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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 of smaller cohorts – are mostly ignored. We use a dynamic longitudinal microsimulation model to explore to what extent investments in human capital could offset the adverse economic impact of low fertility. We implement our model in the Finnish context, which is a particularly interesting case as Finland is the fastest-ageing European country and experienced dramatic fertility declines and stagnant education 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 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 to be 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 indicators of economic sustainability such as old-age support ratio and various dimensions of pension burden. 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.

Forecasts of the impact of declining fertility rarely account for the fact that potential dynamic effects may offset some of the adverse effects of declining fertility. By dynamic effects, we refer to mechanisms that operate through pathways other than the mere expected decline in the size of the labor force. Important exceptions to the rule – studies that include dynamic effects, such as Lutz et al. (2019) – are often based on models that are otherwise highly stylized and do not include context-specific nuances of complex economies.

We are motivated by the observation that while countries are increasingly concerned about the long-term implications of low fertility, policies aimed at increasing fertility appear to deliver meager results. If the reality is that low fertility is here to stay, as is argued, for example, by Skirbekk (2022), the key question is how societies adapt to low fertility.

In the context of low and declining fertility, we are interested in the potential of the saved human capital investment in the educational system following the smaller cohorts that are being born. Few earlier empirical studies have paid attention to assessing the long-term economic impact of this potential, often relying on cross-sectional data and making a number of strong assumptions (e.g. Mason and Lee 2006; Lee and Mason 2010). We build on earlier notions on the importance of human capital for demographic transition, economic development, and for its plausible role of mitigating future challenges related to population aging. For example, Lutz et al. (2019), analyzing a large global dataset of populations by their human capital level, demonstrates that human capital is crucial for understanding demographic transition and economic growth. They propose that the level of human capital rather than the population age structure per se drives economic growth. Therefore, policies concerned with sustainable development of their populations should focus on human capital.

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

We define a small number of key pension indicators as proxies of economic sustainability and analyze the impact of declining fertility on those indicators with and without ambitious human capital investment. We adopt a human capital investment strategy in which the total investment remains constant despite a shrinking student population. This increases the resources available to each student, operating on both the intensive and extensive margin. 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 declining numbers of students has the potential to offset much of the negative impact of a smaller labor force on pension burden. Indeed, the positive impact is not limited to reduced pension burden, as increased human capital also has a positive impact on the working years, retirement years, health, and longevity of the population.

We discuss the feasibility of our proposed human capital investment strategy, and we suggest that it is more feasible than alternatives that rely on setting top-down targets to increase fertility (Gietel-Basten, Rotkirch, and Sobotka 2022). In the Finnish context in particular, the feasibility of the strategy is high, as the country's educational attainment has been stagnant or even declining for recent cohorts, and in response to this the government has set ambitious goals to increase the educational level (Valtioneuvosto 2021). In such a context, demographic policy focusing on human capital, or 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, or the "quantity" dimension of the labor force. In this sense, our macro-level analysis mirrors the quantity-quality tradeoff occurring at the micro-level that economists since Becker (1960) have argued, where parents invest increasingly into the "quality" of the children at the expense of "quantity" when fertility declines.

## Low and Late Fertility: Implications for the Society and Individuals

From a societal perspective, declining fertility levels are a concern as they lead to decreasing old-age support ratio and are therefore projected to put pressure on economic sustainability in the long run. Figure 1 shows the development in the observed and projected old-age support ratio (population aged 20-64 relative to population aged 65 and above) in 2000–2090 based on UN Population Division forecasts (United Nations 2022). Finland has currently among the lowest old-age support ratios in the world: in 2022 there were 2.4 20–64 year old people per every 65+ year old person. Only Saint Helena, Japan, and Monaco rank lower than Finland.

[FIGURE 1 HERE]

The impact of decreasing fertility levels on the old-age support ratio is observed with a delay. Lower levels of fertility observed now will appear as a shrinking work force approximately 20 years from now. In Finland, the size of the birth cohorts currently at working age is around 60 000–75 000. The size of the birth cohorts at ages 0–4 is on the other hand around 50 000 or lower, 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 should the future TFR remain at 1.45, and further to 1.3 should the future TFR remain at 1.3 (Figure 1). These ratios are crude in the sense that they do not consider the role of the educational structure or productivity of the population (Lutz et al. 2019; Marois, Bélanger, and Lutz 2020).

However, lower and later fertility may also bring about 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 more public resources available per child, unless these are scaled down in response to smaller cohorts. Smaller cohorts may also face less competition among peers in the labor market (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 as well as incentives for education.

The US postwar baby boomers have been studied extensively with regard to the links between cohort size and educational attainment and earnings (Welch 1979; Connelly 1986; Stapleton and Young 1988). Recent empirical studies have expanded to other contexts and cross-county analyses, and many find that smaller cohorts facilitate human capital accumulation and higher earnings of the cohort members (e.g. Bound and Turner 2007; Fertig, Schmidt, and Sinning 2009; Brunello 2010; Babcock, Bedard, and Schulte 2012).

However, the existence of the link between cohort size and human capital accumulation – or more directly, educational attainment – depends crucially on how dynamically the educational system responds to smaller cohort size (e.g. Lee and Mason 2010). For example, Kaufmann (2005) has drawn attention to 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, which is the case in Finland, the policymakers may face incentives to reduce total investments in education if cohorts get smaller, as this could keep the per capita investment constant. In our empirical application, we study the impact of such an approach, and contrast that with an alternative strategy that keeps the total costs constant, hence increasing per-capita investment.

While our empirical analysis focuses explicitly on the human capital of the children's generation, we acknowledge that lower and later fertility may also have other important impacts on the parental and child generation. Low fertility can be seen as problematic if there is a gap between desired and actualized fertility (Gietel-Basten, Rotkirch, and Sobotka 2022). Beaujouan and

Berghammer (2019) estimated gaps of around 0.28 between intended and realized cohort total fertility among women born in the early 1970s in a number of European countries and the US. Evidence from the Nordic countries indicates that this fertility gap is increasing among women born in the 1980s, as their predicted completed cohort fertility is declining more steeply than their personal ideal family size (Fallesen et al. 2022).

Parenthood entry is also consequential for parental education, career development, and overall well-being. For instance, Kleven et al. (2019) analyze earning losses for mothers after the first childbirth across several countries and find large and long-lasting motherhood penalties, even in welfare states such as Denmark and Sweden. The timing of parenthood entry is also crucial as having children later in life enables individuals to pursue education further and develop better career trajectories. For instance, Miller (2011) find strong earnings increases in response to motherhood delay in the U.S. In Finland, Nisén et al. (2022) find that delaying parenthood improves the educational and labor market trajectories of women more strongly than those of men. Having children at an older age is also associated with higher parental well-being (Myrskylä and Margolis 2014).

On the other hand, low fertility, which is associated with a smaller number of siblings and lower average birth order, may benefit children. A smaller number of siblings (e.g. Booth and Kee 2009; Mogstad and Wiswall 2016) and lower birth order (e.g. Pavan 2016; Lehmann, Nuevo-Chiquero, and Vidal-Fernandez 2018) may enhance children's well-being, educational outcomes, and health. Moreover, while being born to older parents is associated with adverse early-life outcomes such as lower birth weight (Aradhya et al. 2023), longer-term outcomes such as cognitive ability at adult ages and educational attainment are positively associated with older parental age, possibly because of the higher socioeconomic attainment of older parents (Myrskylä et al. 2013; Barclay and Myrskylä 2016; Goisis, Schneider, and Myrskylä 2017).

## 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 (Frejka and Calot 2001; Andersson et al. 2009). After a rapid decline in fertility in the 1960s, as observed in many developed countries – the Finnish period total fertility rate (TFR) declined from 2.72 in 1960 to 1.49 in 1973 – the TFR fluctuated around 1.6–1.9 in Finland (Ruokolainen and Notkola 2007). By the early 2000s, a bifurcation in fertility levels had emerged among high-income countries, with TFRs reaching 1.9 in Northern and Western Europe (including Finland) and the United States, and rates declining to around 1.3 or below in Central, Southern, and Eastern Europe, and East Asia (Rindfuss, Choe, and Brauner-Otto 2016). Similar patterns have also been observed in lifetime fertility, which is free from the distorting impact that changes in fertility timing have on TFRs (Bongaarts and Feeney 1998). Lifetime fertility declined continuously, particularly in Southern Europe and East Asia, reaching levels around or below 1.4 for the late 1970s cohorts. In the Nordic countries lifetime fertility stabilized around 2 children (Myrskylä, Goldstein, and Cheng 2013; Zeman et al. 2018) and was also projected to remain at similarly high levels (Schmertmann et al. 2014).

However, in 2010, period fertility began to decline in high-income countries with relatively high fertility levels, as observed in the Nordic and Western European countries and the US (Vignoli et al. 2020; Hellstrand et al. 2021). The declines seemed to have initially been triggered by the

Great Recession in 2008, but continued after economic recovery (Goldstein et al. 2013; Comolli et al. 2021). 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). This is below the European average (1.53 in 2021) and places Finland among the lowest fertility countries in Europe (Eurostat 2023). Forecasts of lifetime fertility indicate that this decline is likely to lead to a fall from 1.9 to 1.4–1.7 for the late 1980s cohorts (Hellstrand et al. 2021).

Structural factors offer limited help in explaining the recent fertility decline, as the continued decline cannot be linked to business cycles or policy changes in Finland (Comolli 2018; Hiilamo 2020). Instead, some suggest a cultural shift where the childbearing norm is no longer as strict as it used to be (Rotkirch et al. 2017). The Finnish fertility decline is largely driven by first births, and childless couples do not proceed to either the first birth or marriage to the same extent as before (Hellstrand, Nisén, and Myrskylä 2022). Finnish surveys report increased childfree values among young adults, and uncertainty and lifestyle reasons appear to be important factors in postponing or forgoing childbearing (Savelieva, Jokela, and Rotkirch 2023; Golovina et al. 2023). Finland may even have reached the "low-fertility trap", where low fertility in itself leads to social norms or structures of society that support childlessness and small families, which would consequently keep fertility at low levels in the future (Lutz, Skirbekk, and Testa 2006). Hence, it is possible that fertility in Finland will not quickly recover to pre-2010 levels. Instead, the Finnish society may have to find ways to adjust to the new low fertility landscape.

The adjustment of the Finnish society to this landscape is challenged by the fact that the educational level of more recent cohorts has also stagnated or even declined (Härkönen and Sirniö 2020). The share of 35-39 year old Finns with tertiary education reached its peak in 2013, at 55% among women and 37% among men; thereafter it fell to 52 and 34% respectively in 2022 (own calculations based on Official Statistics of Finland (OSF) 2023a). The share of this age group educated to the basic level has stagnated at around 11% for women and 20% among men since the late 1990s or early 2000s. Currently the level of education in Finland is below the OECD average (OECD 2023). In 2022, 41% of 25-34-year-olds in Finns were educated to the tertiary level – whereas the corresponding OECD average was 47%. These figures hide a substantial gender dimension, as 47% of women but only 35% of men are currently educated to the tertiary level in Finland. Most other Nordic countries (Denmark, Sweden, Norway) have levels above the OECD average. The Finnish government has set a goal to raise the educational level of Finns in the coming decades, such that half of young adults would be educated to the tertiary level by the year 2030 (Valtioneuvosto 2021).

Two recent papers have analyzed the potential of investments in human capital to attenuate the inevitable economic burden of an aging society in the Finnish context. Marois, Rotkirch, and Lutz (2022) forecast the productivity weighted labor force dependency ratio, which is a proxy for economic sustainability, under various education and fertility assumptions until 2060. These include two increasing fertility scenarios (TFR stabilizing at 2.0 or 1.6) and one decreasing (TFR declining to 1.2). The education scenarios include steady increases based on long-term trends and a high-education scenario in which men reach women's currently higher levels. Marois et al. find that the impact on economic sustainability between high and low fertility variants is similar to that of the two education scenarios, and conclude that fertility around 1.6 should not be a major economic concern if labor force productivity increases. For similar conclusion, see Striessnig and Lutz (2013). It is, however, unclear whether an increase of fertility to levels of 1.6 is realistic in the current low fertility landscape, in which there are no clear signs of recovery.

Further, while the applied microsimulation model has several nuances, it is a generic model with little context-specific detail, such as how labor-force trajectories vary by level of education in Finland. The high education scenario in which men reach women's education level is also potentially challenging to implement.

Mäki-Fränti et al. (2023) model the economic growth in Finland under varying human capital investment scenarios until 2070 using the Bank of Finland's long-run forecast model (Kokkinen, Obstbaum, and Mäki-Fränti 2021). Three scenarios are analyzed: 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). Important differences with respect to Marois, Rotkirch, and Lutz (2022) are that fertility is held constant at TFR of 1.45 throughout the scenarios, and that each scenario has stronger in-migration than what official Statistics Finland forecasts assume. The amount of migration varies across the scenarios, such that the high education scenario is combined with high in-migration, and the low-education scenario with low migration. The conclusion of the analysis is that investments in human capital are key to economic growth; however, separating the effect of education from migration across these scenarios is not straightforward as the high-education scenario also includes highly-educated and employment-based immigration.

Marois, Rotkirch, and Lutz (2022) and Mäki-Fränti et al. (2023) are key studies on the interlinkages of education, population structure, and economic sustainability in the context of 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, and is therefore 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 levels of education.

## Scenarios: Fertility and Human Capital Investment Strategy

To explore the extent to which human capital investment could offset the adverse economic impact of low fertility, we produce three different future scenarios: baseline, lowest-low fertility, and high education investment. The foundation of these scenarios is Statistics Finland's long-term projections of mortality, fertility, and migration. In the baseline scenario, TFR is 1.45 as in Statistics Finland projection, but it is reduced to 1.30 in the other two scenarios. The simulated level of 1.30 corresponds closely to the most recent observed TFR levels. Mortality is age-, sex-, and education-specific across the scenarios and 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 as higher-educated persons have lower mortality. Across the scenarios, migration is constant at 15,000 persons, as in the population projection by Statistics Finland.

***Baseline Scenario***: In this scenario the TFR is set at 1.45, as in Statistics Finland's most recent population forecast (Official Statistics of Finland (OSF) 2021). 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, further to 1.35 in 2019 and then back to 1.45 in 2021 (Official Statistics of Finland (OSF) 2019, 2021)). A TFR of 1.45 still serves as a useful baseline as it is the level currently used in official forecasts, and it can be argued that it is reasonable in the sense that it is within the range of predicted lifetime fertility levels for women born in the late 1980s (Hellstrand et al. 2021) and approximately matches the tempo-adjusted TFR for year 2022[1]. In this baseline scenario, we assume no additional investment in human capital.

***Lowest-Low Fertility Scenario*****:** In this scenario, we assume a "lowest-low" fertility scenario where the TFR is constant at 1.30. Lowest-low fertility was coined by Kohler, Billari, and Ortega (2002), as a TFR at or below 1.3 and corresponded 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 at the beginning of 2023 (the preliminary 12-month TFR between July 2022 and June 2023 was 1.28) (Official Statistics of Finland (OSF) 2023b; Helsinki Times 2023), is experiencing lowest-low fertility levels for the first time. Similar to the baseline scenario, this scenario also assumes no additional investment in human capital. Comparison of the baseline and lowest-low fertility scenarios allows us to identify the long-term economic impact of the recent decline of TFR from 1.45 to 1.3, holding everything else constant.

***High Education Investment Scenario*****:** This scenario adopts the fertility, mortality, and migration patterns of the lowest-low fertility scenario and asks to what extent the adverse impact of lower fertility can be offset by increased human capital. Suppose that the total public spending on education remains constant when the cohort size shrinks. Then each person from the smaller cohort would obtain more educational resources. The higher per capita investment in education thus enables cohort members to accumulate more human capital and eventually leads to a more highly educated population. We do this by keeping the total education investments at the same

[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).

level as in the baseline scenario with a TFR of 1.45, but distribute the investments to lowest-low fertility cohorts that correspond to a TFR of 1.3. This corresponds to approximately 12% (1.45/1.3 = 1.12) higher education investments per child, without increasing the costs compared to the baseline scenario. For details of the implementation, please see Appendix Table 1.

In order to produce realistic scenarios, we pose limits to the education distribution so that the shares in lower and higher tertiary education respectively do not exceed 40%. These limits are based on the education projection among the most highly educated countries across the globe from the Wittgenstein Centre for Demography and Global Human Capital (Lutz et al. 2018). In these projections, several countries reach higher education levels, therefore we consider our simulated high-education scenario to be ambitious yet realistic and feasible. Appendix Figure 1 illustrates this by comparing Finland to other countries.

[FIGURE 2 HERE]

Figure 2 further illustrates how our projection in the baseline scenario and in the high education investment scenarios compare to other countries and regions[2]. In the baseline scenario (as well as in the lowest-low fertility scenario), the share of the cohort educated to the tertiary level remains low at around 46%. With the investment of savings from educating a smaller cohort, large educational improvement is observed. The proportion starts at 66% in the cohorts born in the first decade of the century and eventually reaches 80% in the youngest cohorts born in the 2040s. The high education investment scenario approximates the projected trajectory of other Nordic

[2] To enable the comparison, we use education distribution at age 30 and combine every five birth years into cohort groups using our projected data, except the first cohort group where birth cohorts from 2008 to 2010 are combined.

countries, namely Sweden and Norway, and the share gradually approaches the level of other most highly educated countries.

Further, we impose limits on the three lower educational categories at the basic and secondary levels, at 3% respectively, so that none of these categories empties out. Education improvement is observed in shrinking lower educational categories: the share educated to the basic level only drops from 14% to 8%, and the shares of general and vocational secondary education change from 8% to 3% and from 30% to 9% respectively. Figure 3 shows the educational level by gender in the scenario including human capital investment. Women and men born in the 2030s and 2040s respectively reach the imposed limits.

[FIGURE 3 HERE]

## The Model

We explore the impact of the three scenarios on economic sustainability by using the Finnish Centre for Pensions' microsimulation model ELSI[3]. This is an established model that we have modified slightly to suit the purposes of our present analysis. The key outcomes we consider are GDP per capita, wage sum, and annual pension expenditures relative to the wage sum[4].

[3] This is an acronym for Pension Simulation (in Finnish Eläkkeiden simulointi).

[4] The financing of Finnish pensions is highly dependent on demographic developments and wage sum because the pensions are only partially funded. Earnings-related pensions cover over 90 % of the total pension expenditure. The system is a defined benefit scheme with partial funding, with a funding ratio of around 30 percent. The accrual of pensions is based on career earnings. Pension accrues 1.5 percent for all earnings with no ceilings. The pensions are indexed based on price and wage changes. There are two automatic adjustment methods that depend on observed mortality.

## The ELSI Model

We build on the ELSI microsimulation model, which has been developed by the Finnish Centre for Pensions. The model shares many similarities with 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, the transitions among population states are not based on behavioral equations, but on Markovian transition probabilities. The model has a cross-sectional aging process with one-year time steps, which builds a synthetic life history for each simulated individual. Educational level, in addition to sex, is the main driver of the differences between individuals. The highly educated have typically fewer career breaks (e.g. due to unemployment), higher wages, and longer lives.

ELSI has a modular structure. The most essential parts for the current analysis are the first two modules, which are the population module and the earnings module. Subsequent modules determine the amount of pension based on the results of these two modules. These other modules are described in detail in Tikanmäki and Lappo (2020).

ELSI is connected via a micro-macro link to the semi-aggregated Long-Term Projection Model (LTP), also developed and operated by the Finnish Centre for Pensions (see Tikanmäki et al. 2023). The target population of ELSI comprises the entire adult population resident in Finland and those adults living abroad who have previously accrued earnings-related pensions under the Finnish pension system.

The data used in creating the source datasets for the ELSI model are generally of high quality and comprise all people covered by the Finnish earnings-related pension system. The individual-level data used in the ELSI model is primarily based on register data on highest education level provided by Statistics Finland; register data on marital status and primary residence provided by the Digital and Population Data Services Agency; the Finnish Centre for Pensions register of earnings-related pension contingencies; and various additional registers on statutory pensions and earnings. For more details, see Tikanmäki and Lappo (2020).

Population modeling in ELSI is based on 21 population states that depict the main activity in a given year. A person is in a single population state for one year at a time. Employment is divided into three population states based on the length of consecutive employment, in order to break the strict no-memory assumption of the Markov model. Similarly, those receiving unemployment benefits are divided into two states based on whether they are on the unemployment pathway to retirement. There are 11 population states for retired people, mostly corresponding to the various types of pensions that a person can receive. There is one state for disability benefits preceding full disability pension. People who are outside the labor force for other reasons are in one of three states, depending on whether they have accrued earnings related pension or not and whether their situation is considered to be temporary or more permanent. Persons in these three states include, for example, non-employed students, those doing mandatory military service, those on child home care allowance or on a longer sickness allowance, and incarcerated people. Other career breaks, such as earnings-related parental leaves, are modeled independently of the model states.

The population module is the first simulation module in the ELSI model. It simulates the development of the target population by generating new cohorts that enter the population and by modeling immigration, emigration, education dynamics, and transitions between population states. State transitions include, for example, labor market dynamics, transitions into retirement, and deaths. The first simulated year is 2017, and simulation is done until 2090. Population state transitions are modeled with the help of the 21 population states. Population state modeling has a simple Markovian structure, where the only factors affecting the probabilities of transitioning into other states are country of residence, sex, age, education level, and current population state.[5] The original transition probabilities are estimated through non-parametric estimates.

A single year in the ELSI population module is simulated as follows. The basis for the yearly simulation is last year's simulated data, or actual data in the case of the first simulation year. The ELSI transition probability matrix is updated in such a way that the probabilities match the corresponding Long-Term Projection Model probabilities.

ELSI does not simulate in detail the duration of post-compulsory education, only degrees completed. Educational levels are adjusted based on probabilities calculated from the source data. The factors that define the probabilities for a rise in education level are current education level, age, and sex. For the high education investment scenario, we modify these transition probabilities so that we get the desired educational distribution for 30-year-olds.

The second module of the ELSI model is the earnings module. The main role of the earnings module is to simulate annual wages for working individuals. The wage simulation is based on two time series models that are fitted to Finnish earnings data from 2005-2015. Wages are simulated using a dynamic AR(2) type model in the case of individuals with a wage history. This dynamic model incorporates past wage information, providing a realistic depiction of their earnings trajectory over time. Models for wages account for differences in sex, age, and educational level, the individual's wages in the two preceding years, their employment state, and

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

a factor reflecting the individuals' occupation. For those who are entering the labor force, and thus have no wage history, initial wage is simulated through a static model, because it is not possible to account for previous wages and occupation. For more details, see Tikanmäki and Lappo (2020).

After simulating the employment careers in the population module and wages in the earnings module, we calculate the pension amounts based on the current pension rules, and aggregate these to population-level indicators such as the pension expenditure, the wage sum, and the GDP for each simulation year. One key measure we consider is the pension expenditure relative to the wage sum. This is the most natural ratio to consider in pay-as-you-go schemes. It is also very informative in partially funded schemes like the earnings-related pension system in Finland (see Tikanmäki et al. 2023).

For this analysis we run the ELSI model without the micro-macro link so that the impacts of the scenarios are not overwritten by the model dynamics. However, the impact of the wage sum growth in pension indexing is explicitly taken into account. The analysis is static in the sense that the population in each education, sex, and age group across scenarios is assumed to be similar to those in the baseline scenario, meaning that 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 shows the trajectory of GDP per capita for the three scenarios, with baseline scenario scaled to 100. In the lowest-low fertility scenario, GDP per capita initially increases relative to baseline because of the smaller cohorts sharing the GDP, but then declines below the baseline level. In the high education investment scenario, the trajectory is similar or slightly below the lowest-low fertility scenario until approximately 2040. This is expected, as the population structures are the same, and the only difference is higher investment in education. This investment starts to pay off starting from 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 over 80% of the faster growth in the high education scenario is due to the growth in average wages and the rest is due to employment growth. Between the years 2030 and 2090, wages grow annually by 0.16 percentage points faster on average in the high education investment scenario than in the baseline scenario or in the lowest-low fertility scenario.

[FIGURE 4 HERE]

Figure 5 illustrates the dynamics of wage sum over the three scenarios. These closely mirror the GDP per capita patterns, with the difference that the patterns are not scaled to the population. In the lowest-low fertility scenario, wage sum keeps up with the baseline scenario until approximately the 2040s, when the smaller cohorts enter the labor force and consequently wage sum starts to decrease. In the high education scenario, higher education delivers wage sums that stay at similar levels as in the baseline scenario, or slightly higher, even though the population earning these wages is smaller.

[FIGURE 5 HERE]

Figure 6 shows pension expenditures relative to wage sum. In all scenarios, there is first a short-term decline in the 2030s and then a long-term increase from the 2040s. In the baseline scenario, relative pension expenditure grows rapidly starting from the 2040s, and reaches 36% by the mid-2080s. Lowest-low fertility delivers even faster increases in relative pension expenditure, from 28% in 2045 to 39% in 2085.

In Figure 6, the high education investment scenario is split into two in the analysis of relative pension expenditure. This is because higher education increases wages, but this is also reflected in the earnings-related pension levels as pension payments in Finland are indexed 20% to changes in wages and 80% to changes in prices. For accrued pension rights, the weights are the other way around. Hence, the gain in wages may be offset by added costs in pensions, and the impact of the investment in human capital on the financing of pensions is smaller than the impact on GDP, as the growth in wages leads to higher pension levels and pension expenditure.

In the first high education investment scenario (blue solid line in Figure 6), we allow pensions to be indexed to wage growth. The result of this scenario is that the relative pension expenditure closely follows the baseline scenario. In other words, higher education offsets but does not overcompensate for the smaller labor force that is due to lower fertility. In the second variant of the high education investment scenario (blue dotted line in Figure 6) we do not index the individual pensions to grow with the growing wages, but instead keep them at the level that corresponds to the lowest-low fertility scenario that does not have higher education. In such a scenario, the investments in education more than offset the impact of the lower fertility. We return to the feasibility of such an overcompensating model in the discussion.

[FIGURE 6 HERE]

Figure 7 illustrates how different education groups contribute to the wage sum in different scenarios and over time. The figure decomposes the wage sum into education groups and shows that in the baseline scenario, which equals the lowest-low fertility scenario, approximately one third of the wage sum is earned by the three lowest education groups in both 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 has occurred only partially. By 2090, most of the working-age cohorts are educated to the tertiary level 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.

[FIGURE 7 HERE]

## Discussion

Low fertility is likely to accelerate population ageing, and thereby put 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 desired family size is higher than realized fertility (Gietel-Basten, Rotkirch, and Sobotka 2022). It is possible that low fertility is here to stay, and the question of adaptation requires more attention. We utilize a detailed longitudinal microsimulation model of the economy to explore to what extent an ambitious human capital investment strategy could offset the adverse economic impact of low fertility. We base our analysis on Finland, which is a particularly interesting case as it is the fastest-ageing European country and has also witnessed dramatic declines in fertility since 2010 and stagnated levels of education in recent cohorts. Our results indicate that a human capital investment strategy that keeps the total costs of education constant despite the declining numbers of individuals in the educational system, thereby increasing per capita investment in human capital, has the potential to offset the negative impact of the smaller labor force on pension burden. The gains from such human capital investment are not limited to controlling pension burden, as working years, retirement years, pension income, and longevity of the population also increase. We argue that policies focusing on human capital investment are likely to be a feasible tool for maintaining economic sustainability amid the landscape of low fertility.

Our results rely on one key assumption that relates to productivity and how that responds to changing educational distribution. In each of the scenarios, wages (or productivity) for people in each education, sex, and age group are assumed to be similar to those in the baseline scenario with no additional investment in education. This assumption needs to be considered critically, especially in the high education scenario in which average levels of education increase, as it is not obvious that the additional people educated to the higher levels would be as productive on average as the smaller share of people educated to these levels in the baseline scenario.

The first question is whether education increases productivity at all, or whether it is just signaling. Human capital theories suggest that education enhances individuals' productivity and thus increases earnings (Becker 1962). Large wage differentials have been observed across groups with differing levels of educational attainments. Psacharopoulos and Patrinos (2004) compute the earning gap between those with and without college degrees and estimate the global average rate of return on higher education to be around 20 percent. Despite potential selection by ability and signaling of higher education, the increasing productivity brought about by higher levels of education is believed to be a pivotal reason behind the gap.

The second question is whether the impact of higher education increases or is diluted with increasing education. It is possible that a larger share of high-educated leads to higher productivity and wages per highly educated individual. At the macro level, human capital spillover may induce technological externalities and improve aggregate productivity over the direct impact on private productivity (Hendricks and Schoellman 2023). Further, the college wage premium has been observed to grow over time despite the expansion of higher education and the surge in college-educated labor supply (e.g. Card and Lemieux 2001). Skill-biased technical change, which increases the relative productivity of skilled labor and demand for it, is proposed by many to be the driving factor (Krusell et al. 2000).

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

We conclude that the past evidence does not suggest strongly diminishing returns on education with an increasing share of highly educated persons, neither on the individual nor societal level. Whether this will hold in the future is difficult to predict. Nevertheless, the scale of the effect that we observe in our high education investment scenario is so large that even if only half of it were realized, it would have a significant impact on economic growth and the financing of pensions. Thus, by unlocking the so-called Easterlin effect, our calculations suggest that smaller cohorts may not be harmful for the long-run economic sustainability of societies if there is ambitious human capital investment in the fewer children born. As discussed by Kaufmann (2005), educational policies that strengthen inclusiveness have the potential to compensate for the declining size of birth cohorts. Inclusiveness may be an important aspect, as not only the stagnation in the educational attainment since the cohorts born in the mid-1970s is visible, but there are also signs of concurrently increased educational inequality from initially low levels in Finland (Härkönen and Sirniö 2020).

Our model further assumes constant fertility rates across education levels. Among women, increasing education may be associated with decreased fertility, but this link has become weak in recent cohorts in countries like 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 postponement of births (Ní Bhrolcháin and Beaujouan 2012). However, the simulated level of TFR 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.

While our model is static in terms of behavioral responses such as fertility, the model has several nuances that make the simulation implicitly dynamic. These include the linkages between education and pensions, and education and longevity. Our high education intervention, which strongly increases the fraction of highly educated people, also increases, in the long run, average levels of pension through higher pension accrual, and how long these pensions need to be paid at the individual level because of increasing longevity. Our key results were focused 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.

Our findings align with existing literature that emphasizes the key role of human capital in demographic and economic development (Lutz 2014) and suggests that macro-level sustainability is possible with lower than replacement levels of fertility. Marois, Bélanger, and Lutz (2020) also highlight the high stakes involved with migration in terms of mitigating the support ratios in advanced aging economies. However, based on their projections, changes in educational attainment, related changes in labor force participation, and the integration of migrants have more impact in the long run than mere numbers of migrants or levels of fertility. Thus, it is critical to focus on improvements in these areas to mitigate the increasing burden of population aging.

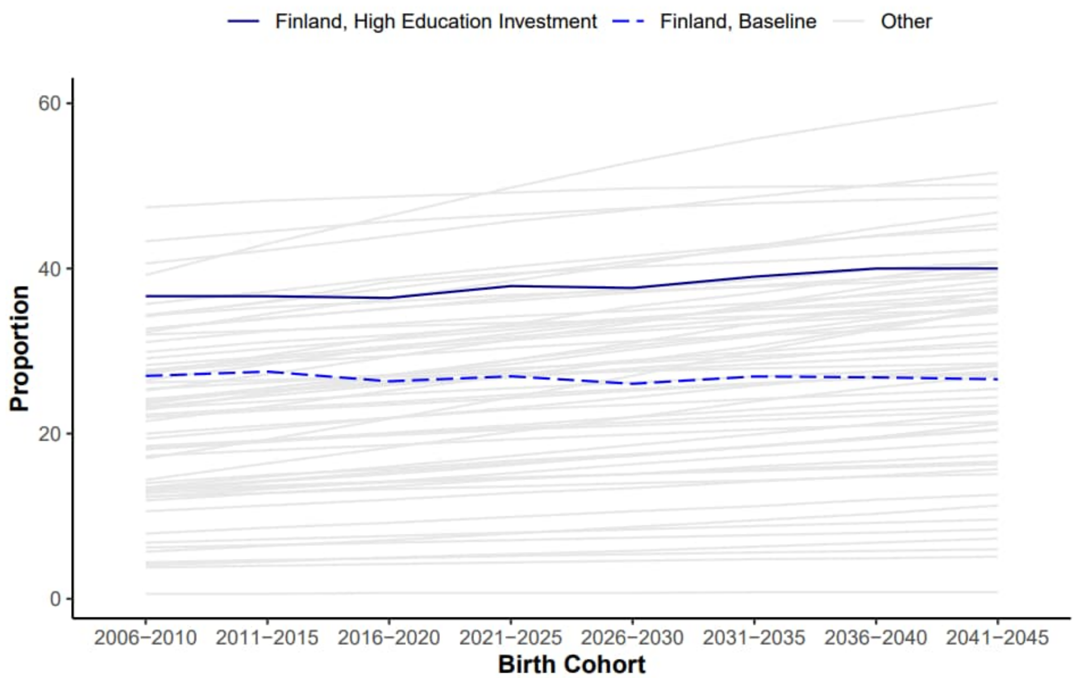
According to Striessnig and Lutz (2013), the optimal level of fertility from the point of view of long-run economic sustainability is also sensitive to the age at retirement. In their calculations, under the core assumption that the share of the cohort being educated to the tertiary level would increase and stabilize at the level of 60%, the optimal level of TFR from the perspective of education-weighted support ratios in 2100 is below two children (in countries such as Finland, Germany, Romania). In their projections for Finland, a further assumption of a parallel increase in life expectancy and retirement age would lead to a projected retirement age of 74 in 2010. In this scenario, the highest level of support would be provided by a TFR level of 1.78. Under an alternative assumption, according to which the pension age would increase by only half the increase in life expectancy, where the retirement age would equal 67 in 2100, the highest support ratio would be reached at a TFR level of 2.0. The reason for higher levels of TFR not providing higher economic sustainability in the long run is the higher cost of educating larger cohorts relative to the gains in productive potential.

Two recent papers that focused on the Finnish context also found results that highlight the importance of human capital for economic sustainability. Marois, Rotkirch, and Lutz (2022) forecast productivity weighted labor force dependency ratio under various fertility and education scenarios. They conclude that a TFR around 1.6. should not be a major economic concern if the labor force productivity increases along the lines that they project, with an education intervention that removes the gender gap in education. It is however unclear whether the TFR of 1.6 is a realistic long-term goal in the current low-fertility landscape, and what policies would be needed to approach such fertility levels. Mäki-Fränti et al. (2023) model economic growth in Finland under various human capital investment scenarios, and also include in these scenarios varying levels of migration. They also conclude that investments in human capital are key to economic growth; however, separating the effect of education from migration across their scenarios is not straightforward.

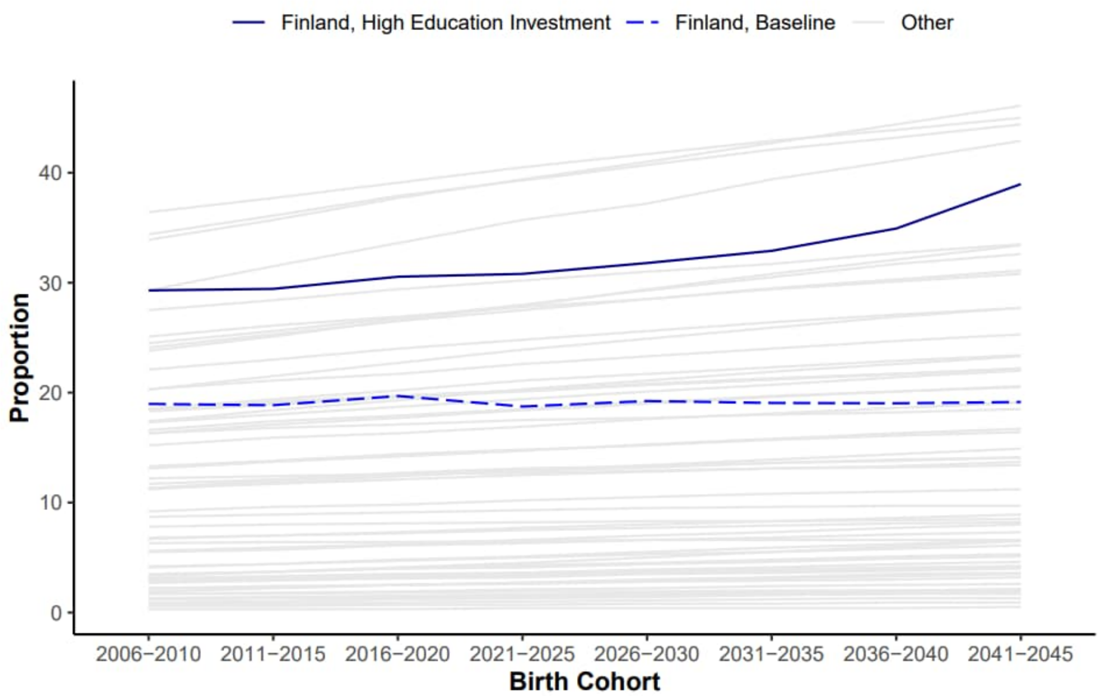
Even if macroeconomic sustainability is attainable with low fertility, it is important to consider the implications of lower fertility for individuals. Existing evidence finds many positive impacts of lower fertility, for the parents and the children alike. When family sizes are smaller, children tend to perform better in multiple aspects, potentially due to family size effect and birth order effect. Much literature has documented that children's educational attainment decreases with increasing family size (e.g. Mogstad and Wiswall 2016). Children with lower birth orders have been shown to have better cognitive abilities, higher education, and lower mortality (Barclay 2015; Barclay and Kolk 2015). When family sizes are smaller, there are more children with lower birth orders, thus the overall outcomes among children are better.

To conclude, our analysis builds on the recent papers by Marois, Rotkirch, and Lutz (2022) and Mäki-Fränti et al. (2023) by combining realistic fertility scenarios, including stability at the current level of TFR 1.3, 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 context like Finland, where the population is rapidly ageing, period fertility is at a lowest-low level, and educational expansion has stagnated. Overall, our results provide further empirical support for the claim that the improvement of the human capital of the populations, rather than demographic targets (such as a specific level of fertility) should be the focus of population policies. One of the reasons for this is that discussion focusing on concepts like replacement level of fertility do not account for the qualitative aspect of the population. Demographic targets of fertility may also be viewed as questionable from a human rights perspective. This does not mean that continued attention should not be paid by governments to find ways to alleviate the barriers to childbearing that contribute to the gaps between individuals' intended and realized fertility.

## Appendix Figures and Tables




a) Lower Tertiary




b) Higher Tertiary

Appendix Figure 1: The share of the population with a) lower and b) higher tertiary education in Finland in the baseline and high education investment scenario, and for all countries globally based on data from the Wittgenstein Centre for Demography and Global Human Capital.

Appendix Table 1: The human capital investment scenario procedure.

| | |
|---|---|
| **Step 1** | We produce population forecasts in the scenarios where the TFR is 1.45 and 1.30, and focus on the 30-year-old population by gender and education in 2024–2090 – corresponding to birth cohorts born in 1994–2060 – in all further calculations. We focus only on those who live in Finland at the age of 18, but immigrants who arrive at adult ages are later added to the total population, as it might not be realistic to impact on the education distribution of these people on a large scale. We consider the following five education categories (measured at age 30 and considered complete thereafter) for these cohorts: 1) basic education, 2) secondary general education, 3) secondary vocational education, 4) lower tertiary education, and 5) higher tertiary education (Appendix Table 2) and calculations are carried out separately for men and women. |
| **Step 2** | We calculate the difference in the total costs of education for these cohorts in the TFR 1.45 and 1.30 scenarios. We assume an approximate cost of 10 000€ per individual per year enrolled in education for all levels of education (Löyttyniemi and Heikkinen 2023), and the length of enrollment in education to be 9, 12, 12, 15.5, and 17 years respectively for the five education categories ranging from basic to higher tertiary education (Ministry of education and culture 2022). |
| **Step 3** | We use the savings originating from a smaller cohort x being born to educate cohort x-15 to higher levels. We invest proportionally according to the size of the categories among the basic, secondary general, and secondary vocational education, and upgrade these proportionally to lower and higher tertiary education until we run out of savings. |

Appendix Table 2: The classification of education used in this study.

| | **ISCED 2011/National Classification** |
|---|---|
| **Basic Education** | Less than upper-secondary education, ISCED 0–2 |
| **Secondary General education** | Upper-secondary general education, ISCED 3(1) |
| **Secondary Vocational Education** | Upper-secondary vocational education and post-secondary non-tertiary education, ISCED 3(2) and 4 |
| **Lower Tertiary Education** | Short-cycle tertiary education and bachelor level education, ISCED 5 and 6 |
| **Higher Tertiary Education** | Master and doctoral level education, ISCED 7 and 8 |

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## Figures and Tables

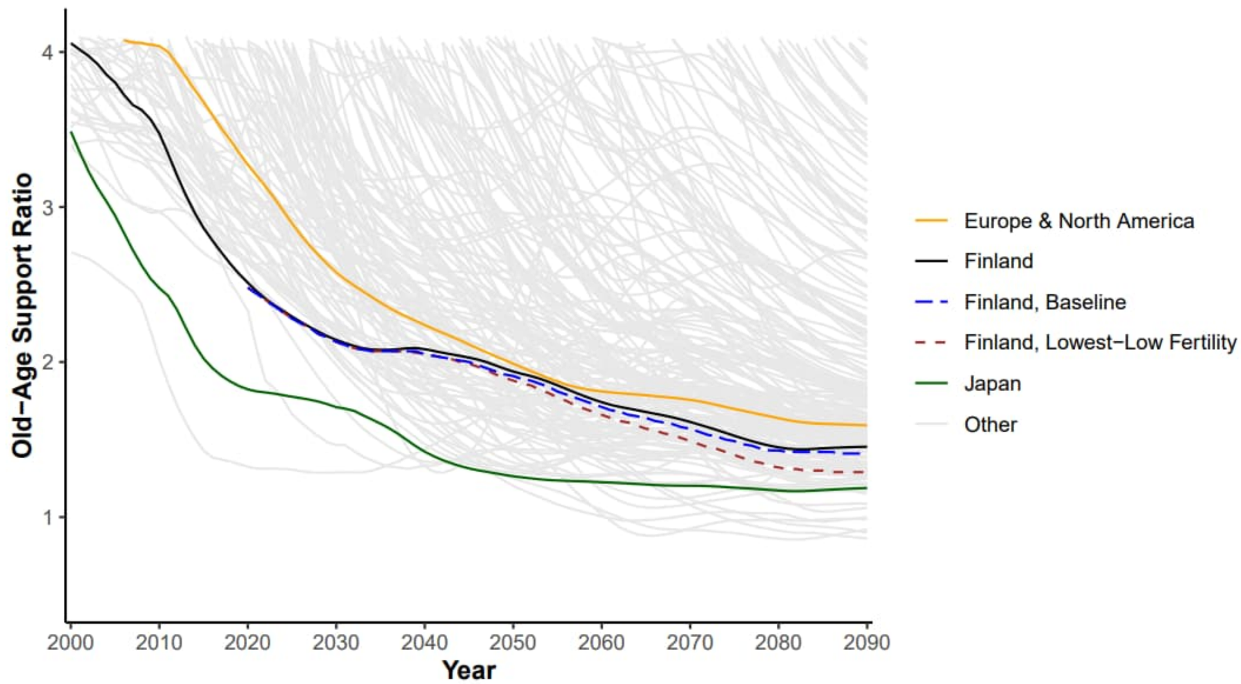


Figure 1: The old-age support ratio (observed and forecasted) for all countries/regions in 2000-2090 calculated based on the UN Population Division forecasts (United Nations 2022) as well as Finland in the baseline and lowest-low fertility scenario.

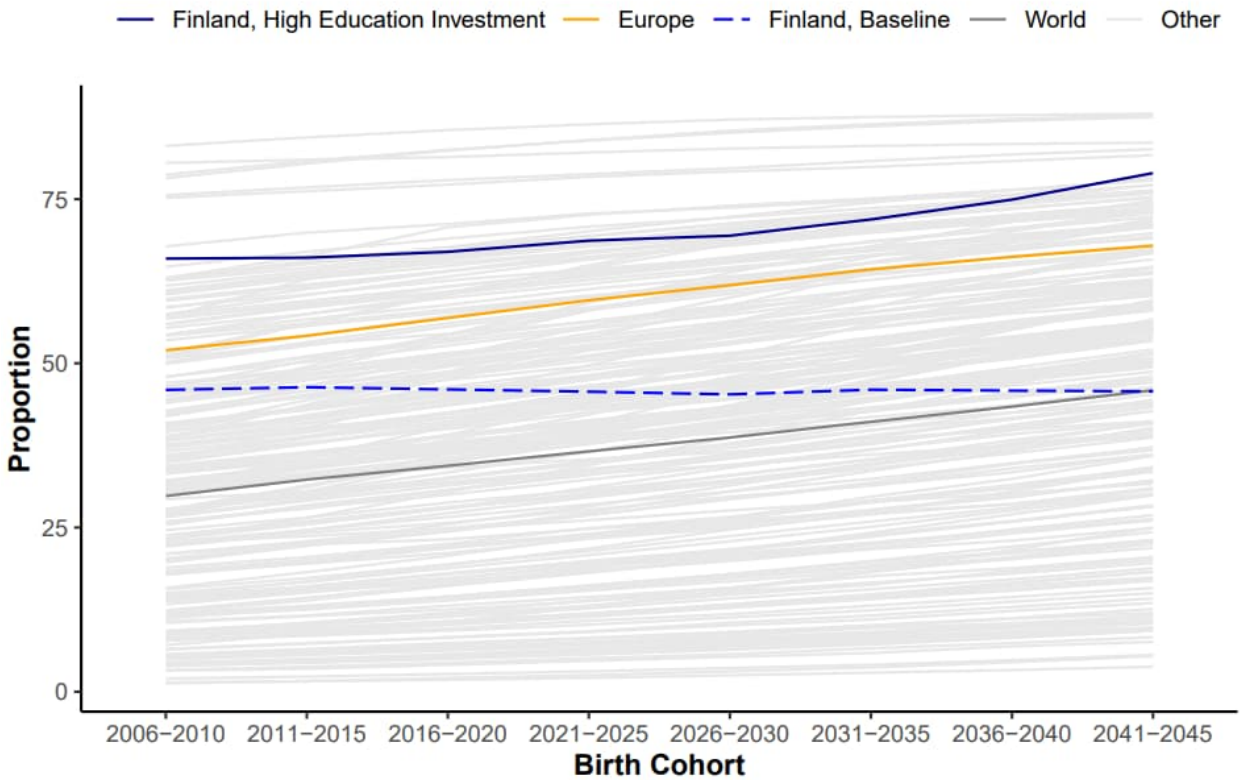


Figure 2: The share of the population with tertiary education in Finland in the baseline and high education investment scenario compared to all countries/regions, based on data from the Wittgenstein Centre for Demography and Global Human Capital.

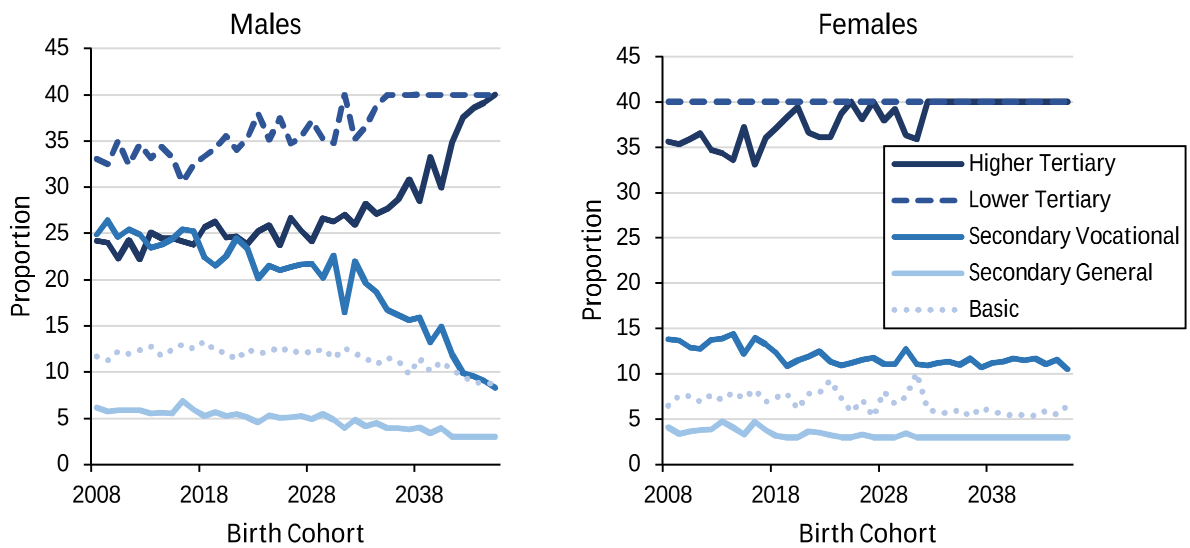


Figure 3: Education distribution for cohorts born in 2008–2045 in the high education investment scenario, males and females.

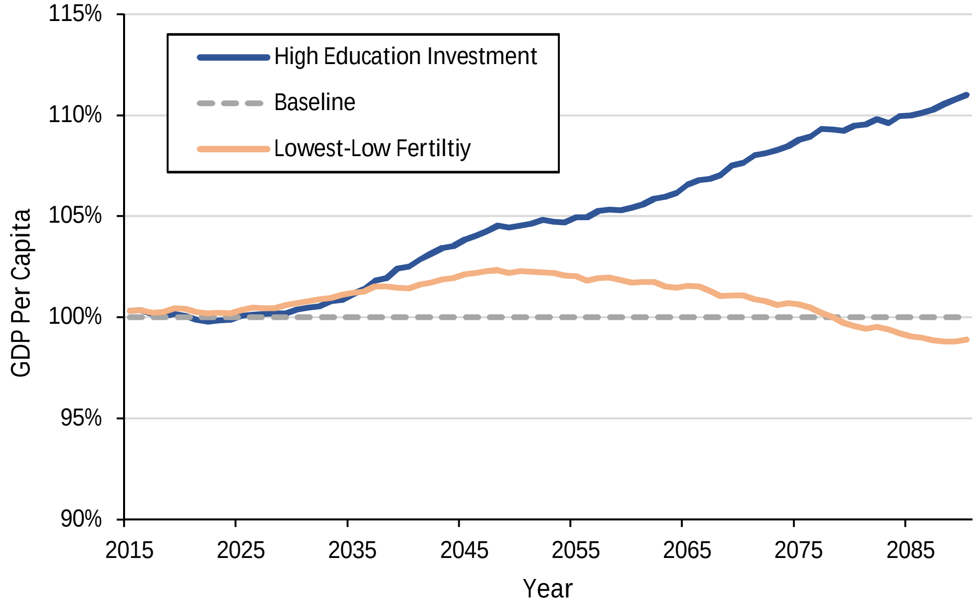


Figure 4: The trajectory of GDP per capita for the three scenarios, with baseline scenario scaled to 100.

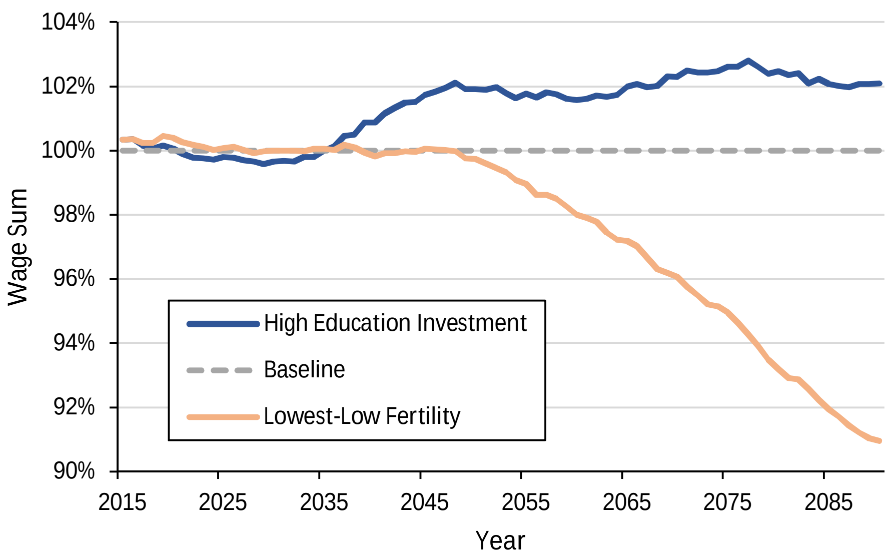


Figure 5: The trajectory of wage sum for the three scenarios, with baseline scenario scaled to 100.

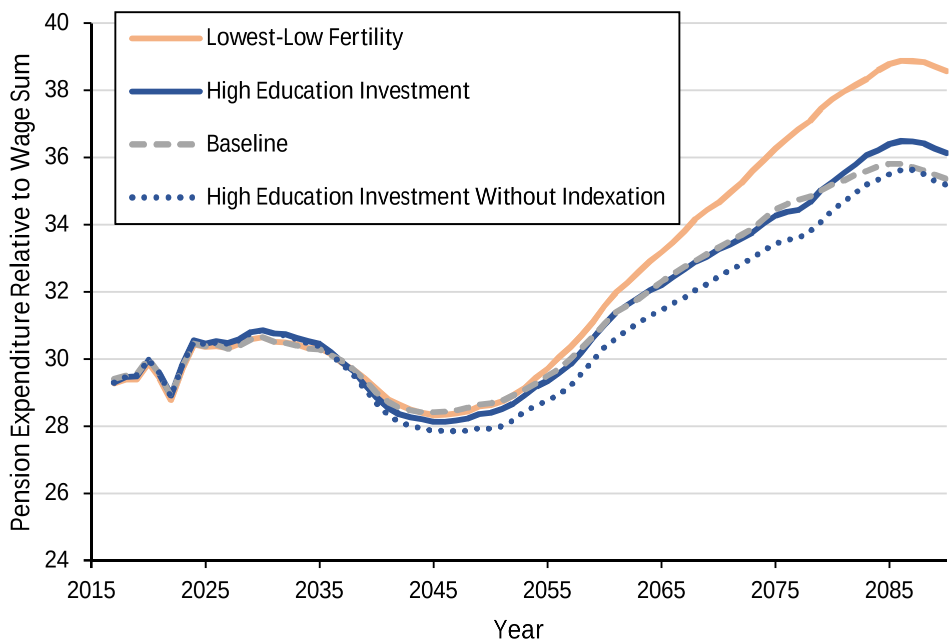


Figure 6: The trajectory of pension expenditure relative to wage sum for the three scenarios.

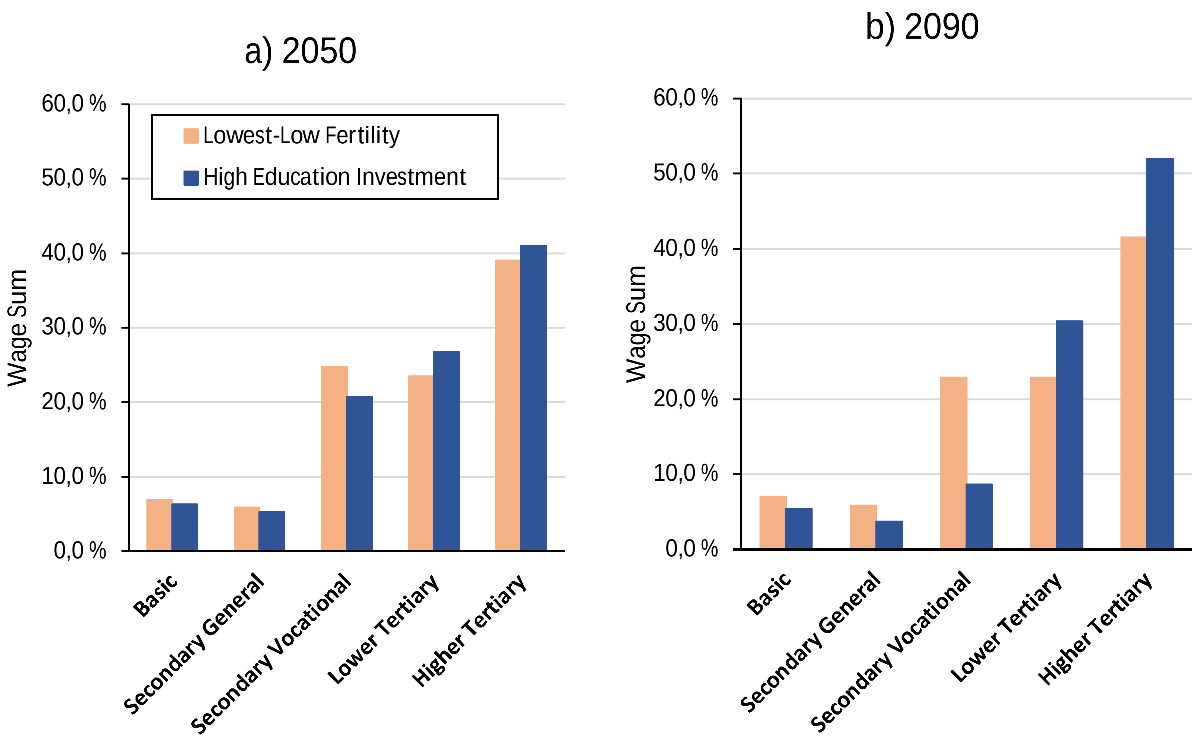


Figure 7: Wage sum by educational levels in 2050 (panel a) and 2090 (panel b).