Replacement Fertility is Neither Natural nor Optimal nor Likely

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Low fertility is widely decried. In 2022, Pope Francis called it a "social emergency" while Elon Musk declared that "population collapse due to low birth rates is a much bigger risk to civilization than global warming."[1] In 2024 China introduced a series of new "birth support policies aimed at building a society more conducive to raising children."[2] In that same year, Russia enacted a law banning "child-free propaganda." The number of countries with policies aimed at raising the birth rate tripled, from 19 to 55, between 1986 and 2015, and efforts in this direction have only accelerated since then.[3]

Many developed countries have now experienced below-replacement fertility for several decades, with an increasing number of middle-income countries joining the club. Fertility rates crossed below the replacement level in the United Kingdom in 1973, Japan in 1974, France in 1976, South Korea in 1985, China in 1992, and Brazil in 2005. Nonetheless, the issue of how to think about the phenomenon has gained increased salience in recent years. Among the possible explanations for this increased attention are:

- The fact that low fertility has now been in place for so long in some countries that it clearly is not a passing phenomenon (along the lines of the Baby Boom) or a reflection of a tempo effect as women move to higher ages of childbirth. There was an initial tendency on the part of many observers to view below replacement fertility as the result of some sort of temporary disequilibrium associated with modernization that would self-correct as institutions and attitudes adjusted. As an example of this phenomenon, Figure 1 revisits the analysis of Myrskyla, Kohler, and Billari (2009), who claimed, examining 2005 data, that there was evidence that at sufficiently high levels of the Human Development Index (HDI), there was a rebound in fertility. In 2019 data, this rebound is absent, and, though fertility seems to stop falling at sufficiently high levels of HDI, it does not rise.

- The extension of the low fertility trend to levels of TFR that would have seemed unimaginable even a few decades back. For example, the TFR in South Korea was 0.92 in 2019, before the arrival of COVID-19. In 2023, with the effects of the disease mostly past, the TFR was 0.72. While South Korea holds the title for world's lowest fertility, other countries are not so far behind, including Singapore at 0.97 in 2023 and Spain at 1.16 in 2022.

- The arrival of the long-predicted consequences of low fertility, specifically a rapidly rising rate of old age dependency and, in an increasing number of countries, negative rates of natural increase, a decline in the size of the working-age population, and a decline in overall population size. Changes in the rate of natural increase (i.e. the crude birth rate minus the crude death rate) lag behind fertility because of demographic momentum. Changes in total population, in turn, deviate from the rate of natural increase because of

[1] https://www.catholicnewsagency.com/news/251214/pope-francis-low-birth-rate-is-a-social-emergency https://www.cnn.com/2022/08/30/health/elon-musk-population-collapse-wellness/index.html
[2] Xinhua News Agency, October 28, 2024. Link.
[3] Sobotka *et al.* (2019).

net migration. In Japan, where net migration is low, the TFR fell below replacement in 1974 while deaths first exceeded births in 2005, and population began to decline in 2012. Population similarly peaked in Italy in 2014, Russia in 2019, South Korea in 2020, and China in 2022. In Germany, deaths have exceeded births for several decades, but population continues to grow because of migration. In the US, the TFR hovered near replacement until 2009, but since then has fallen significantly, but the rate of natural increase in 2019 was close to 1%.

- In Europe and the United States, the growth of sentiment opposing immigration. To the extent that migrants tend to arrive young and ready to work, immigration is often seen as a natural counterbalance to low fertility. Consequently, the closing down of immigration makes the problem of low fertility look all the more salient. Reading various calculations of the sizes of immigration flows that would be required to cushion the effect of low fertility on public finances, one can't help but be struck by how unrealistic they seem. In the case of the Eurozone, for example, net migration was approximately 1.33 million people (0.4% of the population) annually in 2019. Holding this flow constant, the ratio of people aged 65+ to those aged 20-64 is projected to rise from 35% in 2019 to 57% in 2050, while taxes as a fraction of GDP would have to rise by five percentage points (to 46%) in order to maintain old age support in the face of this projected demographic change. That tax increase could be held down to three percentage points if the pace of immigration were allowed to quintuple, to 2% of the population annually (Berardino *et al.*, 2024). In the current political climate it is hard to imagine such a thing happening.[4]

- The general lack of efficacy of pro-natalist policies that have been rolled out in numerous countries in an effort to raise fertility back toward replacement. In the case of Japan, for example, the "1.57 shock" of 1989 was followed by repeated rounds of policy initiatives, new laws, and administrative changes aimed at raising the birthrate. While these initiatives may have had some impact, by 2019 the TFR stood at 1.36 (Stone, 2020; Sobotka et al., 2019).

Knowledge of demographic history can be useful in putting the current situation in perspective. First, the current panic over fertility rates being below replacement has an obvious parallel in the over-population worries that peaked in the 1960s, 70s, and 80s. The fact that the chilling predictions of population pessimists such as Ehrlich (1971) and Hardin (1993) failed so miserably is a useful caution to those who predict demographic disaster today. That being said, the failure of past predictions is no guarantee that the present ones are wrong. Further, as I will argue below, there is deep link between the two concerns: Although primarily focused on poor rather than rich countries, the fundamental worry of the population "doomsayers" (as Julian Simon labeled them) was that there was nothing that anchored fertility at the replacement level, and that absent government coercion, population would inevitably grow to the point of

[4] Under the baseline assumption of constant immigration, 30% of the population of the Eurozone in 2060 would be made up of immigrants from outside the zone and their descendants. If immigration were to cease immediately, that number would only be 10% in 2060, while under the assumption that immigration was five times its current level, the figure would be 65%.

immiseration. Modern concern about below-replacement fertility is similarly driven by the worry that there is nothing that anchors fertility at replacement, and is drawn to the question of what policy changes would be required to hit this target. "Zero population growth" which was initially a slogan of those who wanted to keep fertility down, could now equally well be embraced by those who want to raise it.

A second piece of perspective comes from noting that even the issue of low fertility is far from new. A thread of worry regarding declining births, if not for the population as a whole, at least for the upper class, runs through Western thought for at least the last two centuries, even though for much of this time explicit discussion of the means of preventing pregnancies was impermissible. Adam Smith, in *The Wealth of Nations* comments on the low fertility of elite women, attributing to "barrenness" what he presumably knew was the result of deliberate choice. The gynecologist Horatio Storer, who led the movement to ban abortion in the United States in the latter half of the 19th century, condemned not only abortion but contraception as well: "... marriage where conception or the birth of children is intentionally prevented [is] in reality, but legalized prostitution, a sensual rather than spiritual union."[5] Low fertility became a *cause célèbre* in France in the late 19th century, after census data showed that in the period 1890-92, deaths had exceeded births in the country. This was probably the first time that such a thing had happened in an advanced country, capable of tracking population data, in the absence of war or famine.[6] The French sociologist Robert Hertz wrote in 1910 that "one can hardly open a newspaper or a review without finding an article on depopulation, on its causes and its effects, and on the remedies which must be implemented." Émile Zola's 1899 novel *Fécondité* decries the foolishness of fertility restriction. References to contraception -- generally linked negatively with women's vanity -- appear in passing in all sorts of places, including Tolstoy's *Anna Karenina* and in the novel *Unleavened Bread,* which was the third-ranked fiction bestseller in the United States in 1900.

In the United States, President Theodore Roosevelt was an energetic proponent of higher fertility.   Addressing the National Conference of Mothers in 1905, he thundered:

> There are many good people who are denied the supreme blessing of children, and for these we have the respect and sympathy always due to those who, from no fault of their own, are denied any of the other great blessings of life. But the man or woman who deliberately forgoes these blessings, whether from viciousness, coldness, shallow-heartedness, self-indulgence, or mere failure to appreciate aright the difference between the all-important and the unimportant -- why, such a creature merits contempt as hearty as any visited upon the soldier who runs away in battle, or upon the man who refuses to work for the support of those dependent upon him, and who though able-bodied is yet content to eat in idleness the bread which others provide.

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[5] Storer, 1866.
[6] Cole (2000), Ch. 6.

In 1906, at a joint meeting of the American Economic Association and the American Sociological Association devoted to the topic of "Western Civilization and the Birth Rate," the sociologist E. A. Ross warned that "This exaggerated individualism, that avoids marriage or else dodges its natural consequences, forebodes the extinction of the class, the people, or the race that adopts it."

In the period between the world wars, fertility was near or below replacement in many advanced countries, with population continuing to grow only because of demographic momentum. This was widely viewed as an alarming situation. In France, the law of 31 July 1920, made any individual who distributed, sold, or even discussed contraceptives liable to six months in jail, and also greatly strengthened the already existing prohibition on abortion.[7] In the United Kingdom, a National Birth-Rate Commission issued a report on "Problems of Population and Parenthood" in 1920, examining the sources of fertility decline and what could be done about it. The report decried selfish family limitation and urged citizens to procreate for the good of the country: "The call of the nation to its manhood and womanhood to endure hardships, run risks, meet dangers and make sacrifices was fully and finely responded to during the war. There should be a similar response to a call for the continuance and increase of life."

Notestein (1945) described the populations of Europe, North America, Australia, and New Zealand as having entered a stage of "incipient decline." Notestein went on to discuss various economic and social implications of low fertility, and even contemplated the possibility that governments might attempt to use policy to address the trend, commenting that in most of these countries, "fertility would have to rise substantially to forestall [population] decline, and such reversals will not be easily obtained, short of drastic governmental policies of an essentially totalitarian kind." The post-War baby boom and the rise of migrant flows to levels well above those of the interwar period temporarily forestalled the decline that Notestein had predicted.

A final piece of perspective comes from noting the similarities of the current moment to the fluorescence of worry about low fertility in the early 20th century that was associated with the eugenics movement. The professed concern of eugenicists was the excess fertility of the groups in the population that they considered inferior, whether that be specific ethnic or racial groups, as in the "race suicide" view propounded by E.A. Ross in 1901, or simply less worthy members of the dominant race. But one of the underlying drivers of this worry was precisely the observation that women who were most elite and modern -- those with education, career ambitions, egalitarian ideals, access to contraception, and living in cities -- were at the vanguard of fertility reduction. To a large extent, today's low fertility can be seen as a product of the diffusion of the attitudes and opportunities from this small elite group to the broader population.

In the background of all of these discussions of where the fertility rate is going are two related questions. The first is whether there is some sort of "natural" fertility rate toward which we should expect human populations in developed countries to gravitate. If there were such a natural rate, and if that natural rate happened to be the replacement rate, then we could interpret deviations from replacement fertility as being unnatural, meaning that they might be

[7] Tomlinson (1985).

expected to go away on their own, or that it might be an appropriate goal of policy to drive the fertility rate toward this natural level. The second question is whether replacement fertility is optimal in the sense that it maximizes some social welfare function. Again, if this were the case, then there would be a potential role for policy in providing incentives that led private actors toward implementing this optimum.

This paper argues against the idea that there is anything natural about replacement fertility in the context of a modern, developed country; that there is no reason to expect fertility to anchor itself at the replacement rate anytime soon; and that there is little good reason to think that replacement fertility would in fact be optimal from a social welfare perspective based in economic outcomes. Of course, governments or society more broadly may have non-economic reasons for wanting fertility to return to the replacement level. These could include national defense or desire to preserve the size of one's national or ethnic group.

1. Replacement Fertility as a Natural Anchor

A useful starting point for thinking about this issue is the observation that replacement fertility has indeed been a characteristic of the human population for most of our history. We know this from the fact that overall population size was so stable in the long run. To give an example, from the birth of Christ to the year 1500, world population is estimated to have grown from 231 to 438 million (Maddison, 2001). The implied annual growth rate is four one hundredths of one percent per year, or about one percent per generation. Allowing for an enormous degree of measurement error in these population estimates would not change the fundamental conclusion that fertility was incredibly close to the replacement rate for this period.

The explanation for this near constancy of population was famously provided by Malthus (1798). His model has two simple pieces: First, for an economy dependent on a fixed natural resource such as land, the standard of living will be a negative function of population size. Second, in the world as he observed it, population growth was a positive function of the standard of living. This latter effect could result from two causal channels: the "positive check" via which low living standards both raised mortality and lowered biological fecundity, and the "preventive check" which represented the conscious choices of people to adjust their fertility to their economic situation. In the absence of technological change, which was indeed glacial in the period before Malthus wrote, this model delivers a stable steady state of population size. (Although Malthus did not make this point, the model also delivers the implication that those at the top of the economic ladder will outbreed and displace those at the bottom. This "great replacement" of the poor by the rich indeed characterized much of human history until the 19th century, and it is the reversal of this process during the Demographic Transition that so upset eugenicists.)

Malthus understood that his model applied to not only humans but to animals as well, with the crucial difference that only humans were capable of consciously deploying the preventive check. Animal populations will expand to fill their ecological niche. Allowing for interactions among predators and prey, external shocks, and so on can lead to more complex dynamics, but animal populations generally display stability along the lines that Malthus discussed -- that is, replacement fertility in the long run.

Given its ubiquity in nature, then, should replacement fertility be seen as natural? The answer is yes, if pieces of the mechanism that Malthus laid out are operative, and no otherwise.

The first piece, the negative effect of population size on the standard of living, is still important in many developing countries. In richer countries, where fixed natural resources play a much smaller role in determining the level of output, it is hard to see this channel as being very relevant. Indeed, much of the discussion of the negative effect of low fertility is premised on the idea that countries would be better off economically if population were higher (or at least growing). Beyond this, it should be obvious that in countries where fertility is lowest, the standard of living is far above any sort of subsistence level, at which a reduction in income would trigger the Malthusian positive check of higher mortality.

The second piece of the Malthusian model, whereby higher income triggers higher fertility, is whether things have really gone off the rails. People in developed countries today have standards of living that Malthus would have found unimaginable, but their propensity to produce babies has fallen far below what he observed in his own time.

The long term decline in the propensity to produce babies is called the "fertility transition," and is often conceptualized in terms of a broader "demographic transition," in which both fertility and mortality rates moved from their high pre-industrial levels to low modern levels. Stylized depictions of the demographic transition often look Figure 2.

The upper left part of the figure, with birth and death rates roughly equal in the long run, is perfectly consistent with Malthus. The first act of the story told in the picture is then the decline in death rates. Death rates fell as a result of a rise in the standard of living (due to economic growth); public health interventions, most notably clean water; changes in private behavior that reflected advances in the biological understanding of disease; and vast improvements in medical care. In the countries that went through the mortality transition first (Europe and some of its colonial offshoots, as well as Japan), these four sets of changes arrived in roughly the order just given, with some notable exceptions such as variolation for smallpox. Mortality rates started to fall in the late 18th or early 19th century, and this decline has continued ever since. Oeppen and Vaupel (2005) note the eerie constancy of the trend line for life expectancy in the world's leading countries, which has risen at a pace of three months per year since 1840. (The fact that the crude death rate stabilizes in the figure of the Demographic Transition just shown results primarily from falling fertility, which shifts the age distribution of the population into ages at which people are more likely to die.)

In countries that went through the mortality transition later, the order in which the different drivers described above took hold was less standardized -- for example, antibiotics were deployed to save lives at a time when the population was still largely malnourished, which was not the case among the early developers. Additionally, the speed of the mortality transition was far higher in the countries that started later. This rapid mortality transition in turn contributed to population growth rates in late-developing countries reaching far higher levels than they did in the earlier starters.

The standard figure of the demographic transition emphasizes the similarity of the fertility and mortality transitions, with only a time shift separating them. Similarly, many accounts of the demographic transition (e.g. Dyson, 2010) stress the primacy of mortality transition as the main driver of fertility transition. The underlying idea is that potential parents, in making their fertility decisions, care about the number of *surviving* children that they produce. As mortality falls, they lower fertility in order to hit a target number of survivors. The lag between declines in mortality and fertility is often attributed to lags in the perception that mortality has declined as well as the slow process of changing social arrangements governing fertility.[8]

While mortality decline was probably the most important driver of fertility decline in the vast majority of historical cases, it was clearly not the only one. Rather, the average number of surviving children that people would have produced in the absence of child mortality fell over time as well.

The non-mortality reasons for fertility decline are all, at least to some extent, wrapped up with the process of economic growth and development that took place over the last several centuries. The reason that Malthus failed to anticipate them was his narrow focus on the effect of *income* on fertility. What Malthus did not see was that rising income came along with a set of changes in the structure of society and the economy, in modes of thought, and in relations among individuals that can messily be summed up in the term "modernization." Among the aspects of modernization that drove down desired fertility were

- Rising returns to human capital, which induced households to produce fewer children and invest more in each one.
- Urbanization, which lowered the economic value of children as workers in household enterprises.
- The rise of the state as a provider of a social safety net, support in old age, and general protection from threats of violence, all of which displaced the role formerly played by family.
- Secularization
- Women's increased agency within the household as well as legal and technological changes that improved opportunities for them in broader society.

Beyond these social, intellectual, and economic changes, a final driver of declining fertility was a two century long process of technological improvement, falling costs, growing convenience, and spreading knowledge about contraception. Malthus viewed "passion between the sexes" as a fundamental of human nature, and since he thought that the only acceptable means of reducing

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[8] Rather than looking at crude birth and death rates, a better way to get a handle on the time lag between mortality and fertility declines is to look at, for mortality, the probability of a child surviving through adulthood, and for fertility the TFR.

fertility was delayed marriage, his expectation was that only extreme economic constraints, such as the fear of seeing one's children starve to death, would be enough to hold back that passion. Even at the turn of the 20th century, with the fertility transition well underway in most developed countries, the available means of avoiding conception (other than abstinence) remained unreliable, expensive, and often injurious to a woman's health. By comparison, in developed countries today, the economic and utility costs of not having children are much lower.

All of these changes lowered the number of children that people wanted to have, and made it easier for them to hit their target. The fact that there were so many non-mortality drivers of falling fertility makes it extremely hard to imagine why the end result of all of these changes would be replacement fertility. Going back to the standard diagram of the Demographic Transition, then, my view is that the coming together of mortality and fertility rates in the lower right corner of the picture is entirely a fiction. The population stability that characterized the Malthusian regime (in the upper left) is being inappropriately grafted onto a world where it no longer applies.

Absent any sort of equilibrating mechanism of the type that operated during the Malthusian regime, there is no reason to expect that the various social and economic forces the reduced fertility from its pre-transition level will play out in such a way that fertility hits the replacement rate. This observation has a corollary: given that social and economic structures differ among countries, there is no reason to think that all countries will settle down at the same level of fertility. The same is true within countries looking at regions or ethnic groups. Some may see semi-permanent declining population and some semi-permanent population growth (I say "semi-permanent" because at some point additional constraints come into play, but that point may be very far in the future.)

Despite the logic of the argument just laid out, the idea that replacement fertility is somehow natural is surprisingly persistent. Sometimes the vision of naturalness is in the sense of an equilibrium toward which society will move, in the same way that macroeconomists talk about the natural rate of unemployment. At other times, naturalness is used in a more normative sense: replacement fertility is what would happen if there were not some distortion that moved people away from it.

People will often fall back on various informal justifications for why replacement fertility will (or should) be where countries end up. A common one is that "two kids just feels right." While this may be true for many people, the fact is that even in countries where fertility is at the replacement level, most women do not have exactly two children. For example, among women in the US born in 1960, a group that had a collective total fertility rate of 2.0, only 35% had exactly two children. It is also worth noting that for most of human history, having only two children would have seemed an unusual and indeed absurdly low number. Women who survived into adulthood were more likely to have five or more, depending on the setting. So, again, it is hard to argue that now all of a sudden two is the natural number.

Another informal justification that I have heard for replacement fertility is that a TFR of 2.0 is consistent with every family having a boy and a girl. A bit of simple math can be used to establish the conclusions that (assuming families are not able to select the sex of their children), (i) every woman having exactly two children would mean that only half of them got a boy and a girl and (ii) if every woman had children until she had both a boy and a girl, that would lead to a TFR of three rather than two.

Wattenberg (2004), whose examination of below-replacement fertility is generally thoughtful and balanced, in the end can't help expressing his view that the phenomenon is "strange and unnatural." In a similar vein, the journalist Jonathan Last (2013) uses the term "freakish" to describe things like buildings in cities with declining populations being taken down and replaced with parks as well as prostitutes being retrained as elder-care nurses. But surely some of this discomfort is simply because it is different from what we are used to. Why is it more freakish to take down a house and replace it with a park than to pave over farmland to build housing developments? And surely it is no less freakish for a woman to engage in sex work than it is for her to care for the elderly in return for money.

An alternative statement of the above argument would be that replacement fertility is "natural" only in the sense that many behaviors that we consider harmless or even admirable are fundamentally unnatural. Behaviors in this category might include using eyeglasses to correct defective vision, flying in airplanes, and nursing our injured peers back to health rather than leaving them to die. We should no more expect fertility to naturally return to the replacement level than we should expect these other unnatural behaviors to cease.

2. Optimality

Popular discussions of sub-replacement fertility and negative population growth frequently take it for granted that these are bad things for the economy. Economists tend to see the situation in much more nuanced terms. Sometimes discussion on the matter can seem confused at the trivial level of not distinguishing between growth of income per capita, on the one hand, and total income, on the other. Economists are most comfortable with a framework in which "economically bad" is associated with "lower income per capita" or, if we want a broader measure, "lower per-capita welfare." From this perspective, a situation in which growth of total output is low or even negative because population is falling, even as income per capita continues to rise apace, does not look like a bad thing.[9] This being said, economists are not necessarily averse to using a measure of welfare that goes beyond per-capita measures, to include weight on the total number of people experiencing that welfare.

[9] Furthering the confusion, a good number of observers evidently believe that falling total output, even if income per capita was rising, would be inconsistent with the continuation of capitalism. This idea seems to have its roots in Marx's view that continual expansion was necessary in order to prevent capitalism from being destroyed by its internal contradictions. I have not seen this idea fleshed out using the tools of modern economics.

Thus in thinking about the economic effects of low fertility, it is useful to distinguish between technical issues regarding conventionally measured economic outcomes and more philosophical issues regarding the measurement of welfare. The technical issues arise because fertility outcomes today have economic implications that play out over decades or even centuries. The philosophical issues include how much to discount future outcomes relative to the present as well as how to think about the welfare of people who might or might not come into existence.

2.1 Dependency and its Dynamics

A good starting point for thinking about the economic effect of low fertility is in the context of a society's burden of dependency. Both labor input and consumption have life-cycle patterns. In advanced economies, children and old people on average consume more than they produce, with people in the middle of their lives doing the opposite. In a simple, stylized model, the population can be divided into three discrete age groups (for example, 0-19, 20-64, and 65+), with the assumptions that labor supply is zero for the young and old groups and uniform within the working age group, and further that per-capita consumption is equal across all groups. More sophisticated versions of this analysis can allow for consumption to vary both between and within age groups, and similarly for a more realistic pattern of lifetime labor supply.[10] For now, however, I stick with the simple structure for illustration (the model presented here is a simplified version of Lee, 1980).

With this simple economic setup, and temporarily abstracting from the issue of how income is redistributed from working age adults to others, one can graphically analyze the role of demographic change in affecting consumption. In Figure 3, the age structure of the population is represented as a point in the space delineated by the fraction young (on the horizontal axis) and the fraction old (on the vertical axis). In this space I also show a set of "iso-dependency" lines. Lines closer to the origin represent a demographic structure with less dependency, and thus higher per-capita consumption.

One can then show how demographic change moves a population through this dependency space. The blue line in Figure 4 shows this process for South Korea.

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[10] Bloom and Kotschy (2023) stress the importance of changes in the borders between age groups, most notably that between working and old age. Specifically, they examine the difference between what they call a *retrospective* or chronological measure of entry into old age, based on a fixed number of years since birth, and a *prospective* measure, which takes into account changes in age-specific functional capacity. A simple example of the latter would be defining the entry into old age as being the age at which life expectancy falls below 15 years. In the United States, this cutoff age rose by seven years between 1970 and 2020. In the analysis below, it is easy to show that raising the age at which old age begins will *ceteris paribus* lower the rate of population growth that maximizes consumption in a stable population. While Bloom and Kotschy do not study it, the age cutoff between dependent youth and working age should presumably also be modeled as having risen over time, though not by the same amount as the cutoff for old age. The rise in this cutoff will similarly lower the rate of population growth that maximizes consumption in a stable population.

It is easy to show algebraically how these movements in turn translate into consumption. The key equation relates the growth rates of GDP per capita, GDP per worker, and the fraction of the population that is working age:

$$g_{GDP\ per\ capita} = g_{GDP\ per\ worker} + g_{workers\ per\ capita}$$

In the case of South Korea, the working age share of the population rose from 0.46 to 0.64 over the period 1975-2000, providing a 1.3% per year "tailwind" to the growth of GDP per capita. Over the period 2020-2050, the working age share will fall from 0.67 to 0.43 meaning that GDP per capita will grow 1.1% per year more slowly than GDP per worker.

Fernández-Villaverde *et al*. (2023) show that this sort of adjustment for slippage between GDP per working-age adult, on the one hand, and GDP per capita, on the other, does a very good job of matching observed growth rates in a set of eight rich countries over the period 1991-2019. Specifically, a model calibrated to match growth of output per working age adult fits the data significantly better than one calibrated to match the growth of output per capita. Similarly, Bloom and Kotschy (2023) verify empirically in cross-country panel data that changes in the working age share of the population have the predicted effect on the growth of GDP per capita. According to their estimates, demographic change will lower the growth rate of GDP per capita an average of 0.8 percentage points below the growth rate of the GDP per working age adult in the OECD over the period 2020-2050.

This analysis captures the simple intuition for why many commentators think that population aging brought about by low fertility is bad for the economy: we can see that the old-age dependency burden is rising as a result of low fertility, and this directly impacts consumption. However, such a conclusion misses the point that the aging taking place in many developed countries is really just the end of the decades-long demographic dividend, i.e. the period following a decline in fertility in which both youth dependency and old age dependency are low (Bloom, Canning, and Sevilla, 2003). The demographic dividend is inevitably transitory.

An easy way to demonstrate this is to look at stable populations, that is, theoretical populations in which age-specific fertility and mortality rates have been constant for long enough that the age structure has stabilized. A stable population can have a positive, negative, or zero growth rate. In Figure 4, the green line represents the locus of possible stable populations for South Korea, constructed using the life table for 2020. Points are labeled to show the growth rate associated with different combinations of youth and old age dependency. In this figure, the consumption-maximizing growth rate for a stable population comes at the tangency of the green locus with an iso-dependency line, which in this case happens to be quite close to zero population growth. Adjusting the labor and consumption profiles, or taking on board some of the extensions discussed below, would change that conclusion. But the bigger point is that the green curve of stable populations has much less of an inward arc to it than the blue curve of actual populations. In other words, the differences in consumption among different stable populations are much smaller than the differences in consumption seen along the transition path: A stable population that is shrinking at 2% per year is not much worse off than a stable population with replacement fertility. But moving from replacement to sub-replacement fertility produces a temporary boom in consumption (Weil, 1997; Weil 1999).

One direction in which to take the above analysis is to be more serious about the relative consumption needs of people in different age groups. In the simple graphical analysis -- and in similar analyses that focus solely on total dependency ratios -- the implicit assumption is that people of all ages have the same consumption. This assumption can easily be relaxed. Let Y, M, and O denote the fractions of the population that are young, working-age, and old and let P_Y and P_O denote the relative "needs" of the old and young, where the needs of working-age adults are set at 1. Specifying these age specific levels of consumption needs clearly sweeps a lot of interesting economics under the rug, including how resources are actually transferred to people in different age groups, and whether these needs themselves are subject to change over time. In practice, we will simply assume that via some unspecified process, consumption of people in different age groups is set proportionally to their needs.

Assuming that output is produced only by the working age, consumption per capita (in working-age equivalents) is simply proportional to the needs-adjusted support ratio, denoted α:

$$\alpha = \frac{M}{P_Y Y + M + P_O O}$$

Cutler *et al*. (1990) construct a measure of consumption needs that varies by age, adjusting for the different levels of education spending, medical spending, and other consumption of children, the elderly, and working-age adults. Their summary measure weights people aged under 20 at 0.72 the consumption need of a working-age adult and people over 65 at 1.27 times the consumption need of a working age adult.

Table 1 uses life table data from South Korea to construct support ratios for stable populations with growth rates between -2% and 2%. The table also shows the support ratio for each stable population growth rate relative to the support ratio when population growth is zero. The calculations are performed both for the case where consumption needs are equal for all age groups and for the case where needs vary according to the weights in Cutler *et al*.

For the case of equal needs, the rate of population growth that maximizes consumption is roughly -0.25%, which is to say, extremely close to zero. But this is something of a coincidence. In the case of age-adjusted needs, the population growth rate that maximizes consumption is slightly less than one percent per year. In a narrow sense, this second result is another way of making the point that replacement fertility is not optimal in a static sense, although here the message is that it is in fact *lower* than optimal. However, what I view as the more important take-away from this table is that differences in the support ratio (and thus in needs-adjusted consumption) that result from different population growth rates, in the case of stable populations, are just not that large. Consider the comparison between zero population growth and a stable population shrinking at a rate of two percent per year. The latter situation, which is roughly what would be observed if the TFR were one and the average age of mothers at birth was 35, is surely what most observers would consider a catastrophic rate of population decline. Without needs adjustment, consumption with this negative rate of population growth would be 7.5% lower than when population growth was zero. Adjusting consumption for age-specific needs, consumption when population growth was -2% would be 14.5% lower than when population growth was zero. This is an economically significant amount, but seems incommensurate with the degree of anxiety that is often expressed about the economic effects of population decline.

Returning to the point that differences across stable populations are much smaller than differences along transition paths, Table 2 uses the historical and projected population age structures for South Korea to construct needs-adjusted support ratios for the period 1980-2050. As in Table 1, these support ratios are reported both in absolute terms and relative to a baseline (in this case, the year 2020). Also as in Table 1, the calculation is done both assuming equal consumption needs and allowing these needs to vary by age group.

Table 2 shows that the effect of demographic change on needs-adjusted consumption will be large over the next three decades. Compared to 2020, the support ratio in 2050 is 27.5% lower when age groups are treated equally, and 32.5% lower when needs are allowed to vary by age. These effects are more than twice as large as the differences across stable populations examined above. Further, this comparison of results understates the differences between the two exercises because the range of population growth rates considered in Table 1 is larger than the range of population growth rates that will actually be experienced in Korea within the projected time period. Above, I described a fall in population growth of two percentage points; in practice, Korean population growth will only fall by about one percentage point, from 0.2% to -0.7% per year, between 2020 and 2050.

Two obvious extensions to add to this model are a government sector and capital accumulation.

Capital

Cutler *et al*. (1990) consider the problem of optimal consumption in a Ramsey growth model with a demographic structure very similar to the one just presented. Although their primary concern is with optimal saving rates along transition paths, their model can also be used to address the same issue as the model above, that is, what demographic structure maximizes per-capita consumption for a stable population. It is easy to see that if this is the only consideration being added to the simple model, the answer is that taking capital into account leads to the consumption-maximizing population growth rate being *lower* than in the model where capital is ignored. The reason is that population growth requires the investment of resources in producing capital for new workers. A shrinking population can economize on this spending. (The Cutler *et al.* paper considers only physical capital, but a related conclusion holds when one looks at human capital: the more that a society spends on human capital investment per child, the lower is the consumption maximizing rate of population growth.)

Taking account of capital accumulation in this manner would in principle affect the calculation of the population growth rate that maximizes needs-adjusted consumption in a stable population that was undertaken above -- and thus it would be relevant to the question of whether replacement fertility was optimal. Weil (1997), using a stylized version of the Cutler *et al*. model shows that taking into account the role of physical capital lowers the steady-state consumption maximizing growth rate of population by roughly half a percent per year. However, this result would only hold in an economy closed to international capital flows, or similarly if one was somehow trying to solve for optimal population growth in the group of developed countries as a whole, rather than one at a time.

In the Cutler *et al.* model, capital is accumulated by an optimizing social planner. An alternative is to model capital as being accumulated by private agents with finite lives. In this case, one can reach the conclusion that population aging (in a closed economy, or if it is a worldwide phenomenon) will lead to a decline in the real interest rate (Eggertsson, Mehrotra, and Robbins, 2019). The decline in real interest rates over the last several decades is often attributed to this effect. Lower real interest rates may contribute to macroeconomic instability and secular stagnation, on the one hand, but also make financing of investments to deal with climate change or simply rolling over debt easier, on the other.

Government Transfers and Distortions

The simple model of dependency presented above does not address the issue of how income is transferred from working age to dependent groups. Accumulation of wealth through life cycle savings is one obvious mechanism. The other two are transfers within families and transfers mediated by governments. In most developed economies, the family channel is much more important with respect to children and the government channel is conversely more important for old people. For example, among the countries in Europe, an average of 74% of the consumption of the elderly is funded by public transfers.[11] This means that old age dependency has an associated tax distortion that is not present for youth dependency. If the deadweight loss associated with this distortion is large, it implies that the consumption-maximizing level of fertility is higher than it would be in an economy where the distortion was not present. Another way of looking at this issue is to say that in modern developed economies, the incentives facing potential parents are not properly aligned with social costs: potential parents face a private cost of childbearing, but they do not internalize the social benefits of the taxes that their children will pay to support future old people. Last (2013) suggests that this problem could be addressed by giving people with children enhanced Social Security benefits (or reducing their Social Security contributions). An alternative would be to lower the private burden on families in producing children, a policy that is often deployed in an effort to increase fertility (I discuss the efficacy of such policy below).

[11] National Transfer Accounts Data Sheet, National Transfer Accounts Project, 2016. The age cutoff between youth and working age in this data is 25.

2.2 Beyond Dependency

Technological Progress

In just about every model that economists construct, the only driver of economic growth over the very long run is technological progress. New technologies have the property that they are non-rival, so that benefit from an invention is scaled by the population that has access to it. In turn, creation of new technologies requires resources in the form of labor, human capital, and physical capital. An economy with more people will *ceteris paribus* have more people working on creating new technologies, and thus faster economic growth. Jones (2022) argues that for this reason, zero or negative population growth will have a negative impact on the long-run standard of living.

While this is a reasonable argument, there are several caveats that suggest that it may not be a relevant consideration in thinking about the optimality of replacement fertility. First, since technological progress is shared among a large set of countries that are at or near the technology frontier, the speed of technological progress experienced by any one country (unless it is very large) is invariant to that country's own rate of population growth. A South Korea that experiences negative population growth for the next 50 years will have the same level of technology in 2075 as a South Korea that experiences positive population growth.[12] Second, for the next several decades, the stock of researchers in the world will be growing despite contraction in the labor forces of many developed countries. This is both because of new countries joining the group that is at the technological cutting edge, and because of rising human capital of the labor force, and thus growth in the number of potential researchers, in populous countries such as China and India.[13] Even taking the Jones model fully seriously, the transition to zero or negative population growth affects the speed of technological progress with an extremely long lag.

Third, a driving mechanism in the Jones model is that the only level for influencing the speed of technological progress is the size of the population. In the Jones (2022), the production of new ideas is simply a function of population size; in similar work, such as Jones (2002), idea production is proportional to the number of R&D workers, but the ratio of such workers to total population is taken as fixed. In practice, however, producing more people in general is a relatively inefficient way to produce more scientists. A much simpler way is to change human capital policy.

Finally, even if one fully takes on board the Jones argument, this would lead to the conclusion that the optimal growth rate of population is higher than it would be were technological progress

[12] Berk and Weil (2015) construct a model in which this statement does not hold true because a country with lower population growth will have a labor force that is on average less technologically up to date, both because they were educated further in the past and because the same is true of their teachers.
[13] Focusing solely on the issue of human capital: The projections of the Wittgenstein Centre for Demography and Global Human Capital (2018) show global population beginning to decline in 2075 (earlier than UN projections), but the stock of secondary school educated people continues to grow through 2100, which is as far out as the projection is carried.

to be exogenous. That optimum corresponding to zero population growth would still be a knife-edge case.

The Environment

An issue that is similar in structure to the effect of population size on the speed of technological progress, but which goes in the opposite direction, is the effect of population size on the depletion of nonrenewable natural resources, where a clean environment or an atmosphere with carbon dioxide below some specific level can be considered such a nonrenewable resource. Lower fertility will mean more available resources for every person, and thus a higher standard of living. For most industrialized countries, the relevant stocks of resources are those at the global level: income per capita in France is not that sensitive to resources per capita in France, because France is integrated into the world market. This would not be true in developing economies where smallholder agriculture is a major part of the economy, nor would it be true in resource exporters such as Saudi Arabia. But these groups of countries are mostly not the ones that are concerned about sub-replacement fertility. A rich country that took a global perspective might want to lower fertility in order to reduce its resource footprint, but the country would reap only a small part of the benefits.[14]

Most current analyses of the interaction of population and natural resources focus on the emissions of greenhouse gasses (GHGs) as drivers of climate change. It is clear that *ceteris paribus*, smaller populations will emit fewer GHGs, and similarly that, holding migration constant, lower fertility leads over time to smaller populations. There are several subtleties to the problem, however. In the case of developing countries with rapidly growing populations, the same social and economic changes that are associated with rapidly falling fertility are also associated with higher carbon footprints per capita. To take the most salient example, between 1990 and 2020, China's population grew at a rate of 0.7% per year while India's grew more than twice as quickly, at 1.6%. At the same time, China's GHG emissions grew at a rate of 4.7% per year, vs. India's 3.2% per year.

For wealthy countries where worry about low fertility is most severe, the idea that this mechanism would run in reverse -- that is, that higher population growth would lower per-capita GHG emissions -- seems unlikely to hold. Thus a reasonable argument against the optimality of raising fertility is that doing so would make it harder for such countries to achieve GHG reductions that are desirable for the welfare of the planet. McKibbin (1998) argues that "the next fifty years will be crucial to our planet's future -- they are the years that could so devastate the earth's biology that it will never again be able to support life as abundantly as it

[14] The issues of endogenous technological change and resource depletion are sometimes combined into the claim that high population growth is necessary in order to achieve a high rate of resource-saving technological change in order to avert a resource crisis (such as carbon emissions above a specific threshold). In a simple model in which the people doing the inventing are the same as the people consuming the resources, this argument does not fly: slower population growth indeed means that at any point in time, the level of technology is lower than if population grew quickly, but it also means that fewer resources will have been used up. It is easy to show that the level of technology for any level of cumulative resource use is higher when population grows more slowly.

does at present. How many people we have on the planet during that half century -- especially in its richest sections -- will go a long way to determining how deep that damage is." By contrast, Kuruc *et al*. (2024) claim that low fertility and falling population are relatively unimportant in preventing the worst outcomes of climate change. Specifically, they show that meeting targets for reduced GHG emissions that would be required to hold the global temperature rise below some particular threshold (for example 3 degrees C) would in practice require reductions in per-capita emissions of GHGs at a rate rate far faster than what has been experienced in the past -- to the point that by the end of the current century per capita emissions would be relatively close to zero. In this setting, the differences in population size later in the century that would be induced by differences in fertility starting today do not make much difference to total GHG emissions. More concretely, total warming in a world where population of the developed countries had stabilized, with replacement fertility starting today, would be only slightly higher than if fertility had remained below replacement. (Of course, if rapid decarbonization in per-capita terms did not happen, then a declining population would make the resulting climate disaster much less bad than it would have been if population had stabilized.)

Government Debt

Finally, discussion of the costs of negative population growth often touches on the problem that with a shrinking population there will be fewer people to carry debts incurred by the present and past generations. The argument is most frequently advanced in the case of Japan, which has both a shrinking working-age population and a record-setting debt/GDP ratio. The fact that the Japanese government can borrow at low real interest rates suggests that financial markets do not consider this to be a pressing problem. Further, for the reasons discussed below, a rise in fertility would have a negative impact on the government's budget for a period of three decades or longer. Thus breeding up a large generation of future taxpayers is unlikely to be a viable policy option for governments faced with heavy debt burdens.

2.3 Population Size, Discounting, and the Long Horizon

Almost all of the analyses above have the characteristic that changes in fertility will change the entire future path of the economy: both the standard of living and the number of people who will enjoy that standard of living.

The issue of how to evaluate welfare along paths that involve different numbers of people goes all the way back to the work of Sidgwick (1874), who pointed out that Utilitarians had not really reckoned with the problem. If the goal of "the greatest happiness for the greatest number" is interpreted as maximizing the sum of individual utilities, it is possible that the social optimum will involve a very large population of people who are very poorly off -- what the philosopher Derek Parfit (1984) called "the Repugnant Conclusion." In thinking about population growth in the context of developing countries, Julian Simon (1996) makes the argument that those who wanted to reduce fertility were ignoring loss of utility benefits that would accrue to people who would not be born in restrictive policies were effective.

In the context of low fertility in developed countries, it is easy to see that embracing total (rather than per-capita) future welfare as a target will lead to higher optimal population growth. Exactly how much higher the optimal population growth will be depends on issues like whether there is a fixed factor of production, the discount rate being applied, the curvature of the utility function being used to evaluate welfare, and the utility assumed to arise from being alive. Adhami et al (2024) provide an extended treatment of many of these issues. But it is easy to see that using the tools of conventional macroeconomic analysis, the optimal population size under a "totalist" utility function is a large multiple of the current population in most developed countries, and as a consequence optimal fertility is well above replacement.

The discussion of how to take into account potential people is related to the issue of how to think about the welfare of future people, potential or otherwise. The long time horizons associated with demographic change make the issue of the discount rate particularly salient. Applying standard personal or market discount rates implies that things that happen one century from now are simply not that important to discounted utility. Thus there would be little reason to worry about the impact of fertility now on technological change, resource depletion, or the size of the population in the distant future. Stern (2006) famously argued for using a lower discount rate for assessing the impact of climate damages. Many people would argue that the appropriate discount rate would be zero. Going down that road may imply that in thinking about optimal fertility, concerns about economic outcomes in the near future should be completely overshadowed by concern for what decisions maximize the probability of survival of the human species (MacAskill, 2022). Many environmentalists would argue that given the threats humanity currently faces, this long-run survival probability would be maximized by a much smaller population than the current one. In this case, fertility below the replacement rate is optimal.

Even if one takes the long-run survival of the human species off the table, putting a value on non-human outcomes, such as the health of the environment or the extinction of other species, can push in the direction of a lower level of population being optimal. This argument is made by McKibben (1998), among many others.

3. Likelihood

The intellectual arc of demographers slowly abandoning the anchor of replacement fertility can be seen in the projections periodically published by the United Nations Population Division. Up to the year 2000, the medium fertility projections were anchored to replacement fertility in the long run. That is, countries with above-replacement fertility were projected to see fertility decline (at a faster or slower pace, depending on an individual country's characteristics) until it reached replacement, and similarly countries with below-replacement fertility were projected to see their fertility rise up to replacement. However, projections that countries with below replacement fertility would see births rise back up to the replacement level kept being wrong. For example, the 1992 forecast for Japan showed the TFR gradually rising from its current level of 1.5 to reach 1.7 by 2020, 1.9 by 2035, and 2.1 by 2050. In practice, the downward trend in fertility that had been in place prior to 1992 largely continued, and by 2019, the TFR had fallen to 1.36.

Starting with the 2002 revision of their projections, the UN abandoned this anchoring with respect to countries with below replacement fertility. Specifically, they assumed countries that already had below-replacement fertility would converge to total fertility of 1.85 in the long run, and similarly, in the case of countries with above-replacement fertility that was declining very rapidly, they assumed that such countries would pass through the replacement level before reversing course and converging to a long-run value of 1.85 children per woman.[15] Of course, the number 1.85 itself was only slightly less arbitrary than replacement fertility as an anchoring point, and in practice it proved not much better as a prediction.

Even having made this change in their methodology, the demographers of the UN backed away from it when they turned to really long-run projections. The projections made in 2002 as well as the next few rounds that followed carried their projections (incorporating the 1.85 TFR anchor) only went out to the year 2050. In 2010, however, the UN did longer range projections, going all the way out to 2100. Magically, in these long-range projections, fertility in the years 2050-2100 moves back to be centered around the replacement level. Evidently it was simply too hard to contemplate a semi permanent state of sub-replacement fertility. Finally, in 2012, the UNDP abandoned the methodology that anchored long run fertility at replacement or any other level, instead embracing a more statistical approach -- for example estimating the probability of a below-replacement fertility country experiencing a rise back to the replacement level by looking at how frequently that has happened in the data so far. As a result, the demographers now contemplate fertility far below replacement as a long-run state of affairs. For example, in the 2022 revision of the UN forecasts, the median projection of TFR in Japan is 1.47 in 2050 and 1.55 in 2100. In South Korea the projections are 1.17 in 2050 and 1.43 in 2100, while in Italy they are 1.44 in 2050 and 1.52 in 2100.[16]

For another approach to this question, one can look at the full distribution of UN projections, rather than just the median. The UN procedure for projecting fertility takes into account a country's own history of fertility as well as the fertility histories of other countries that historically experienced the target country's current fertility. Uncertainty is introduced regarding both a country's eventual long-run level of fertility and the speed with which it will approach that level. A large number of future fertility pathways are generated for each country, and the distribution of these in any given year is available as an object of study. Of course, given the nature of the stochastic projection exercise, the probability of projected fertility being *exactly* at the replacement rate is infinitesimal, but it would surely be unfair to use this property of the exercise as a basis for concluding that fertility was not likely to hit replacement. People who believe that replacement fertility is a likely long-run outcome presumably mean that fertility will be in the neighborhood of replacement. Or similarly, people who expect fertility in countries where it is currently low to return to replacement would consider their predictions correct if fertility ended up

[15] *World Population Prospects: The 2002 Revision*, Volume II (New York: United Nations, 2003), 24.
[16] *World Population Prospects: The 2010 Revision (Volume I: Comprehensive Tables)* (New York: United Nations, 2011), 29. *World Population Prospects: The 2012 Revision (Highlights and Advance Tables)* (New York: United Nations, 2013), 25. United Nations, Department of Economic and Social Affairs, Population Division (2022), *Probabilistic Population Projections Based on the World Population Prospects 2022* https://population.un.org/wpp/ .

being above replacement.

Since the UN does not publish full distributions, we are restricted to looking at specific quantiles, but this is still very informative. For example, the upper limit of the 80% probability region of the distributions of projected fertility in 2100 Japan, South Korea, and China (1.92, 1.80, and 1.83, respectively) are somewhat below replacement.[17] In other words, roughly speaking the UN thinks that the probability that these countries will have fertility at or above replacement is less than 10%. The upper limit of the 95% probability regions for these countries are 2.12, 2.00, and 2.04. Among the highly developed countries in Western Europe, the upper limit of the 80% probability regions to sit close to replacement, for example, Germany (1.99), France (2.13), the Netherlands (2.01), Italy (1.88), Spain (1.90) and the United Kingdom (2.03). The upper limits of the 95% probability regions are all above replacement, with the highest being France at 2.40. For the United States, the upper limit of the 80% probability region of the 2100 distribution sits just above replacement, at 2.10, while the median is 1.71.

Turning briefly to countries with currently high fertility, there is much greater uncertainty regarding which side of replacement they will be on. For Nigeria, the 80% probability region for 2100 fertility runs from a TFR of 1.50 to 2.70. Some other highly populous countries with currently higher fertility and highly uncertain futures, with 80% probability ranges for 2100, are Ethiopia (1.47, 2.48) and Pakistan (1.45, 2.41)

In short, then, UN demographic projections give little indication that an anchoring of fertility near the replacement rate is likely for most countries. Of course, these are just statistical projections, made by fallible humans. In particular, while the UN methodology no longer puts into the model any special role for replacement fertility, it is always possible that such a special role is appropriate, and we just don't yet understand why.[18]

Changes in Policy Regarding Fertility

One potential issue with the statistical approaches described above is that by necessity fertility is projected based on current and past policy environments. A case could be made that developed countries might now be entering an unprecedented phase of pro-natalist policy -- indeed, that this will be targeted exactly at bringing the birthrate back to at least the neighborhood of two. To the extent that this is the case, it would mean that as in the Malthusian regime, replacement fertility is similarly a homeostatic outcome even in a highly developed country. Put more crudely, the argument would be that "replacement fertility is natural, and thus likely, if the government wants it to be natural."

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[17]Although my focus is on replacement fertility, it is worth noting just how low the UN considers it possible for fertility to fall. The 10th percentile of the 2100 fertility distributions for Japan, South Korea, and China are 1.17, 0.95, and 1.09, respectively.

[18] Long run population projections from other groups, such as IIASA (2024), tend to be even lower than those of the United Nations. Fernández-Villaverde (2024) claims that UN projections have systematically underestimated both the speed of past fertility decline and the speed of that decline going forward.

The list of government policies that might affect the level of fertility is truly enormous. These include the generosity of old-age transfers; the level of public support provided for childcare and education at all different levels; the quality of government-provided health care; the progressivity of the tax system as well as whether married couples are taxed jointly or as individuals; zoning and other policies that affect the affordability of housing; and so on. Recent empirical literature has been focused on a narrower set of policies that are more specifically directed at raising the birth rate. These include cash payments at birth, longer and better paid parental leaves; incentives to employers to provide more flexible working hours; support for IVF; and pro-child propaganda. The most effective such policy appears to be provision of high quality child care with opening hours that are aligned with parental work schedules and which starts as soon as maternity/paternity leave ends (Sobotka et al., 2019).

Stone (2020), analyzing estimates from 22 academic studies of the effect of government policies that support child-rearing or fertility and putting their results in consistent terms, finds that the effect of an increase in the lifetime value of support for children equal to 10% of a household's annual income in a single year would produce an increase in fertility of between 0.5% and 4.1%. Taking the middle of this range, and applying it to the case of the United States: raising fertility from its 2020 level of 1.71 children per woman up to the replacement rate would require an additional benefit of $5,300 per year per child under 18. There were 73 million children under 18 in the US in 2020, so the cost would be around $387 billion, or about half of the defense budget in that year. Similarly, the estimates in Feyrer et al. (2008) imply that raising the US TFR by 0.30 would require a quadrupling of government support for families.

Among policies that have actually been implemented so far, the most effective ones seem to have been able to halt the long-term decline in fertility in a number of countries, but not to raise fertility back toward replacement. An additional and perhaps discouraging finding from experience so far is that the biggest effect of large-scale expansions of pro-fertility policies is to shift women to having children at younger ages, and to shorten the interval between births, rather than getting them to produce more children overall (Sobotka et al., 2019). That being said, it is surely the case that rich-country governments have the policy tools with which raise fertility to the replacement level, and that while doing so might be expensive, it would be well within the realm of possibility, and would almost certainly involve less of an impact on the economy than, say, fighting a major war.

Whether actual politicians -- beholden to current voters -- would want to undertake these policies, and in particular, whether they would want to do this for *economic* reasons, is a different question. One could in principle pursue this issue using the model of dependency and consumption in stable populations from Section 2.1 of this paper. A costly pro-fertility policy could be modeled as an increase in the relative consumption needs of children. If one then knew the function that mapped from pro-fertility policy to the birthrate, it would be possible to choose the policy and resulting birth rate that maximized needs-adjusted consumption.

While the approach just described might well yield replacement fertility as an optimum, there is an important reason to doubt that such a thing would happen in the real world, and this is the issue of the timing of such a policy's costs and benefits. The analysis above showed that when fertility falls, there is a period of unusually low dependency (the demographic dividend) before the population returns to dependency that is consistent with a stable population. The same thing holds true in reverse: when fertility rises, there is a period of unusually *high* dependency that ensues before the population moves to dependency that is consistent with a stable population.

Figure 5 makes this point using demographic projections from the United Nations Population Division. Specifically, it compares the support ratio for South Korea under the UN Medium Projection to the case of an instant return to replacement fertility as of 2024.[19] The comparison is done for the cases of equal consumption needs (panel A) and age-adjusted needs (panel B).[20]

The figure makes it clear just how long the economic benefits of higher fertility take to arrive. In the unadjusted case, the support ratio remains higher in the medium projection than in the instant replacement projection through the year 2056. In the case of age-adjusted needs, the last year in which the medium projection features higher consumption is 2051. Not surprisingly, the gap in support ratios between the two scenarios peaks after 19 years, in 2043. Using age-adjusted needs, consumption in the instant replacement projection is 8.9% lower in that year than in the medium projection.

The fact that raising fertility will lead to a temporary period of dependency that is even higher than it would have been absent the fertility increase is a relatively obvious point, but I believe that it is also underappreciated. It is often confused with a different issue that was mentioned above, which is that rising dependency over the next several decades is the result of a passing period of low dependency, i.e. the so-called demographic dividend. Bloom and Kotschy (2023) use the term "demographic drag" to describe the reduction in the growth of output per capita relative to output per worker that results when old-age dependency rises in response to low fertility several decades earlier. But this fading of the demographic dividend will happen pretty much regardless of what happens to fertility. By contrast, what I will call "demographic debit" refers to the rise in dependency that results from an increase in fertility following a period during which it was depressed. This demographic debit can bring the economy to a level of overall dependency that is greater than what is observed in a stable population.

Terminology aside, the point being made here is that policies designed to raise fertility would not be appealing to elderly or near elderly voters who want to ensure the solvency of their pensions. And such policies would similarly be a bad choice (at least on economic grounds) for politicians

[19] The Medium Projection features the TFR rising slowly to reach 1.0 in 2047 and 1.3 in 2100. In both the medium and instant replacement projections, life expectancy at birth (both sexes) rises from 84.4 in 2024 to 87.3 in 2050 and 93.1 in 2100.
[20] The support ratios in Figure 5 cannot be directly compared to those in Tables 1 and 2 because the figure uses UN demographic projections that include changing mortality up through the year 2075 while the tables apply the 2020 life table.

whose time horizons tend to be relatively short. Focusing on voters: the results above say that for South Korea, a return to replacement fertility would lower needs-adjusted consumption on a flow basis for the next three decades or so. Obviously, then, any voter who is within three decades of death would be made worse off. Further, even voters with a longer horizon of, say, four decades would be made worse off in present value terms. This means that a majority of voters would not benefit, and this would be all the more true in the context of an age distribution of the population heavily tilted toward the elderly. Thus it would be hard to find majority support for pursuing such a policy, at least if voters acted selfishly.

Finally, it is worth noting that the deployment of expensive pronatalist policies becomes less likely, the further that countries fall into the state of fiscal restraint that results from population aging. This observation is related to the notion of a "demographic meltdown" that is sometimes brought up when discussing future fertility. The idea of a demographic meltdown is that population aging in a country could become sufficiently burdensome that it would feed back to lower fertility of the working age population. That burden would be both through government finances (working-age people paying high taxes to fund transfers to the elderly) and through within-family mechanisms (only children feeling burdened in caring for their elderly parents, and thus not having time to produce children of their own). Hock and Weil (2012) explore these possibilities in a dynamic overlapping generations model. It is worth noting that this mechanism is not a great explanation for currently low fertility. For example, in the marquee case of South Korea, fertility is low even though the current old-age dependency burden is quite modest. Similarly, in Japan, Italy, and many other countries, fertility fell well below replacement at a time when old-age dependency was quite low. Nonetheless, it is possible that this mechanism will operate to reduce fertility in the future, making a return to replacement fertility seem even less likely.

Changes in Population Composition Regarding Fertility Preferences

It is sometimes argued that low fertility will be inherently self-limiting because of the changes in population composition that it induces. Charles Galton Darwin (1960) coined the terms *Homo contracipiens* and *Homo progenitivus* to describe the human subspecies more or less prone, due to genes or culture, to restrict their own fertility. His concern was with excessively high rather than low fertility, but the mechanism is the same: if the two types occupy a single niche, then the former will be driven to extinction, and fertility will be determined by the preferences of the latter. In the current context, Darwin's story would predict that the average fertility rate will rise over time as low-fertility types are outbred.

Empirically, the importance of this effect hinges on fertility as being at least somewhat heritable. One way to look at this is by examining the relationship between the number of a person's siblings and the number of their children. During fertility transitions, the intergenerational correlation of fertility is shifted downward because of the uneven adoption of modern fertility practices: elites that have the highest fertility in the pre-transition period are also the first to adopt fertility control (Vogl, 2020). In developed countries, in modern data, with the fertility transition well past, the relationship is positive, but relatively modest. Murphy (2013) finds that having an extra sibling raises the number of children that a person would be expected to have by four percent.   Put another way: the correlation between the number of siblings and the number of children tends to be mildly positive, in the range of 0.1 - 0.2. In the United States, it is 0.1. The correlation reflects characteristics that tend to be persistent between parents and children, such as education and religion, but even when these factors are controlled for, the correlation remains. This mild correlation would be expected to exert only a small upward trend to fertility, and would not bring it up to the replacement level in most countries.

It is possible that the statistical analysis just described misses out on the importance of some groups that are currently small relative to the population that are characterized by both high fertility and a high degree of cultural persistence. In the United States, this could include Latter Day Saints, ultra Orthodox Jews, and Hutterites. If such groups did not change their characteristics, their growing share of the total population would indeed induce a rise in fertility back to the replacement level. Such a process would take many generations, however: the largest of the groups just listed, Latter Day Saints, currently make up only about 2% of the US population. Further, if such a thing happened, it would not lead to replacement fertility as a permanent state; rather, the fertility rate would be accelerating upward as it passed the replacement rate.

4. Conclusion

Of the three claims made in this paper's title, the one in which I have the least doubt is that replacement fertility is not natural for human populations in modern, developed countries. The homeostatic model described by Malthus kept births and deaths in close balance for most of human history, as it similarly did for all of the other species on the planet. But it does not apply today. Our astounding standards of living, long life spans, conscious control of fertility, gender equality, and high human capital are all inconsistent with that homeostatic model.

Getting over the presumption that replacement fertility is a natural anchor has taken a long time, and figuring out how to think about a world in which such an anchor is absent is an ongoing project. Ironically, much of the thinking about how to deal with non-homeostatic population was done in the context of worry about fertility being too high, rather than too low. Hardin (1993) described the world of Malthus as one in which "power" and "responsibility" regarding fertility both rested with parents. They chose the number of children and bore the consequences. Hardin's worry was that the development of the welfare state had removed responsibility from the equation, removing what Malthus called the preventive check on fertility, and unleashing immiserating population growth: "If we are unwilling to go back, then we must go forward and bring power and responsibility together in a new locus, in the community itself. If the community has the responsibility of keeping children alive it must also have the power to decide when they may be procreated. Only so can we save ourselves from the degradation of runaway population growth." Modern worry about low fertility is really just a restatement of this view, in a setting where observers think that the privately-chosen level of fertility is too low in comparison to the needs of the community.

The issue of the optimality of replacement fertility is somewhat more complicated. First, there are a large number of different effects that have to be taken into account. In the discussion above, I focus my initial attention on the narrow topic of dependency and the needs-adjusted level of consumption in a stable population. Here the most important finding is not about the optimal level of fertility (as implied by the optimal growth rate of population.) Rather, it is about the relative insensitivity of needs-adjusted consumption to the growth rate of population within a relatively large region around whatever that optimum is. This insensitivity implies that even without knowing the true optimum, we can be confident that even very negative growth rates of population are not in fact so bad. This analysis also showed that what many commentators see as the key problem of low fertility -- the rise in old-age dependency that is now underway in many developed countries -- is in fact just the fading of the transitional period of low dependency known as the demographic dividend.

The calculation just described can be expanded in many different ways: to take account of tax distortions, changing ages of entry into adulthood and old age, different weights on the consumption needs of different age groups, environmental considerations, capital flows, and so on. In principle, for each twist added to the model, there will be a different optimal level of fertility. Further, for some sets of factors, and for some parameterizations, the optimal level of fertility will be close to replacement. However, my sense is that the result regarding the relative insensitivity of needs-adjusted consumption with respect to population growth will survive these changes, and so, once again, knowing the true optimal level of fertility is not that important.

Moving beyond the simple analysis of dependency in stable populations raises dynamic issues, including the evolution of the population age structure over time as well as feedback from the size of the population to the speed of technological progress and the state of the environment. Some of these are simply technical issues that can be addressed in a dynamic model with an intertemporal social welfare function. But other issues challenge the ability of economists to discuss optima. How shall we value the lives of future people, or even worse, potential future people, who may or may not come into existence depending on the level of fertility? Do we really have to think through the question of how long the human race is going to exist in order to answer questions about whether today's fertility rate is socially optimal? In this paper I have only lightly touched on these issues, in part because I think that this is all that is required to establish the narrow point that taking them into account is very unlikely to say that the optimal level of fertility today is two children per woman. But this is not to say that the issues are not worthy of far more consideration.

Finally, regarding the likelihood of replacement fertility, my starting point is again the non-applicability of the Malthusian model of homeostasis. In the absence of such an anchor, it is hard for me to see why fertility should settle near the replacement rate, or why observers should be so surprised when it doesn't. My interpretation of the history of long-run population projectionions since World War II is that experience has gradually taught demographers the lesson that they could have drawn from theory. Whatever the driver of their intellectual development, demographers who are in the business of long-run population projection have by now almost completely abandoned their allegiance to replacement fertility as a long run anchor.

The most interesting issue that comes from this analysis is whether governments might insert themselves into this situation in order to achieve something close to zero population growth. The literature on the efficacy of interventions to raise fertility suggests that while hitting the target of replacement might be costly, it is certainly possible. The question is then whether there will be political will to undertake such a project. Looking solely at economic considerations, it is hard to see such a thing as likely. In addition to the high costs of inducing people to have more children, there is also the problem that the economic benefits of higher fertility in terms of reduced dependency take three decades or so to arrive.

That being said, I certainly don't rule out this possibility. People's feelings about the importance of children -- their own and those of others -- are complicated and subject to unpredictable changes. During times of war, individuals are willing to make enormous sacrifices to achieve goals related to the future of the collective. It is certainly possible that people who do not want many children themselves will nonetheless be willing to vote for expensive policies that induce other people to procreate in order to achieve population stabilization. Less democratic countries may also have an easier time prioritizing long run population goals.

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Table 1: Support Ratios in Stable Populations

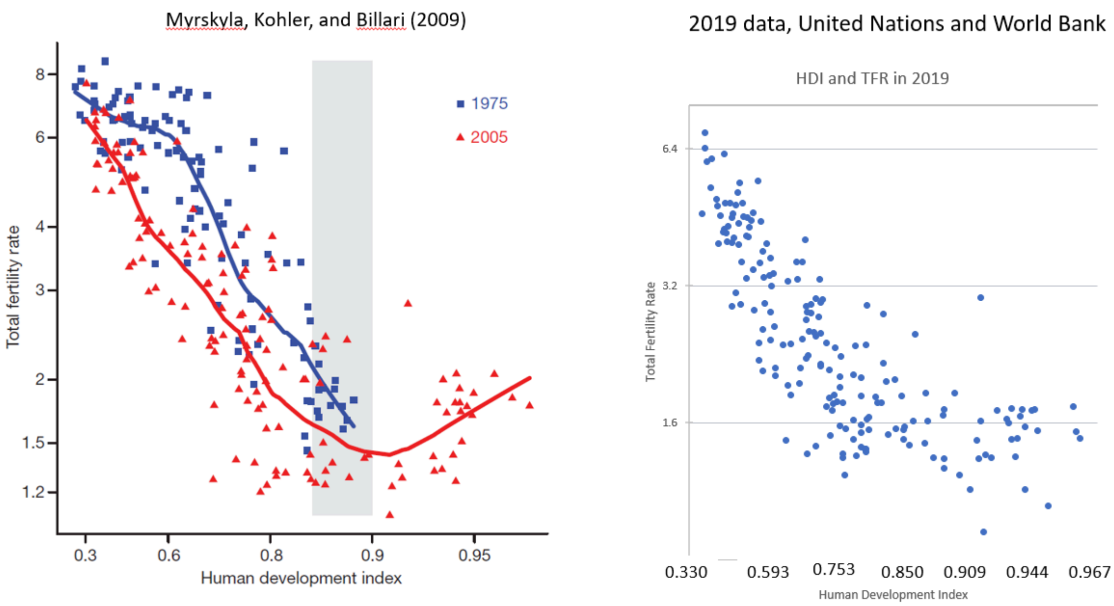
			No Adjustment for Relative Needs		Adjusted for Relative Needs	
Population Growth Rate	Fraction Aged 0-19	Fraction Aged 65+	Support Ratio	Support Ratio Relative to Zero Population Growth	Support Ratio	Support Ratio Relative to Zero Population Growth
2.0%	0.416	0.096	0.488	0.906	0.537	0.986
1.5%	0.372	0.120	0.508	0.943	0.548	1.005
1.0%	0.329	0.148	0.524	0.972	0.553	1.015
0.5%	0.286	0.179	0.534	0.991	0.552	1.013
0.0%	0.246	0.215	0.539	1.000	0.545	1.000
-0.5%	0.209	0.254	0.537	0.997	0.532	0.977
-1.0%	0.175	0.295	0.530	0.984	0.514	0.944
-1.5%	0.144	0.339	0.517	0.960	0.492	0.903
-2.0%	0.117	0.383	0.499	0.926	0.466	0.856

Table 2: Support Ratios Over the Course of Korean Demographic Transition

				No Adjustment for Relative Needs		Adjusted for Relative Needs	
Year	Population Growth Rate	Fraction Aged 0-19	Fraction Aged 65+	Support Ratio	Support Ratio Relative to Year 2020	Support Ratio	Support Ratio Relative to Year 2020
1980	1.5%	0.454	0.041	0.505	0.755	0.571	0.849
1985	1.4%	0.408	0.045	0.547	0.818	0.609	0.906
1990	1.0%	0.358	0.052	0.590	0.882	0.645	0.960
1995	1.1%	0.318	0.060	0.622	0.931	0.671	0.998
2000	0.9%	0.287	0.072	0.641	0.959	0.683	1.015
2005	0.6%	0.252	0.089	0.659	0.986	0.692	1.029
2010	0.3%	0.232	0.107	0.661	0.990	0.686	1.020
2015	0.5%	0.201	0.129	0.670	1.003	0.685	1.019
2020	0.2%	0.174	0.158	0.668	1.000	0.672	1.000
2025	0.0%	0.159	0.202	0.638	0.955	0.632	0.940
2030	-0.1%	0.149	0.247	0.603	0.903	0.589	0.876
2035	-0.2%	0.140	0.290	0.570	0.852	0.548	0.815
2040	-0.4%	0.136	0.329	0.534	0.800	0.509	0.757
2045	-0.5%	0.136	0.358	0.507	0.758	0.479	0.712
2050	-0.7%	0.136	0.381	0.483	0.723	0.454	0.675

Note: Population growth rates are for the previous five years.

Figure 1: Relationship Between Fertility and Human Development



Note: In both figures, horizontal scale is $-\ln(1-HDI)$

Figure 2: Stylized Depiction of the Demographic Transition

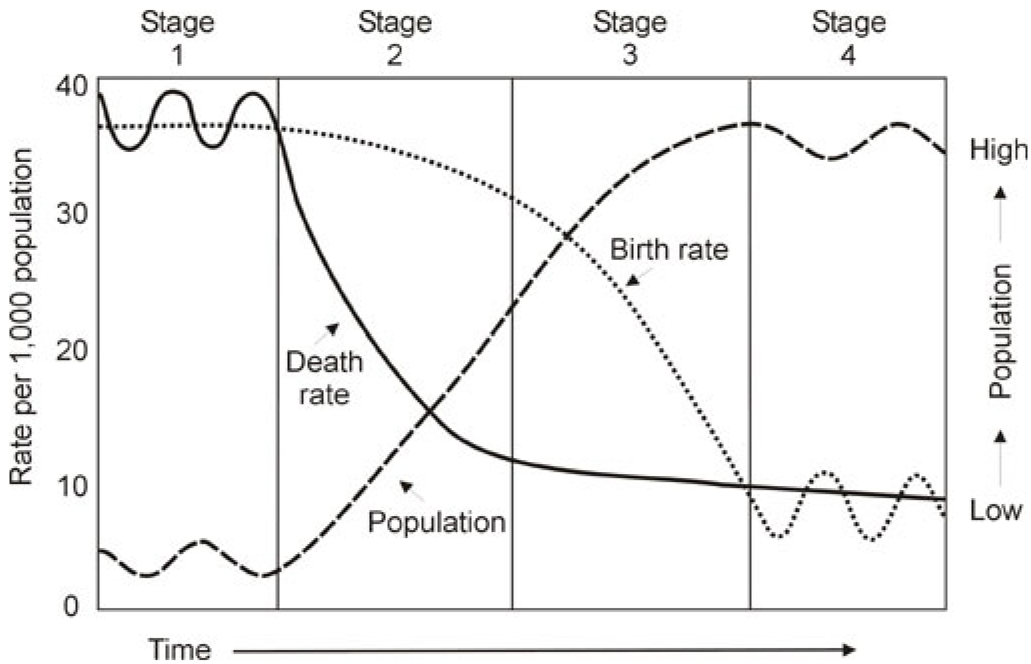


Figure 3: Iso-Dependency Lines

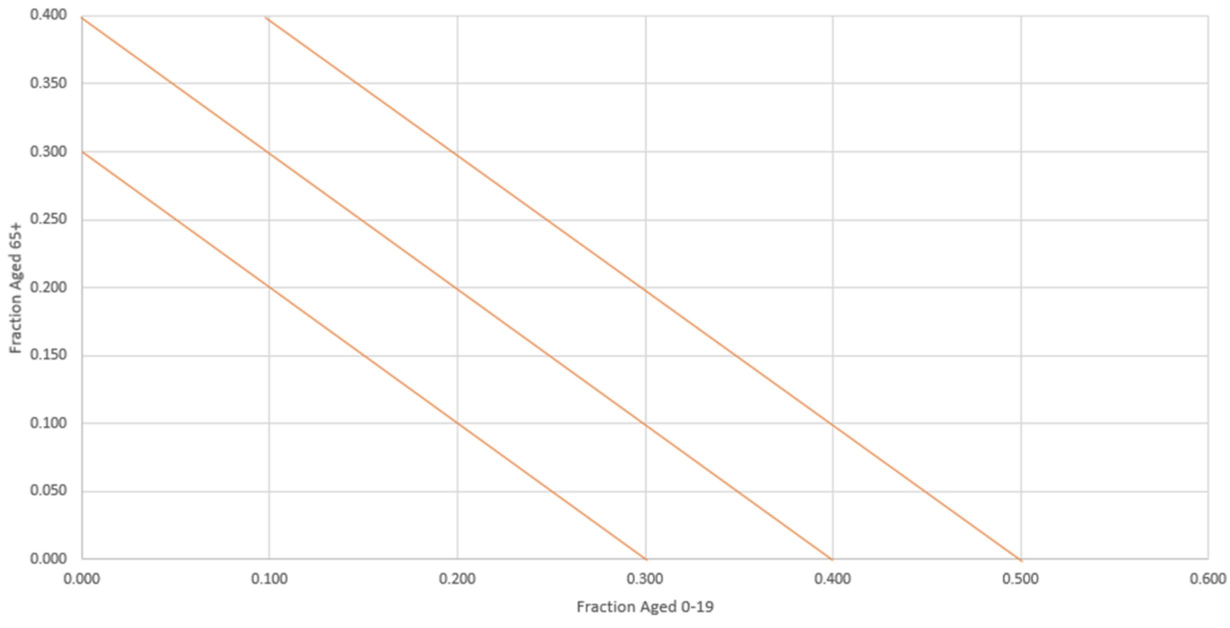


Figure 4: Population Age Structure Dynamics in Korea

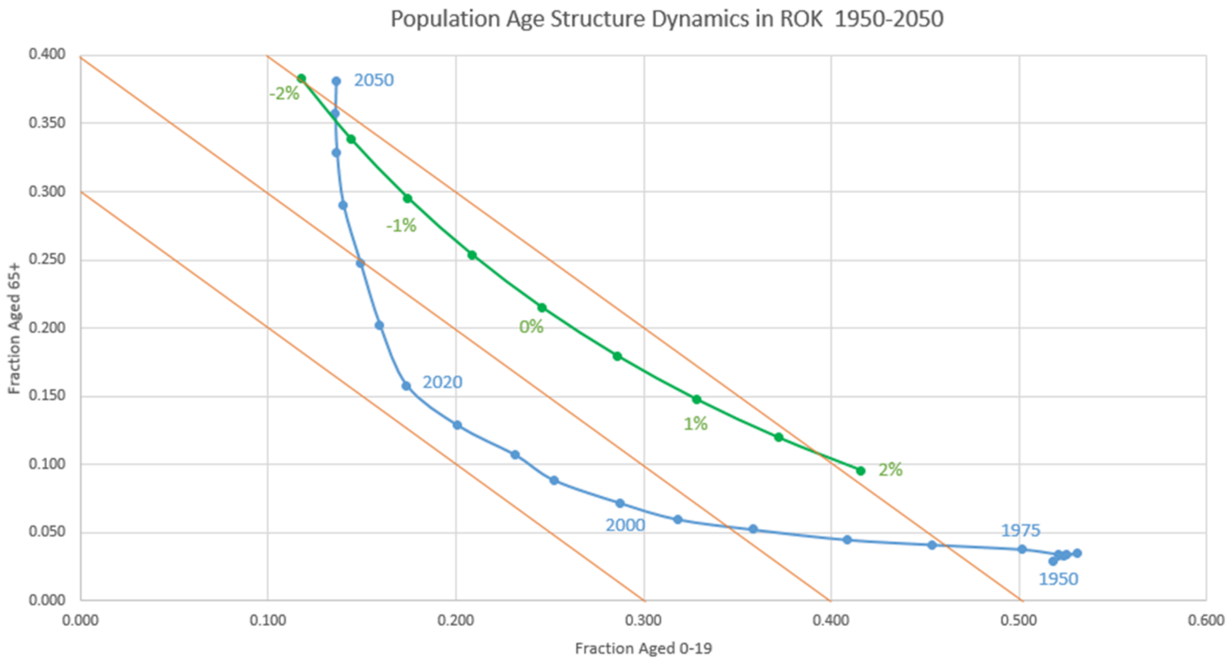
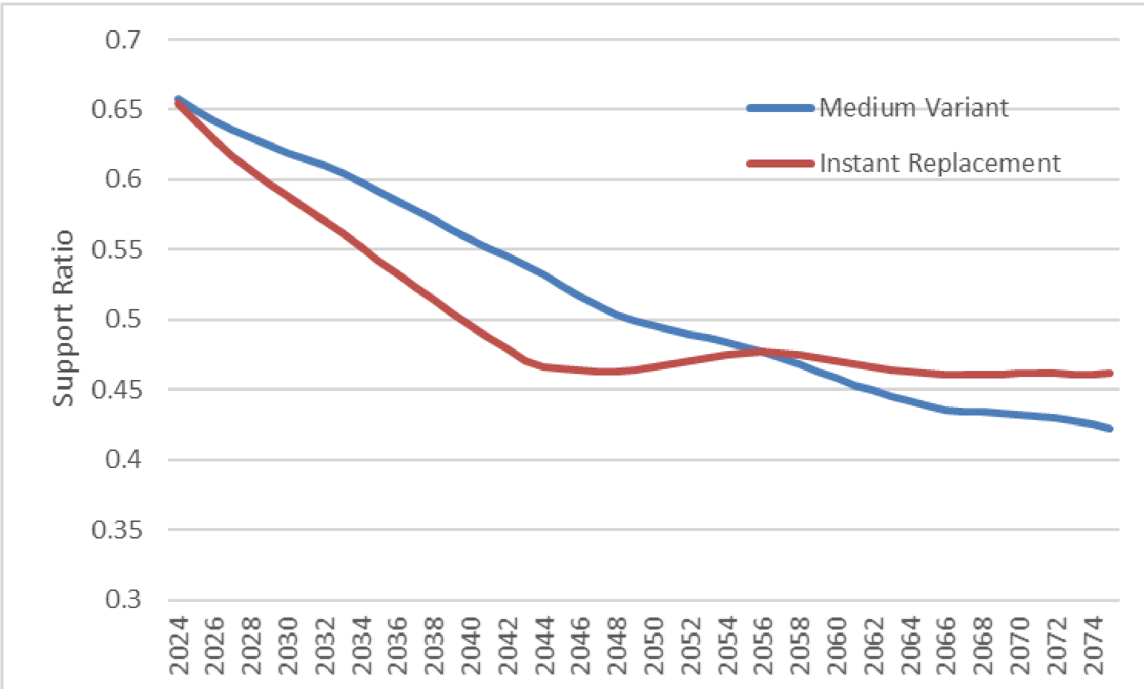


Figure 5: South Korea Support Ratio Dynamics with Increased Fertility

A: Equal Consumption Needs



B: Age-Adjusted Consumption Needs