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The Implications of a Declining Labor Force

 Charles Kenny and George Yang

Abstract

This paper explores the potential implications of a declining absolute labor force on economic outcomes. It explores key macroeconomic variables during periods of negative and positive prime age (15-65) population growth (PAPG). These variables include 10-year bond yields, consumer price indices, female labor force participation, GDP, government expenditures, government revenue, and stock returns. We find effects may include lower economic growth, declining government revenues, flat or declining labor force participation, and lower investment returns. As negative PAPG is spreading worldwide, this portends a less favorable economic outlook.

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1 Introduction

For nearly all of the past 200 years (and longer), the vast majority of the world's countries have seen population growth and, in particular, working age population growth.¹ But since 1990, more and more countries are seeing declines in working age populations. By the 2050s, the majority of the world's people will live in countries where the working age population is falling. This paper is a descriptive study exploring the potential implications of this change on economic outcomes. It looks at key macroeconomic variables during periods of negative and positive prime age (15-65) population growth (PAPG). These variables include 10 year bond yields, consumer price indices, total and female labor force participation, GDP, government expenditures, government revenue, and stock returns. The analysis suggests negative PAPG is often associated with weaker economic performance.

As well as a literature on the impact of overall changes on growth,² a number of studies have looked specifically at the impact of declining prime age population share in the economy, and suggested it is associated with slower economic growth through a range of channels including a lower worker to population ratio, an aging workforce that is less innovative, lower savings rates, fiscal challenges including health and pensions outlays, and greater demand for products from sectors that see low productivity growth.³ We are particularly interested in the transition from positive to negative *absolute* PAPG. This is clearly related to a declining prime age share of the population, but is a less common and potentially more extreme event, in that it suggests the potential for stranded capital in the face of declining availability of labor. Stranded capital is an idea associated with climate change and the risk that investments in carbon-intensive industries will fail as policy and technological change reduce demand for carbon-intensive products. A similar process may occur with labor-intensive industries in the face of a declining labor force. And it might be associated with lower stock market returns and depressed interest rates, declining tax revenues and lower growth.

¹See the Maddison dataset for general population growth over the long term: <https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2020>

²Jones, Charles I. 2022. "The End of Economic Growth? Unintended Consequences of a Declining Population." *American Economic Review*, 112 (11): 3489-3527.

³Cooley, Thomas F., Espen Henriksen, and Charlie Nusbaum. 2020. "Demographic Obstacles to European Growth." SSRN Scholarly Paper ID 3356824. Rochester, NY: Social Science Research Network. Nagarajan, N. Renuga, Aurora A. C. Teixeira, and Sandra T. Silva. 2016. "The Impact of an Ageing Population on Economic Growth: An Exploratory Review of the Main Mechanisms." *Análise Social* 51 (218): 4-35. See Charles Kenny. 2023. "The Ultimate Resource is Peaking." CGD Working Paper 630. Washington, DC: Center for Global Development for a review.

2 Data Sources

We obtained GDP data from Penn World Tables;⁴ government revenues and government expenses data from the IMF, the UNU-WIDER Government Revenue Dataset, and OECD; population data from UN World Population Prospects (WPP); and stock market returns, consumer price index, and bond yields from the Global Financial Database (GFD). Note that throughout, we do not use raw stock indices and CPI data, but rather growth in these variables.⁵

Table 2.1: Summary Statistics

	Year Start	Year End	Countries	Observations	Mean	SD
10 year bond yields	1950	2021	48	1653	7.5	9.1
Consumer Price Index YoY Growth Rate (%)	1950	2021	50	3407	7.4	11.7
Female Labor Force Participation (%)	1960	2021	210	4317	46.7	15.7
GDP (Billions)	1950	2022	183	10920	346.3	1326.2
GDP per capita	1950	2022	173	10455	14117.0	18851.6
Govt expenditures (% of GDP) (IMF Fiscal Monitor)	1991	2026	191	6108	31.9	18.9
Govt revenue, incl. Social Contributions (% GDP) (UN GRD)	1980	2020	188	5482	28.4	15.2
Stock Price Index YoY Growth Rate (%)	1950	2021	35	1825	9.9	30.4
Total Labor Force Participation (%)	1960	2021	210	4317	59.6	10.2
Total Population (Millions)	1950	2100	199	30049	38.0	134.4
Total Working-Age Population (Millions)	1950	2100	199	30049	23.6	85.5

3 Analysis

In Figure 1, we plot the number of countries with **positive** or **negative** Prime Age Population Growth, over 5 year periods between 1950 and 2100.⁶ As can be seen, negative PAPG remained extremely rare until the 1990s, but as soon as 2060 the majority of countries will be experiencing the phenomenon.

In Figure 2, we plot the same five year periods with columns displaying average GDP/capita growth rates for the countries with **negative PAPG** and **positive PAPG**. In earlier periods,

⁴The Penn World Tables' RGDP^{NA} variable is used. Where there are gaps in the data, year-over-year growth rates are calculated from the World Bank Indicators GDP PPP (NY.GDP.MKTP.PP.KD) series, then that growth rate is applied to previous years of RGDP^{NA} to fill-in missing values.

⁵Country-years where CPI Growth was > 100% are omitted from the CPI summary statistics.

⁶UN World Population Prospects 2019, Historical then medium variant projections.

rare and often temporary episodes of negative PAPG do not appear to have been consistently associated with negative GDP per capita growth. Since the 1990s, however, the association with weaker performance has become more robust.

In Figure 3, we plot the same five year periods with columns displaying average government revenue growth rates for the countries with **negative PAPG** and **positive PAPG**. It appears negative PAPG is reasonably consistently associated with slower growth in government revenues.

Figure 1: Count of countries with expected negative vs. positive prime-age population growth (PAPG)

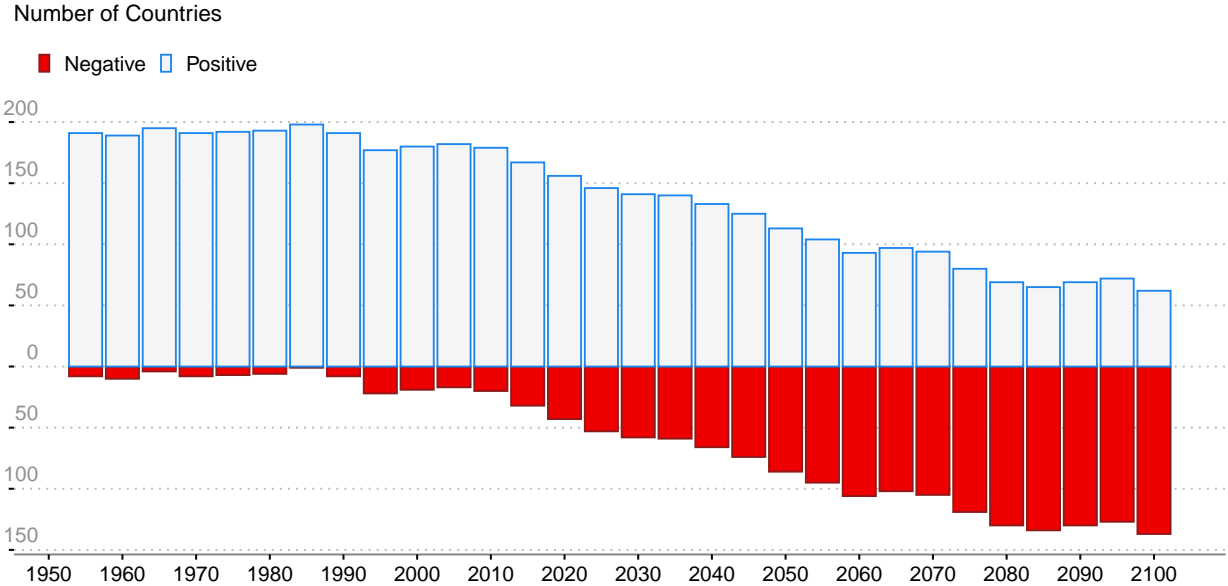


Figure 2: Annualized GDP per capita growth of countries with expected negative vs. positive prime-age population growth (PAPG)

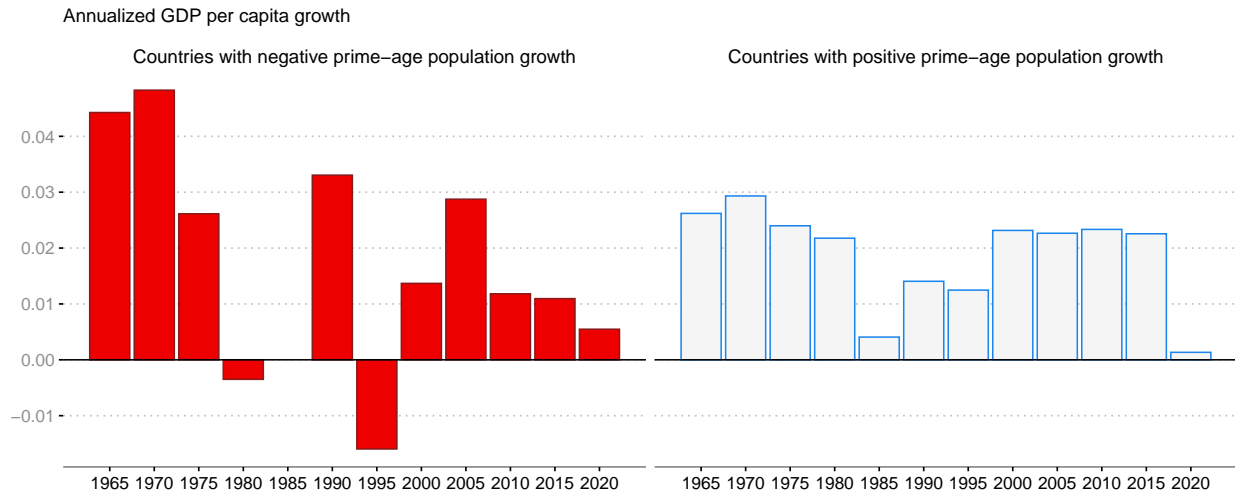


Figure 3: Annualized government revenue (% GDP) growth in countries with expected negative vs. positive prime-age population growth (PAPG)

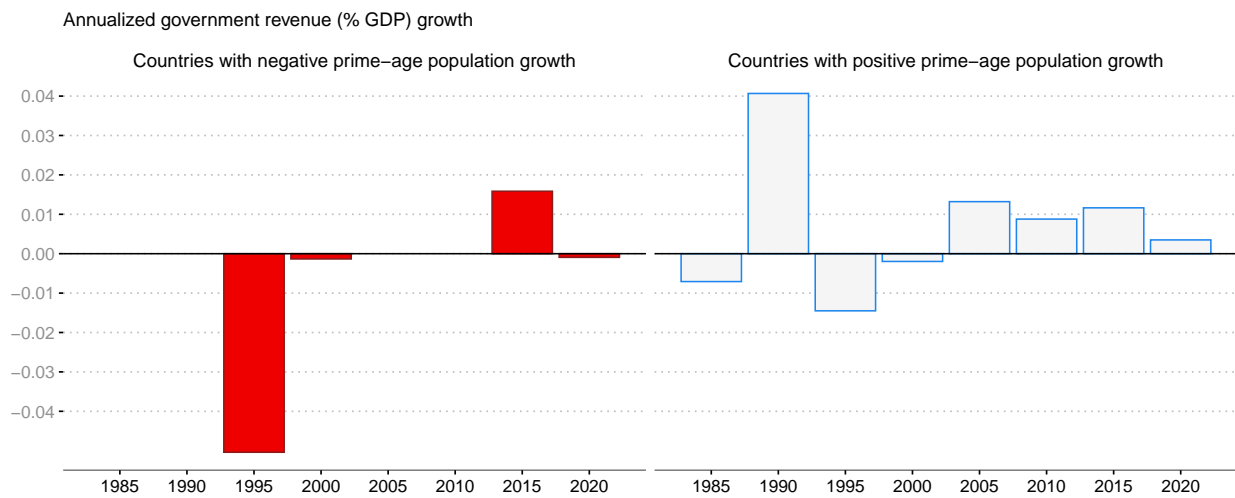


Table 3.1 compares growth rates of various measures during periods of negative and positive PAPG in high income countries (HIC) and upper middle income countries (UMIC) (For female labor force participation, labor force participation, and bond yields, we do not use growth rates, but rather differences, as changes in these variables, which are already in percentage form, are typically quoted in percentage points). The second column, the aggregation method, has two categories: between, and within. The third column, labor force growth, has two symbols: positive (+) and negative (-), denoting positive and negative PAPG. The *between* aggregation takes averages of all country-years of data with positive PAPG and compares it to the average of all country-years of data with negative PAPG. The *within* aggregation is limited to countries that have seen negative PAPG during the period covered by our data and also have data on a prior period of positive PAPG. For those countries we took an average of the variable of interest during the period(s) of positive PAPG and then during the period(s) of negative PAPG, within that one country, before averaging the positive and negative country average PAPG period growth rates across countries (effectively weighting each country's average equally).

Focusing on a few results:

- GDP shifts are quite large. Looking at the within numbers for HICs experiencing positive prime-age population growth saw, on average, 2.9 percent annual GDP growth. Those same countries during periods of negative population growth saw around 1.4 percent annual GDP growth. Regarding GDP per capita, while the between numbers suggest slightly faster growth in negative PAPG countries, the within numbers suggest growth dropping from 1.9 percent to 1.5 percent in the case of HICs.
- Growth in government expenditures are higher during periods of negative PAPG. For example, UMICs with negative PAPG experienced a 1.1 percent annual rise in expenditures, while positive PAPG periods in those same countries saw on average essentially no change. While for HICs government revenue grew at a slower rate during periods of negative prime-age population growth, for UMICs, government revenue actually grew faster on average.
- Moving to CPI, inflation rises more slowly on average in HICs as countries move into negative PAPG (the within picture suggests the reverse for UMICs).
- Total labor force participation (unsurprisingly) declines faster or grows slower in countries as they move into negative PAPG. Female labor force participation (FLFP) on

average falls in high income countries during negative PAPG, but seems to grow faster during negative PAPG in UMICs.

Table 3.1: Growth (%) during periods of working age population decline vs. periods of working age population growth

Number of country-years (between), or country means (within), are in parentheses.

Variable	Aggregation Method	Labor Force Growth	HIC	UMIC
10 year bond yields	Between	+	-.25 (432)	-.27 (159)
		-	-.34 (127)	-.21 (45)
	Within	+	-.33 (12)	-.33 (4)
		-	-.31 (16)	-.23 (6)
Consumer Price Index	Between	+	2.6 (701)	35 (242)
		-	1.4 (232)	28 (45)
	Within	+	2.6 (20)	7.6 (6)
		-	1.6 (24)	22 (6)
Female LFP	Between	+	.35 (864)	.29 (555)
		-	.14 (271)	.021 (159)
	Within	+	.31 (26)	.15 (13)
		-	-.51 (31)	.29 (21)
GDP	Between	+	2.8 (1130)	3 (930)
		-	1.5 (286)	1.5 (186)
	Within	+	2.9 (26)	2.3 (15)
		-	1.4 (36)	.38 (22)
GDP per capita	Between	+	1.3 (1130)	1.6 (930)
		-	1.7 (286)	2 (186)
	Within	+	1.9 (26)	1.9 (15)
		-	1.5 (36)	.75 (22)
Govt expenditures	Between	+	.82 (964)	1.1 (833)
		-	1.4 (292)	.77 (176)
	Within	+	.96 (26)	.0089 (14)
		-	1.3 (37)	1.1 (23)
Govt revenue incl. Social Contributions	Between	+	.49 (882)	.38 (663)
		-	.26 (239)	.52 (139)
	Within	+	.5 (25)	-.36 (15)
		-	-.52 (30)	1.6 (21)
Stock Index inflation adjusted	Between	+	7.5 (512)	6.7 (190)
		-	6.8 (150)	8.3 (32)
	Within	+	7.4 (14)	9.2 (5)
		-	10 (17)	10 (5)
Total LFP	Between	+	.11 (864)	.14 (555)
		-	-.015 (271)	-.0055 (159)
	Within	+	.13 (26)	.52 (13)
		-	-.68 (31)	.18 (21)

NOTE — The *between* aggregation simply takes averages of all country-years of data with positive PAPG and compares it to the average of all country-years of data with negative PAPG. The *within* aggregation is limited to countries that have seen negative PAPG during the period covered by our data and also have data on a prior period of positive PAPG. For those countries we took an average of the positive and an average of the negative periods of growth before averaging the positive and negative PAPG period growth rates across countries. For female labor force participation labor force participation and yields we do not use growth rates but rather differences as changes in these variables (which are already in percentage form) are typically quoted in percentage points. ILO estimates are non-modeled national reports. Government revenue includes social contributions. Venezuela CPI data was omitted.

Table 3.2 reports annual two way fixed effects regressions that regress PAPG on the variables of interest. We see that higher PAPG is correlated with lower government expenditure, greater revenue, higher 10 year yields, and greater stock index returns, but suggests an insignificant effect on growth and labor force participation.

Table 3.3 shows the same regressions, but we add an indicator variable that allows for a disjoint intercept at zero. Table 3.4 also adds an interaction term, allowing for a disjoint intercept and different slopes with negative and positive PAPG. Looking at the coefficients for $PAPG < 0$ in both tables that are relatively stable, we see that real GDP per capita growth, while unconditionally uncorrelated with PAPG (Table 3.2), is on average lower by 0.9 percentage points when PAPG is negative. And 10 year yields are lower by 0.7-0.8 percentage points.

Table 3.2: Two way fixed effects regression

	Real GDP/Capita % growth	Govt ex- penditure (% GDP)	Govt revenue (% GDP)	Inflation %	10 year yield	Stock index % growth	Female labor force participa- tion	Labor force participa- tion
PAPG	0.3	-1.6****	-0.9***	1.1****	0.5****	2.8**	0.5	0.3
Num.Obs.	3112.0	1406.0	1380.0	3285.0	1182.0	1788.0	1859.0	1859.0
R2	0.3	0.9	0.9	0.4	0.7	0.3	0.8	0.7
R2 Adj.	0.3	0.9	0.9	0.3	0.7	0.2	0.8	0.6
R2 Within	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2 Within Adj.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RMSE	3.2	3.3	3.1	8.8	2.3	22.5	5.7	4.5
FE: Year	X	X	X	X	X	X	X	X
FE: Country	X	X	X	X	X	X	X	X

Note:

OLS of variable of interest on annual percent PAPG, with country and year fixed effects. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

Table 3.3: Local linear regression with different intercepts

	Real GDP/Capita % growth	Govt ex- penditure (% GDP)	Govt revenue (% GDP)	Inflation %	10 year yield	Stock index % growth	Female labor force participa- tion	Labor force participa- tion
PAPG	0.1	-1.4****	-0.9**	1.2****	0.3***	3.4**	0.2	0.0
PAPG<0	-0.9****	0.7*	-0.3	0.8**	-0.9***	3.4	-1.6***	-1.3***
Num.Obs.	3112.0	1406.0	1380.0	3285.0	1182.0	1788.0	1859.0	1859.0
R2	0.3	0.9	0.9	0.4	0.7	0.3	0.8	0.7
R2 Adj.	0.3	0.9	0.9	0.3	0.7	0.2	0.8	0.6
R2 Within	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2 Within Adj.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RMSE	3.2	3.3	3.1	8.8	2.2	22.5	5.7	4.5
FE: Year	X	X	X	X	X	X	X	X
FE: Country	X	X	X	X	X	X	X	X

Note:

OLS of variable of interest on annual percent PAPG and an indicator variable of whether PAPG is negative, with country and year fixed effects. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

Table 3.4: Local linear regression with different intercepts and slopes

	Real GDP/Capita % growth	Govt ex- penditure (% GDP)	Govt revenue (% GDP)	Inflation %	10 year yield	Stock index % growth	Female labor force participa- tion	Labor force participa- tion
PAPG	0.1	-1.5****	-1.0***	1.3****	0.3**	3.3**	0.0	-0.1
PAPG<0	-0.6**	1.2**	-0.1	0.3	-0.8***	4.8**	-0.6	-0.9
PAPG × PAPG<0	0.9*	1.3**	0.5	-1.6	0.3	4.9	2.6	1.2
Num.Obs.	3112.0	1406.0	1380.0	3285.0	1182.0	1788.0	1859.0	1859.0
R2	0.3	0.9	0.9	0.4	0.7	0.3	0.8	0.7
R2 Adj.	0.3	0.9	0.9	0.3	0.7	0.2	0.8	0.6
R2 Within	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2 Within Adj.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RMSE	3.2	3.3	3.1	8.8	2.2	22.5	5.7	4.5
FE: Year	X	X	X	X	X	X	X	X
FE: Country	X	X	X	X	X	X	X	X

Note:

OLS of variable of interest on annual percent PAPG, an indicator variable of whether PAPG is negative, and an interaction term, with country and year fixed effects. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

Finally, we look at a narrower set of HICs and UMICs which experienced 10 consecutive years of negative PAPG. We measure their outcomes relative to all other UMICs and HICs. We graph the relative performance of these countries that switched from positive to negative PAPG for 10 years on either side of the switch.

Let X be the variable of interest, and G be all the countries that experienced a 10-year consecutive negative prime-age population decline. $\text{HIC UMIC} \setminus G$ are all countries that have HIC or UMIC classifications in 1989 that are not in G . Let t be the year, and let τ_i be the initial year of the negative prime-age population decline for country i .

The countries in G and their first year of consecutive negative prime-age population decline τ_i are shown in Table 3.5.

Table 3.5: Countries with 10 years of consecutive negative prime-age population decline

Country	First Year (τ_i)
Spain	2011
Finland	2011
Netherlands	2011
Portugal	2006
U.S. Virgin Islands	2004
Greece	2003
Puerto Rico	2002
Germany	1997
Hungary	1997
Japan	1996
Romania	1995
Guam	1951
Ireland	1951

First, we take a ratio of the variable of interest (e.g. GDP) for our negative PAPG country compared to all the UMICs and HICs (excluding those in G):

$$R_{i,t} = \frac{X_{i,t}}{\text{mean}(X_{\text{HIC UMIC} \setminus G, t})}$$

The index we construct for a single country i at time t is

$$\text{index}_{i,t} = \frac{R_{i,t}}{R_{i,\tau_i}} \cdot 100$$

We center this index based on the initial year of negative prime-age population decline (τ_i) for every country in G . Thus, when graphing, we graph $\text{index}_{\text{Japan}, t - \tau_{\text{Japan}}}$ together with $\text{index}_{\text{Germany}, t - \tau_{\text{Germany}}}$ on the same x axis location. This construction ensures that the index value for the year τ_i will always be 100. We also plot an unweighted average of these indices in red.

Figure 4 shows the result. We see a relative drop in inflation before and after negative prime-age population growth. Negative prime-age population growth is associated with declining labor force participation. And, again, it is associated with declines in GDP, GDP per capita, government revenue, government expenditures, and stock indices. We also see a rise in yields, but this is driven by Greece, which is an outlier due to the debt crisis.

4 Conclusion

Figure 5 uses historical data and UN forecasts to present the proportion of the world's population living in countries experiencing positive and negative PAPG over time 1950-2100. The effects associated with negative PAPG will spread from a few, predominantly high and upper middle income countries to more of the world. A declining working age population may be associated with a rising labor share of income as well as (arguably) greater environmental sustainability. But these effects may also include lower economic growth, declining government revenues, flat or declining labor force participation and lower investment returns. That suggests a less favorable economic environment and lends credence to the idea that the switch to negative PAPG may strand assets.

With regard to mitigation strategies, automation and artificial intelligence may well reduce demand for labor in particular occupations, as well as improve overall productivity,⁷ but there is little evidence of widespread impact to date. For example, robots remain highly concentrated in manufacturing where employment is already predicted to fall.⁸ Raising the retirement age has proven politically very challenging, while female workforce participation rates appear to have peaked.⁹ This leaves migration as an effective option for the countries

⁷Damioli, G., Van Roy, V., Vertesy, D. (2021). The impact of artificial intelligence on labor productivity. *Eurasian Business Review*, 11, 1-25.

⁸Cette, G., Devillard, A., & Spiezia, V. (2021). "The contribution of robots to productivity growth in 30 OECD countries over 1975-2019." *Economics Letters*, 200, 109762.

⁹Axelrad, Hila, and Kevin J. Mahoney. 2017. "Increasing the Pensionable Age: What Changes Are OECD Countries Making? What Considerations Are Driving Policy?" *Open Journal of Social Sciences* 5 (7): 56-70. and on female labor force participation, World Bank data suggests that globally it fell

leading the way in labor force decline, but it is worth noting that as potential sending countries grow richer and older and eventually enter labor force decline themselves, this source of workers will begin to dry up.¹⁰

from 51 percent in 1990 to 48 percent on the eve of the Covid-19 pandemic (male participation has been falling faster, but from a higher level) <https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS>, <https://data.worldbank.org/indicator/SL.TLF.CACT.ZS>

¹⁰Kenny, C., & Yang, G. (2021). “Can Africa Help Europe Avoid Its Looming Aging Crisis?” Center for Global Development

Figure 4: Responses to negative prime-age population growth (PAPG)

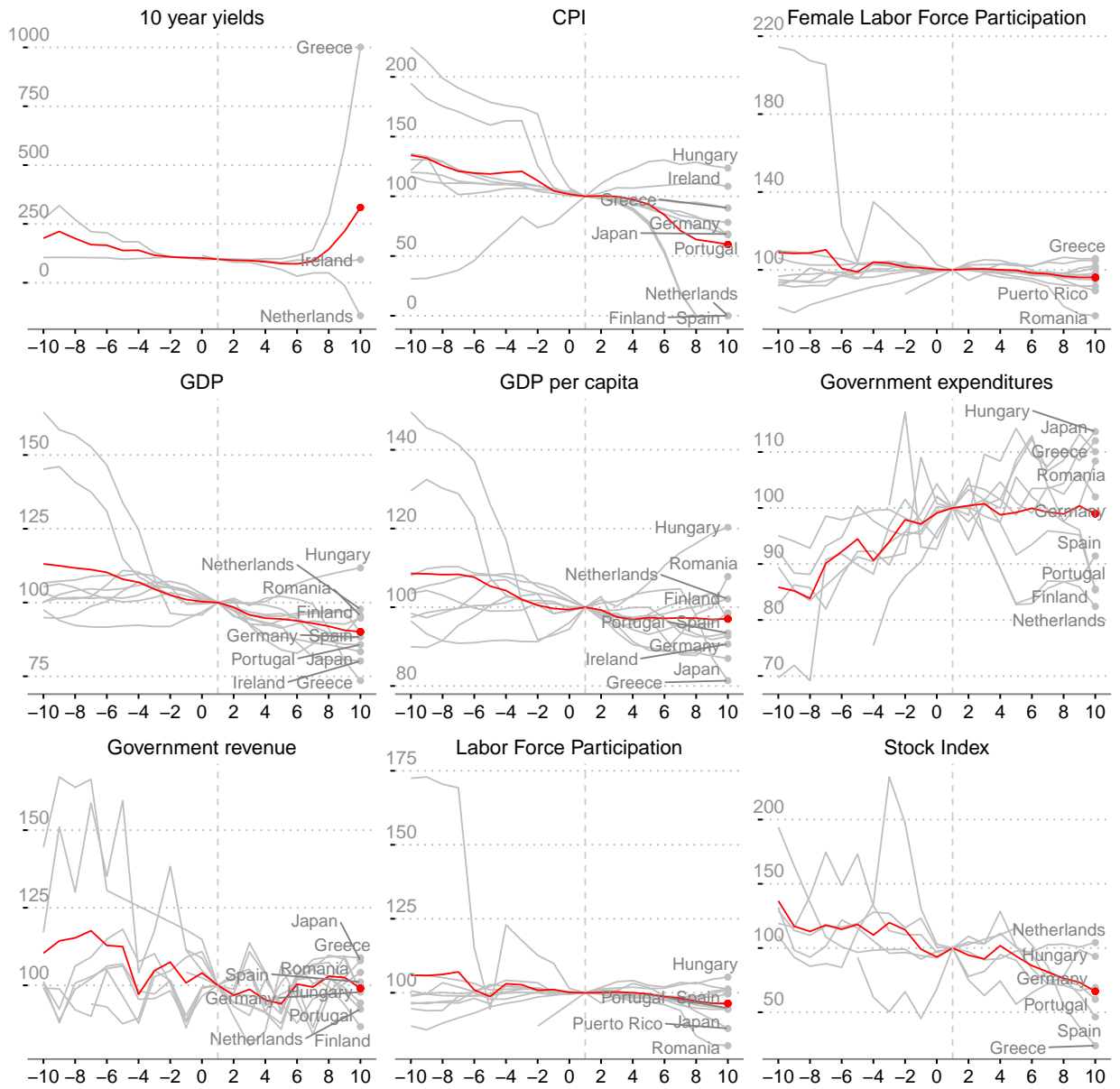


Figure 5: Proportion of global population in country experiencing negative or positive prime age population growth (PAPG)

Percent of global population living in countries where growth in working age population (15–64) is expected to grow or decline

