

Declining Fertility, Human Capital Investment, and Economic Sustainability

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ABSTRACT Future fertility is a key input when charting the sustainability of social security systems, and declining fertility is often expected to put pressure on economic indicators, such as pension burden. Such expectations are based on a narrow view of the impact of fertility on the economy, focusing on age structure. Dynamic impacts—for instance, the potential for increased human capital for smaller cohorts—are mostly ignored. We use a dynamic longitudinal microsimulation model to explore the extent to which investments in human capital could offset the adverse economic impact of low fertility. Our research context is Finland, the fastest aging European country and the site of dramatic fertility declines and stagnant educational levels in the 2020s. We find that an ambitious but simple human capital investment strategy that keeps the total investment constant despite declining cohort size, thereby increasing per capita investment, can offset the negative impact of a smaller labor force on the pension burden. Human capital investment not only reduces pension burden but also increases working years, pension income, retirement years, and longevity. Policies focusing on human capital investment are likely a viable strategy to maintain economic sustainability.

KEYWORDS Low fertility • Human capital investment • Economic sustainability • Finland • Dynamic longitudinal microsimulation model

Introduction

The future path of fertility is a key input when charting the sustainability of social security systems. In low-fertility countries, declining fertility is expected to put pressure on key economic sustainability indicators, such as the old-age support ratio and pension burden (e.g., Folbre and Wolf 2013; Lee and Mason 2010, 2014). The mechanism in such calculations is often based on a static view of the impact of fertility on the economy, with the declining share of workers as the key force (Lutz et al. 2019).

Forecasts of the impact of low fertility rarely account for the fact that potential dynamic effects might offset some of the adverse effects of low fertility. By dynamic effects, we refer to mechanisms that operate through pathways other than the expected decline in the size of the labor force. Studies that include dynamic effects (e.g., Lutz et al. 2019) are exceptions to the rule, but they are often based

on models that are otherwise highly stylized and do not include context-specific nuances of complex economies.

Although countries are increasingly concerned about the long-term implications of low fertility, policies aimed at increasing fertility rarely succeed. Certain family policies show causal impacts on fertility. However, in settings where family policies are already well developed, young generations might take the existing support for granted, and policies might become less effective in the long run (Bergsvik et al. 2021). If low fertility is here to stay, as Skirbekk (2022) and others have argued, the key question is how societies adapt to low fertility.

We are interested in the potential of using the savings that result from the smaller birth cohorts in the educational system. Few earlier empirical studies assessed the long-term economic impact of this potential, often relying on cross-sectional data and making strong assumptions (e.g., Lee and Mason 2010; Mason and Lee 2006). We build on earlier notions of the importance of human capital for the demographic transition and for mitigating the challenges of population aging. For example, in a global analysis, Lutz et al. (2019) demonstrated that human capital is crucial for understanding demographic transitions and economic growth. They argued that economic growth is driven by human capital rather than by population age structure and that policies for sustainable development should therefore focus on human capital.

We combine a dynamic approach with a highly detailed multistate model of the economy to explore in a realistic setting the extent to which an ambitious human capital investment strategy could offset the adverse economic impacts of low fertility and the mechanisms through which it would operate. We base our analysis on Finland, which is a particularly interesting case because it is the fastest aging European country, has experienced dramatic declines in fertility since 2010, and has witnessed stagnating or even declining educational attainment (Rotkirch 2021).

We define key pension indicators as proxies of economic sustainability. We then analyze the long-term sensitivity of those indicators to different levels of low but stable fertility, such that some of the scenarios include an ambitious human capital investment strategy. We adopt a human capital investment strategy in which the total investment remains constant despite a shrinking student population. This constant investment increases the resources available to each student, operating on the intensive and extensive margins. We assume that educational investments are driven primarily by public sector investments, which is empirically largely the case. For example, in 2018, 82% of funding for educational institutions in OECD countries came from public funding. The proportions differ across countries. For example, public funding accounts for more than 95% of total educational spending in Finland, Norway, and Sweden but approximately two thirds of educational spending in Australia, the United Kingdom, and the United States (OECD 2021).

The human capital investment strategy that delivers these benefits is effectively a way of unlocking the so-called Easterlin effect, which argues that smaller cohorts benefit from access to more public resources and less competition (Easterlin 1978). We show how this effect benefits not just the smaller cohorts but the entire population.

Our results indicate that an ambitious but simple human capital investment strategy that keeps the total costs of education constant despite a declining number of students can offset much of the negative impact of a smaller labor force on the pension burden. Indeed, the positive impact is not limited to a reduced pension burden:

increased human capital also has a positive impact on the population's working years, retirement years, health, and longevity.

Our proposed human capital investment strategy is more feasible than alternatives that rely on setting top-down targets to increase fertility (Gietel-Basten et al. 2022). The strategy is highly feasible in the Finnish context, in particular. The country's educational attainment has been stagnant or even declining for recent cohorts, and the government has responded by setting ambitious goals to increase educational levels (Valtioneuvosto 2021). In such a context, demographic policy focusing on human capital (the "quality" dimension of the labor force) is likely to be more feasible and more effective in maintaining economic sustainability than attempts to increase fertility (the "quantity" dimension), although investment in human capital need not exclude efforts to sustain fertility in the long term. In this sense, our macro-level analysis mirrors the quantity–quality trade-off that economists since Becker (1960) have argued occurs at the micro level, with parents increasingly investing in the "quality" of the children at the expense of "quantity" when fertility declines.

Low and Late Fertility: Implications for the Society and Individuals

Declining fertility levels are a societal concern because they decrease the old-age support ratio and are therefore projected to put pressure on economic sustainability in the long run. Figure 1 shows the development of the observed and projected old-age support ratio in 2000–2090 based on UN Population Division forecasts (United Nations 2022). Finland has among the lowest old-age support ratios in the world: in 2022, there were 2.4 individuals aged 20–64 per every individual aged 65 or older. These values are very close to those of Italy and Portugal. Only Saint Helena, Japan, and Monaco rank lower than Finland.

The impact of decreasing fertility on the old-age support ratio comes with a delay. Lower fertility levels today will appear as a shrinking workforce approximately 20 years from now. In Finland, there are approximately 60,000–75,000 individuals per birth cohort aged 20–64. Comparatively, approximately 50,000 or fewer children were born per year during the past five years, reflecting the declining fertility rates observed in the last decade. In the long run, such small birth cohorts would lead to a shrinkage of the working-age population, placing additional pressure on the old-age support ratio. For instance, the old-age support ratio would decline to 1.4 by 2090 if the TFR remains at 1.45 or to 1.3 if the TFR remains at 1.3 (Figure 1).

However, lower and later fertility might also elicit benefits for individual parents, the children, and cohorts of children. In particular, the cohort of children might benefit from lower fertility through the Easterlin effect of smaller cohorts. A smaller cohort means that more public resources are available per child unless these resources are scaled down in response to smaller cohorts. Smaller cohorts might also face less labor market competition among peers (Easterlin 1978). Depending on the substitutability between young and old workers and between the higher and lower educated, the size of the cohort at young adult ages could alter their relative earnings and incentives for education. The U.S. postwar baby boomers have been studied extensively with regard to the links between cohort size and educational attainment and earnings (Connelly 1986; Stapleton and Young 1988; Welch 1979). Recent empirical studies

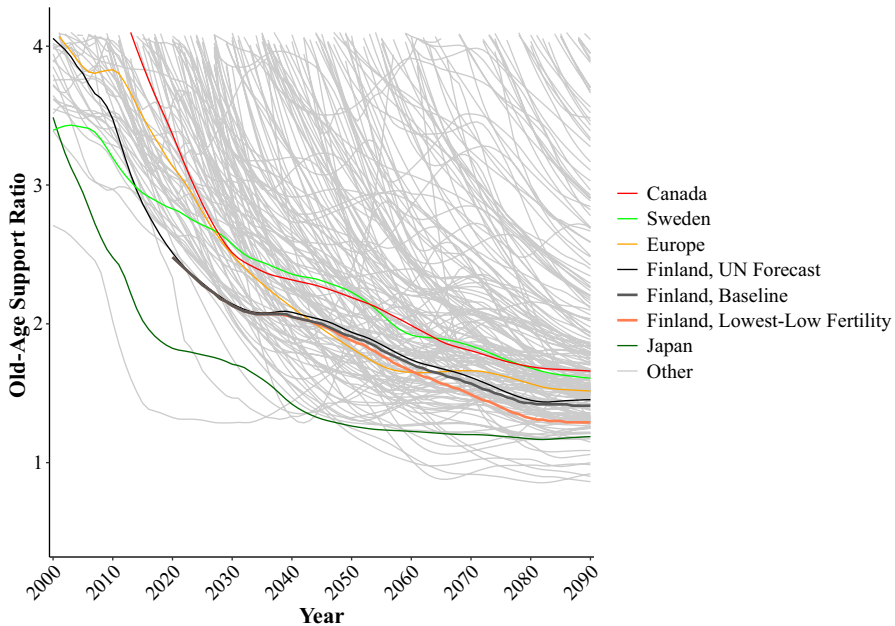


Fig. 1 The old-age support ratio (observed and forecasted) for all countries/regions in 2000–2090 calculated using the UN Population Division forecasts (United Nations 2022) and for Finland in the baseline and lowest-low fertility scenarios

have expanded to other contexts and cross-country analyses, with many finding that smaller cohorts facilitate human capital accumulation and higher earnings for cohort members (e.g., Babcock et al. 2012; Bound and Turner 2007; Brunello 2010; Fertig et al. 2009).

However, the link between cohort size and human capital accumulation—or, more directly, educational attainment—depends crucially on how dynamically the educational system responds to a smaller cohort size (e.g., Lee and Mason 2010). For example, Kaufmann (2005) noted the importance of the human resources of future generations and called for stronger welfare state policies to invest in inclusive education to compensate for the declining size of birth cohorts. In a context where education is publicly financed, such as Finland, policymakers might reduce total investments in education if cohorts get smaller because doing so could keep the per capita investment constant. In our empirical application, we study the impact of such an approach and contrast it with an alternative strategy that keeps the total costs constant, increasing per capita investment.

Investments in the education of diminishing cohorts can be seen as a variation in the theme of the demographic dividend in economic growth (Bloom et al. 2003; Bloom et al. 2000; Bloom and Williamson 1998; Lee and Mason 2010; Mason and Lee 2006; Sánchez-Romero 2013; Williamson 2013). The demographic dividend refers to the significant changes that occur in the age distribution of a population when fertility rates decrease and the subsequent adjustments in economic resources, the composition of the labor force, and individual benefits, such as increased investments in education.

The demographic dividend and its consequences are commonly linked to economic growth through three mechanisms. First, in the short term, the fertility decline will result in a larger share of individuals at working age, making available an excess of resources that can be used to invest in human capital or education. Second, in the medium term, fewer children means smaller family sizes and more resources available per child to be invested in education and health. When the smaller cohorts age, they face less competition for jobs, making it easier for them to advance in the labor market. Third, in the long term, better investments in children's education and health accumulate over generations, and this continuous improvement boosts the country's overall economic growth.

These traditional mechanisms linking demographic dividend and economic growth might not entirely apply to the Finnish context, given its aging population. For example, in an old and aging society, investments in the human capital of the young—which might indirectly benefit the old over time—compete with direct investments in the well-being of the old. Nevertheless, at least in principle, an aging society with low and declining fertility can leverage the rationale behind the long-term returns to education. Specifically, an investment strategy focusing on education—effectively increasing the number of students pursuing higher education—is one potentially viable approach.

Investing in early childhood education and primary school produces beneficial effects on adult health (Campbell et al. 2014), labor market outcomes (De Haan and Leuven 2020), and particularly productivity (Heckman 2006). However, in Finland, a low-fertility country with an educational system recognized for its excellence, it seems reasonable that investments in education should expand secondary and tertiary education. The objective of this investment strategy is to increase the number of highly educated individuals while considering the feasibility of its implementation. Finland limits student enrollment in secondary and tertiary education, leading to fewer students graduating from specific courses at these levels. Investing early in education can improve skills but does not ensure high levels of education after primary school.

A higher educational investment strategy seems particularly relevant in Finland, our case country. Between 2012 and 2018, average annual spending on educational institutions from primary to tertiary levels increased by 1.7% across OECD nations while student numbers remained stable, leading to a 1.6% yearly growth in spending per student. During the same period, Finland decreased educational spending by 0.8% annually while the student population increased by 0.3% per year, resulting in a 1% annual decline in spending per student. These figures highlight the potential for an educational investment strategy in Finland (OECD 2021).

Although our empirical analysis focuses explicitly on children's human capital, low fertility might have other important impacts that must be considered. Low fertility can be seen as problematic if there is a gap between desired and actualized fertility (Gietel-Basten et al. 2022). Beaujouan and Berghammer (2019) estimated gaps of roughly 0.28 between intended and realized cohort total fertility among women born in the early 1970s in several European countries and the United States. Evidence from the Nordic countries indicates that this fertility gap is increasing (Fallesen et al. 2022). Thus, evidence suggests the demand for higher fertility within individuals, and the focus of our analyses does not imply that decision-makers should avoid addressing this gap.

The Finnish Setting: Fertility and Education

Finland has historically been situated within the Nordic high-fertility regime, with relatively high fertility, high female labor force participation, and public policies that promote work–family reconciliation and gender equality (Andersson et al. 2009; Frejka and Calot 2001). Like many developed countries, Finland experienced a rapid decline in fertility in the 1960s, with the period total fertility rate (TFR) declining from 2.72 in 1960 to 1.49 in 1973; between the mid-1970s and the mid-2010s, the TFR fluctuated at approximately 1.6–1.9 (Human Fertility Database 2023; Ruokolainen and Notkola 2007). By the early 2000s, a bifurcation in fertility levels had emerged in high-income countries, with TFRs reaching 1.9 in Northern and Western Europe (including Finland) and the United States and declining to roughly 1.3 or below in Central, Southern, and Eastern Europe, as well as East Asia (Rindfuss et al. 2016). Similar patterns have also been observed in lifetime fertility, which is free from the distorting impact of changes in fertility timing on TFRs (Bongaarts and Feeney 1998). Lifetime fertility declined continuously, particularly in Southern Europe and East Asia, reaching levels of approximately 1.4 or lower for the late-1970s cohorts. In the Nordic countries, lifetime fertility stabilized at roughly 2 children (Myrskylä et al. 2013; Zeman et al. 2018) and was projected to remain at similarly high levels (Schmertmann et al. 2014).

However, in the 2010s, period fertility declined in high-income countries with relatively high fertility levels, as observed in the Nordic and Western European countries and the United States (Hellstrand et al. 2021; Vignoli et al. 2020). The declines seemed to have initially been triggered by the Great Recession in 2008 but continued after economic recovery (Comolli et al. 2021; Goldstein et al. 2013). The period fertility decline was particularly strong in Finland, where the TFR fell from 1.87 in 2010 to an all-time low of 1.35 in 2019 and further to 1.32 in 2022 after a temporary recovery in 2020–2021 (Official Statistics of Finland [OSF] 2023b). These rates are below the European average (1.53 in 2021), positioning Finland among the lowest fertility European countries (Eurostat 2024a). Forecasts of lifetime fertility indicate a decline from 1.9 to 1.4–1.7 for the late-1980s cohorts (Hellstrand et al. 2021).

Structural factors are limited in explaining the recent fertility decline, given that the continued decline cannot be linked to business cycles or policy changes in Finland (Comolli 2018; Hiilamo 2020). Instead, some researchers have pointed to a cultural shift involving a loosening of the childbearing norm (Rotkirch et al. 2017). The Finnish fertility decline is mainly due to fewer first births, with more couples remaining childless and unmarried (Hellstrand et al. 2022). Finnish surveys have reported increased child-free values among young adults, driven by uncertainty and lifestyle choices (Golovina et al. 2024; Savelieva et al. 2023). Finland might even have reached a low-fertility trap, where low fertility in society leads to social norms or societal structures that support childlessness and small families (Lutz et al. 2006).

Finnish society's adjustment to this landscape is challenged by the declining or stagnating educational level of more recent cohorts (Härkönen and Sirmö 2020). The share of 35- to 39-year-old Finns with tertiary education reached its peak in 2013, at 55% among women and 37% among men; by 2022, it had fallen to 52% and 34%, respectively (OSF 2023a). The share of this age group with at most a basic education has stagnated at roughly 11% for women and 20% among men since the late

1990s or early 2000s. Finland's tertiary education falls behind the OECD average (OECD 2023b). In 2022, 41% of 25- to 34-year-old Finns had a tertiary education, compared with the OECD average of 47%. These figures hide a substantial gender dimension: 47% of women but only 35% of men in Finland have a tertiary education. Most other Nordic countries (Denmark, Sweden, and Norway) have tertiary education levels above the OECD average. The Finnish government aimed to raise the educational level so that half of young adults would attain tertiary education by 2030 (Valtioneuvosto 2021).

The employment rate in Finland has trended upward since 2016 (OSF 2022), reaching 78% among those aged 20–64 in 2023—above the European Union (EU) average (75%) but lower than the average in other Nordic countries (80% to 85%) (Eurostat 2024b). On average, the EU employment rate is roughly 10 percentage points higher for men than for women. However, Finland is unique in that male and female employment rates nearly converged by 2023. For those aged 15–29 and 55 or older, women's employment rate even surpassed that of men. Employment level varies from 56% among those with an education below upper-secondary level to 89% among the tertiary educated (OECD 2024). This is the widest gradient of all Nordic countries, reflecting the very low employment rate among the lower educated Finns. Although employment in Finland is similar for men and women, income differences exist. Median monthly earnings of full-time wage and salary earners were 2,401€ and 2,933€ for the least educated women and men, respectively, in 2020; the corresponding earnings were 4,337€ and 5,225€ among those with a master's degree (OSF 2020). Among those born around 1950, working life expectancy at age 50 is roughly 7–8 years for manual workers and nearly 12 years for nonmanual workers (Leinonen et al. 2018).

At 5.6 million inhabitants in 2023, the Finnish population is small (OSF 2024c). Since 2017, the natural population change has been negative, but the population has been growing slowly as a result of immigration. Overall, Finland has a short history of immigration relative to other Nordic and Western countries (Busk and Jauhiainen 2022). Russian and Estonian migrants are the two largest migrant groups in Finland, especially among women. On average, net migration increased from 9,000 per year in the 2000s to 15,000 in the 2010s (OSF 2024b). These numbers are nontrivial in light of the magnitude of the decline of the birth cohorts, from 61,000 in 2010 to 45,000 in 2022 (OSF 2024a). Despite a positive trend, the flow of permanent-type immigration relative to the population size was still below the OECD average in 2022 (OECD 2023a).

Two recent studies analyzed the potential of human capital investments to attenuate the economic burden of the aging Finnish society. First, Marois et al. (2022) forecast the productivity-weighted labor force dependency ratio under various education and fertility assumptions until 2060. The education scenarios included steady increases based on long-term trends and a high-education scenario in which men reach women's currently higher levels. The study concluded that a TFR of roughly 1.6 should not be a major economic concern if labor force productivity increases. Striessnig and Lutz (2013) reached a similar conclusion. However, achieving a TFR of 1.6 might be challenging because of the current low fertility rates. Further, although the applied microsimulation model has several nuances, it is a generic model with little context-specific detail, such as variation in labor force trajectories

by educational level. The high-education scenario in which men reach women's education level is also potentially challenging to implement.

Second, Mäki-Fränti et al. (2023) modeled Finland's economic growth under varying human capital investment scenarios until 2070 using the Bank of Finland's long-run forecast model (Kokkinen et al. 2021). They analyzed three scenarios: one with modestly increasing investments in education (baseline), one with strongly increasing investments (optimistic scenario), and one with no additional investments in education (pessimistic scenario). Unlike Marois et al. (2022), they held the TFR constant at 1.45 throughout the scenarios, and their scenarios had stronger in-migration than the official Statistics Finland forecasts assume. Mäki-Fränti et al. concluded that human capital investments are key to economic growth. However, separating the effects of education and migration across these scenarios is not straightforward because the high-education scenario also includes highly educated and employment-based immigration.

Marois et al. (2022) and Mäki-Fränti et al. (2023) are key studies on the interlinkages of education, population structure, and economic sustainability in Finland. We aim to build on these analyses by combining realistic fertility scenarios, including stability at the current TFR of 1.3, with an educational investment strategy that increases per capita investments but does not require additional funding, making it politically feasible. We implement our analysis in the Finnish Center of Pension's highly refined pension microsimulation model, which provides a realistic description of the labor force transitions and trajectories based on educational levels.

Scenarios: Fertility and Human Capital Investment Strategy

We explore whether investing in human capital can counter the adverse economic impact of low fertility by simulating three scenarios: baseline, lowest-low fertility, and high educational investment. The baseline scenario mirrors Statistics Finland's projection based on a TFR of 1.45. The other two scenarios use a TFR of 1.30, matching recent observed rates. Mortality varies by age, sex, and education across scenarios and is calibrated such that the total population mortality matches Statistics Finland projections for baseline and low-fertility scenarios. In the high-education scenario, total population mortality declines because higher educated persons have lower mortality. Across the scenarios, net in-migration is held constant at Statistics Finland's official projections of 15,000 annually. Importantly, because our migration assumptions are the same in all scenarios, migration does not impact our comparisons across scenarios.

Baseline Scenario

We set the TFR at 1.45, as in Statistics Finland's most recent population forecast. This level is somewhat arbitrary, and Statistics Finland continues to adjust their TFR assumptions according to TFR developments. For example, they lowered the TFR assumption from 1.7 in 2015 to 1.45 in 2018 and to 1.35 in 2019; they increased it to 1.45 in 2021 (OSF 2019, 2021). A TFR of 1.45 is a useful baseline because it is

the level currently used in official forecasts, it is within the range of predicted lifetime fertility levels for women born in the late 1980s (Hellstrand et al. 2021), and it approximately matches the tempo-adjusted TFR for 2022.¹ In this baseline scenario, we assume no additional human capital investment.

Lowest-Low Fertility Scenario

In this scenario, we assume lowest-low fertility, with the TFR constant at 1.30. Kohler et al. (2002) used “lowest-low fertility” to refer to a TFR at or below 1.3, corresponding to the situation when many Southern, Central, and Eastern European countries first attained and sustained such low levels in the 1990s. Finland, with its TFR at 1.32 in 2022 and a continued decline in births thereafter (the preliminary TFR in 2024 was 1.25; OSF 2025), is experiencing lowest-low fertility levels for the first time. Like the baseline scenario, the lowest-low fertility scenario assumes no additional human capital investment. Comparing the baseline and lowest-low fertility scenarios allows us to identify the long-term economic impact of the recent TFR decline from 1.45 to 1.3, with everything else held constant.

High Educational Investment Scenario

This scenario assumes the patterns of the lowest-low fertility scenario and explores offsetting lower fertility impacts through increasing human capital. It assumes constant total public education expenditures and thus that individuals from smaller cohorts receive more resources. This increased per capita educational investment enables individuals to gain more human capital, leading to a better educated population. This scenario keeps the total educational investments at the same level as in the baseline scenario with a TFR of 1.45 but distributes the investments to lowest-low fertility cohorts that correspond to a TFR of 1.3. This redistribution intervention corresponds to approximately 12% ($1.45 / 1.3 = 1.12$) higher educational investments per child without increasing the costs relative to the baseline scenario. For details of the implementation, see Table A1 (online appendix).

To create realistic scenarios, we cap the education distribution: neither lower nor higher tertiary education exceeds 40%. This cap is based on Wittgenstein Centre for Demography and Global Human Capital projections for the most highly educated countries (Lutz et al. 2018). Given that these projections show several countries reaching higher education levels (see Figure A1, online appendix), we consider our simulated high-education scenario to be ambitious yet realistic and feasible.

Figure 2 shows the development of the share of the population with tertiary education at ages 30–39 over time and contrasts our baseline and high educational investment scenarios with other countries and regions. In the baseline scenario (as well as in the lowest-low fertility scenario), the share of the cohorts with a tertiary education

¹ The average difference between the TFR and the tempo-adjusted TFR (Bongaarts and Feeney 1998) since the mid-1980s has been 0.16, and the crude tempo-adjusted TFR based on the development in 2021–2022 was 1.45 in 2022 (authors’ own calculations based on the Human Fertility Database (2023)).

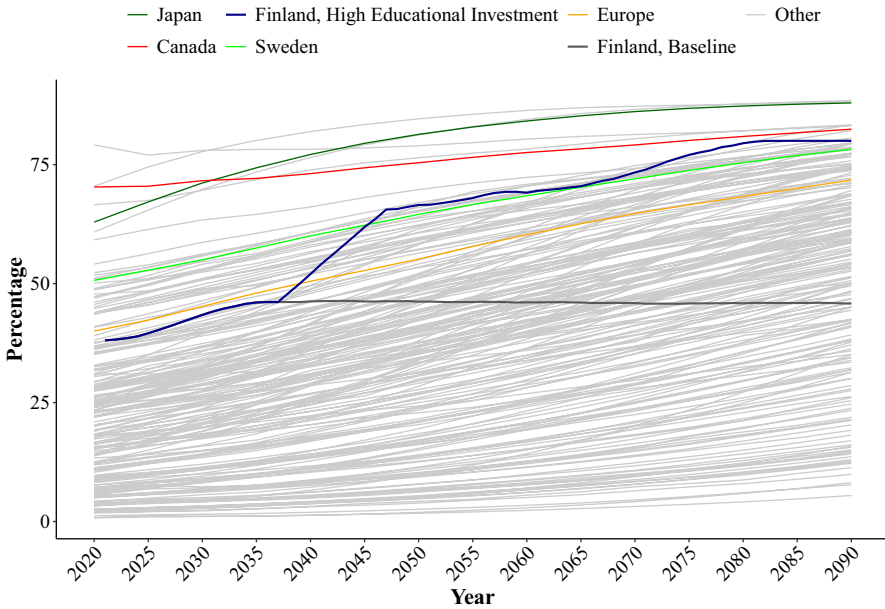


Fig. 2 The share of the population with tertiary education at ages 30–39 in Finland in the baseline and high educational investment scenarios compared with all countries/regions, based on data from the Wittgenstein Centre for Demography and Global Human Capital (available every fifth year). In this and the following figures, the calculations for the Finnish scenarios are based on the assumption that education is completed at the age of 30

remains low, at roughly 46%. When savings from educating a smaller cohort are invested in further education, education improves significantly. In this scenario, the proportion stays at the same level as in the baseline scenario until 2038, when the intervention first impacts the 2008 cohort at age 30, and then gradually increases to 80% for the population aged 30–39 by the 2080s. The high educational investment scenario aligns with Sweden’s projected trajectory and gradually approaches but does not exceed the level of the most highly educated countries.

Further, we impose limits on the three lower educational categories at the basic and secondary levels, at 3% for each, so that none of the categories empty out. Educational improvement is observed in shrinking lower educational categories: the share with basic education drops from 16% to 8%, and the shares with general and vocational secondary education change from 8% to 3% and from 38% to 9%, respectively. [Figure 3](#) shows the educational level by sex in the human capital investment scenario. Men reach the imposed limits in the 2080s, and women reach them slightly earlier.

The Model

We explore the impact of the three scenarios on economic sustainability by using the Finnish Centre for Pensions’ microsimulation model ELSI (the acronym for Pension Simulation, which is *Eläkkeiden simulointi* in Finnish). We focus on three

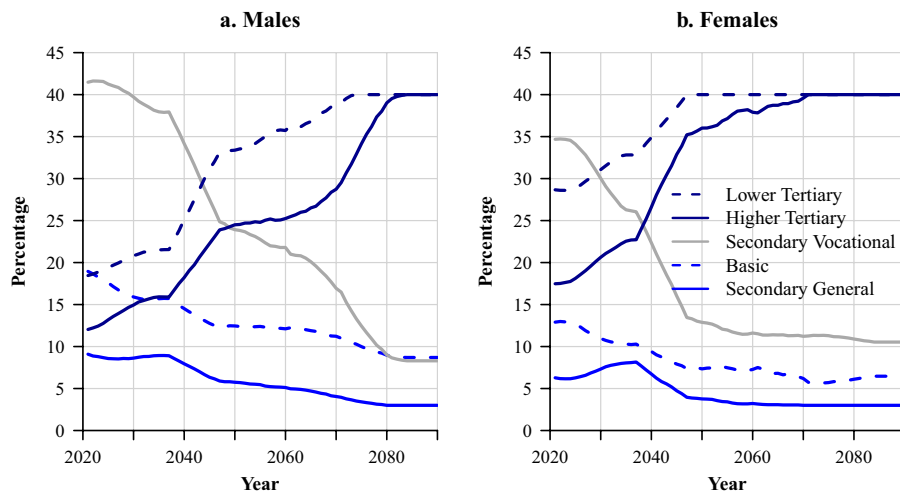


Fig. 3 Education distribution at ages 30–39 in 2021–2090 in the high educational investment scenario, for males and females

key outcomes: GDP per capita, annual wage sum, and annual pension expenditures relative to the annual wage sum.

The model simulates the Finnish pension system, which is highly dependent on demographic developments and the wage sum because the pensions are only partially funded. Earnings-related pensions cover more than 90% of the total pension expenditures. The system is a defined benefit scheme with partial funding, with a funding ratio of roughly 30%. The accrual of pensions is based on career earnings. Pension accrues at 1.5% for all earnings with no ceilings. Earnings-related pension benefits are disability, old-age, partial old-age, years-of-service, and survivors' pensions. The pensions are indexed based on price and wage changes. Two automatic adjustment methods depend on observed mortality. First, the initial pension amount is adjusted with a life expectancy coefficient based on changes in life expectancy. Second, the retirement age increases gradually from 63 years (for the 1954 birth cohort) to 65 (for the 1962 birth cohort) and will be linked to changes in life expectancy from the 1965 birth cohort onward. The national pension and the guarantee pension secure an income for pensioners with a small or nonexistent earnings-related pension. The national pension can be paid as an old-age or disability pension. For a complete description of the Finnish Pension system, see Ritola and Väänänen (2023).

Our description of the ELSI model is an abridged version focusing on the aspects most relevant to the fertility and educational investment scenarios. For more details on the model, see Tikanmäki and Lappo (2020). The ELSI model is similar to other European pension microsimulation models (Dekkers and van den Bosch 2016). ELSI is dynamic in time in that it has a dynamic aging structure. However, rather than behavioral equations, Markovian transition probabilities determine population state transitions. The model uses one-year time steps, creating a synthetic life history for each simulated individual. Educational level and sex mainly drive individual differences. Individuals with more education have fewer career breaks (e.g., from unemployment), higher wages, and longer lives.

ELSI has a modular structure. The most essential parts of the current analysis are the first two modules: the population module and the earnings module. Subsequent modules determine the pension amount based on the results of these two modules.

ELSI connects to the semi-aggregated long-term projection (LTP) model, also developed by the Finnish Centre for Pensions (see Tikkanmäki et al. 2023). The target population of ELSI is all adults resident in Finland and those living abroad with previously accrued earnings-related pensions under the Finnish pension system.

The ELSI model uses high-quality data from the Finnish earnings-related pension system, covering all individuals in the system. It also uses register data on education, marital status, and primary residence provided by Statistics Finland and the Digital and Population Data Services Agency.

ELSI's population modeling employs 21 states representing an individual's main activity in a given year. Employment is split into three states, varying by consecutive employment length, to break the strict no-memory assumption of the Markov model. Unemployment benefits recipients are divided into two states by whether they are on the unemployment pathway to retirement. Retired individuals fit into 1 of 11 states according to their pension type. Another state exists for individuals on disability benefits before full disability pension. Those outside the labor force fall into one of three states on the basis of earnings-related pension accrual and whether their situation is temporary or permanent. Persons in these three states include, for example, nonemployed students, mandatory military service members, child home care allowance recipients, longer sickness allowance recipients, and inmates. Other career breaks, such as earnings-related parental leaves, are modeled independently of the model states.

The population module is the first one in ELSI. It simulates the development of the population from 2017 to 2090 by generating new cohorts and modeling immigration, emigration, education dynamics, and transitions between population states. State transitions include, for example, labor market dynamics, transitions into retirement, and deaths. Population state transitions are modeled with 21 population states. Population state modeling follows a Markovian structure. The transition probabilities are influenced by country of residence, sex, age, educational level, and current population state.² The original transition probabilities are estimated through a nonparametric approach.

The probability of emigration from Finland or immigration back to Finland is affected only by the individual's age and sex. The number of emigrants varies depending on these probabilities and on the population structure during the simulation period and between the simulated scenarios. New immigrants are generated into the population in a way that yearly net migration is at the level given by the population projection (15,000). In the simulation model, 54% of migrants are men, and their employment rates in the first two years are lower than among the native population, based on the observed differences in the source data. The difference narrows over time and is determined only by educational level and previous employment. The probability of retiring is assumed to be the same for immigrants and the native

² There are a few minor exceptions to this principle. For instance, transitions to the years-of-service pension depend on the length of working life, which can be understood as an extension of the state space of the Markov process.

Finnish population for a given age, education, and sex. However, because migrants are less educated than natives, their average retirement age is lower.

ELSI models completed educational degrees, not duration. ELSI adjusts educational levels on the basis of source data probabilities using current education, age, and sex. In the high educational investment scenario, these transition probabilities are modified to achieve the desired educational distribution for 30-year-olds.

The model assigns starting educational levels and population states to immigrants using distributions calculated from the source data.³ In the high educational investment scenario, new immigrants' education is assumed not to be impacted by the investment if they arrive in the country after age 18.

The earnings module in the ELSI model simulates annual wages using data from two time-series models fitted to Finnish earnings data (2005–2015). Wages are simulated using a second-order dynamic autoregressive model incorporating past wage information for individuals with a wage history, considering factors such as sex, age, education, previous wages, and employment state. For labor force entrants with no wage history, wages are simulated using a static model.

After simulating the employment careers in the population module and wages in the earnings module, we calculate the pension amounts using the current pension rules and aggregate these to population-level indicators, such as pension expenditures, the wage sum, and the annual gross domestic product (GDP). One key measure is pension expenditures relative to the wage sum, the most natural ratio to consider in pay-as-you-go schemes and partially funded schemes, such as the earnings-related pension system in Finland (see Tikanmäki et al. 2023).

This analysis explicitly accounts for the impact of the wage sum growth in pension indexing. The analysis is static in that the population in each education, sex, and age group across scenarios is assumed to be similar to those in the baseline scenario. Thus, any impacts that these characteristics have—for instance, on wages—are assumed to be the same as in the baseline scenario. We return to this point in the Discussion.

Results

Figure 4 illustrates how higher education translates into higher employment (panel a), higher average wages (panel b), and longer working lives (panel c). Panel a shows that relative to the baseline scenario in which the TFR is 1.45, the scenarios with a TFR of 1.3 have much lower total employment over the century. However, the impact of lower fertility on employment is slightly smaller in the educational investment scenario. Panel b shows average wages (annual total wage sum divided by total employment) indexed to the baseline scenario. The scenario with high educational investment starts to deviate from the baseline around the 2040s when the better educated cohorts enter the labor force. By the 2090s, average wages are almost 10%

³ In the simulation, new immigrants' educational distribution is based mainly on Statistics Finland's 2018 register data. For 2018, a survey was additionally conducted to complement the incomplete information from the registers (i.e., missing qualifications in case they are not accomplished in Finland), and therefore the information from this year is of better quality than that from other years.

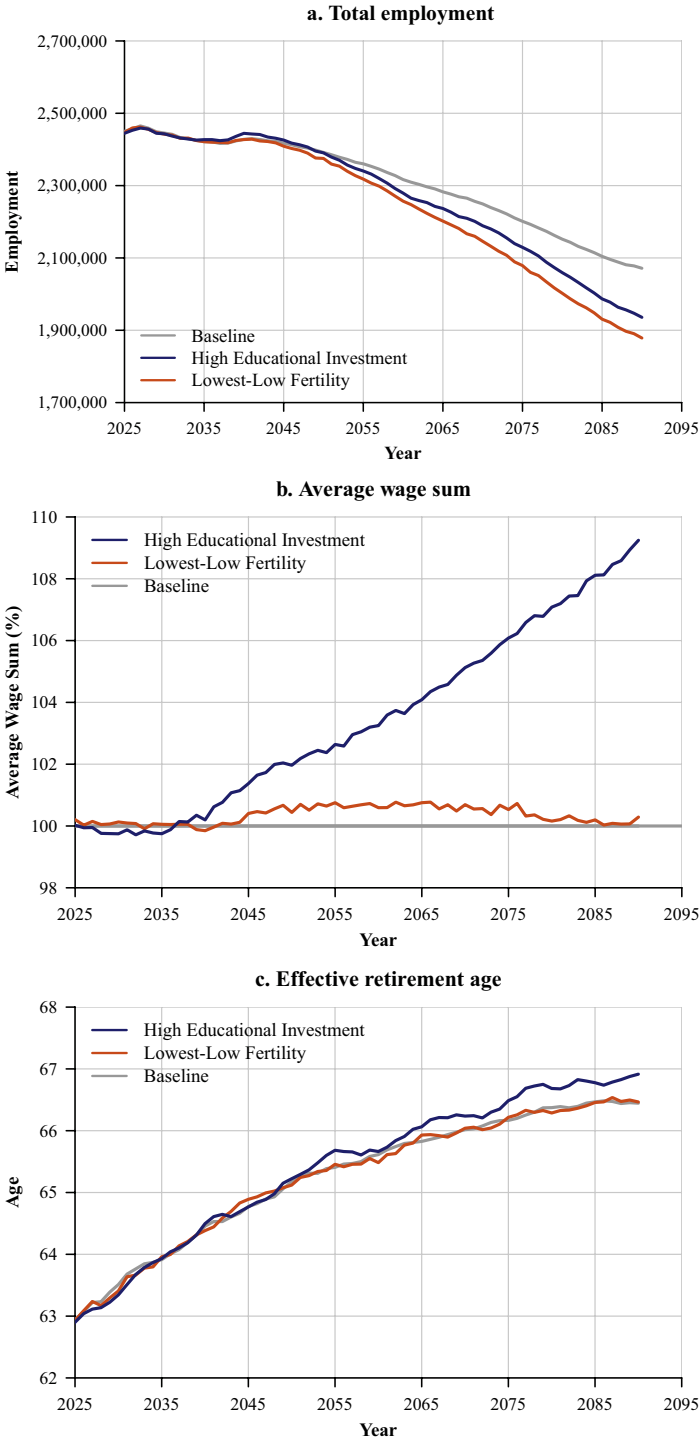


Fig. 4 Employment, average wages, and the effective retirement age across scenarios

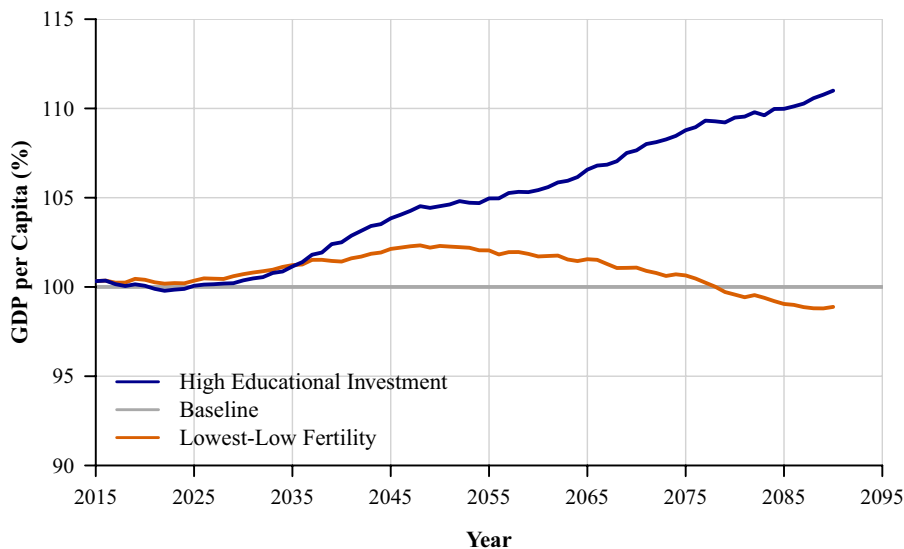


Fig. 5 The trajectory of GDP per capita for the three scenarios, with the baseline scenario scaled to 100

higher than in the baseline scenario. Panel c shows the efficient retirement age, a period measure for the length of working lives. The baseline scenario indicates an increase from 63 years in 2025 to 66.4 in 2090, whereas the high education scenario has a 0.5-year later retirement (at 66.9) in 2090.

Figure 5 shows the trajectory of GDP per capita for the three scenarios, with the baseline scenario scaled to 100. In the lowest-low fertility scenario, GDP per capita initially increases relative to the baseline because of the smaller cohorts sharing the GDP, but it then declines below the baseline level. In the high educational investment scenario, the trajectory is similar or slightly below that of the lowest-low fertility scenario until approximately 2040. This trajectory is expected because the population structures are the same, and the only difference is higher investment in education. This investment starts to pay off in 2040, when the smaller and better educated cohorts enter the labor force. By 2090, the high-investment scenario delivers more than 10 percentage points higher GDP per capita than the baseline or lowest-low fertility scenarios. Additional results (not shown) indicate that more than 80% of the faster growth in the high-education scenario is due to the growth in average wages and that the rest is due to employment growth.

Figure 6 illustrates the dynamics of wage sum over the three scenarios. These dynamics closely mirror the GDP per capita patterns, with the difference being that the patterns are not scaled to the population. In the lowest-low fertility scenario, the wage sum keeps up with the baseline scenario until approximately the 2040s, when the smaller cohorts enter the labor force, causing the wage sum to decrease. In the high-education scenario, higher education delivers wage sums that stay at similar or slightly higher levels compared with the baseline scenario, even though the population earning these wages is smaller.

Figure 7 shows pension expenditures relative to the wage sum. In all scenarios, there is first a short-term decline in the 2030s and then a long-term increase from the

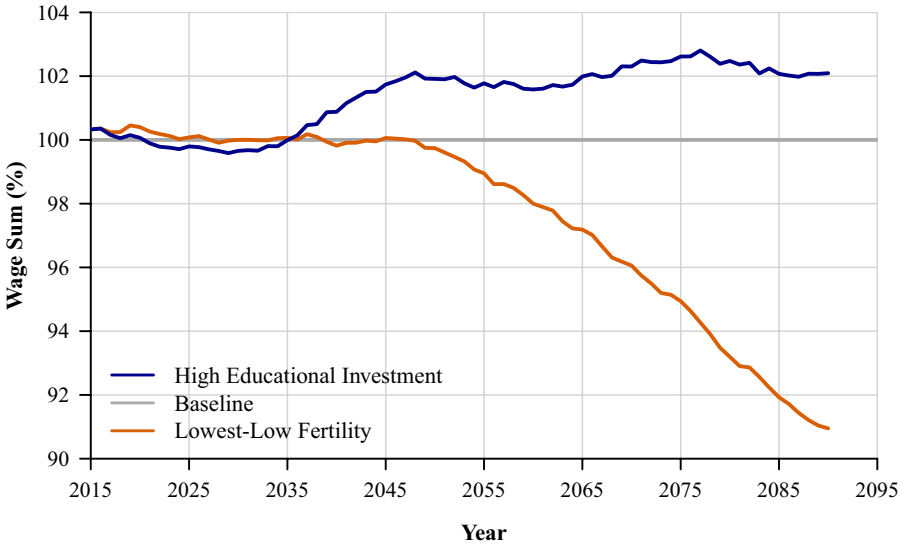


Fig. 6 The trajectory of wage sum for the three scenarios, with the baseline scenario scaled to 100

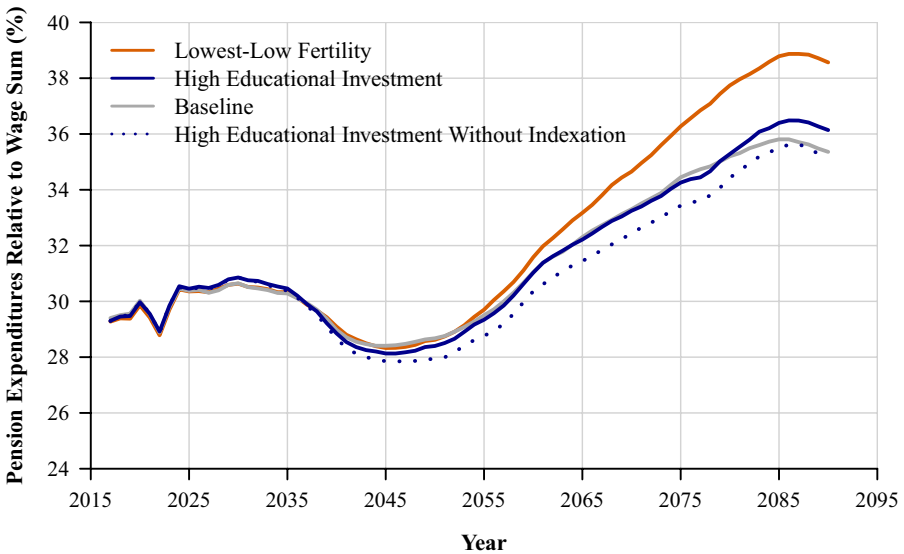


Fig. 7 The trajectory of pension expenditures relative to the wage sum for the three scenarios

2040s. The initial decline in the 2030s is because large baby boom generations born in the late 1940s are dying, and two major pension reforms implemented in 2005 and 2017 will cut the pension levels and increase the pensionable ages of cohorts born in the 1950s or later. In the baseline scenario, relative pension expenditures grow rapidly starting from the 2040s, reaching 36% by the mid-2080s. Lowest-low fertility delivers even faster increases in relative pension expenditures, from 28% in 2045 to 39% in 2085.

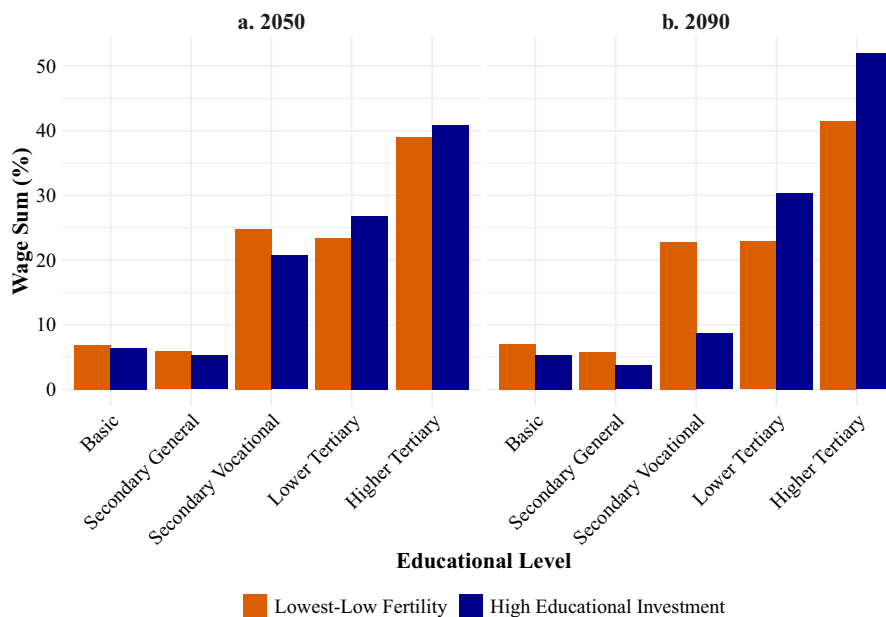


Fig. 8 Wage sum by educational level in 2050 (panel a) and 2090 (panel b)

In Figure 7, the high educational investment scenario is divided in two in the analysis of relative pension expenditures because higher education increases wages. However, this increase in wages is also reflected in the earnings-related pension levels, given that pension payments in Finland are indexed by 20% to changes in wages and by 80% to changes in prices. For accrued pension rights, the weights are the other way around. Hence, the gain in wages might be offset by added pension costs, and the impact of the investment in human capital on pension financing is smaller than the impact on GDP because wage growth leads to higher pension levels and expenditures.

In the first high educational investment scenario (blue solid line in Figure 7), we allow pensions to be indexed to wage growth. The result of this scenario is that the relative pension expenditures closely follow the baseline scenario. In other words, higher education offsets the impact of the smaller labor force resulting from lower fertility. In the second variant of the high educational investment scenario (blue dotted line in Figure 7), we do not index individual pensions to grow with the growing wages. Instead, we keep them at the level corresponding to the lowest-low fertility scenario that does not have higher education. In such a scenario, educational investments more than offset the impact of lower fertility.

The offsetting impact of the educational investment scenario in Figure 7 does not mean the pension burden stops increasing. What we observe is that if the TFR declines from 1.45 to 1.3, the impact of this 0.15 TFR difference can be offset by an educational investment strategy. A TFR of 1.3 with high educational investment results in a similar pension burden as a TFR of 1.45. A TFR of 1.45 remains challenging: the policy does not remove all problems but attenuates the impact of the recent TFR decline.

Figure 8 illustrates how different education groups contribute to the wage sum in different scenarios and over time. The figure shows that in the baseline and lowest-low

fertility scenarios, approximately one third of the wage sum is earned by the three lowest education groups in 2050 and 2090. In the high-education scenario, we see a shift of the wage sum to the higher education groups. In 2050, the shift is only partial. By 2090, most working-age cohorts have a tertiary education and are assumed to experience the corresponding higher wage levels. Therefore, we see almost a 20-percentage-point decrease in the share of the wage sum of the three lowest education groups combined.

A highly educated workforce dominating the wage sum indicates a skilled workforce that can increase productivity and engage in complex tasks, implying shifts in economies toward more advanced industries, such as technology and services, and enhancing productivity and adaptability. This adaptability can help maintain stability in the face of external pressures and internal transformations, particularly those exerted by population aging.

Discussion

Low fertility accelerates population aging and puts increasing pressure on the economic sustainability of low-fertility societies. There is limited evidence for the success of policies targeted at increasing low fertility, even in contexts where the desired family size is higher than realized fertility (Gietel-Basten et al. 2022). Low fertility might be here to stay, and the question of adaptation requires more attention.

We use a longitudinal microsimulation model to examine whether an ambitious human capital investment strategy can mitigate the economic impact of low fertility, focusing on fast-aging Finland, which displays declining fertility and stagnating education levels. Our results indicate that maintaining the current total education costs, thereby increasing per capita investments, can offset some of the negative effects of a smaller labor force on the pension burden. The gains of this investment are not confined to pension burden control; educational investment also increases employment, wages, and retirement age.

Our findings rely on the assumption that the productivity response to changes in the educational distribution is consistent with that in the baseline scenario. This assumption should be considered critically. In a scenario with higher education levels, it is not guaranteed that a larger proportion of highly educated individuals would maintain the same productivity levels as in the baseline scenario, where the share of highly educated individuals is smaller.

The first question is whether education increases productivity at all or whether it is just signaling. Human capital theories suggest that education enhances individual productivity and thus increases earnings (Becker 1962). Large wage differences have been observed across groups with differing educational attainment levels. Psacharopoulos and Patrinos (2004) computed the earning gap between those with and those without college degrees and estimated the global average rate of return on higher education to be approximately 20%. Despite potential selection by ability and signaling of higher education, the increasing productivity elicited by higher levels of education appears to be a pivotal reason for the gap.

The second question is whether the impact of higher education is diluted or strengthened with increasing overall education. It is possible that a larger share of

high-educated workers increases productivity and wages per highly educated individual. At the macro level, human capital spillover might induce technological externalities and improve aggregate productivity over the direct impact on private productivity (Hendricks and Schoellman 2023). Indeed, the college wage premium has been observed to grow over time despite the expansion of higher education and the surge in the college-educated labor supply (e.g., Card and Lemieux 2001). Skill-biased technical change, which increases the relative productivity of skilled labor and the demand for it, is proposed to be the driving factor (Krusell et al. 2000).

Educational expansion might also lead to changes in the labor market structure, impacting the wage distribution across industries and occupations (Mincer 1996). Such change would imply that wage disparities might arise even among highly educated individuals. Nevertheless, although an expansion in education levels does not ensure higher wages for everyone, it might contribute to higher wages, on average, for the entire workforce and thus for the population.

We conclude that evidence does not suggest strongly diminishing returns on education with an increasing share of individuals who are highly educated. Nevertheless, even if only half of the effect in our high educational investment scenario is realized, it would significantly impact economic growth and pension financing. Hence, our analysis indicates that smaller cohorts might not harm long-term economic sustainability if there is robust human capital investment in fewer children, thereby unlocking the Easterlin effect. Inclusiveness might be an important aspect: not only is the stagnation in educational attainment among cohorts born in the mid-1970s onward visible, but signs also point to concurrently increased educational inequality from initially low levels in Finland (Härkönen and Sirmiö 2020).

Our model further assumes constant fertility rates across education levels. Among women, increasing education might be associated with decreased fertility, but this link has become weak in recent cohorts in countries such as Finland (Nisén et al. 2021). For men, the pattern is likely to be the opposite (Trimarchi and Van Bavel 2017). The most likely impact of increased education is the postponement of births (Ní Bhrolcháin and Beaujouan 2012). However, the simulated TFR of 1.3 in the high-education scenario already includes strong postponement. Therefore, we consider it a realistic assumption that increasing education does not contribute strongly to declining fertility.

Although our model is static in terms of behavioral responses, such as fertility, it has several nuances that make the simulation implicitly dynamic. These nuances include the linkages between education and pensions and between education and longevity. For example, as expected, the wage sum declines in the low-fertility scenario relative to the baseline scenario owing to the workforce reduction, even if average wages do not decrease. The decline can have serious long-term economic effects, reducing economic growth via various indirect mechanisms. Lower wage sums imply decreased consumer spending, which is a crucial economic factor. With fewer young workers, the incentives for innovative investments, especially in sectors influenced by young consumers and employees, might decrease. Furthermore, the reduced wage sums might negatively affect tax revenue, impacting public services and the capacity to support pensions and health care for an aging population. Instead, our high-education intervention, which strongly increases the fraction of highly educated people, also increases average levels of pension through higher pension accrual and

the length of time these pensions need to be paid at the individual level because of increasing longevity. Our key results focus on how pensions are financed, but these implicit linkages between pension levels and longevity mean that the positive impact of the intervention goes beyond increased macro-level sustainability.

The implicit dynamics of the model also apply to immigrants arriving in Finland, yet our analysis assumes a constant level of education among arriving new adult immigrants. Nopola (2019) evaluated the long-term implications of migration for the sustainability of the pension system in Finland and stressed that migration groups not only differ in their skill levels and employment rates but also in their fertility: the latter might compensate for the former in the long run, given that groups with low skills tend to have higher fertility. However, as fertility declines globally, initial skill levels and the integration of migrants might be even more crucial for economic sustainability in the future. Despite the importance of migration for economic sustainability, we argue that an assumption of constant migration across the scenarios, as in the current study, allows a more direct identification of the impact of higher human capital because this impact is not combined with that of immigration.

Our findings align with research emphasizing the key role of human capital in demographic and economic development (Lutz 2014) and suggest that macro-level sustainability is possible with below-replacement fertility. Marois et al. (2020) also highlighted the high stakes involved with migration in terms of mitigating the support ratios in advanced aging economies. However, their projections suggest that changes in educational attainment, labor force participation, and the integration of migrants have a long-run impact beyond migrant numbers or fertility levels.

According to Striessnig and Lutz (2013), the optimal fertility level for long-run economic sustainability is also sensitive to the age at retirement. Under the core assumption that the share of individuals with a tertiary education would increase and stabilize at 60%, the optimal TFR from the perspective of education-weighted support ratios in 2100 is below two children (in countries such as Finland, Germany, and Romania). In their projections for Finland, a parallel increase in life expectancy and retirement age would lead to a projected retirement age of 74 in 2100. In this scenario, the highest level of support would be provided by a TFR of 1.78. Under an alternative assumption in which pension age increases by only half the increase in life expectancy, where the retirement age would be 67 in 2100, the highest support ratio would be reached at a TFR of 2.0. Higher TFRs do not lead to higher economic sustainability in the long run because of the higher cost of educating larger cohorts, which outweighs productivity gains. Results of two recent studies focusing on the Finnish context also highlighted the importance of human capital for economic sustainability: Marois et al. (2022) concluded that a TFR of roughly 1.6 should not be a major economic concern if labor force productivity increases, and Mäki-Fränti et al. (2023) concluded that investments in human capital are key to economic growth.

How feasible is the proposed educational investment strategy? Implementing policy interventions is challenging. However, our proposed educational intervention aligns with the Finnish government's goals. More importantly, rather than requiring additional financing, our strategy suggests avoiding savings when birth cohorts decrease, making it comparatively feasible.

We implemented our hypothetical intervention in the Finnish setting. Whether our single-country results have more general relevance across low-fertility countries

depends on two aspects. First, are there individual-level productivity gains to education? Second, is the education distribution close to a saturation point at which further population-level gains to education would rapidly decrease? In sum, do we observe similar gains to education in other countries as we documented for Finland?

To answer the first question, we compare Finland with other countries. First, in examining whether the individual-level gains to education are exceptionally strong in Finland, we find the opposite—at least across OECD countries. The gains in Finland are modest compared with peer nations (OECD 2020). Therefore, we argue that many countries might reap even larger benefits from our proposed educational investment strategy. Even if individual-level gains to education would decrease by half, for example, we would still see an important population-level attenuation of the macro-level negative effect of low fertility.

Second, the question regarding saturation is less straightforward. We lack good evidence of countries reaching a threshold at which additional education provides little or no further productivity gains for highly educated populations, although saturation can occur among the most highly educated populations. The proposed educational investment policy will likely work best in countries with large educational productivity gains and where education saturation is not within reach. Thus, countries with very weak productivity gains to education or with an average educational level that is already quite high might not benefit from the proposed strategy. Countries with a similar (or lower) educational distribution could experience educational gains similar to those we found for Finland. In countries with comparatively high gains to education and an educational distribution that is not exceptionally high, the macro-level gains are likely to be strong, even if the individual gains start to decline in the future.

In our model, we assumed different levels of low or very low fertility and stable fertility in each of the scenarios. We then added to some of these scenarios an ambitious educational investment strategy, allowing us to analyze the extent to which the macroeconomic impact of low fertility can be mitigated by investments in human capital. However, if fertility in Finland continues declining rather than remaining stable at a low level, the societal challenges would be even larger than what our study suggests.

The generalizability of our findings mainly rests on these aspects of gains to education, not on other aspects of how society is arranged. In particular, the way pensions are financed is not critical to the question we are asking. It is relatively straightforward to argue that our results might extend to countries with similar pension financing. However, our results are more strictly relevant to overall macroeconomic health, as is illustrated by our figures on GDP per capita and the wage sum. These factors are dependent on the population's human capital and the productivity gains to higher education. Therefore, we argue that the generalizability of the results goes beyond the set of countries with pension financing similar to that of Finland.

To conclude, our analysis combines realistic fertility scenarios with an educational investment strategy that increases per capita investments but does not require additional funding. We argue that such a strategy is politically feasible, especially in a country such as Finland, where the population is rapidly aging, period fertility is at a lowest-low level, and educational expansion has stagnated. Overall, our results provide further empirical support for the claim that improving a population's human capital rather than demographic targets (e.g., a specific fertility level) should be the focus of population

policies. Discussions focusing on concepts such as replacement-level fertility do not account for the qualitative aspect of the population. Further, demographic targets of fertility might be viewed as questionable from a human rights perspective. Still, governments should continue to find ways to alleviate the barriers to childbearing that contribute to the gaps between individuals' intended and realized fertility. ■

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