The Effects of an Aging Population on GDP Growth Rate in the Developed World

Introduction

Goal

The purpose of this project is to present a rational and data driven analysis to capture the effect an aging population has on the growth of a country’s per-capita economic output.

Assumption 1

An increasingly aging population would indicate that a larger proportion of a country’s population is less productive and/or less involved in the workforce.

Assumption 2

An increasingly aging population would lead to a reduction in the increase in total output of a country, measured in terms of GDP. This is a consequence of the first assumption.

Literature Review

Cost of Aging - Lee, R., & Mason, A. (I.M.F. FINANCE & DEVELOPMENT, March 2017, Vol. 54, No. 1)

- Various types of economies face **an unproductive young and aging populations with high consumption habits that puts strain on a country's economy.**

The Effect of Population Aging… - Maestas, N., Mullen, K. J., & Powell, D. (RAND Corporation, 2016)

- This paper by the RAND Corporation finds that **states in the US, with an increasing aging population, were experiencing adverse effects on their GDP Per Capita.**

Data

Overview and Sources

Our data was pulled from:

- The World Bank’s “World Development Indicators” database
- The St. Louis Federal Reserve Economic Database (FRED)
- OECD Data
- Population data from several of the census bureau's of developed countries (USA, Canada, Australia, New Zealand, Western Europe, Japan, and South Korea)

Preliminary Data Analysis - Japan

Figure 1

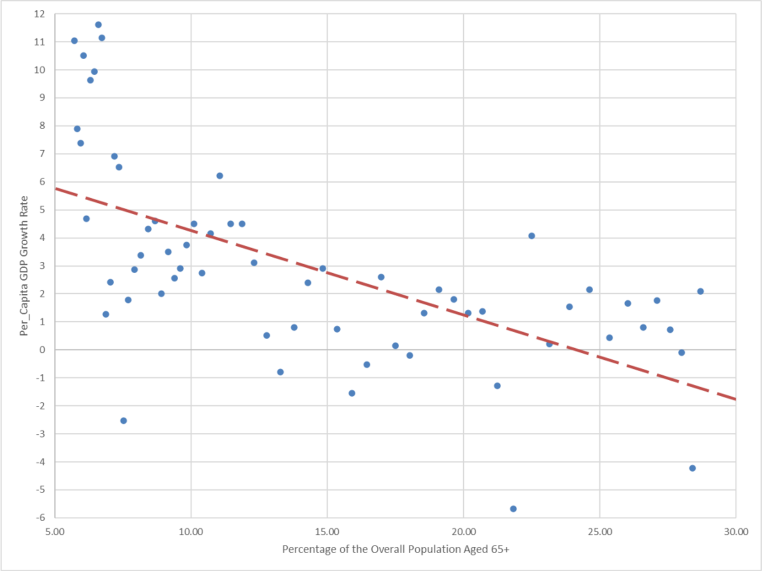

Figure 1 illustrates the relationship between the percent change in GDP per capita and the Percent of the population over the age of 65 for Japan.

Figure 1 illustrates Japan's relationship between the percent change in per capita GDP and the percent of the total population over the age of 65. A line of best fit organizes the trend of the data.

- At a glance, Japan's **steep decline in Per Capita GDP, as its population ages**, is likely the best representation of our argument.
- However, Japan is one of the more extreme cases of this relationship and is being combated by legislation and monetary policy.

Preliminary Data Analysis - Contrast with China

Figure 2

Figure 2 illustrates China's GDP growth rate compared to the percent of its population that is 65+ years old.

Table 1

Country	% of Population over 65	Annual GDP Growth Rate
Australia	14.85%	2.17%
China	9.33%	7.04%
Germany	21.22%	1.49%
Japan	26.02%	1.56%
United States	14.64%	2.71%
United Kingdom	17.97%	2.62%

Table 1 illustrates the differences in the percent change of GDP growth and the Percent of the population over the age of 65 for a selection of developed countries in 2015.

In contrast, China's population ages while its GDP growth rate continues to grow.

- This is because Japan and China are in different economic development stages, highlighting the importance of analyzing developed countries.

Model and Results

Creating the Preliminary Model

Due to the characteristics of our data, we have decided to use a fixed effects panel regression model as the best course of analysis

Hypotheses:

- **H_0: The change in the population of 65+ has a negative effect on GDP per-capita growth.**

- **H_1: The change in the population of 65+ has no effect on GDP per-capita growth.**

We created a preliminary model in an attempt to isolate the effects of the aging population:

$$\mathbf{GDP_{it} = \alpha_i + \beta_1 65_{it} + u_{it}}$$

- GDP_{it} is the percent change in GDP per-capita on an annualized basis
- 65_{it} represents the percentage of a nation's population above 65.

Preliminary Regression Results

Table 2

R^2	0.1723					
gdpcap	Coefficient	Error	t	P>t	95% Confidence	
65_{it}	-0.3358	0.024	-14.02	0	-0.3829251	-0.2888684
constant	6.951651	0.3412826	20.37	0	6.28189	7.621411

Table 2 illustrates the regression output for our initial regression. Note the low R-squared value.

- This model yielded results with a relatively low R-Squared value, as seen in table 2.

We believe this relatively **low R-Squared value is apparent because our preliminary model did not include any control variables.** This prompts us to add several control variables to find a better fit for our data and to provide a more conclusive answer to our question of how an aging population will affect the economy at large.

Secondary Regression Model

Below is the newly developed equation:

$$GDP_{it} = \alpha_i + \beta_1 65_{it} + \beta_2 C_{it} + \beta_3 X_{it} + \beta_4 G_{it} + \beta_5 I_{it} + u_{it}$$

- Where GDP_{it} is the percent change in GDP per-capita on an annualized basis
- 65_{it} represents the percentage of a nation's population above 65
- C_{it} represents the total household expenditure per-capita
- X_{it} represents a nation's net exports balance
- G_{it} represents a nation's total government expenditures totals in a given year
- I_{it} is the total capital formation in a given year

Secondary Regression Results

Table 3

R^2	0.1537					
gdpcap	Coefficient	Error	t	P>t	95% Confidence	
65_{it}	-0.128	0.048	2.650	0.008	-0.222	-0.033
G_{it}	-5.08E-12	1.59E-12	-3.190	0.002	-8.20E-12	-1.95E-12
C_{it}	-0.001	0.000	-3.500	0.000	-0.002	0.000
I_{it}	3.16E-12	9.12E-13	3.460	0.001	1.37E-12	5.65E-12
X_{it}	1.80E-12	1.96E-12	0.910	0.361	-2.06E-12	5.65E-12
_cons	6.303	0.456	13.830	0.000	5.408	7.197

Table 3 illustrates the regression output for our secondary regression. Note that the 65_{it} variable representing the percentage of the population 65+ is statistically significant at the 99% level.

- At a glance, our main variable (65_{it}) is negative and statistically significant at the 99% confidence level. This would lead us to reject the null hypothesis.
- However, our R-Squared value decreased from the original regression, hinting towards potential endogeneity

Endogeneity Control

- After running our preliminary regressions, **we recognized the potential for a baseline endogenous effect** on our variables that may not be captured or accounted for by our analysis.

- Because we recognize the possibility of this effect we attempt to control for the potential of endogeneity in our model by introducing the GDP per capita variable from the previous period as an additional variable:

$$\mathbf{GDP_{it} = \alpha_i + \beta_1 65_{it} + \beta_2 C_{it} + \beta_3 X_{it} + \beta_4 G_{it} + \beta_5 I_{it} + \beta_6 GDP_{it-1} + u_{it}}$$

This is justified by our previous observation that the R squared decreased in our preliminary analyses.

Endogeneity Control

Table 4

R^2	0.1987					
gdpcap	Coefficient	Error	t	P>t	95% Confidence	
65_{it}	-0.105	0.048	-2.150	0.031	-0.199	-0.010
$Gcap_{it-1}$	0.151	0.036	4.150	0.000	0.079	0.222
G_{it}	-4.06E-12	1.61E-12	-2.530	0.012	-7.22E-12	-9.12E-13
C_{it}	0.000	0.000	-3.500	0.002	0.000	0.000
I_{it}	2.55E-12	9.18E-13	-3.050	0.002	7.51E-13	4.35E-12
X_{it}	1.52E-12	1.96E-12	0.077	0.439	-2.33E-12	5.36E-12
_cons	5.314	0.520	10.210	0.000	4.292	6.335

Table 4 shows the regression output from our fixed-effects panel regression. (T-1 regression)

Table 5

Wald X^2	42.19					
$p>X^2$	0					
gdpcap	Coefficient	Error	z	P>|z|	95% Confidence	
gdpcap	0.149	0.035	4.260	0.000	0.080	0.218
65_{it}	-0.110	0.048	2.650	0.008	-0.222	-0.033
G_{it}	-3.74E-12	1.59E-12	-2.350	0.019	-6.86E-12	-6.20E-13
C_{it}	8.56E-05	2.86E-04	-2.99	0.003	-1.42E-04	-2.95E-05
I_{it}	2.39E-12	8.99E-13	2.660	0.008	6.28E-13	4.15E-12
X_{it}	1.49E-12	1.88E-12	0.790	0.428	-2.20E-12	5.19E-12
_cons	5.270	0.505	10.440	0.000	4.280	6.258

Table 5 shows the regression output from our Arellano-Bond dynamic panel-data regression.

- After controlling for endogeneity, our results are consistent with our previous analyses of the same variables.
- Based on the chi-squared and weld chi-squared outputs, we **fail to reject the null hypothesis**, proving that the GDP growth rate is negatively affected by an aging population.

Conclusions, Limitations, and Findings

Limitations

- The inability to account for the potential of the government retirement threshold changing in developed countries
- Specific examples of legislative or governmental actions that are quantifiable to combat this problem of aging (outside of Japan).
- The presence of endogeneity.
- Literature that covered our exact variables

Conclusions and Findings

- For all 4 regressions, the 95% confidence interval for the variable 65_{it} is negative and does not include 0, meaning that our assumption is significant. The results show that **an aging population could indeed lead to a decline in a developed country's GDP growth rate.**
- Further, **the variable 65_{it} is statistically significant at the 99% confidence level** for every regression except for the t-1 regression (endogeneity control), where it is still significant at the 95% level.

Conclusions and Findings

Other Variables:

- **Government expenditure (G_{it})** is seen to be negative and statistically significant at the 95% confidence level for all models where it was included. This would mean that as a government decreases spending, their GDP growth rate would rise for developed countries.
- **Total Capital Investment (I_{it})** is positive and and statistically significant at the 99% confidence level for all models in which it was included. This would indicate that as more capital is invested in the economy, the GDP growth rate increases, logically.

Final Remarks - Conclusion of our Analysis

Because the variable for a nation's aging population (65_{it}) is negative and statistically significant at a 95% confidence interval for all of our regressions, **we fail to reject the null hypothesis** that the change in the population of 65+ has a negative effect on GDP per-capita growth.

We can conclude that, in the scope of our model, as a developed country's population ages, they can expect to see a decline in their GDP Per Capita growth rate moving forward.

Works Cited

Farfaras, A., Pateras, J., Panariti, E., Pierrakos, G., Sarris, M., Soulis, S., & Skolarikos, P. (2016). The Greek economic crisis leads to declining birth rates. *International Journal of Child Health & Human Development*, *9*(2), 157–162.

Lee, R., & Mason, A. (2017, March). *Cost of Aging*. Cost of aging -- Finance & Development, March 2017. Retrieved September 9, 2022, from https://www.imf.org/external/pubs/ft/fandd/2017/03/lee.htm

Maestas, N., Mullen, K. J., & Powell, D. (2016, August 24). *The effect of population aging on economic growth, the labor force and Productivity*. RAND Corporation. Retrieved September 9, 2022, from https://www.rand.org/pubs/working_papers/WR1063-1.html

U.S. Bureau of Economic Analysis, Gross Domestic Product [GDP], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDP, August 29, 2022.

World Bank, Crude Birth Rate for the United States [SPDYNCBRTINUSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/SPDYNCBRTINUSA, August 29, 2022.

World Bank. (n.d.). GDP (constant 2015 US$) - Japan, United States, Canada, European Union, China. Retrieved August 29, 2022, from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?end=2021&locations=JP-US-CA-EU-CN&most_recent_value_desc=true&start=1960&view=chart

World Bank. (2022). *World development indicators*. DataBank - World Development Indicators. Retrieved September 29, 2022, from https://databank.worldbank.org/reports.aspx?source=world-development-indicators#

Žmuk, B., Dumičić, K., & Harmina, A. (2020). Features of Business Demography Statistics in European Countries: Relation of Enterprise Deaths and Births to Gdp per Capita and Unemployment. *Interdisciplinary Description of Complex Systems*, *18*(2–A), 116–134. https://doi.org/10.7906/indecs.18.2.4