Preliminary Draft – still to be further elaborated

Optimal Fertility

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Abstract

In this paper we challenge the wide-spread notion that replacement level fertility is the most desirable level of fertility both for countries currently above and below this level. We first discuss possible alternative criteria for choosing one fertility level over another. Dismissing for the time being the two extreme criteria of ever increasing national strength (which would imply unlimited population growth) and preservation of the environment without human interference (which would rather see human numbers go to zero) in this paper we focus on age dependency as the sole criterion. But we do so by relaxing the strong assumption that all individuals of a given age are equal in terms of their economic contribution to society and introduce education as probably the most relevant observable source of population heterogeneity. Our criterion variable is the education weighted support ratio and we perform thousands of alternative simulations for different constant levels of fertility starting from empirically given populations. If education is assumed to present a cost at young age and results in higher productivity during working age then for most countries the optimal long term TFR turns out to be well below replacement fertility.

1. Introduction

Assume for the moment that fertility was a policy variable and we could choose among different hypothetical future pathways, which average number of children should we be promoting as a social norm in the best interest of society? Demographers have so far been quite reluctant to even hint at possible answers to this rather normative question, whereas the factual trends in the levels of fertility, as well as their projection into the future have received widespread attention. If at all, then normative judgements are voiced indirectly, for example from scientists expressing their concern about high-fertility in some contexts and possible "low-fertility traps" in others. Yet, what enables them to judge and describe such scenarios as possible catastrophes?

The goal of our paper therefore is to find possible criteria to prefer one fertility future against others? How is it even possible to identify one pathway that would be preferable compared to all others? And what could valid criteria for considering one trend as being more desirable than another look like? This is in short the normative analysis that is being conducted in Section 2. Section 3 introduces the model and our base-line assumptions that the results – presented in Section 4 – are based on. Section 5 consists of detailed sensitivity analysis before a final discussion will revisit – and challenge – the theme developed in many previous discussions of the disastrous long-term consequences of low fertility. It delivers a potentially unexpected message to governments on what should be the goal of their policies in the context of population ageing and shrinking.

2. Criteria of Optimality

When asked what a desirable fertility level for populations in Europe might be, most politicians, journalists and even social scientists would say that demographers intimate it is around two children per woman – a level called 'replacement level fertility'. The reasons stated in support of this level of fertility (which in most European countries is higher than the one currently reported) usually refer to maintaining the size of the labour force and stabilizing the old-age dependency ratio. But a closer look at the demographic models that underlie this reasoning reveals that this supposedly precise level of 2.1 (actually more like 2.06 under low mortality conditions) is only derived from a highly stylized theoretical model of stable population. It has little to do with maintaining the size of the labour force in contemporary *real* European societies. These have an age structure which is highly irregular due to past fluctuations in fertility and net migration.

But even in the hypothetical absence of migration, in countries with a high share of young people (positive momentum of population growth) fertility should be well below replacement level if the goal is to maintain the absolute size of the working age population. Conversely, in countries with relatively few younger people (i.e. that have already entered a phase of negative momentum) fertility should be significantly above replacement level if again the goal is to maintain the working age population. Lutz et al. [1] showed that Europe's population entered the phase of negative momentum around the year 2000. Hence in this context of real European populations and their empirically given age structures, a reference to replacement level fertility makes little sense in terms of the stated goal of maintaining the labour force in its current size.

Another line of argumentation in favour of two surviving children per woman refers to individual preferences and a supposedly "natural" desire for a man and a woman to have two children together to replace themselves and hence continue living in their children. Recently Lutz and Scherbov argued that it is worth distinguishing between population level replacement and individual level replacement [2]. They stress that at the individual level it is sufficient to have one child (under low child mortality conditions) if the primary goal is to pass on your genes and continue to live on in the next generation. In the absence of cloning it takes a partner of the opposite sex to produce this one offspring. As such, the child is made up of only half each parent's genes. Yet, having two or three children does not make the offspring more similar to you. It would of course spread your genes more widely, but this is a very different goal from replacement and if this were the goal then, of course, you should have as many children as possible. There would be no reason to stop at two. There may clearly be other individual level reasons for having a second child such as providing your first child with a sibling, but again this is not related to the question of replacement. We only mention this important distinction between societal and individual level replacement here in order to make sure that the following discussion of optimal fertility at the societal level is not confounded with that of personal optimal fertility at the level of individuals and couples. Seen from the individual perspective it may be optimal to minimize the difference between desired and actual family size, however the resulting aggregate level of fertility may not be 'optimal' for society.

When thinking about what would be the 'optimal' level of fertility in the longer run for any given population, one must first think clearly about the criteria for making such judgments. In the context of current European populations, most of the concern in the discussion of demographic trends centres on the economic and social security consequences of population ageing. In this context the criteria for optimality are to minimize the projected increases in the old-age dependency burden and, more generally, to maximize the economic well-being of the average citizen in the population studied. But in times of major concerns about global climate change, the possible impacts of different demographic trajectories on future paths of greenhouse gas emissions and on future generation's ability to cope with the expected negative consequences of climate change also must be, at least conceptually, taken into consideration. With respect to this environmental dimension, there is generally little doubt that fewer people would be better. Still, the major challenge is how to quantify this effect and how to weigh it against the costs and benefits of the ageing dimension.

However, there still may be a third, quite powerful criterion for judging the desirability of alternative longer-term fertility trends and levels. We may label this criterion 'national identity', reflecting a population's fears of having a smaller population in relation to its rivals. Population growth, although economically unreasonable or unsustainable, may become desirable. This can operate at both inter- and intra-national levels and may explain the prevalence of high birth rates among both Palestinians and Israeli Jews despite the relatively high level of education in both societies [3].

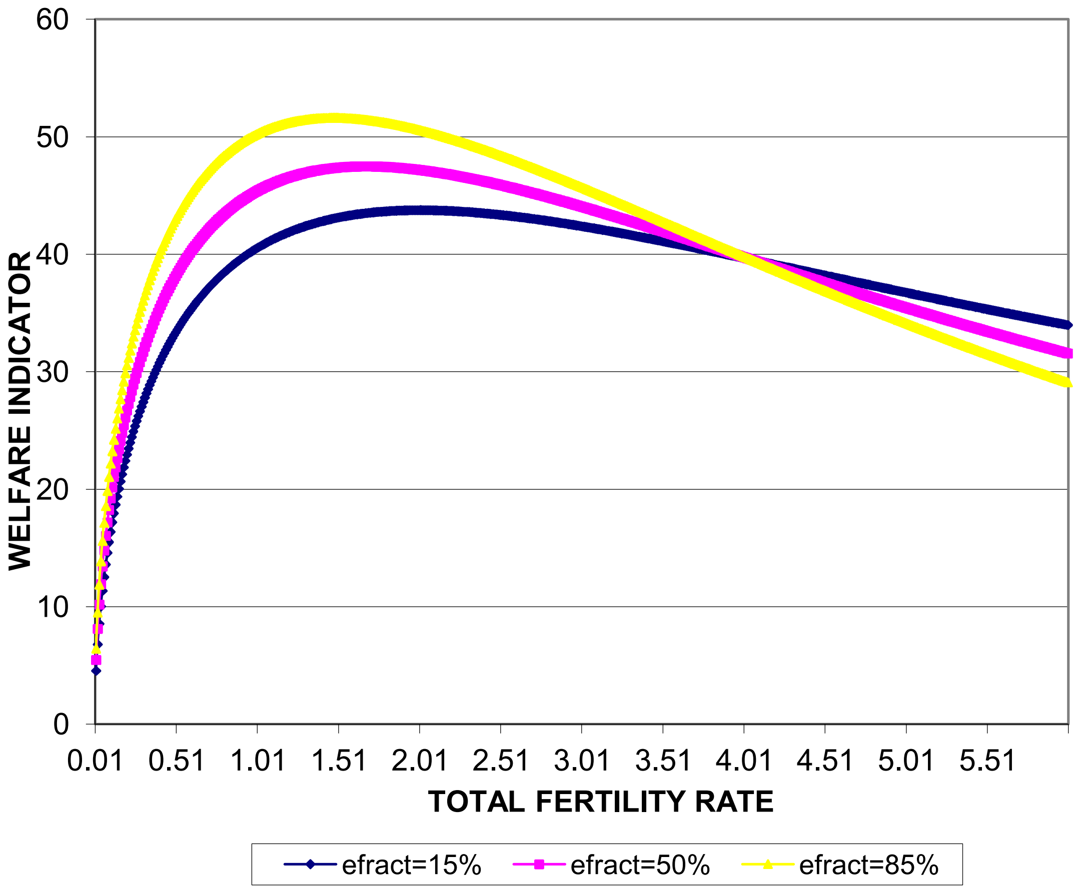
While at some point these non-economic criteria must also be taken into consideration – not always so much because of their stringency but because they exert a significant influence in real world discussions –, in the following we focus solely on the economic aspects associated with the changing age-structure of the population while explicitly taking education into account.

3. **The Model**

In 2004, Lutz, Sanderson and O'Neill published their "Population Balance" Model which directly addressed the question of optimal fertility [4]. The welfare indicator that was used to assess "optimality" was sensitive to age- and education-specific productivity, cost of pension and cost of education. They asked whether the per capita welfare decline caused by rising dependency ratios could be counterbalanced by the improved education of the smaller young cohorts. This might increase their productivity, offsetting the costs of rising dependency ratios. At the same time, smaller young cohorts cost less at a given level of education expenditure per child.

The effects of alternative levels of education on welfare were evaluated in the context of different fertility scenarios. Each steady-state level of fertility produces a distinct age structure which becomes stable in the long run. The results are shown in Figure 1 below. They clearly indicate that in the case of low education the optimum is very broad – meaning that the welfare indicator is not very responsive to changes in fertility – and peaks around two children. In the context of higher education levels, however, the optimum moves to the left (around 1.4 – 1.7 children per woman) and the overall level of welfare increases. This clearly illustrates that under hypothetical stable conditions, sub-replacement fertility can be optimal if society is willing to spend more on each child's education.

Figure 1: Welfare Indictor for Stable Populations By Fraction Educated and Total Fertility Rate, Baseline Parameters.



We will now further expand this analysis, conduct sensitivity studies and, most importantly, apply the model to the actual age and education structures of selected European countries. In order to assess the welfare impact of different long term patterns of fertility we use a simple population model, that enables us to calculate education weighted support ratios, based on observed initial (2010) population structures and survival probabilities as reported by the UN in its 2008 revision of the World Population Prospects [5]. Using the IIASA/VID data and projections on educational attainment [6] the population is first divided into four education categories (none, primary, secondary and tertiary – where for the European countries studied the first category is irrelevant). We then apply different weights to these categories, both with regard to the dependency burden due to getting education and to differential support that people in working age groups can supply for those not actively taking part in the labour force. This is a somewhat more sophisticated and realistic extension of the conventional support ratio where every person of working age is assumed to make the same contribution to the support of the dependent population.

Since there is overwhelming evidence that in virtually every society the more educated are more productive in economic terms and hence contribute more, this effect is captured here in terms of giving them higher weights when calculating the numerator of the support ratio.[1] In the figures the specific assumptions made are listed in the box on the upper left where "ed1_weight" refers to the weight given to working age people with only primary education (this is usually set to 1.0), "ed2" refers to those with at least junior secondary and "ed3" to those who have at least a completed first-level tertiary education. In all other respects this analysis makes the same simplifying assumption as the usual support ratios (that everybody of working age who no longer goes to school is in the labour force, there is no unemployment, etc).

As far as the dependents (denominator of the education-weighted support ratio) are concerned, retirees get the same weight (here assumed to be 1) but the ages of labour market entry and exit are education-specific. In other words, uneducated and primary- educated people are assumed to move from the denominator of the support ratio to the numerator after age 15, secondary- educated after age 18, and tertiary- educated follow at the age of 25. We also assume that those getting secondary and tertiary education require a higher education input after the age of 10. Here the assumed values are listed under "ed_cost" where the cost is 1.0 for everybody up to age 10. It is then increased to "ed2_cost" for those with secondary education up to age 18 and to "ed3_cost" for those going on to study to age 25.

But education has benefits as well as costs. When retiring from the labour market and thus returning to the denominator, the primary educated are assumed to make the transition at the age of 57, secondary educated retire at 61, and tertiary educated at 65. This tries to roughly resemble the current pattern in some European countries – however, current trends across the continent strongly suggest these ages will increase over the coming decades. For simplicity the retirement ages are assumed to be the same for men and women, but this could easily be changed as could all of the other assumptions on weights and transition ages.

[1] The specific weights at this stage are rather arbitrarily chosen but as sensitivity analysis shows in the following, the optimum does not respond greatly to the choice of these weights. Rather they affect the level of the support ratio.

4. Results

In the context of real populations with non-stable age distributions the time dimension becomes extremely important in this exercise. If the time horizon for optimization is only 10 or 20 years, the optimum for increasing the support ratio is very different from that of a longer time horizon. In all the following figures it was assumed that the fertility moves from its current level to the target level (listed on the TFR-axis) by 2015 and then remains constant. The standard assumption used here for all education trends is the global education trend (GET) scenario – defined as the baseline in the IIASA-VID education projections. It assumes a further improving trend following the countries that are already more advanced in their educational structure with tertiary education assumed to level off at a maximum proportion of 60 percent of a cohort. A three-dimensional representation of our base line results for Finland is given in Figure 2. Figure 3 cuts through this "support-mountain" and shows the support-optimizing level of fertility in selected years.

Figure 2: Support Ratio for Global Education Trend (GET) – Scenario. Base line for Finland, 2010-2100.

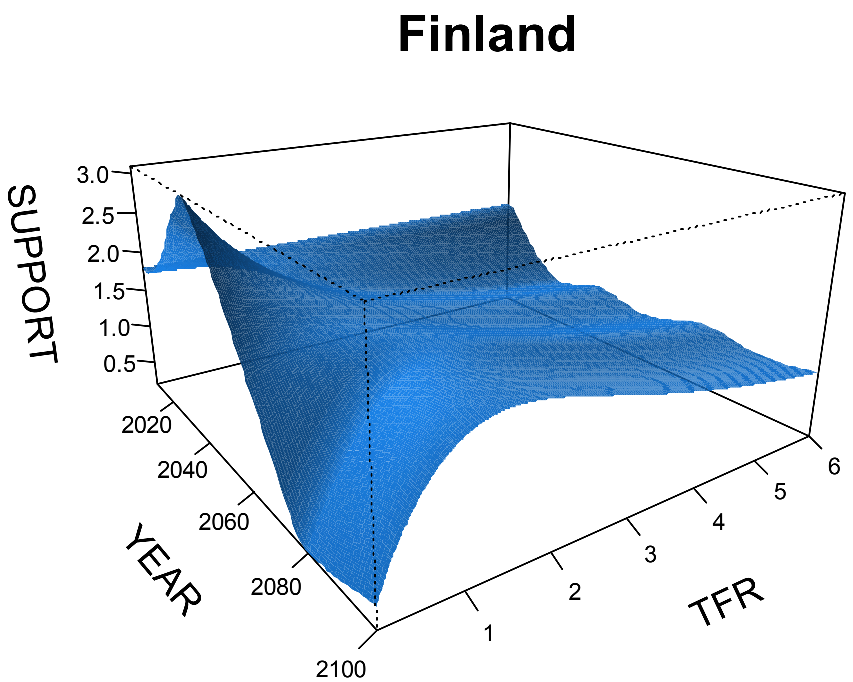
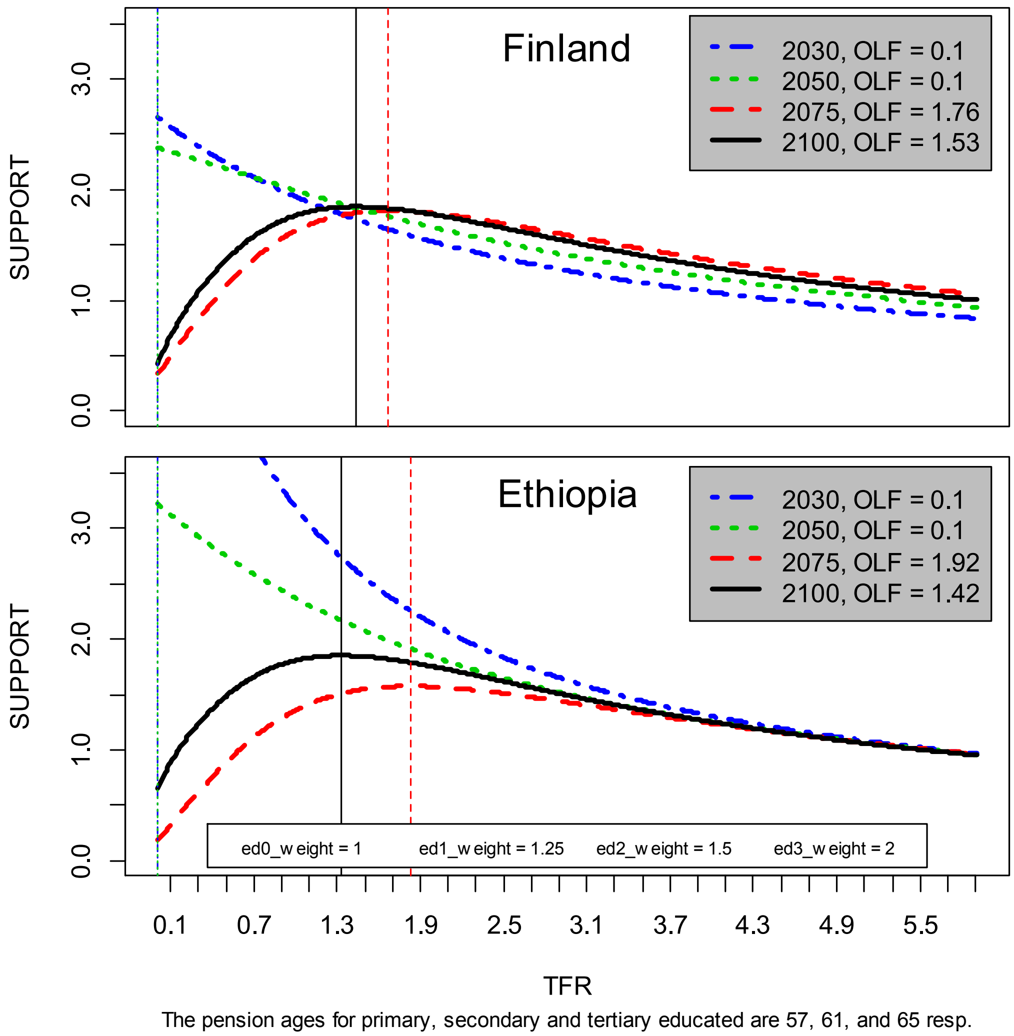


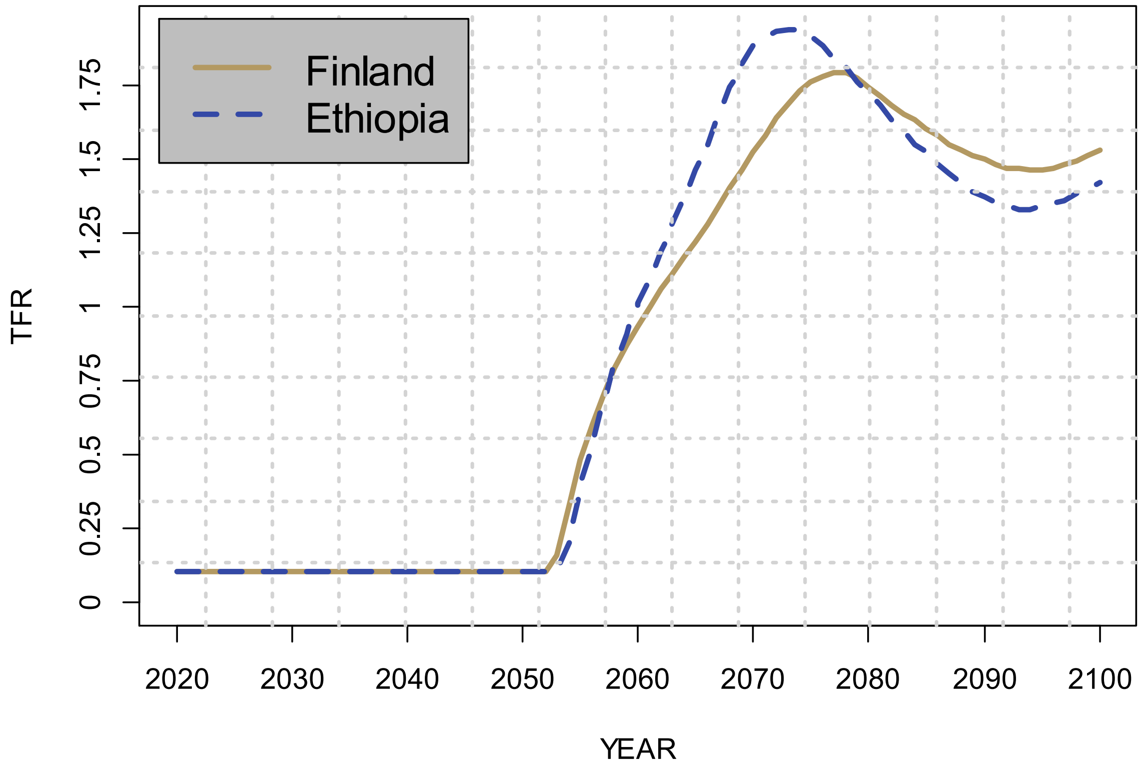
Figure 3: Support Ratio for Global Education Trend (GET) – Scenario. Base line for (a) Finland and (b) Ethiopia with lines at 2030 to 2100.



As shown in Figure 2 and Figure 3, extremely low fertility is optimal for all time horizons in which these fewer children do not yet affect the size of the labour force but only bring down young age dependency. In this case, not to have children is best. Such a policy increases the support ratio, but is of course very short-sighted because it will begin to starve the economy of workers after 15 years. As can be seen in the second half of the century the pattern of an inverted U-shape appears which characterizes all of the graphs for the longer run. It is also interesting to note that the curve declines more steeply to the left for cases of extremely low fertility and somewhat slower to the right for cases of high fertility. The TFR which shows the highest level of our welfare indicator is also indicated for different points in time in the box in the lower right corner.

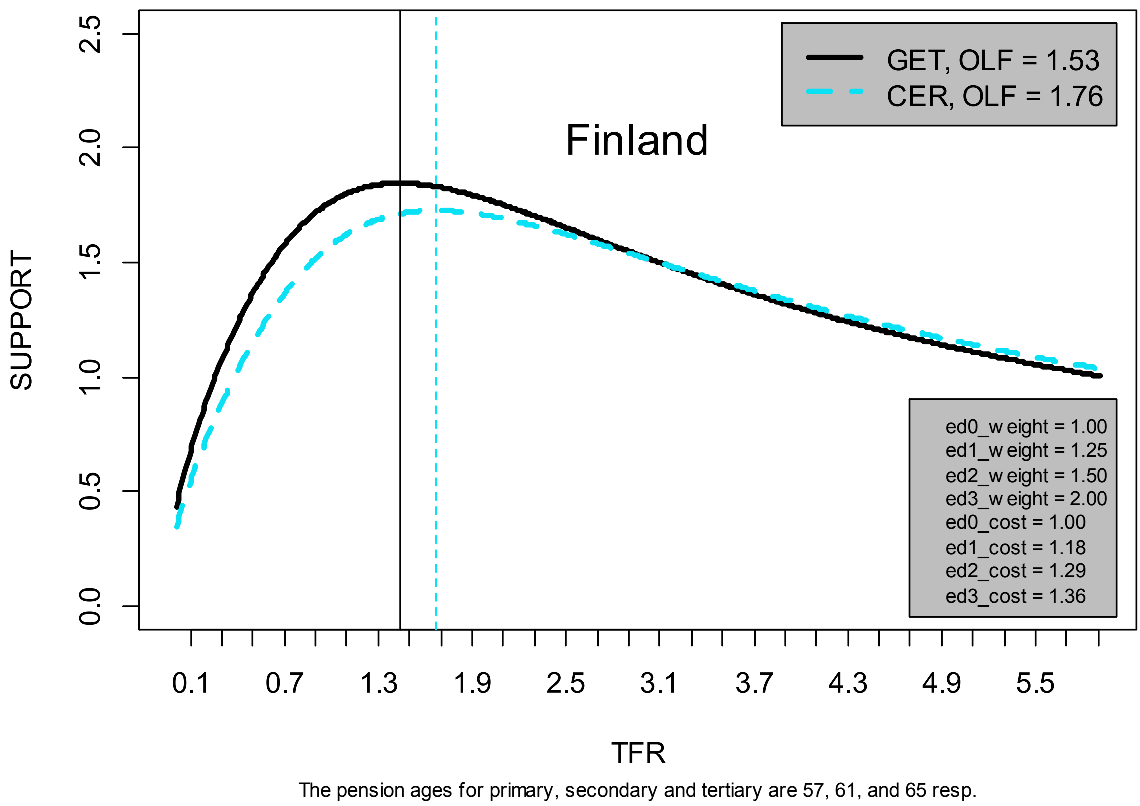
Figure 4 goes further into detail showing the total fertility rates optimizing support in every year up until 2100 for these two countries. And as we shall see, in the GET-scenario for any year these levels of TFR are well below replacement level fertility and within the range that was indicated by the population balance model.

Figure 4: Optimal TFR for Finland and Bulgaria (GET), individual years 2020-2100.



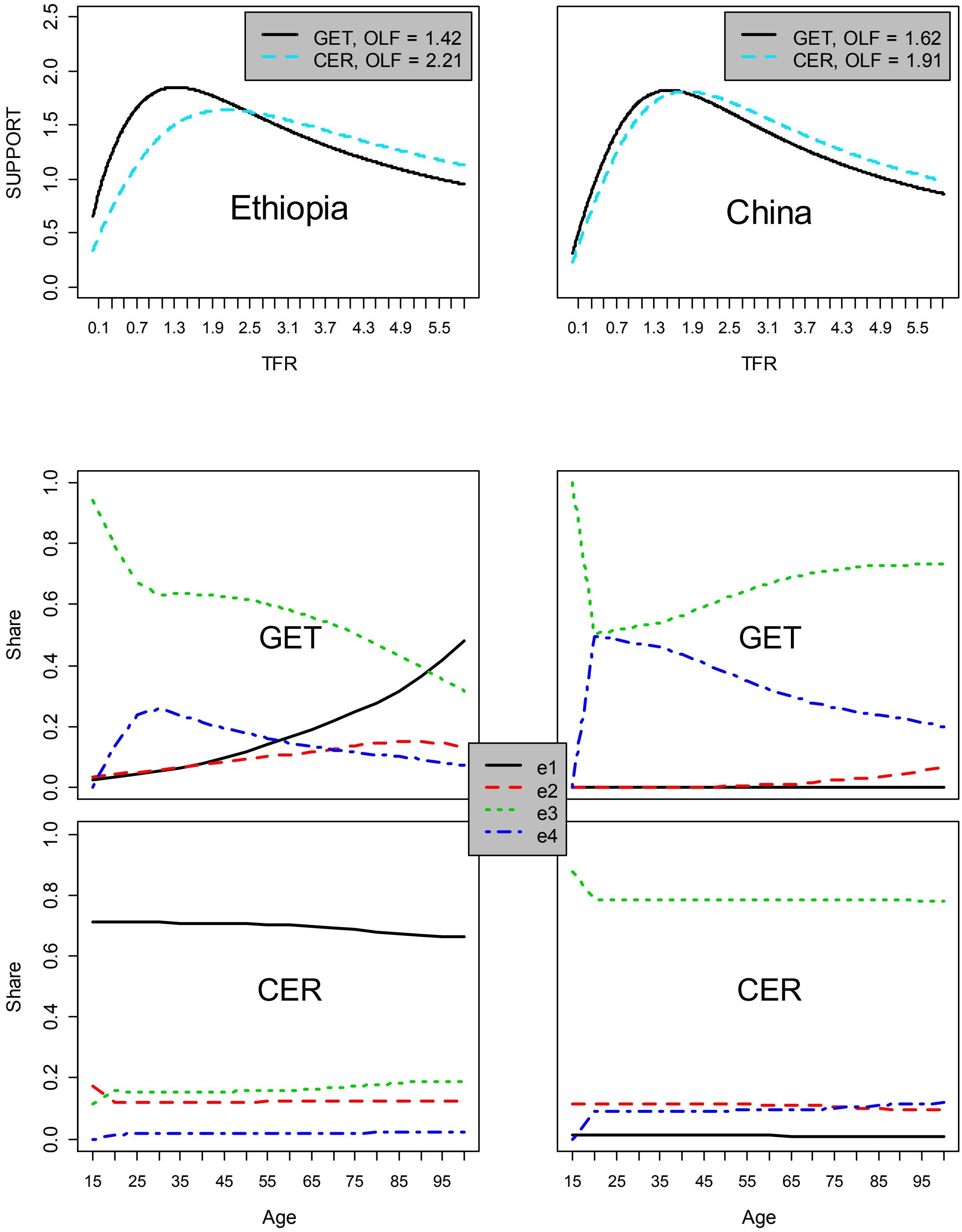
But what if the educational system does not, as assumed in the GET-Scenario, continue to expand over the course of the 21st century but rather show stagnation? In our next step we are looking at the sensitivity of the education weighted support ratio with respect to alternative educational structures of the population. This is illustrated in Figure 5 for the case of Finland where we compare our baseline scenario with the CER (Constant Enrolment Rate) – Scenario. It assumes constant education levels based on current (2010) age-specific school enrolment rates. The picture clearly shows that more education not only brings a higher support ratio (and hence a higher level of per capita material well-being) but also that the optimal TFR is lower in a population with higher average education.

Figure 5: The effect of alternative education trajectories. Support Ratio in 2100.



This becomes even clearer comparing the cases of Ethiopia and China. As can be seen in Figure 6, the educational system in China is already quite developed in 2010 and continuation of 2010 enrolment rates leads to quite a high share of people with secondary education in 2100. Ethiopia, on the other hand, still has a lot of potential for catching up. Comparing the effects of future education trajectories in the two countries therefore yields quite different results. If current enrolment rates continue to be achieved in China up to the year 2100, the level of overall support in China will be almost indistinguishable from the level achieved in the CER-scenario. This result is of course a consequence of our assumptions on education-specific ages of labour market participation, as well as the productivity weights and the costs we assign to different education categories. There may be much more people with tertiary education in China in 2100 in the GET-scenario, yet – given our current choice of these parameters – these gains in “quality” of the workforce together with modest quantity gains from later labour market exit do not exceed the quantity losses from the delay in the average entry-age and the increases in the education costs. Having more people with tertiary education in China means having less people with secondary education. This is not the case in Ethiopia where the GET-scenario increases both the share of secondary and tertiary educated people compared to the CER-scenario. The increase in the overall level of support by 2100 is much more expressed despite of the additional costs from keeping more children in school for up to ten years longer.

Figure 6: The effect of alternative education trajectories in Ethiopia and China. Support Ratio in 2100 and corresponding shares of population by education category.



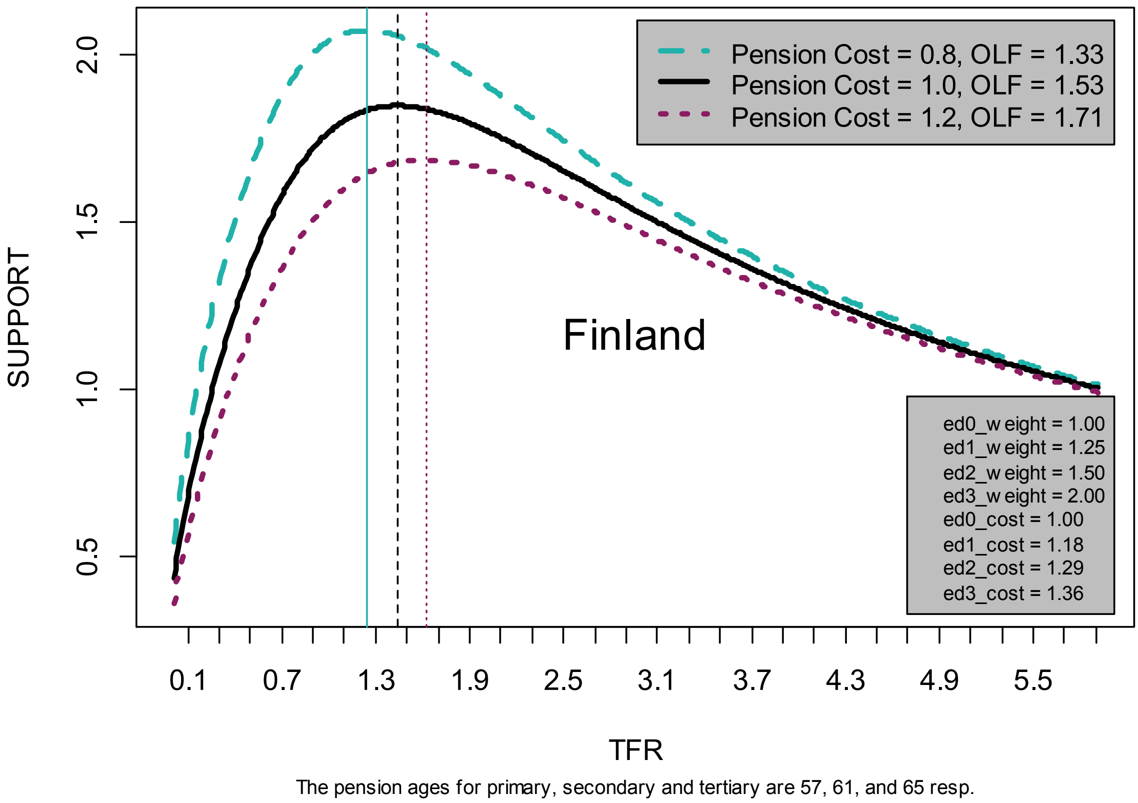
What's interesting about Figure 6 from the optimality perspective is that the OLF does show quite some response to the choice of the education scenario in both countries. Whereas in

China it decreases from an average of 1.91 to 1.62 children, which would speak in favour of lifting its one child policy, switching from GET to CER in Ethiopia the OLF is down from 2.21 to 1.42 children. This reduction is insensitive to the choice of the relative productivity weights. Rather it follows from the increased average age of retirement which in the optimum requires a smaller number of children to pay for a smaller number of future pensioners and the increased total education cost which makes children more expensive.

Of course, having ever more children when they are ever more productive can only lead to an ever higher level of overall support. Yet, before entering the labour force with higher carrying capacity they are a heavy burden on their parents' shoulders who in turn will be all the more burdening for their children once they have retired, depending on how large a cohort they were born in. The time frame is extremely important for understanding this effect. Despite the fact that bigger cohorts of schoolchildren imply larger cohorts of productive adults in the future, they also beget future large cohorts whose education costs will outweigh the prospective benefits. At any point in time, the ratio of schoolchildren to productive adults remains less favourable under conditions of high fertility.

The following graphs will show some sensitivity analysis with respect to the specific weights chosen in the above presented baseline model, as well as the effect of an increase in the pension age for all educational subgroups of the population. While we have performed large numbers of alternative model calculations, Figure 7Figure 10 only summarize the findings with respect to the parameters which the model is most sensitive to. General changes in the education weights for the numerator (ed_weight) and denominator (ed_cost) mostly influence the level of the support ratio and have only minor influence on the shape of the curve, i.e. the resulting optimal level of fertility. But, as might be expected, the shape of the curve is rather sensitive to changes in the pension age, as well as the pension burden (pension cost) relative to the contribution of working age people. Figure 7 below shows three alternative pension costs (0.8, 1.0 and 1.2), for the case of Finland for the year 2100. It clearly shows that the higher the level of pension payments relative to the education-specific carrying capacity of active people, the lower the support ratio (level of wellbeing) and the higher the optimal level of fertility. In other words, under this scenario more children are required to expand the workforce in order to pay for a higher welfare level of pensioners. As shown in Figure 3 for the case of Finland, a pension level of 1.0 results in an optimal fertility of 1.53. If we increase the pension level to 1.2 it would be optimal to have 1.71 children. But one can also read this in a different way and see what pension level would be optimal at a given level of fertility (assuming that fertility cannot be influenced). Then, of course, the result is that the support ratio is the higher the lower the relative pension cost.

Figure 7: GET-scenario in 2100 with three lines for pension cost 0.8, 1.0, and 1.2 respectively



An alternative way of increasing the support ratio is to increase the age of exit from the labour market, as shown in Figure 8 below. However, our results suggest that an increase of the average pension age by 2 years (59-63-67) not only raises the general welfare level as measured by our support ratio, but it also remarkably decreases optimal fertility. Compared to our baseline results in Figure 3, the level of fertility that maximizes support in 2100 is reduced to 1.37 (from 1.53). If again one takes the level of fertility as given, people have to stay in the labour force longer, the smaller the young cohorts to replace them.

Figure 8: The effect of higher pension ages. Support Ratio for Global Education Trend (GET) – Scenario in 2100

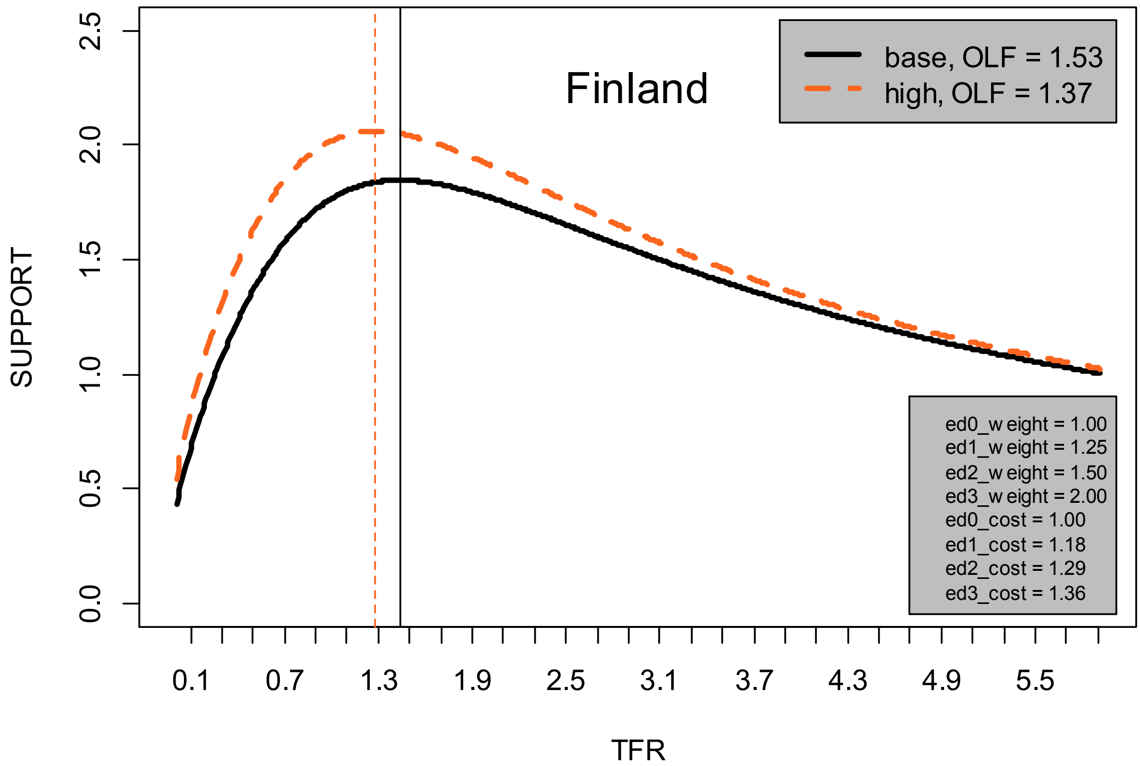


Figure 9 shows what effect an automatic adaptation of the pension-age to gains in life expectancy would have on the optimum. This is shown for three different values of the pension age's "life expectancy elasticity". A value of 0 in the box in the upper right corner means that all life years gained are years spent in retirement, that is, in the denominator of our support ratio. As can be seen this results both in a higher dependency burden and in a higher optimum level of fertility compared to base-line. Likewise, a value of 1 corresponds to all additional life-years spent as part of the labour force. Not only do we observe a higher level of our support ratio, also the optimum shifts significantly to the left. It is shown thereby that whether there is more or less of a need for children as a means of supporting our older future population strongly depends on the extent to which future gains in life expectancy will be translatable into an increased number of years spent as part of the labour force.

Figure 9: The effect of different shares of life-years gained spent in the labour force. Support Ratio for Global Education Trend (GET) – Scenario in 2100.

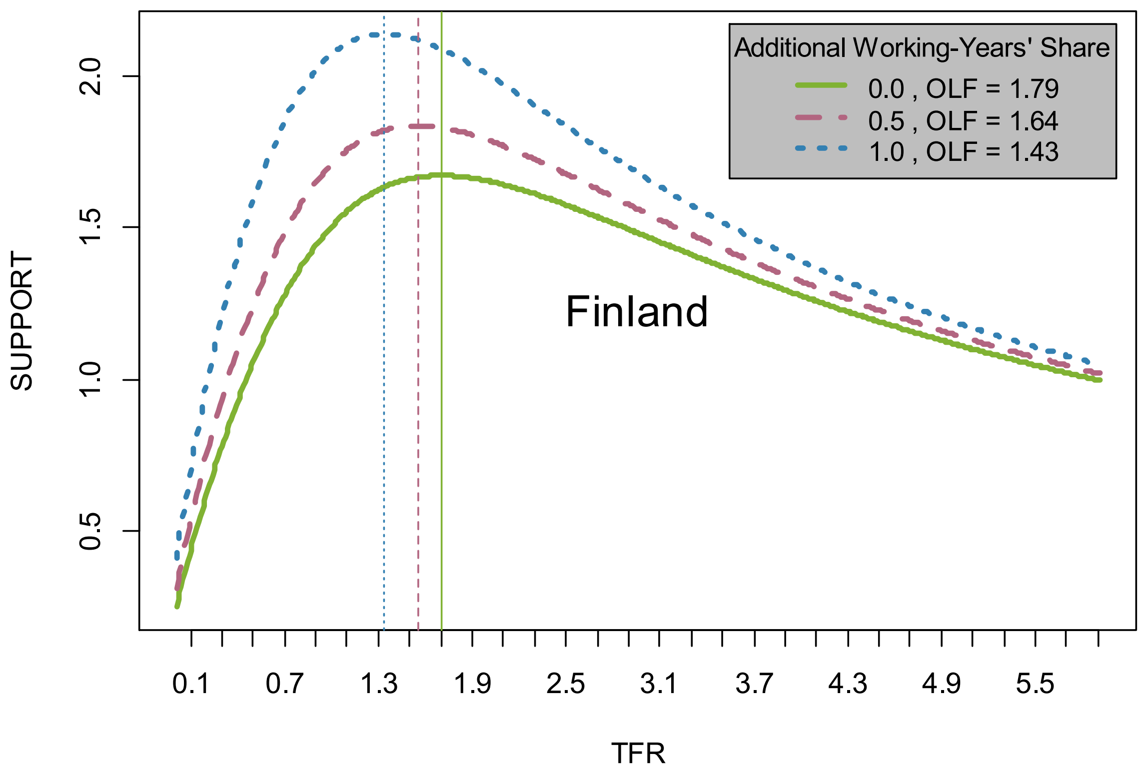
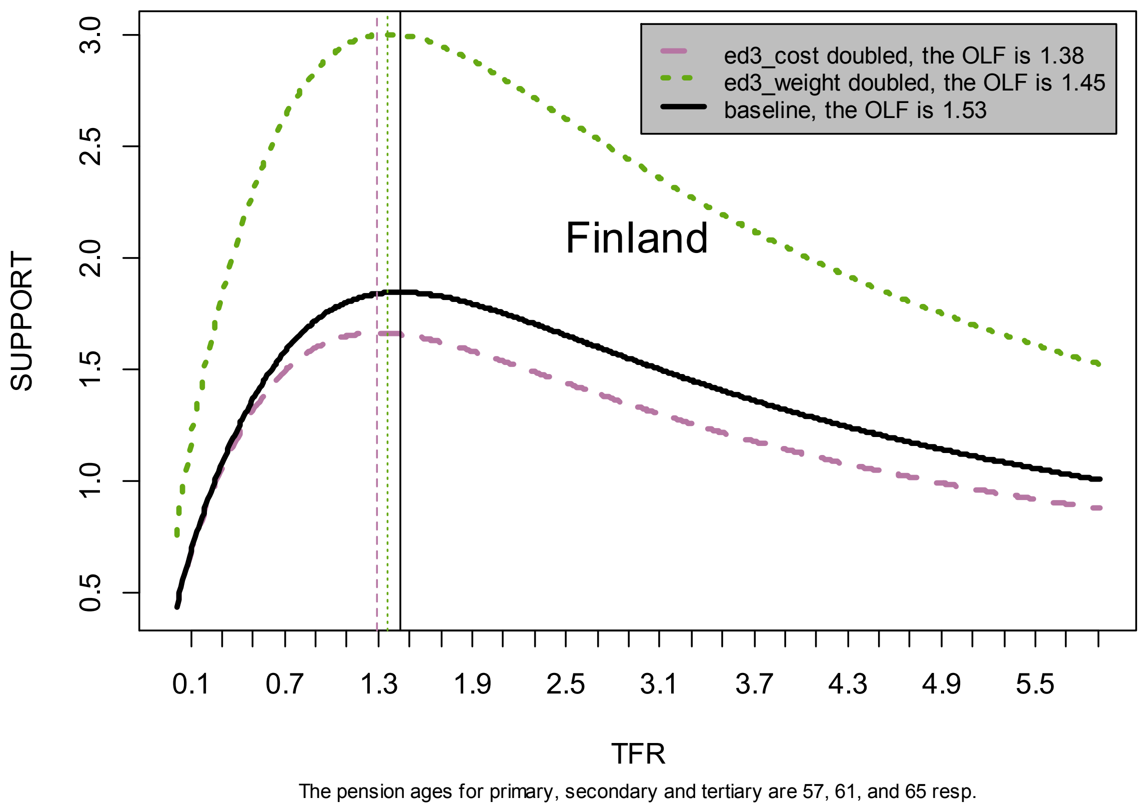


Figure 10 closes our sensitivity analysis looking at the assumed costs as well as the returns to tertiary education. Comparison with our baseline results for Finland shown in Figure 3 reveals that if the returns to tertiary education are doubled (all other things being the same) then the overall level of support hugely increases (remember that the baseline GET scenario assumes 60 percent with tertiary education in the long run) while the optimal level of fertility declines from 1.53 to 1.45. When the burden (cost) of tertiary education doubles the support ratio declines by much less. This is because the time people spent in tertiary education is rather short as compared to their working life. The optimal level of fertility also moves to 1.38.

Figure 10: Baseline with high tertiary education cost and high tertiary returns. Support Ratio for Global Education Trend (GET) – Scenario in 2100.



In conclusion, this brief exercise in education specific population dynamics shows that against widespread expectation it is far from self evident that replacement level fertility should be considered optimal. If education is factored in, a TFR quite clearly below replacement turns out to be optimal. Only very high pension incomes relative to earnings of people in the labour force result in higher optimal fertility but this also comes at the cost of much lower levels of overall well-being. Having said that, our numerical exercise only covers the quantifiable economic burden associated with population ageing. If global environmental change is factored in as a criterion there are likely to be additional forces pulling optimal fertility to yet lower levels. In the next section we discuss the political implications of this finding.

6. Discussion[2]

Many governments in Europe report in international enquiries that they are dissatisfied with the current demographic trends in their countries. The further one goes to the east of the continent, the stronger the publicly expressed concern. While the prime minister of Bulgaria calls his country's 'demographic crisis' the number one policy priority, the president of Belarus even speaks of a national 'demographic security crisis', implying that this may require equally drastic action as a security crisis at the military level. Less dramatic in tone but equally urgent in its message, the President of the European Commission repeatedly called Europe's demographic trends one of the three main challenges facing Europe, the other two being globalisation and technological change.

What do these policy makers have in mind when they refer to demographic crises or challenges? In the eastern part of Europe, where most countries (with the notable exception of Russia, which received many Russians from other former Soviet republics) have experienced significant population declines since the political transformation around 1990, the concern seems to be very deeply rooted and associated with the fear that the country will lose its population base. Bulgaria, for example, had close to 9 million inhabitants in the late 1980s; now (2008) it has only 7.6 million and is projected by Eurostat (2008) to further shrink to around 6.5 million in 2035 and 5.5 million in 2060. This loss of more than one-third of its entire population, which is also associated with very rapid population ageing, is indeed significant, particularly in the context of traditional thinking, where more population meant more soldiers and more power, but also in view of the fact that throughout human history, population shrinking has always been associated with misery and national decline. Hence, in terms of psychology and inference from the past this reaction is understandable but not necessarily correct with respect to the future. In Western Europe the story has been less dramatic because thanks to migration gains, only very few countries are already on a declining trajectory and the public policy concern is mostly with respect to the implications of population ageing.

In the global-level policy debate, for decades the notion of 'population stabilisation' has been the guiding principle and the explicit goal of virtually all population-related policies, both within the United Nations (UN) system and outside. The international political goal of population stabilisation corresponds nicely to the UN population projections which used to assume that in the longer run, all countries of the world converge in their fertility rates to

[2] Part of this section has previously been published by Wolfgang Lutz as a commentary in VYPR 2008

replacement level, resulting (in combination with an assumed levelling-off of life expectancy) in a long-term stabilization, i.e. constant size of the world population as well as of the population of all individual countries. Such a perceived future of population stabilisation is likely to please government officials who do not want to see their population as either disappearing or exploding in the long run. The only problem with this politically attractive concept is that the real world does not seem to follow it. A majority of the world's population already has fertility below replacement level and there is little reason to assume that all countries would eventually converge to this level [7]. Actually the most recent probabilistic population projections by IIASA indicate a probability of more than 85 per cent that world population will peak during this century and then start to decline; this is very different from stabilisation [8]. The notion becomes even more problematic at the level of individual countries. What does the goal of population stabilisation imply for Bulgaria? Does it call on the government to bring the population back up to the 9 million mark of the late 1980s, or keep it constant at the current 7.6 million, or stop it from declining below 7.0 million? None of these seem to be a realistic goal for Bulgaria. But what would be an appropriate population-related goal for a country like Bulgaria? Since this is not obvious, we see a great need for coming up with a more useful and more comprehensive policy paradigm and goal that includes education as well as the number of people by age and sex.

> BOX – **Human capital**: 'People are the wealth of nations. But it is not only the number of people that counts, it is also the skills, abilities and health status of the people that matter. All these aspects viewed together can be called the human resources base, or human capital in more economic language. This broadened view of population also implies that political goals should not be defined in terms of population size but rather in terms of human resources available for producing the best possible quality of life for all citizens.' *Wolfgang Lutz, in role as population adviser to Bulgarian Government*

This shift in paradigm, from a focus on only population size to one that aims at a balanced development of the population by age and sex as well as their capabilities and skills, is not an easy one because for centuries, population size has been the primary target of national and international population policies. Throughout European history, one view has predominated: it assumed that the bigger a kingdom/republic in terms of population, the more powerful this state would be and the better it would be for all of its citizens (see [9]). The rationale behind this view has been primarily in military terms: the bigger the population, the more potential soldiers and the greater the possibilities to defend, or expand, the national territory. But there has been economic reasoning behind this view as well: more people imply greater markets with more trade, and higher population density furthers the division of labour and technological progress—all things that are considered to be conducive for economic growth. In the specific case of Bulgaria, however, the accession to the European Union brought a huge increase in the market even under conditions of population decline.

The opposite view that population growth is detrimental to human wellbeing also has a long tradition – at least since Malthus. Here the reasoning has been that the resource base is limited for any national population and that population growth which leads to higher population density may in the end surpass the carrying capacity of a given territory and hence would lead to lower quality of life and even starvation and death. With such reasoning, regions such as the Netherlands or England were labelled overpopulated in the 19th century. In reality the resource base of these countries was expanded through colonisation for once, but also by means of greater international trade and technological progress has resulted in a much higher quality of life combined with higher population density. A modern version of this Malthusian view is reflected in the "Limits to Growth" study by the Club of Rome [10] and more recently in the notion of the 'ecological footprint' that shows how the number of people in a country and their consumption have ecological consequences far beyond the territory of a given country. There also have been many discussions of what the 'optimal' population size of a given country would be. While this discussion has been inconclusive, the majority of researchers in the field have understood that it makes little sense to have this one-dimensional focus on absolute population size. What really matters is the change over time and most importantly the composition of the population. For this reason the section above considered the more meaningful question about optimal fertility and considers education in addition to age and sex.

Demographers tend to study the composition of the population mostly with respect to age and sex. Changes in the age structure of a population matter for society and the economy in many respects. Most importantly, it is the ratio of persons who pay into the social security system to those who withdraw from it. More generally, it is the number of people who primarily produce compared to those who primarily consume. Significant changes in this ratio can be associated with decreases in the wellbeing of the population. In terms of pension systems, the expectation is that as the population age structure is bound to become much older, with the proportion of the population above age 60 increasing rapidly, there will be growing pressure toward one of the following measures: increasing the mean age of retirement, or decreasing the pension benefits, or increasing the individual contributions to the system, with the alternative of having a huge deficit in the pension fund. Most European countries typically show a combination of these responses. But the process of population ageing has only started. Significant future ageing is already pre-programmed in the existing population age structure, most importantly as a consequence of very low fertility over the last decade. Bulgaria has some more time to prepare for the peak of population ageing than most other European countries, where fertility already declined steeply during the 1970s, a period during which Bulgaria still had fertility rates around replacement level.

There is little doubt that population ageing will pose many serious challenges to European societies and that the more rapidly the proportion of elderly increases in a population, the greater the challenge will be. In this sense—at least at the national level—population ageing is clearly more relevant than decline in absolute population size in terms of potentially diminishing the welfare of individuals. Therefore, should it be the goal of a population policy to try to minimise the speed of population ageing? It would clearly be a more meaningful goal than trying to attain a certain absolute population size because it is much more directly related to consequences for the wellbeing of the population. But – as we were trying to show – this is not yet the full story. Whether a smaller number of young workers actually translates into a decline in total production depends not only on the number of workers but also on the productivity of these workers. If productivity per worker increased at the same rate as the number of workers declined, it would not make any difference for total production (although a distributional issue still remains). There are many factors that contribute to the growth of productivity, but the most important seems to be human capital, a consequence primarily of the education of workers and to some extent of their health status and motivation. In other words, the future development in human capital formation is a crucial determinant of the question to what extent population ageing and decline have negative consequences for the wellbeing of the population. But again, it greatly depends on the skills and capabilities of the additional people whether they are to the benefit or detriment of society.

This focus on human capital is not new in the history of demographic thinking. In 1958 Alfred Sauvy wrote in the context of the miracle of Germany's economic rise after total destruction in 1945 and the fact that it had to absorb five million refugees:

> Why this success, contrary to the forecasts of all doctrines…? Because these men without capital came with their knowledge, their qualifications. They worked and they recreated the capital that was lacking, because they included a sufficient number of engineers, mechanics, chemists, doctors, sociologists, etc. If five million manual workers had entered Western Germany instead there would be five million unemployed today [11] (p.169).

Despite the demographic prominence of Sauvy, mainstream demography has not really incorporated this important line of thinking. Instead such "quality dimensions" were considered too difficult to measure and largely left to economists. Only the more advanced demographic tools of multi-state population dynamics, pioneered at and around IIASA in the 1970s, now allow us to fully and quantitatively integrate the educational attainment dimension into formal demography. As the title of an article by Lutz, Goujon and Doblhammer "Adding Education to Age and Sex" suggests, it seems to be time to more systematically apply the human capital approach in standard population analysis and consequently in population policy [12].

The concept of 'human capital development' combines the concerns about population size with the concerns about the age structure and that of human capital. It goes beyond the more traditional population policy paradigm of 'population stabilisation' which has a one-dimensional focus on population size. Population stabilisation is not a viable policy goal for Bulgaria and for many other countries in Europe over the coming decades because further population shrinking and ageing are already pre-programmed in the given age distribution. Even in the unlikely case that fertility rates increased again up to replacement level, the small cohorts of women born over the past one and a half decades indicate fewer potential mothers in the future and therefore fewer numbers of babies born. Population balance as a policy paradigm, on the other hand, also considers human capital and its distribution by age and sex. This does not imply that the three determinants of population size and age structure—fertility, mortality and migration—do not matter. They continue to be the key drivers of change but they also must be seen in their interactions with education. In the case of migration, for instance, under a human capital perspective, it would not only be the numbers of migrants that count but the numbers (by age and sex) times their skills and qualifications. There are also important interactions between education and fertility (with higher educated women having their births later but also having on average better educated children) and mortality (more educated people being in general healthier) that need to be considered in the formulation of policies.

Further scientific research (including alternative projections and considerations of the criteria of optimal fertility as described above) as well as a dialogue among scientists, stakeholder groups, civil society and government is necessary to find out what is the best way forward. The input of scientists and, particularly, demographers into this process will be crucial. But in order to be useful in this process, demographers need to go a bit beyond their traditional focus areas and apply their very powerful measurement concepts and tools to fields that also includes the quality dimension of population (as approximated by human capital). To do this we need to stop only staring at population size and age structure but include this quality dimension in our models (wherever it is feasible) and also try to address broader societal concerns such as climate change and national identity. This is both a highly demanding and highly important task for the future.

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