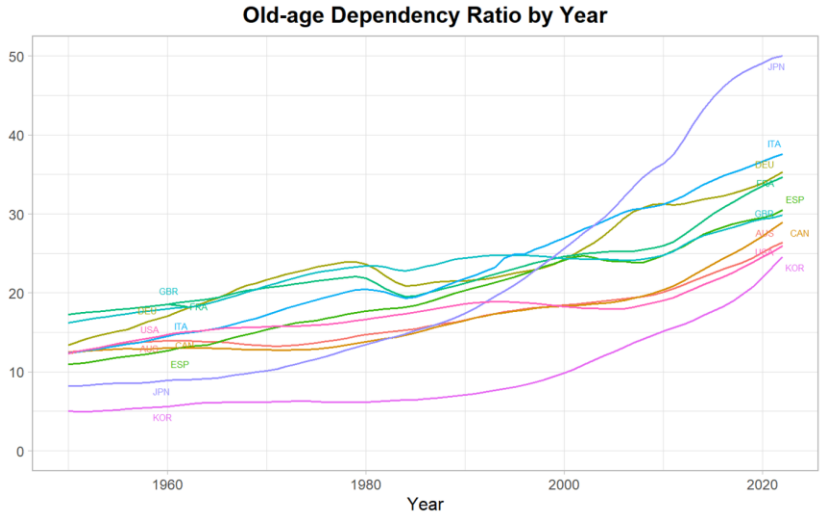
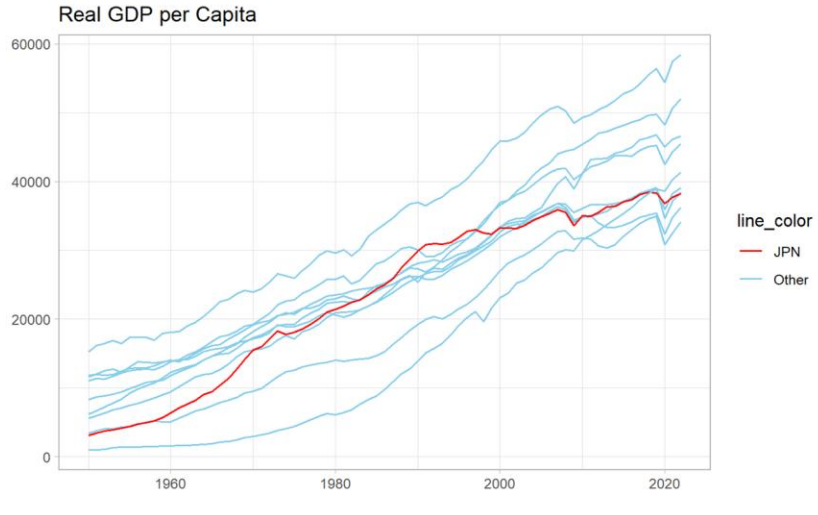
# Population Age Structure and Contemporary Low Fertility: Evidence from Long-Term Changes in Dependency Ratios

**© Junko Koie, Japan Post Insurance System Solutions**
*This presentation has been prepared for the 33rd International Congress of Actuaries.*
*The Institute of Actuaries of Japan (IAJ) and the International Actuarial Association (IAA) assume no responsibility for the opinions or content expressed in these presentation slides. Furthermore, the opinions and content contained herein do not necessarily reflect the views of the IAJ or the IAA.*

# Japan has experienced rapid population ageing, while GDP per capita has continued to grow, albeit at a relatively low rate.




Notes: The old-age dependency ratio is defined as the population aged 65 and over divided by the population aged 15–64.
Source: Source: Author's calculations based on data from United Nations, World Population Prospects 2024.



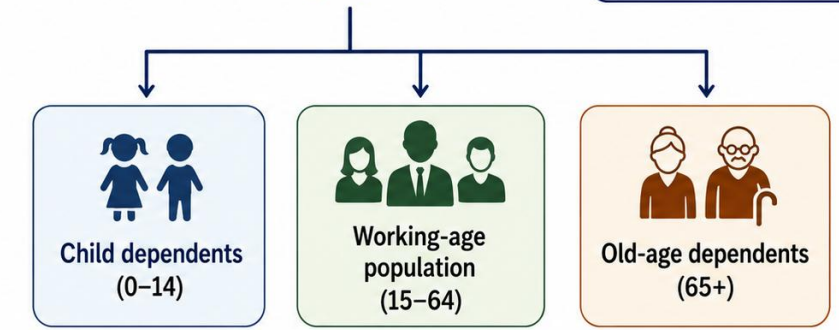

Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# GDP per Capita and Dependency Structure

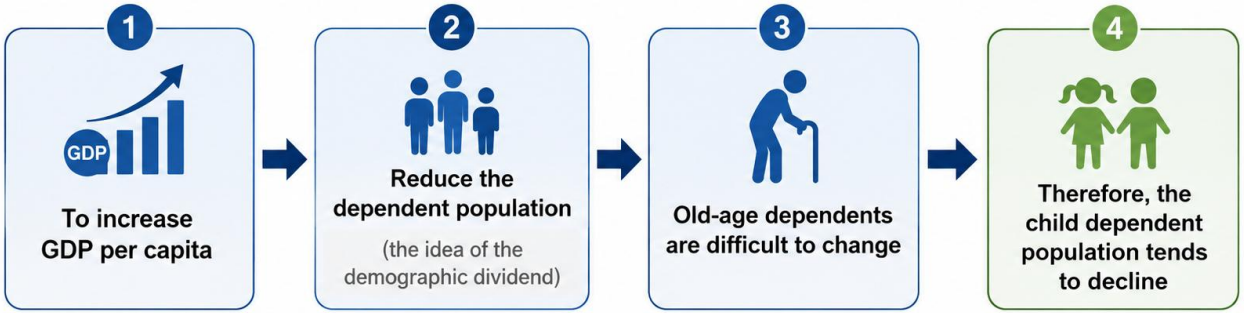
**GDP per capita** = $\frac{\text{GDP}}{\text{Total population}}$

GDP in the numerator is generated mainly by the working-age population.

1. The denominator of GDP per capita is the total population, which includes the dependency-age population.
2. GDP in the numerator is generated mainly by the working-age population.
3. A smaller dependency-age population is advantageous for increasing GDP per capita — the idea of the demographic dividend.
4. The dependency-age population consists of child dependents and old-age dependents.



# Conceptual Framework




## Research Questions

1. What is the relationship between the increase in the old-age dependency ratio and the decline in the child dependency ratio?
2. What explains contemporary low fertility?

# Data Sources and Sample Selection

## Data Sources

- **Population data** — *World Population Prospects 2024*
  United Nations, Department of Economic and Social Affairs, Population Division (2024)
- **GDP per capita** — *Maddison Project Database 2023*
  Bolt and van Zanden, with minor processing by Our World in Data

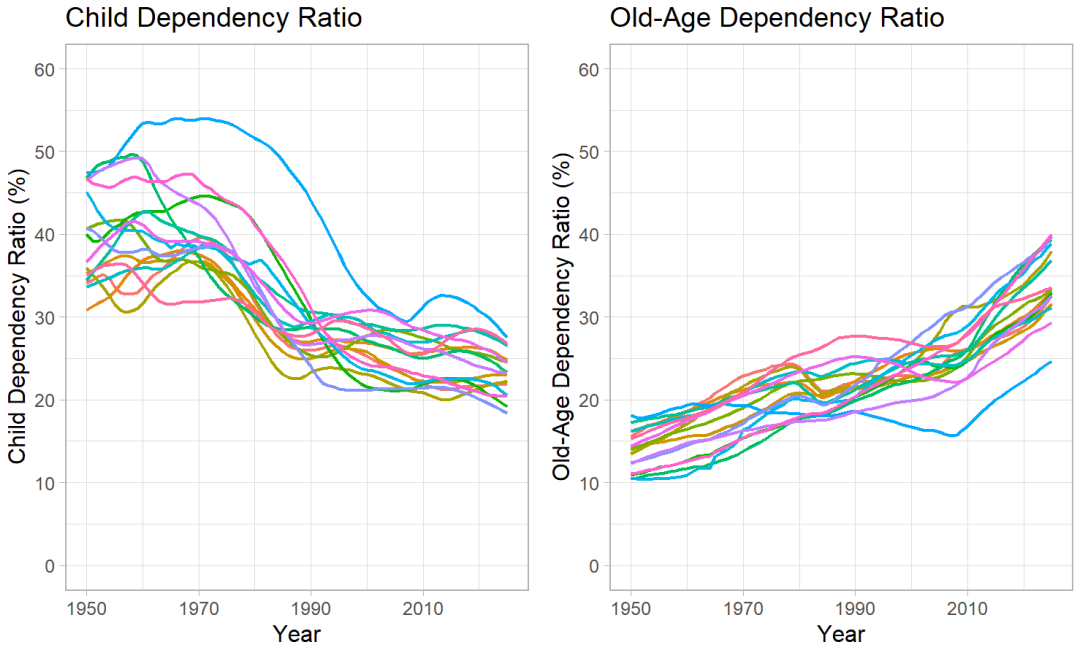
## Sample Selection and Extension

- **Initial sample:** 16 European countries selected using two criteria in 2000:
  - GDP per capita exceeding **20,000 international dollars**
  - Population exceeding **two million**
- **Extended sample:** East Asia, North America, and Oceania satisfying the same economic and population criteria

# ANALYSIS OF DATA FROM EUROPEAN COUNTRIES

# Long-Term Changes in Dependency Ratios in European Countries

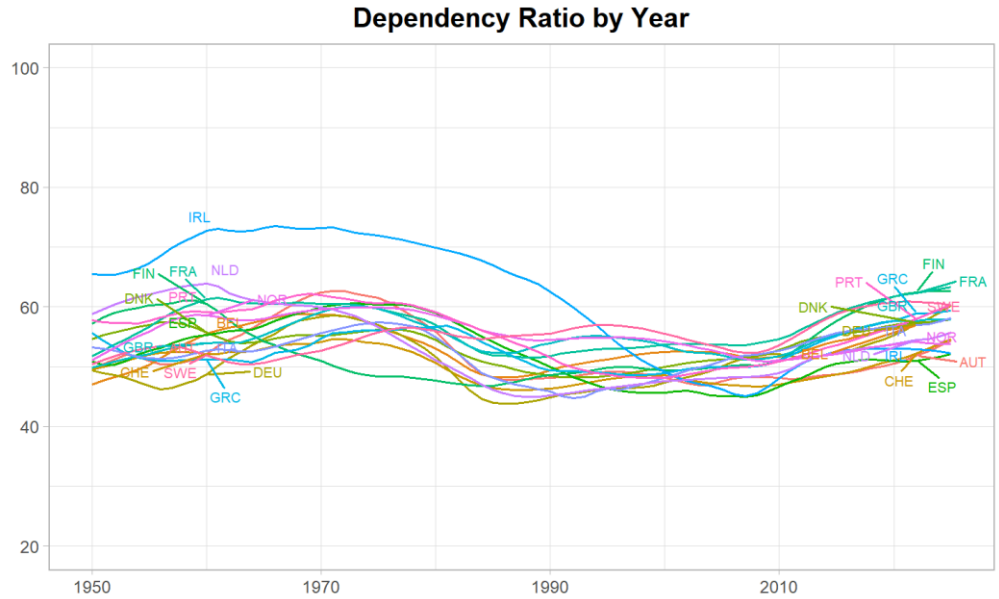
**The child dependency ratio has declined, while the old-age dependency ratio has increased.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# Long-Term Changes in the Total Dependency Ratio in European Countries

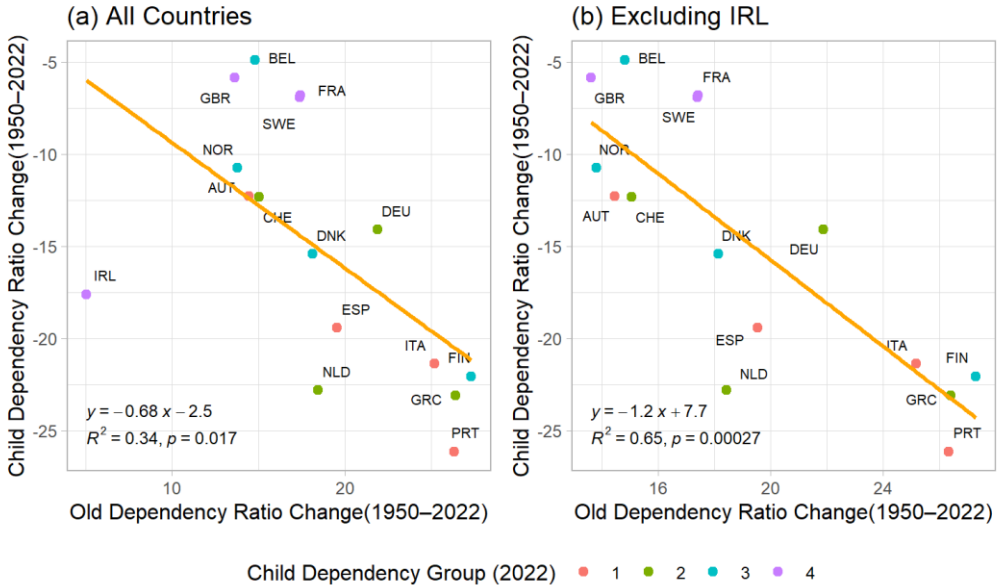
**When combined, the opposing trends largely offset each other, resulting in a relatively stable total dependency ratio.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# Changes in Child and Old-Age Dependency Ratios, 1950–2022

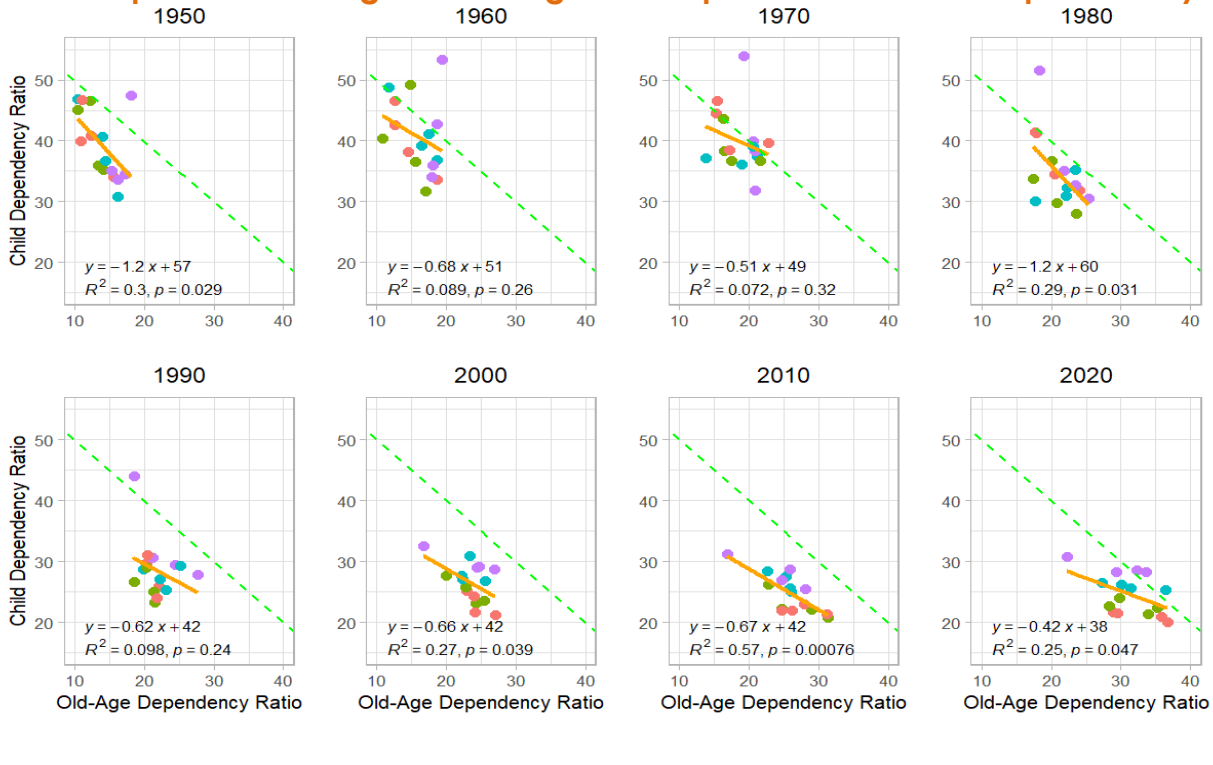
**Countries with larger increases in the old-age dependency ratio tended to experience larger declines in the child dependency ratio.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# Cross-Sectional Relationship between Child and Old-Age Dependency Ratios

**The relationship remained negative throughout the period and became particularly clear after 2000.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# What We Have Found So Far

- Over the period from 1950 to 2022, declines in the child dependency ratio and increases in the old-age dependency ratio were closely related across countries and tended to offset each other.
- In the year-by-year cross-sectional analysis, the child and old-age dependency ratios have been negatively correlated in every year since 2000.

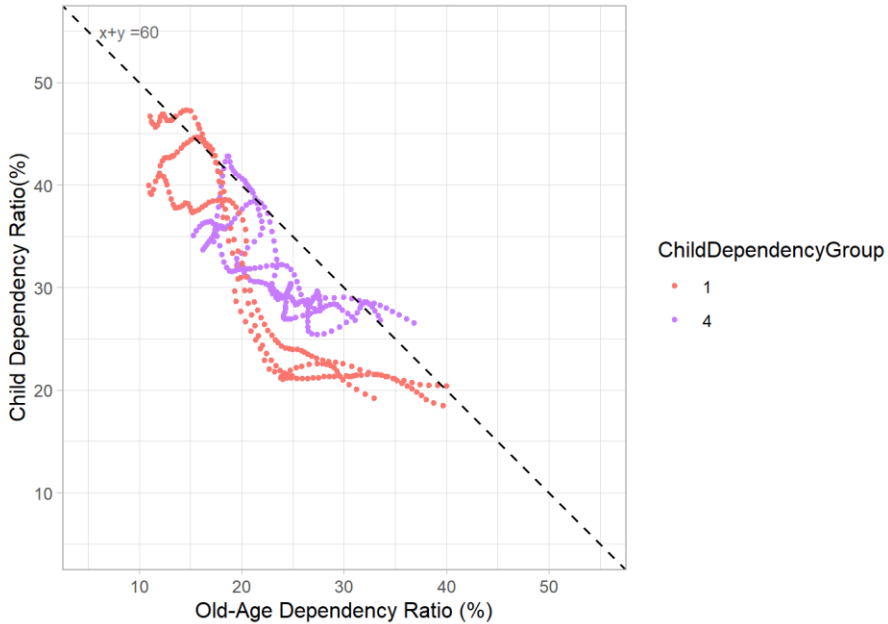
# Next Step

**Focus:** Countries with low child dependency ratios in 2022

**Objective:** Explore how these low levels emerged by examining historical changes in child and old-age dependency ratios

# Long-Term Trajectories of Countries with the Lowest and Highest Child Dependency Ratios in 2022

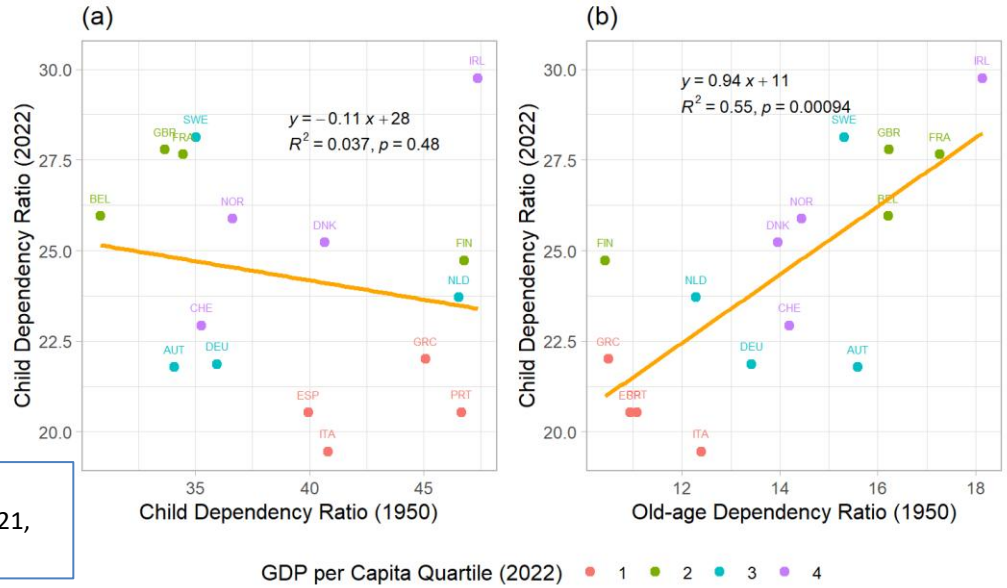
**Countries with the lowest child dependency ratios in 2022 started with relatively high child dependency ratios and low old-age dependency ratios in the 1950s.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# Dependency Ratios in 1950 and the Child Dependency Ratio in 2022

**The child dependency ratio in 2022 was more closely related to the old-age dependency ratio in 1950 than to the child dependency ratio in 1950.**



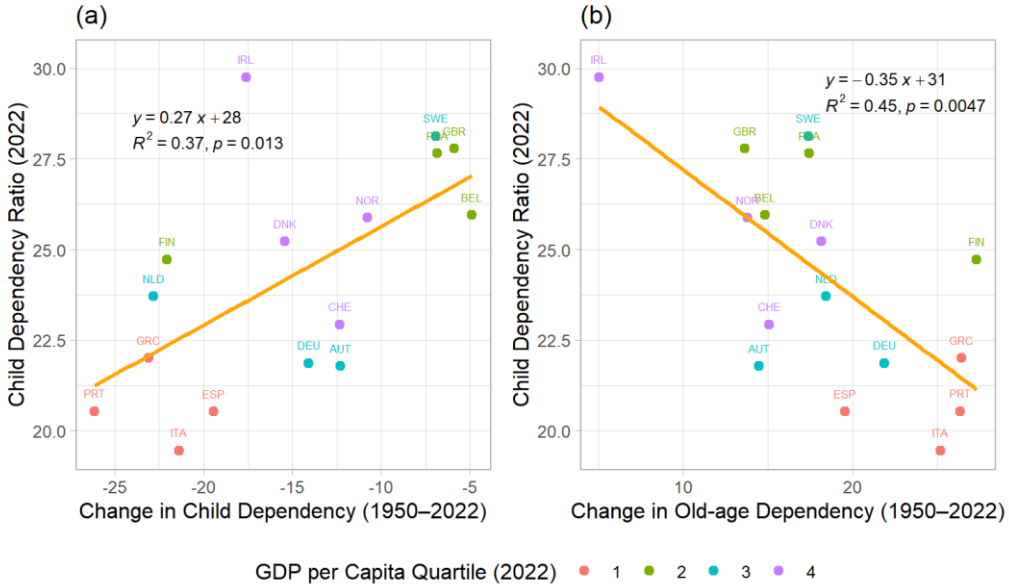

(a)Excuding IRL
y=-0.24x+33,R2=0.21,
p=0.089

Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# Long-Term Changes in Dependency Ratios and the Child Dependency Ratio in 2022

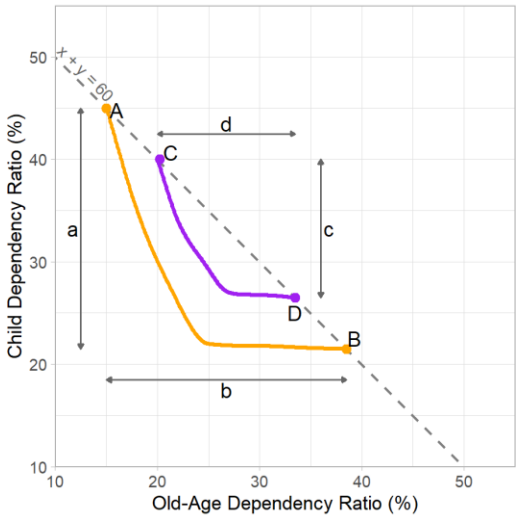
**Countries with lower child dependency ratios in 2022 experienced larger declines in child dependency and larger increases in old-age dependency from 1950 to 2022.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# Summary of the Long-Term Patterns Identified




A and C: 1950
B and D: 2022

If Y(B) < Y(D):

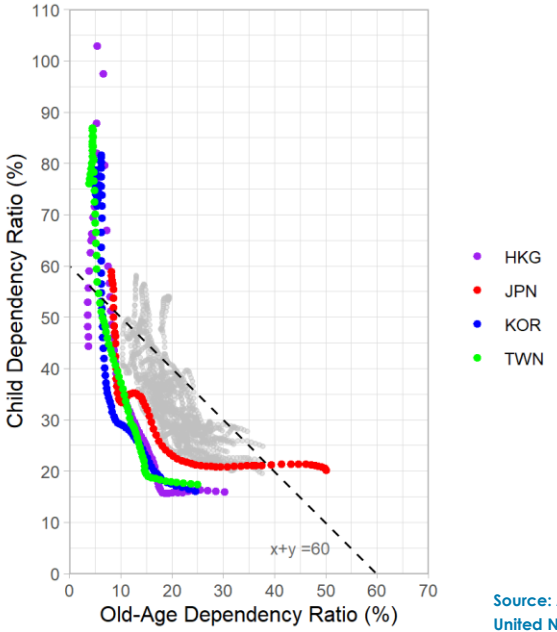
If trajectory AB ends with a lower child dependency ratio in 2022 than trajectory CD:

| Relationship | Short explanation |
|---|---|
| ① Y(A)>Y(C) | Higher child dependency in 1950 |
| ② X(A)<X(C) | Lower old-age dependency in 1950 |
| ③ a > c | Larger decline in child dependency |
| ④ b > d | Larger increase in old-age dependency |

# ANALYSIS OF THE EXTENDED SAMPLE

# Long-Term Dependency-Ratio Trajectories in the Extended Sample, 1950–2022

**The four East Asian economies moved from high child and low old-age dependency in 1950 toward very low child dependency by 2022—a trajectory broadly consistent with the pattern observed in Europe.**




**Light-gray trajectories:**
Other countries in the extended sample, including the European sample

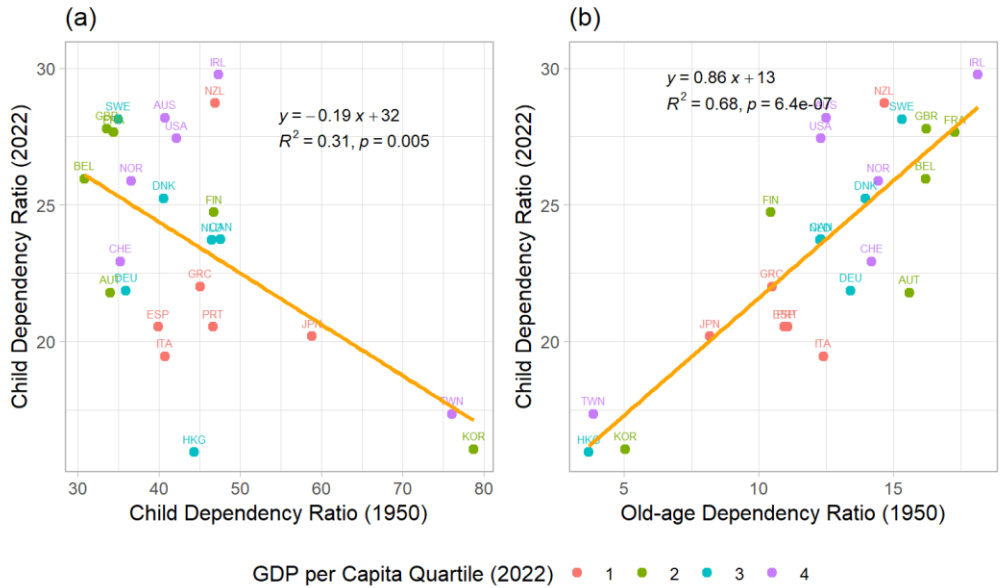
**Japan:** Population ageing is more advanced, and its trajectory extends much farther to the right.
**Hong Kong, Korea, and Taiwan:** Child dependency is already very low, but old-age dependency has not yet risen as far as in Japan.

※ Differences in the stage of population ageing should be kept in mind when interpreting the following results.

Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

# Dependency Ratios in 1950 and the Child Dependency Ratio in 2022

**As in the European sample, the child dependency ratio in 2022 was more closely related to the old-age dependency ratio in 1950 than to the child dependency ratio in 1950.**

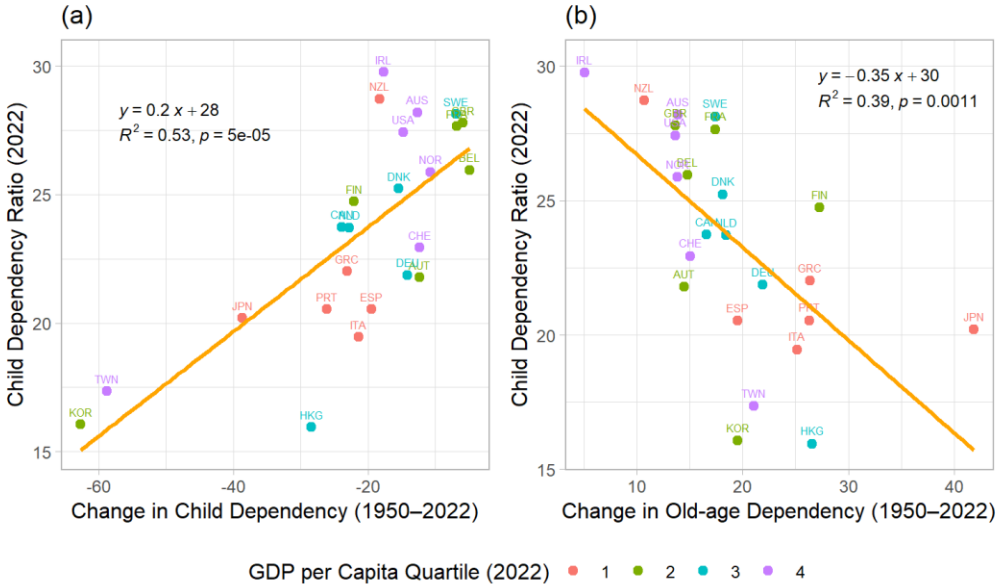



Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# Long-Term Changes in Dependency Ratios and the Child Dependency Ratio in 2022

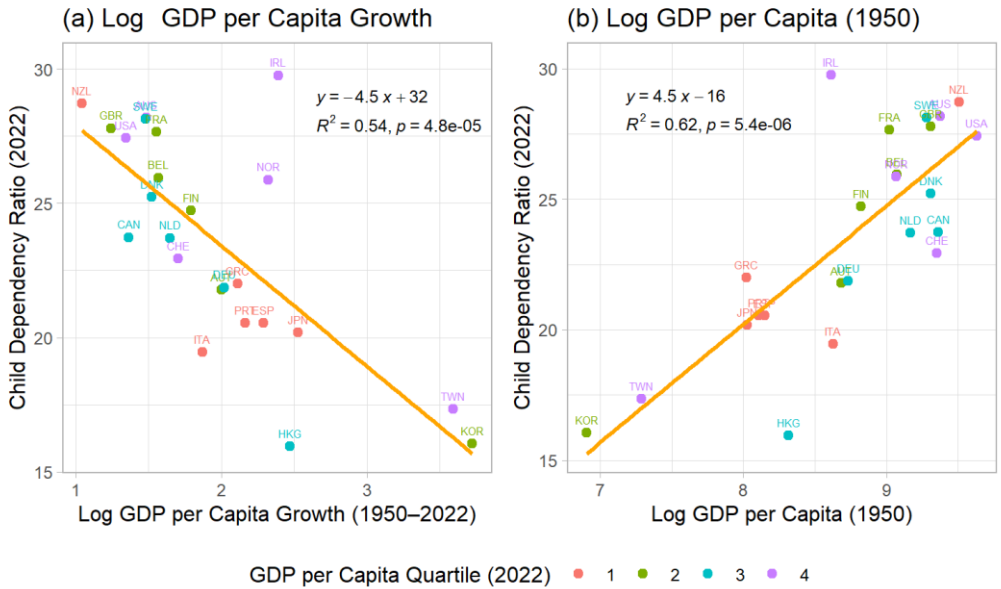
**As in the European sample, countries with lower child dependency ratios in 2022 experienced larger declines in child dependency and larger increases in old-age dependency from 1950 to 2022.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.
Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# Economic Development and the Child Dependency Ratio in 2022

**GDP per capita is correlated with the child dependency ratio in 2022, both in terms of its growth from 1950 to 2022 and its level in 1950.**




Source: Author's calculations based on data from United Nations, World Population Prospects 2024.

Source: Author's calculations based on data from Bolt and van Zanden – Maddison Project Database 2023 – with minor processing by Our World in Data.

# Low Fertility: A Cost of Economic Growth?

## Demographic dividend studies

**Dependency ratios**
(treated as given)

help explain →

**Economic growth**

## This study: observed relationships

**Historical population age structure**

**Greater GDP per capita growth**
1950–2022

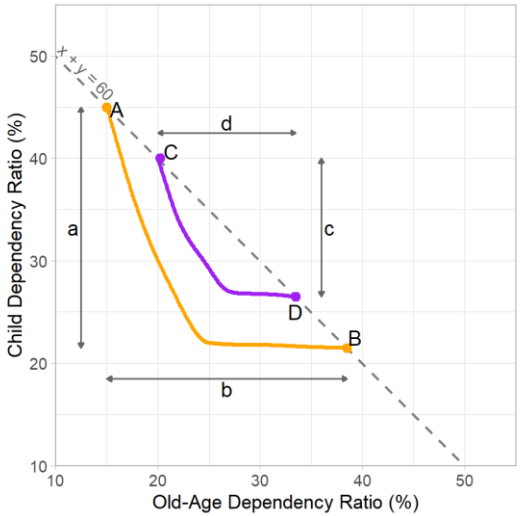
associated with

**Lower child dependency ratios in 2022**

**Possible interpretation** Causality is not established

**Low fertility as a possible consequence and cost of economic growth**

# Summary of Findings




## European countries

A negative correlation between the child and old-age ratios from 2000 onward

## Extended Sample

If Y(B) < Y(D):

① Y(A)>Y(C) Higher child dependency in 1950

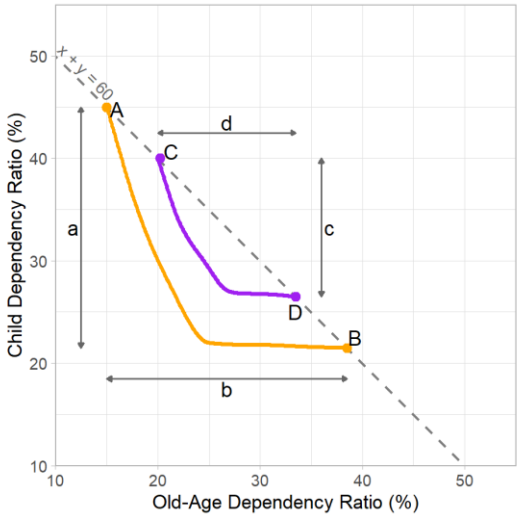
② X(A)<X(C) Lower old-age dependency in 1950

③ a > c Larger decline in child dependency

④ b > d Larger increase in old-age dependency

**GDP per capita** is also correlated with the child dependency ratio in 2022

# unresolved question



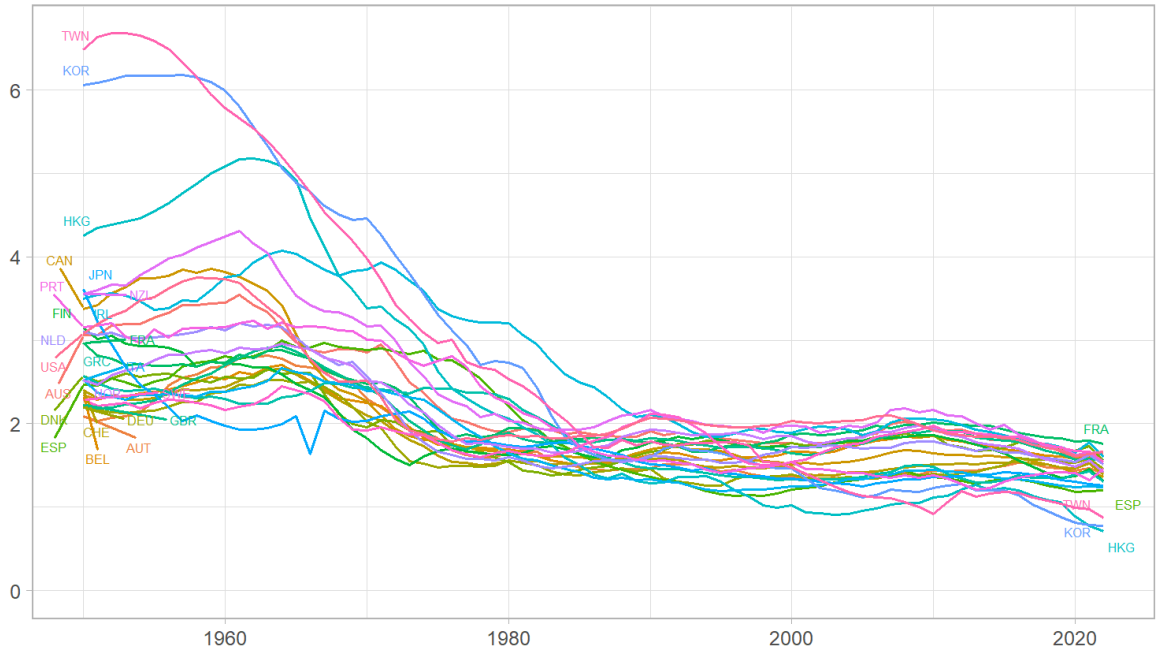

Why did countries with initially high child dependency ratios continue toward particularly low levels, rather than stabilizing at levels comparable to those of other countries?

# THANK YOU

# QUESTIONS?

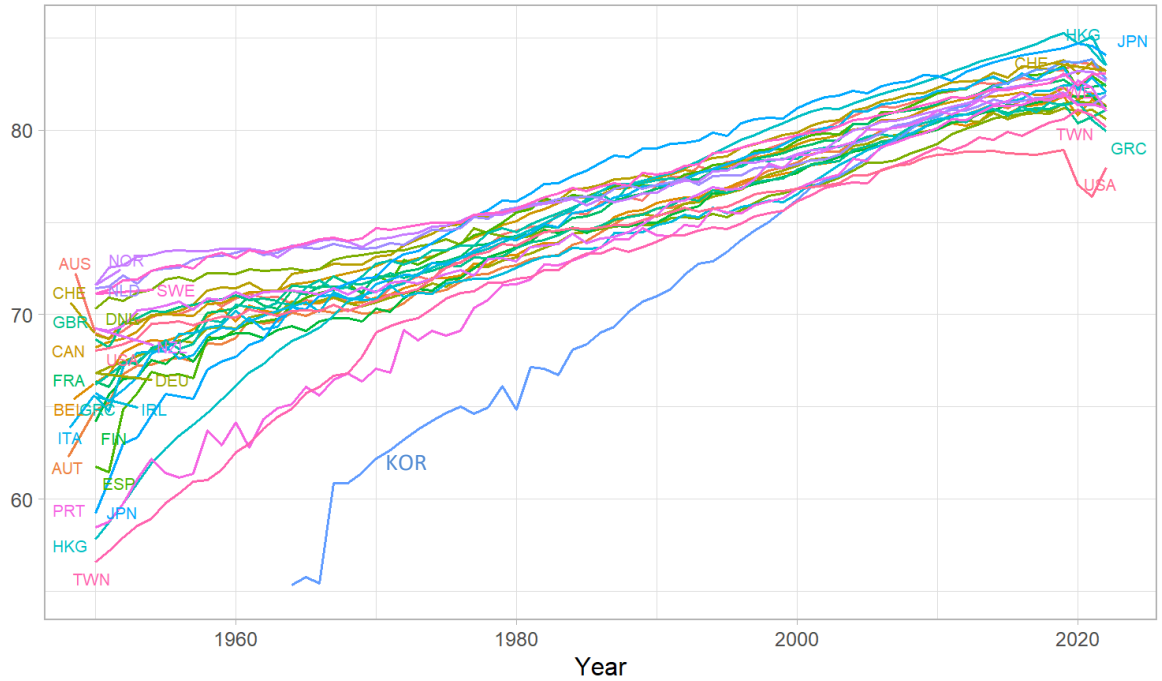
Appendix

# Total Fertility Rate, 1950–2022



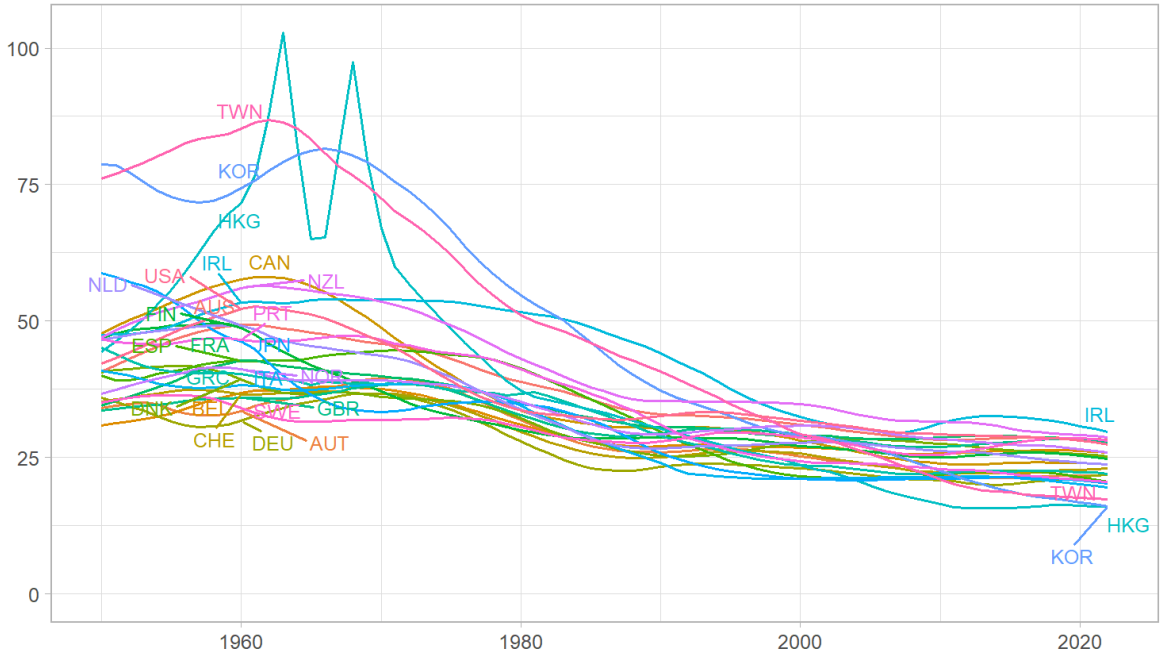
Appendix

# Life Expectancy at Birth, 1950–2022



Appendix

# Child Dependency Ratio, 1950–2022



Appendix

# Old-age Dependency Ratio, 1950–2022

