K_{t-1}, L_{t-1}))) \\ &\dots\end{aligned}$$

$$\ln\left(\frac{Y_t}{Y_{t-1}}\right) - \frac{1}{2}\left[\frac{\omega_t + \omega_{t-1}}{2}\ln\left(\frac{L_t}{L_{t-1}}\right) + (1 - \frac{\omega_t + \omega_{t-1}}{2})\ln\left(\frac{K_t}{K_{t-1}}\right)\right] \tag{5}$$

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