The Impact of OECD Population Aging on Productivity and Economic Growth

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Population aging is expected to slow economic growth. A recent paper by Maestas et al. (2023) finds that a 10% increase in the US population share of individuals aged 60+ decreases GDP per capita by 5.5%, and attributes approximately two-thirds of this decline to a slower growth in labor productivity, using the variation in the predetermined component of aging. I expand this research to all OECD nations, using a similar identification strategy. I find that a 10% increase in share of a nation's population aged 60+ decreases labor productivity per worker by 4.95 percentage points and decreases total factor productivity growth by 0.717 percentage points. Additionally, these results are stronger for earlier members of the OECD, indicating that older nations are at greater risk of economic stagnation due to these demographic shifts.

Introduction

Since the Great Recession, productivity growth has, on average, declined in the US and other OECD Countries (1). A decline in productivity growth is disastrous for long-run growth. Both major theories of long-run growth, Solow's Exogenous Growth Model and Romer's Endogenous Growth Model, place an emphasis on productivity (2-3). Lower productivity results in economic stagnation, as greater input is necessary to achieve the same output. In the long-run, stagnating productivity growth means that future generations must work more to achieve a higher standard of living. There are several possible explanations for this decline, including capital deepening, a deceleration in the rate of technological progress, misallocation of resources through the rise of zombie firms, and major demographic shifts: the last of which being the focus of this paper (4-6).

It is no secret that populations in OECD[1] countries are getting older. Birth and death rates are declining, to a point where the dependency ratio – the ratio of working age to non-working age population in a nation – places a strain on the economy. In 2024, the OECD sat far below the replacement rate of 2.1, averaging a Total Fertility Rate (TFR) of 1.56. The situation is especially dire in nations like the Republic of Korea (TFR of 0.77) and Italy (TFR of 1.24) (7). This demographic shift places further strain on dependency ratios, which in turn impact GDP. Economists also theorize that as workers get older, common 'old age' symptoms arise, including greater difficulty to perform physical tasks or mental deterioration. Additionally, a greater retirement rate results in the "depreciation of knowledge," or the loss of job-related skills that workers develop through years of experience (8).

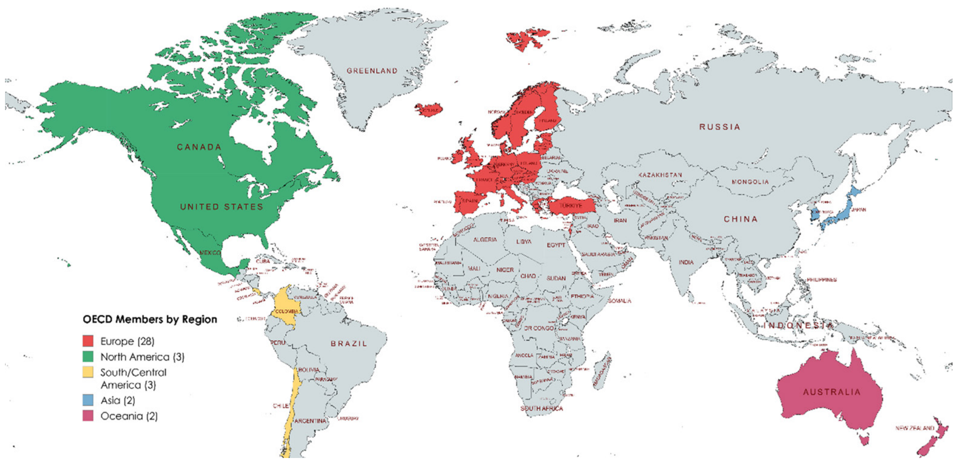

Figure 1: ***Organization of OECD Countries by Region.*** *OECD nations are separated into five main geographic regions: Europe, North America, South America, Asia and Oceania. Israel was placed into Europe, as it is the only member of the OECD in the Middle East and is geographically and economically closest to Europe. Europe has 28 members, North America has three members, South & Central America has three members, Asia has two members, and Oceania has two members (23).*

1) The Organization for Economic Co-Operation and Development (OECD) is an international organization founded in 1961 with the purpose of stimulating economic progress and world trade. Membership in the OECD is typically the standard in determining whether a country is considered "developed." (23)

A recent paper by Maestas et al. (9) investigates the way in which population aging affects economic growth, specifically through the productivity channel. The authors use state-level data and the variation in pre-determined demographic shifts as an instrumental variable for actual state-level demographic shifts. The paper estimated that a 10 percent increase in the proportion of the population aged 60+ causes a 5.5 percent decrease in growth through the productivity mechanism, thus corroborating the idea that an older workforce is less productive.

The scope of these findings is limited to the United States. Since the United States is not alone in this predicament, the question then arises: is the trend observed by Maestas et al. (2023) present across all developed countries? I extend the approach of Maestas et al. (9) to all OECD countries using data from the Economic Conference Board (10), the Penn World Tables (1) and the US Census Bureau (11). Following Maestas et al. (9), I construct an analogous shift-share instrument that is modified for the international scope of this study. I find that a 10 percentage-point increase in the fraction of the population 65+ leads to a 4.95 percentage-point decline in labor productivity growth controlling for regional fixed effects and a 0.717 percentage-point decline in total factor productivity.

Literature Review

While the general consensus is that population aging is detrimental to the medium-run macroeconomic environment, scholars debate the magnitude of the effect and some go as far as to contest the direction of the impact. The direct model for this study, "The Effect of Population Aging on Economic Growth, the Labor Force, and Productivity" by Nicole Maestas et al., contributed tremendously to this body of work by determining that, in the United States, a 10% increase in the fraction of the population ages 60 and older decreases GDP per capita by 5.5% (9). Furthermore, they determine that "two-thirds of the aging-induced reduction in GDP per capita growth arose from a reduction in labor productivity growth, while one-third was due to a reduction in growth in employment per capita" (9 p. 308).

To arrive at these conclusions, they use state population counts by age at ten-year intervals beginning in 1950, using the Census Integrated Public Use Microdata Series and the American Community Series, the latter of which is used to estimate state populations for 2010. They also acquire GDP by state and year from the Bureau of Economic Analysis and match GDP data from the year preceding the census data because annual census outcomes refer to the previous year. For example, GDP data from 1999 is matched to the 2000 census data.

Maestas et al. (9) identify several endogenous variables that pose a challenge to this study, particularly worker migration and differences in industry. Worker migration (whether between states or from other nations) boosts local productivity, thus interfering with an evaluation of the causal effect of population aging. Similarly, a state with an aging population may shift towards industries that are less physically demanding, thus muting the effect of aging on that state's productivity growth. Instead of using a full spatial model or Conley Standard Errors, they elect to use a Bartik shift-share instrumental variable that predicts pre-determined shifts by taking the initial age structure of a state and applying it to national cohort survival ratios. This predicts the older population share per state in a baseline outcome year (9). Since the Bartik instrument uses pre-determined shifts in population, this method eliminates the endogeneity issues presented by migration and industry shifts. This instrument is used in this study as well, and the mechanism is further elaborated upon in the Methodology section. Following their findings on GDP and aging, they use channel decomposition techniques to determine that a 10 percent increase in the share of the population aged 60+ decreases worker compensation per hour by 3.3 percent. They contend that this result reinforces their central finding that an aging population decreases economic growth. They then further strengthen this finding by finding a positive change in the level of capital deepening (9 p. 323).

There is strong evidence that aging has a negative impact on productivity and thus potentially harms economic growth, as findings suggest that aging negatively impacts the demand-side of GDP. Sheiner et al. (12) and Sheiner (13) identify that "population aging will lead to a reduction in per-capita consumption" (12 p. 222), which is then likely to reduce GDP through the aggregate demand channel. Gagnon et al. (14) goes even further, claiming that much of the decline in real GDP growth since the 1980s is due to population aging.

While a country-level analysis is possible, Maestas et al. (9 p. 308) identifies some disadvantages that this paper will have to overcome, notably vulnerability to bias from "unobserved heterogeneity in national pension systems, labor market policies, and cultural norms." Feyrer (15) identifies a link between demographics and productivity with relation to OECD countries. He later investigates these links but ultimately returns to previously accepted growth models in Feyrer (16). His work contributes to the connection between demographic shifts and productivity but does not estimate the impact that this decline in productivity has on economic growth. Furthermore, Aiyar et al. (17) conclude that an aging European workforce reduces growth in total factor productivity by way of labor productivity, estimating decreases of 0.2 percentage points every year for the next two decades. Aiyar et al. (17) include projected workforce aging in 24 of 27 nations in the European Union and use the same shift-share mechanism of projected workforce aging as in Freyer (15), Maestas et al. (9), and this paper. However, Aiyar et al. (17) fails to estimate ramifications to GDP.

There are some dissenting views, including those of Acemoglu and Restrepo (18) and Cutler et al. (19). Acemoglu and Restrepo (18) suggest that investments in automation offset any losses in human productivity due to aging. Alternatively, or perhaps simultaneously, Culter et. al (19) find that increased retirements due to an aging population may trigger capital deepening, or an increase in the ratio of capital to labor. While Acemoglu and Restrepo's findings indicate a net effect on productivity, the gross effect of population aging nevertheless exists and dampens the impact of automation on economic growth. Additionally, Cutler's findings are questioned by Maestas et al. (9), as "the scope of capital deepening is limited in countries like the United States, especially as interest rates have reached historic lows" (9, citing 20 and 21). Emerging from a world of low, zero, and negative interest rate policy over the last decade and a half, this weakness in Cutler's work should suggest that capital has not dramatically decreased and is therefore not a significant factor in the effect of population aging.

The current literature independently identifies a correlation between decreases in productivity growth in the United States and Europe, but it does not encompass all OECD nations nor does it uniformly apply the same statistical methods. There are shortcomings to a cross-country analysis as identified by Maestas et al. (9), but knowledge about such weaknesses allows one to attempt to control for them or, in the case where this is not possible, consider the way in which structural differences between countries affect results. This paper will seek to uncover whether there is homogeneity in this trend across all OECD states, or whether discrepancies between previously analyzed data sets and non-US or European states exist. Such discrepancies, or lack thereof, can provide insight into why the problem of decreasing productivity growth exists and may even pave a path toward a solution to this long-run macroeconomic dilemma.

Data and Summary Statistics

To conduct this work, I have merged data from three sources: The Conference Board's Total Economy Database, the US Census' International Database, and the Penn World Table. The Conference Board publishes annual data covering GDP, population, employment, hours, labor quality, capital services, labor productivity, and total factor productivity for 131 countries (10).

The US Census International Database is another set of panel data on country-specific demographic data for over 200 countries as well as territories and subnational areas. The set includes a variety of relevant demographic data including the total population at every age, from ages 0 to 100+. The shift-share instrument used by Maestas et al. (9) utilizes 10-year age cohorts: 30-39, 40-49, and so forth. I likewise bin the data provided by the US Census Bureau into the same cohorts. This dataset is a compilation of information from various national statistics offices, so date ranges differ between nations. For example, the demographic data for many nations currently in the European Union begin during the 1990s, such as Germany in 1991 and France in 1990, while Australia begins in 1986 (11).

The Penn World Table is published yearly by the University of Groningen and consists of panel data for 183 countries since 1950. This dataset includes a variety of macroeconomic data including real GDP and total factor productivity (1). All data from the Penn World Table, Conference Board, and the US Census International Database is summarized on Table 1.

My preferred outcome for this study is labor productivity per worker (LFP), but I will also use labor productivity per hour as well as two different estimates of Total Factor Productivity (TFP) found in the Penn World Table as my dependent variables. Labor Productivity per hour and per person are simply calculated by dividing GDP by the number of persons in the workforce or the total yearly hours worked, respectively. The first estimate of TFP at current PPPs is chained to the United States in a given year, calculated by dividing the output-side GDP in a given country j by the index country k, and dividing that ratio by the Törnqvist quantity index of factor endowments QT. The other metric, TFP at constant national prices where 2017 = 1, is calculated by dividing the national productivity in year t by that same metric in 2017. This growth rate is then standardized along the Törnqvist quantity index of factor endowments QT.[2]

On average, the change in the share of individuals aged 60+ is positive in Europe and North America, which indicates evidence of long-term population aging in these regions. This figure is within a tenth of a percentage point of 0% growth across South America, Asia, and Oceania. Considering that this data predates OECD membership in these regions, it is possible that this figure is capturing demographic data from a period where TFR was above the replacement rate, as well as more recent data that reflects the current demographic issues.

TFP growth is low across all regions; growth is below 1% across all regions and negative in North America, South America, and Oceania. Labor productivity growth across both per-worker and per-hour metrics are stronger across all regions, suggesting that labor productivity is a strong driver of total factor productivity. On average, Europe

2) This index is defined as: "A method used to calculate the relative change in the aggregate volume of multiple goods or services between two periods of time. It is a geometric mean of price and quantity ratios, weighted by the average share of the total expenditure or revenue. This index is particularly favored for its flexibility and ability to account for changes in both prices and quantities over time, making it a useful tool for analyzing economic productivity and growth" (22).

has the highest labor productivity, both per worker and per hour, with North America, Asia and Oceania closely behind. Regarding Total Factor Productivity in current PPPs, each regional subgroup within the OECD is, on average, below one. This indicates that OECD nations are on average less productive than the United States in any given year. When considering TFP in constant national prices, North America leads with South America narrowly behind. Europe, Asia and Oceania all have productivity levels below 1.

	Europe	North America	South America	Asia	Oceania	Total
Change in log age share 60+	0.012 (1.874)	0.019 (1.893)	-0.020 (1.879)	-0.081 (1.843)	-0.084 (1.920)	-0.000 (1.877)
Growth in Total Factor Productivity	0.137 (2.806)	-0.239 (1.810)	-0.622 (2.445)	0.550 (1.714)	-0.092 (1.335)	0.046 (2.598)
GDP Growth	2.071 (4.014)	2.283 (2.691)	3.722 (3.464)	2.746 (3.247)	2.754 (1.718)	2.305 (3.760)
Growth in productivity per person employed	1.412 (3.208)	0.693 (1.918)	1.475 (2.950)	2.006 (2.389)	1.065 (1.606)	1.362 (2.990)
Growth in productivity per hour worked	1.750 (2.680)	0.819 (2.090)	1.791 (4.039)	2.887 (2.301)	1.272 (1.655)	1.698 (2.737)
TFP at current PPPs	0.870 (0.179)	0.904 (0.141)	0.683 (0.076)	0.717 (0.028)	0.841 (0.032)	0.850 (0.171)
TFP at constant national prices	0.976 (0.104)	1.011 (0.137)	1.009 (0.062)	0.974 (0.015)	0.946 (0.046)	0.980 (0.102)
Productivity per person employed	102.311 (33.133)	101.136 (35.079)	46.943 (11.630)	81.892 (16.960)	97.294 (15.054)	96.481 (34.253)
Productivity per hour worked	64.243 (23.726)	57.254 (18.638)	21.174 (6.833)	41.966 (12.632)	57.026 (10.796)	58.591 (24.661)

Table 1. ***Summary Statistics.*** *Productivity per person employed is calculated in thousands of 2017 PPPs. Productivity per hour worked is calculated in 2017 PPPs. TFP at current PPPs is chained to USA = 1 in a given year. TFP at constant national prices is chained to 2017 = 1.*

The differences in productivity and population aging between South America and the rest of the OECD suggests that there is something structurally different about South American OECD members. It is possible that since Chile, Columbia, and Costa Rica joined the OECD in 2010, 2020 and 2021, respectively, their pre-accession development featured different demographic patterns resembling the transition dynamic growth model instead of the steady-state, Romer-style growth demonstrated by mature economies. Due to the lagged nature of this instrument, it is likely that these pre-developed demographic patterns are being pulled in and upwardly bias their results. Stratifying data according to OECD membership age as an indicator of an economy's maturity may help to identify the connection between demographic patterns and productivity. This will also help to evaluate whether the effect of population aging on productivity is stronger for long-standing OECD members.

Methodology

Population aging is more complex than simply finding the year-over-year difference in population at a specific age—there are other demographic factors such as immigration that must be accounted for. Populations do not stay put over time, and immigration of young people may alter the local rate of population aging. For instance, many nations in the European Union welcome immigrants from Northern Africa and the Middle East. Estimating the rate of population aging amidst this endogeneity poses an incredible challenge. The Maestas et al. (9) shift-share instrument addresses this issue by using predicted age shares over a long period of time. These confounding variables are still relevant at the international level. Immigration is more fluid in other regions of the world, especially within Europe, where most OECD nations are found. Agreements within the European Union such as the Schengen Agreement facilitate the free movement of people to live, work, and study within the Schengen Area in a way comparable to the ability of US residents to move between states without restriction (See Figure 2).

Different nations also have varying levels of industry comparable to how different states have varying levels of industry, so the effect of industry on mortality rates is still a relevant confounding variable. In fact, non-uniformities in demographic patterns may be stronger on an international level than on the state level due to factors including varying diets, cultural practices, and access to healthcare.

To address these potential confounding variables, Maestas et al. (9 p. 313) uses a Bartik shift-share instrumental variable (25) that "exploits variation in the *predetermined* component of population aging across states over time." This relies on an assumption that the nation's past age structure "affects future changes in economic outcomes [in this case, labor productivity or total factor productivity] by only affecting its subsequently realized age structure, and not through any other channel." To satisfy the required exogeneity assumption, Maestas et al. (9) takes the "initial age structure… [from] 0, 10, 20, and 30 years prior to the baseline census year t - and appl[ies] common cohort survival ratios… to predict the older share

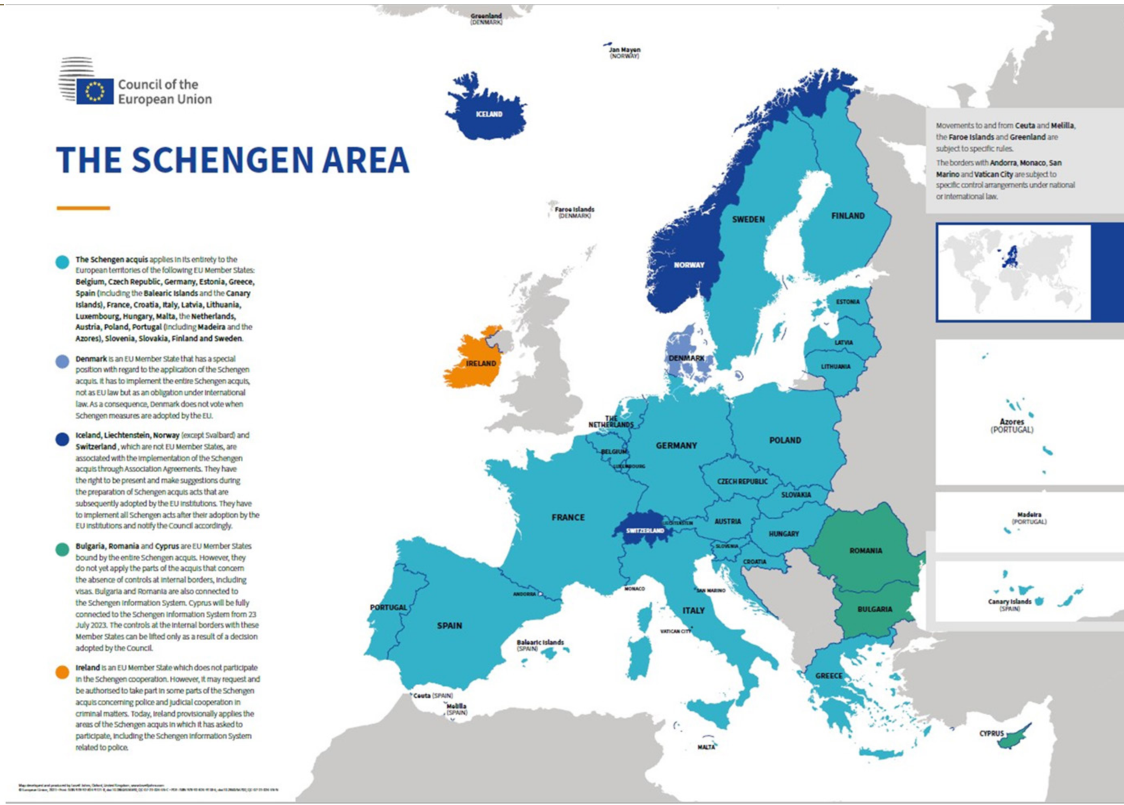

Figure 2. ***The Schengen Area.*** *Source: (24).*

of population in each state 10, 20, 30, and 40 years into the future." (9 p. 314) This method takes the population structure at a given point in time and extrapolates what the future age structure will be from a combination of natural aging and mortality within an age group (defined by the nationwide or international mortality patterns). This allows them to predict the changes in the fraction of the state population above a particular age between periods *t* and *t*+10. Mathematically, the instrument can be expressed as

$$iv_{n,s} = \ln\left(\frac{\hat{A}_{s,t+10}}{N_{s,t+10}}\right) - \ln\left(\frac{\hat{A}_{s,t}}{\widehat{N}_{s,t}}\right)$$

the following:

$$\hat{A}_{s,t} = \left(\sum\nolimits_{j \geq a-x} N_{js,t-x}\right) \cdot \left(\frac{N_{j+x,t}}{N_{j,t-x}}\right),$$

Where:

where $(N_{js,t-x})$ is the number of people of age *j* in country *s* at time *t* - *x*, is the $\left(\frac{N_{j+x,t}}{N_{j,t-x}}\right)$ international survival ratio of age *j* between *t* - *x* and *t*, and *a* indicates the desired population cutoff. For instance, Maestas et al. uses a cutoff of 60+, so the limits of their summation are listed as $j \geq 60 - x$;

$$\hat{A}_{s,t+10} = \left(\sum\nolimits_{j \geq a-x-10} N_{js,t-x}\right) \cdot \left(\frac{N_{j+x+10,t+10}}{N_{j,t-x}}\right),$$

where $\left(\frac{N_{j+x+10,t+10}}{N_{j,t-x}}\right)$ is the national survival ratio of age *j* between *t* + 10;

And

$$N_{s,t+10} = \left(\sum_{j \geq 20-x-10} N_{js,t-x}\right) \cdot \left(\frac{N_{j+x+10,t+10}}{N_{j,t-x}}\right),$$

$$\widehat{N}_{s,t} = \left(\sum_{j \geq 20-x} N_{js,t-x}\right) \cdot \left(\frac{N_{j+x,t}}{N_{j,t-x}}\right)$$

where the summations are calcuated over $j \geq 20 - x - 10$ to illustrate the 20-year lag length between *t* + 10 and *t* age structures.

Predicted national age structure is calculated using international census survival rates, which are calculated by the ratio of the population at an age *j*+*x* in one census to that age group's size in the previous census (at age *j*). This ratio is then multiplied by the country's population at age *j* in order to predict the population at age *j+x*. Maestas et al. (9) includes a helpful example: "… to predict the number of 60-year-olds in Alabama in 2000, we multiply the number of 40-year-olds in Alabama in 1980 by the *national* ratio of 60-year-olds in 2000 to 40-year-olds in 1980." This instrument is particularly helpful, as it circumvents uncertainty due to variation in country-level immigration and mortality rates.

To satisfy the exclusion restriction, Maestas et al. (9 p. 315) considers the literature to reinforce the assumption. They write:

> The variation in the population age structure that we exploit is predictable and observable by residents of the state before time *t*. In this manner, the instrument parallels population aging at the national level. The literature has used lags of the age structure to predict the current age structure as a way to avoid confounding by endogenous migration [citing 26, 27, 17].

Considering that this study employs the same instrument but simply expands the scope, this literature review is sufficient in satisfying the exclusion restriction.

Using international survival rates to predict survival in a given country is likely weaker than predicting state survival rates from national rates, due to international differences in healthcare systems and health-related cultural behaviors. To test whether this instrument remains relevant at the international level, I run a first-stage test by regressing the change in population aging on this instrument. I find that these values are extremely correlated, and thus this instrument remains relevant (See Table 2).

VARIABLES	(1) Change in log age share 60+	(2) Change in log age share 60+	(3) Change in log age share 60+	(4) Change in log age share 60+
IN1	0.823***	0.988***	0.874***	0.845***
	(0.00696)	(0.00707)	(0.00702)	(0.00699)
Constant	-11.42***	-11.08***	-12.00***	-11.83***
	(0.0972)	(0.202)	(0.114)	(0.0987)
Observations	20,168	20,168	20,168	20,168
R-squared	0.409	0.493	0.436	0.420
Fixed Effects	None	Year	Country	Region
F test:	13965	445	409.5	2921

Table 2. *Relevance Test and F Statistics.* *Standard Errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All instrument coefficients across various fixed effect constraints are significant at the 1% level. All F-statistic values are greater than 10, indicating that there is not a weak instrument problem.*

Having built the instrument, I use the following model:

$$\ln\left(productivity_{s,t}\right) = \beta_1\left(iv_{s,t}^{n}\right) + \gamma_t + \alpha_s$$

The subscript *n* on *iv* indicates which age cutoff for "older" is being considered. For instance, if the age cutoff is to be set at 50 years, *n* = 50. Additionally, labor productivity growth per worker is the preferred metric for evaluating labor productivity on a country-level. This is because productivity could be impacted by whether an individual works full- or part-time. While labor productivity per hour is generally considered the more effective metric, that does not hold true in this case. Labor productivity per hour is simply calculated by dividing GDP by the total hour worked. If a decline in productivity is associated with a transition to working less hours, labor productivity per hour will measure decreases in both the numerator and denominator in this term and the effect will be lost. Using labor productivity per worker – which is calculated by dividing output by the labor force – accounts for this discrepancy by capturing the effect that decreasing hours worked may have on a worker's productivity. Since $iv_{s,t}^{n}$ is already expressed in terms of logs, the coefficient β_1 can be interpreted as the change in labor productivity (measured in dollars per worker) caused by a 1% increase in the predicted age structure (if the population, on average, gets 1% older), ceteris paribus. There will be controls for two types of fixed effects, year-fixed effects (γ_t) and geographic fixed effects (α_s). The variable α_s is a general variable that represents two different geographic fixed effects that will be utilized, one on a country-specific level and the other on a regional level.

As previously discussed, Maestas et al. (9 p. 308) identifies some disadvantages of extrapolating their methods on the international level, notably vulnerability to bias from "unobserved heterogeneity in national pension systems, labor market policies, and cultural norms." To address this concern, I account for unmodeled heterogeneity by geographic unit (either region or country) and by the length of membership in the OECD. Using region-based fixed effects will result in more accurate results, as it accounts for varying degrees of heterogeneity within the OECD. For instance, there will be more homogeneity within European Union members than between France and Japan. Additionally, newer OECD members such as Puerto Rico and Columbia may not have arrived at the slower growth rates typical of mature economies (8). This is further exacerbated by virtue of the lagged nature of this instrument, as high levels of productivity correlated with developing countries may be unintentionally pulled in and thus bias results upwards in their respective countries. Comparing within the OECD by creating cohorts based on duration of membership will help to identify and accommodate for this bias.

Results are evaluated using both heteroskedastic-robust standard errors and clustered standard errors. All results using clustered standard errors were statistically insignificant or significant at the 10% level and were ultimately omitted from this paper. This is likely due to the small number of clusters present in the data – results show a maximum of 36 clusters and a minimum of 13, which is far below the necessary threshold of 50 (28 p. 24).

Analysis

Main Findings

I begin my analysis by evaluating the impact of population aging on labor productivity per worker. All results are included in Table 3. Using my preferred specification of regional fixed effects, I find that a one percent change in the proportion of the population aged 60+ causes a 0.419 percentage-point decline in labor productivity per worker. I also find that the same change in the population structure causes a 0.495 percentage-point decline in labor productivity per worker.

Following these results, I can estimate the impact that this dampening effect has on Total Factor Productivity. Continuing to use regional fixed effects, I find that a one percent change in the proportion of the population aged 60+ causes a 0.0717 percentage-point decline in TFP growth. Evaluating the effect on TFP as a level is trickier: a one percent change in the proportion of the population aged 60+ causes a 0.0186 percentage-point decline in TFP at current PPPs, but the same shift causes a 0.00422 percentage-point increase in TFP at constant national prices. This discrepancy is likely explained by the ways in which these variables are calculated: this demographic shift is expected to make countries less productive than the United States (because the value calculated in PPPs is chained to USA = 1 in a given year), but TFP is still expected to grow in a respective country, as compared to their 2017 level. Nonetheless, the demographic shift is expected to cause a decline in TFP growth.

Supplementary Findings

Following these findings, there are a few ways to stratify the data such that supplementary results can be identified. First, I alter the population share cutoffs to include a greater population share. For example, what would be the effect of the change in the log of the population share ages 50+? This would allow us to identify whether a drop in productivity is truly associated with aging instead of an intergenerational loss of job-specific knowledge due to

VARIABLES	Fixed Effects			
	OLS Regression	None	Country	Region
TFP at current PPPs (USA = 1)	-0.000355 (0.000687)	-0.000891 (0.00271)	-0.0142*** (0.00118)	-0.0186*** (0.00244)
TFP at Constant National Prices (2017 = 1)	0.000251 (0.000441)	-0.00211* (0.00127)	0.0127*** (0.00106)	0.00422*** (0.00144)
TFP Growth	0.00307 (0.00993)	0.0304 (0.0378)	-0.0565* (0.0340)	-0.0717** (0.0366)
Growth in Labor Productivity (per worker)	0.00288 (0.0114)	-0.410*** (0.0489)	-0.325*** (0.0424)	-0.419*** (0.0476)
Growth in Labor Productivity (per hour worked)	0.00723 (0.0101)	-0.467*** (0.0446)	-0.428*** (0.0459)	-0.495*** (0.0486)

Table 3. ***Main Findings.*** *Robust Standard Errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Results are statistically significant at the 1% level for all results using region fixed effects and for all results using country fixed effects besides TFP growth, which is statistically significant at the 10% level. Without using fixed effects, results are statistically significant at the 1% level for both labor productivity growth metrics, statistically significant at the 10% level for TFP at constant national prices, and not statistically significant for TFP at current PPPs and for TFP growth. Results are not statistically significant in Column 1, which uses the Ordinary Least Squares method. See Appendix for full results.*

VARIABLES	Change in log age share 60+	Change in log age share 50+	Change in log age share 40+	Change in log age share 30+
TFP at current PPPs (USA = 1)	-0.0186*** (0.00244)	-0.0162*** (0.00231)	-0.0137*** (0.00220)	-0.0135*** (0.00211)
TFP at Constant National Prices (2017 = 1)	0.00422*** (0.00118)	0.00276** (0.00111)	0.00333*** (0.00105)	0.00372*** (0.000991)
TFP Growth	-0.0717** (0.0366)	-0.0411 (0.0340)	-0.0345 (0.0318)	-0.0208 (0.0302)
Growth in Labor Productivity (per worker)	-0.419*** (0.0476)	-0.326*** (0.0435)	-0.263*** (0.0401)	-0.206*** (0.0376)
Growth in Labor Productivity (per hour worked)	-0.495*** (0.0486)	-0.397*** (0.0438)	-0.323*** (0.0405)	-0.256*** (0.0379)

Table 4. ***Altered Instruments using Region Fixed Effects.*** *Robust Standard Errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1 All results are calculated using regional fixed effects. Results are statistically significant at the 1% level for all results across TFP at current PPPs, TFP at constant national prices, and both labor productivity metrics, besides TFP at constant national prices evaluated on the 50+ instrument, which is statistically significant at the 5% level. Results are not statistically significant for all altered instruments (50+ ,40+, 30+) for TFP Growth. See Appendix for full results, including results using different fixed effect specifications.*

increased retirements. Following the same process as the original analysis, I examine the effect of population aging on labor productivity and total factor productivity. The results of this supplemental test are found in Table 4.

I find that not only that all coefficients for TFP growth at current PPPs and both labor productivity metrics are negative and significant, but that the coefficients decrease in magnitude when including younger cohorts, with respect to country fixed effects. The decreasing magnitude of the coefficients from 60+ to 30+ suggests that workers become less productive as they get older, ceteris paribus. Results for TFP at constant national prices reflect results in Table 1, and the drop-off observed across other variables is not observed. Interestingly, results for TFP Growth are not statistically significant, but the magnitude of the coefficients follow the drop-off trend nonetheless.

Finally, anotherwaytostratifythedataistoseparate the countries according to when they joined the OECD. As previously mentioned, the lagged nature of the instrument may pull in data for current members that were previously experiencing Solow-style transition growth. Following the same procedure of beginning with labor productivity and building up to the effect on TFP, there is a clear difference between long-standing members of the OECD and more recent members. Older OECD members are more vulnerable to the effect of an aging population across all indicators, from labor productivity growth to total factor productivity. The results of this test can be found in Table 5.

These results indicate that the general regression is indeed upwardly biased by more recent OECD members. As a result, a more accurate interpretation of these findings is that, while a one percent increase in the fraction of the population 60+ causes a 0.495 percentage point decrease in labor productivity growth per worker across all OECD member states, on average, long-standing members are more vulnerable. A 10 percent increase in the fraction of the population 60+ causes a 0.660 percentage point decrease in labor productivity growth per worker within founding OECD members, on average, with respect to region fixed effects, as compared to a 0.129 percentage-point decline in labor productivity per worker for countries that joined after 1980 and 2000. Growth in labor productivity per hour is similar affected, with a one percent increase in the fraction of the population aged 60+ causing a 0.666 percentage-point decline in founding members, but only a 0.299 and 0.279 percentage-point decline for countries that joined after

VARIABLES	Founding Members	Joined before 1980	Joined after 1980	Joined before 2000	Joined after 2000
TFP in current PPPs	-0.0390*** (0.00342)	-0.0334*** (0.00284)	-0.0257*** (0.00341)	-0.0180*** (0.00276)	-0.0213*** (0.00349)
TFP in constant national prices	-0.00819*** (0.00143)	-0.00434*** (0.00121)	0.0268*** (0.00222)	-0.0142*** (0.00149)	0.0364*** (0.00237)
TFP Growth	-0.0384 (0.0480)	-0.0323 (0.0425)	-0.0450 (0.0607)	0.00249 (0.0426)	-0.0649 (0.0633)
Growth in Labor Productivity (per worker)	-0.660*** (0.0706)	-0.631*** (0.0615)	-0.129* (0.0718)	-0.512*** (0.0587)	-0.129* (0.0771)
Growth in Labor Productivity (per hour)	-0.666*** (0.0581)	-0.647*** (0.0512)	-0.299*** (0.0857)	-0.541*** (0.0505)	-0.279*** (0.0930)

Table 5. ***OECD Membership Date using Region Fixed Effects.*** *Robust Standard Errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1 All results are calculated using regional fixed effects. Results are statistically significant at the 1% level for all results across TFP at current PPPs, TFP at constant national prices, and both labor productivity metrics, besides growth in labor productivity per worker for the cohort that joined after 1980. Results for TFP growth are not statistically significant. See Appendix for full results, including results using different fixed effect specifications.*

1980 and 2000, respectively. This effect is not as prominent for TFP in current PPPs but is nonetheless present.

Most interesting are the results for TFP in constant national prices. Not only does the coefficient increase when older OECD members are excluded from the sample, but the coefficient turns positive for the cohorts containing newer members. These results show that, while all OECD nations are in danger of declining productivity growth due to their aging populations, long-standing economies experiencing steady-state, Romer-style growth face a much more dire situation. Additionally, comparing the magnitudes of the coefficients for the founding member cohorts and the cohorts of newer members suggests that the earlier, surprising results in Table 3 and Table 4 can be explained by this upward bias (See Table 5).

Conclusion

Population aging across the OECD yields, on average, a 0.495 percentage-point decline in labor productivity and a corresponding 0.0717 percentage-point decline in TFP growth. Expanding to the 10 percentage-point figure utilized in Maestas et al. (9), I see that a 10 percentage-point change in the population proportion aged 60+ causes a 4.95 percentage-point decline in labor productivity and a commensurate 0.717 percentage-point decline in TFP growth. This is a significant dampening effect. The effect of aging is clear, as including younger cohorts diminishes the effect. This effect is worse for older OECD members with balanced growth paths than for less developed, newer members of the OECD.

Future Work

Future research must expand this work to estimate the impact of population aging on GDP and GDP growth. While it is well documented that TFP is a strong driver of GDP and GDP growth (29, 30), this Bartik method was unable to uncover statistically significant results. Expanding this work to incorporate GDP is essential to underscore the drastic effect that the demographic shift may have throughout the developed world.

Additional research may also include a more detailed examination of other exogenous factors, including the effect of retirement and considering the lagged effects of technology adoption. The effect of retirements is particularly interesting, as it will allow us to determine whether the observed decline in productivity is attributed to workers staying in the workforce and becoming less productive or simply leaving the workforce. Retirement ages across the OECD vary from 62 to 67 and have changed over time, as in the case of France's controversial increase in the retirement age by two years (31). Future work accounting for variation in retirement age may improve these estimates.

Additionally, the way in which TFP is calculated – typically using GDP – must be considered. It is possible that retirees spend more time contributing to the global economy in ways that are not captured by GDP but indirectly enable GDP growth. One such example would be childcare: an older population available to provide greater (free) childcare would enable more working-age adults into the workforce, so the actions of the retirees may indirectly contribute to GDP growth. Additionally, further research may be conducted to address the limited time series issues in this paper. It was noted that many countries that are currently members of the European Union had age data only going back to the early 1990s, likely a result of the formation of the European Union. If country-specific data on population age from before that time exists, it would contribute significantly to these findings and likely strengthen the effectiveness of the instrument.

Similarly, an aging population is likely to lead to a shift in how care is given to aging individuals. As populations age, care is likely to transition from unpaid labor provided by family members to paid labor in senior living communities and increased medical treatments. Such a shift is also likely to induce an increase in the price paid for such care and medical services, resulting in an index number problem. Such a shift from unpaid to paid care would present as growth in the accounting of GDP, but such growth would be superficial and demonstrates the weakness of GDP. Future work that accounts for the transitions between paid and unpaid labor can improve the strength of these estimates.

Solutions

Countries have attempted to address this problem, with varying degrees of success. It is imperative that nations boost their Total Fertility Rate as a long-run solution, but efforts are relatively muted. Immigration has been touted as a possible solution to this crisis, but the data does not support this belief. While immigrants may boost productivity in the short-run (32), migration does not substantially impact the Total Fertility Rate and is thus not a long-run solution to flagging TFP rates. A paper by the Center on Immigration Studies estimates that the apparent gain to TFR due to immigration is just 0.07 (33).

Many nations including South Korea, Italy, and even some non-OECD nations like China have instituted pro-natalist policies that encourage higher fertility through allowances and tax exemptions, with mixed success. For instance, Italy has recently implemented a three-pronged approach that allocates 1 billion Euro to promoting "family-friendly measures." This includes granting exemptions from social security contributions for families with three or more children, extending paid parental leave, and allocating a "kindergarten bonus" that grants vouchers to low-income families for their children to attend kindergarten (34). China took a similar approach in 2021, laying out "propaganda goals" that include "respecting the social value of childbearing," "engaging couples to share childcare responsibilities," and "eliminating outdated concepts such as high bridal/dowry prices" (35). Both the Italian and Chinese programs have been established recently so it is difficult to evaluate the effectiveness, but similar policies have been in place in the Republic of Korea since 2005 and fertility rates have continued to decline (36). Additionally, Sweden has one of the most expensive pro-natalist programs in the world since the 1980s and, while they have enjoyed some success, remain below replacement rate (37).

Recent attempts in the United States and United Kingdom have involved tax breaks or cash handouts to incentivize new parents, citing successes in Hungary since 2011. A recent article by The Economist describes Hungary as the "poster child for populist pro-natalists everywhere" and, while Hungary's Total Fertility Rate rose from 1.2 in 2011 to 1.6 in 2018, this policy costs 5.5% of their GDP annually. This rate has since dropped off, a phenomenon which could indicate that this policy did not encourage parents to have more children – only to have the same number sooner (38).

Nonetheless, some social policies appear successful. A recent study by Doepke et al. (39) indicates that old models of family economics, particularly those that suggest an inverse relationship between income and fertility, are beginning to break down. In 1980 there was a clear inverse relationship between income and fertility among OECD countries, but that trend has reversed by 2000 and now the wealthiest countries boast the highest fertility (38 pp. 169-170). They also indicate that a similar reversal has occurred regarding women's labor force participation, where family economists have long cited women's engagement in the workforce as a cause of declining fertility. However, studies in both economics and sociology have found that this trend has also reversed, as early as the 1990s (38 pp. 172-173). While mechanisms for this shift are not provided, a study by Purr et al. (40) helps us to attribute some of this shift to enhanced parental leave by finding that a generous parental leave policy in Estonia led to a substantial increase in total fertility. While more work must be done, these findings suggest that some pro-natalist policies are effective and may contribute to raising fertility rates.

Interestingly, literature that evaluates the effect of income inequality (through the Gini index or other means) is scarce. Future work must be conducted to corroborate, but the intuition is clear: in a society where a great share of the population is cash-strapped and the cost of raising a child is sky-high,[3] more couples make the economic decision not to raise a child.

Instead of relying on immigration or intruding into the private lives of their citizens, nations must address the core reasons why fertility rates are declining. Promoting immigration of young workers will boost productivity in the short-run, but the long-run effects are likely null due to the negligible effect of immigration on TFR. The short-sighted solution also carries ethical issues, as there is potential for worker exploitation (42). Instead, nations must address key economic issues that factor into a family's decision to raise a child – issues like rising income inequality. By focusing on the underlying issues that dissuade families from having multiple children, nations can effectively combat this looming threat to economic growth.

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