Replacement Fertility is Neither Natural nor Optimal nor Likely

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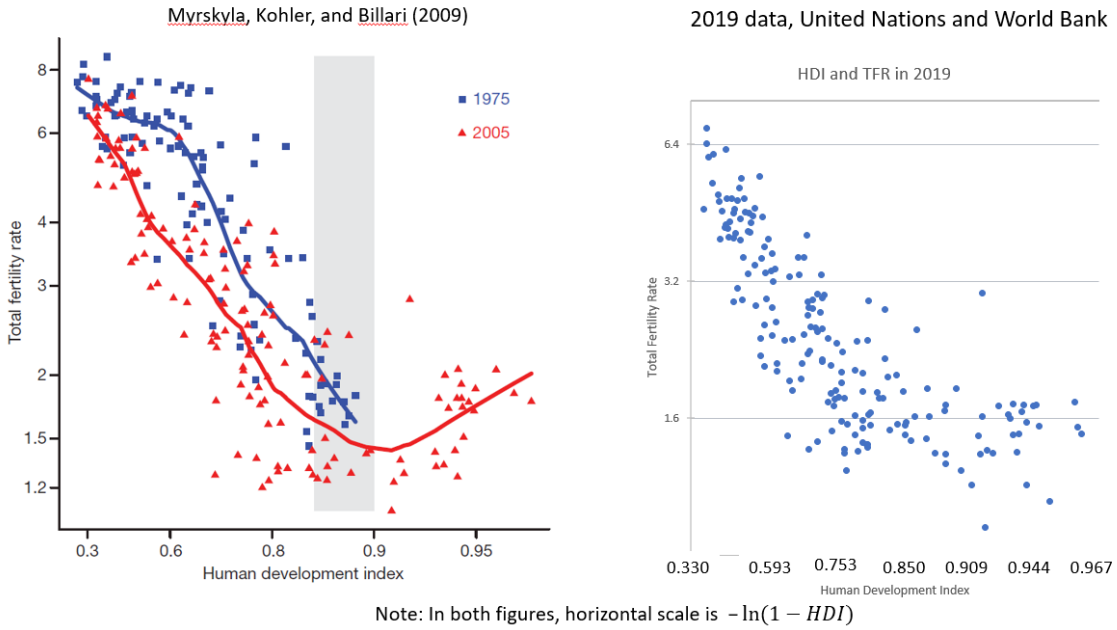
Low fertility is widely decried. In 2022, Pope Francis called it a "social emergency" while Elon Musk declared that "population collapse due to low birth rates is a much bigger risk to civilization than global warming."[1] Although many developed countries have experienced below-replacement fertility for several decades, 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. 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 HDI index, 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.

Figure 1



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

- The extension of the low fertility trend to levels of TFR that would have seemed unimaginable even a few decades back (for example, below 1.0 in South Korea prior to COVID-19).
- 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.

[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

Changes in total population, in turn, deviate from the rate of natural increase because of net migration. In Japan, where net migration is low, the TFR fell below 2.0 in 1975 while deaths first exceeded births in 2005, and population began to decline in 2012. 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%.

- 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 (Stone, 2020).

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. 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 immiseration. "Zero population growth" was thus initially a slogan of those who wanted to keep fertility down, even if now it could 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. The Emperor Augusus harshly addressed the numerous unmarried men of the Roman elite, accusing them of sacrilege and of "betraying your country by rendering her barren and childless." Somewhat more recently, 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.[2] (Émile Zola's 1899 novel *Fécondité* decries the foolishness of fertility restriction.) 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. Writing in 1945 the demographer Frank Notstein 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."[3]

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

[2] Cole, Joshua. *The Power of Large Numbers: Population, Politics, and Gender in Nineteenth-Century France*. Cornell University Press, 2000. Chpt. 6

[3] Notstein, Frank, "Population -- The Long View," in Theodore W. Schultz, ed., *Food for the World*, Chicago: University of Chicago press, 1945, pp. 36-57.

groups, as in the “race suicide” view propounded by the sociologist 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 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.

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.[4] 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

[4] Maddison, Angus. 2001. *The World Economy: A Millennial Perspective*. Paris: Development Centre of the Organisation for Economic Co-Operation and

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.)

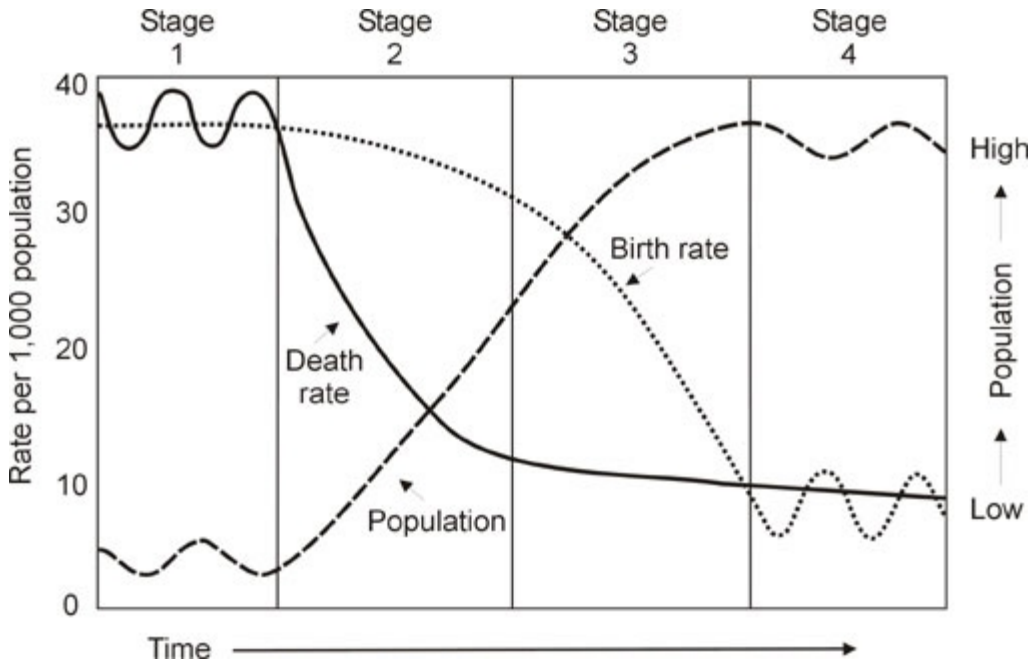
Malthus understood that his model applied to not only humans but to animals as well, with the crucial difference that only humans were capable of consciously deploying the preventive check. Animal populations will expand to fill their ecological niche. Allowing for interactions among predators and prey, 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 like the figure below.



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.[5]

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. (Calling this number a "target" for the number of survivors implies a degree of conscious calculus regarding reproduction that may not have been appropriate in many settings.)

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 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

[5] 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.

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.)

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 similarly converge to a long-run value of 1.85 children per woman.[6] 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.

[6] *World Population Prospects: The 2002 Revision*, Volume II (New York: United Nations, 2003), 24.

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.[7]

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 projections correct if fertility ended up 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 80th percentiles 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.[8] The 95th percentiles for these countries are 2.12, 2.00, and 2.04. Among the highly developed countries in Western Europe, the 80th percentiles of the distribution tend to sit close to replacement, for example, Germany (1.99), France (2.13), the

[7] *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/ .

[8] Although my focus is on replacement fertility, it is worth noting just how low the UN considers it possible for fertility to fall. The 20th percentile of the 2100 fertility distributions for Japan, South Korea, and China are 1.17, 0.95, and 1.09, respectively.

Netherlands (2.01), Italy (1.88), Spain (1.90) and the United Kingdom (2.03). The 95th percentiles are all above replacement, with the highest being France at 2.40. For the United States, the 80th percentile 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 20th percentile for 2100 fertility is 1.50 while the 80th percentile is 2.70. Some other highly populous countries with currently higher fertility and highly uncertain futures, with the 20-80 TFR 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, 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 understand yet why.

Naturalness

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.

The demographer Ben Wattenberg, whose examination of below-replacement fertility is generally thoughtful and balanced, in the end can't help but expressing his view that the

phenomenon is “strange and unnatural.”[9] In a similar vein, the journalist Jonathan Last, in his book *What to Expect No One’s Expecting: America’s Coming Demographic Disaster* 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.[10]

Optimality

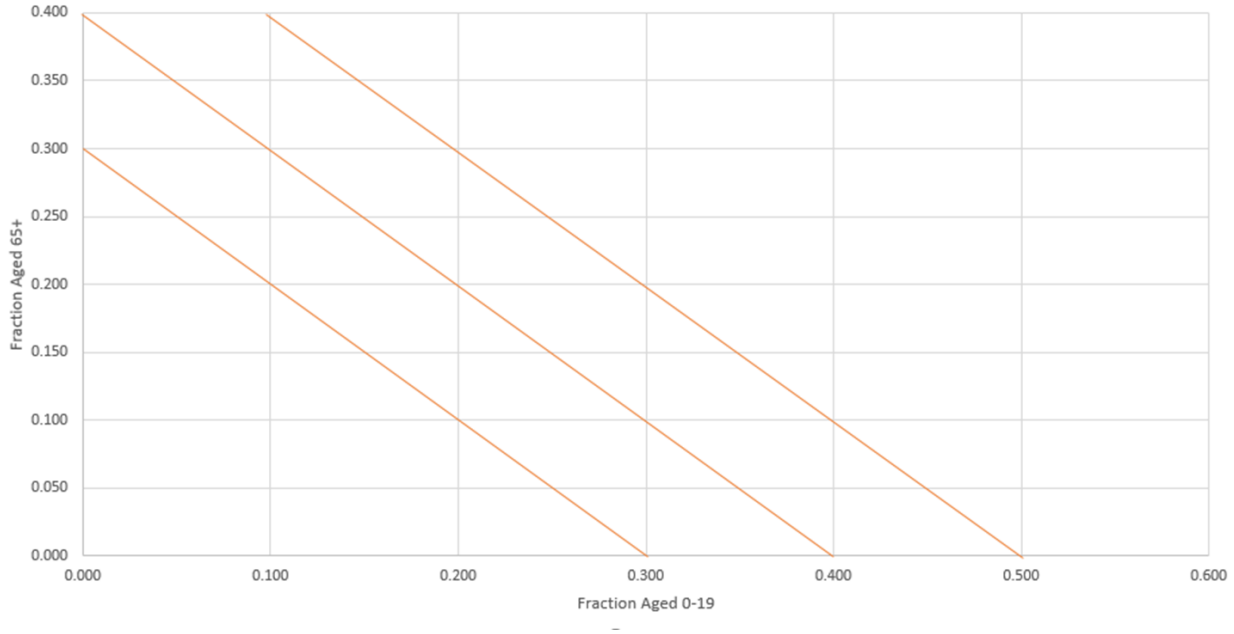
Popular discussions of sub-replacement fertility and negative population growth frequently take it for granted that these are bad things for the economy. Economists tend to see the situation in much more nuanced terms. Fully addressing the issue requires wrestling with both technical and philosophical issues. 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.

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. For now, however, I stick with the simple structure for illustration.

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 the figure below, 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.

[9] P. 224.
[10] Last, Jonathan V., *What to Expect No One’s Expecting: America’s Coming Demographic Disaster,* New York: Encounter Books 2013.

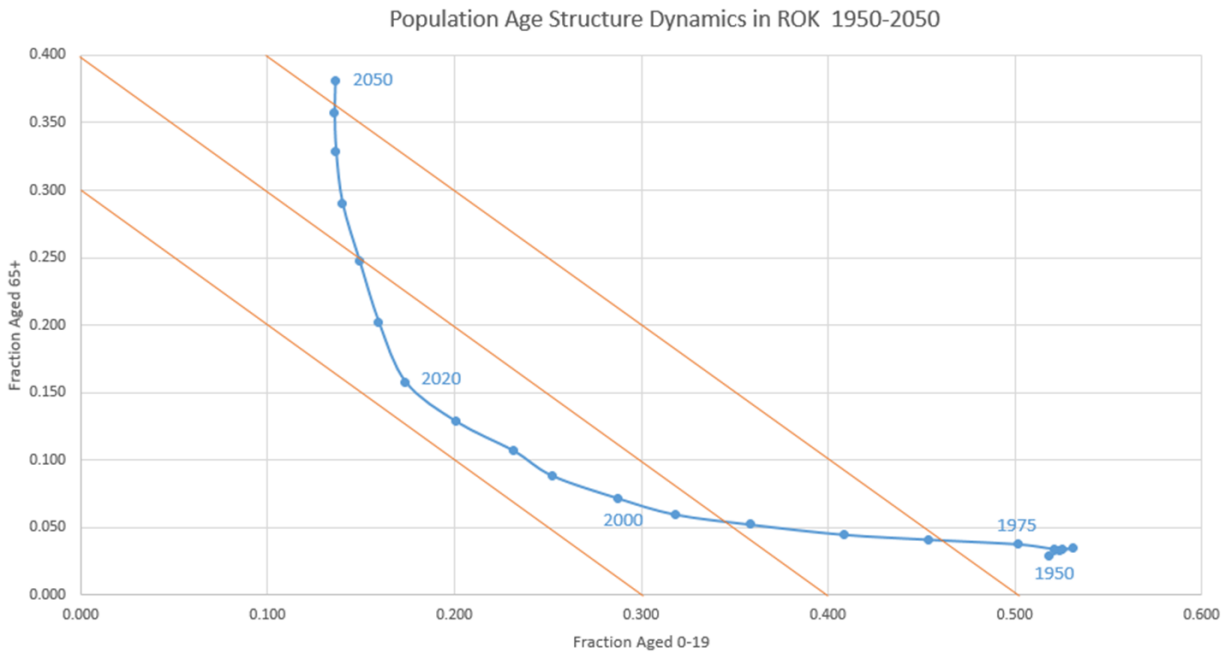


One can then show how demographic change moves a population through this dependency space. The figure below shows this process for South Korea.

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:

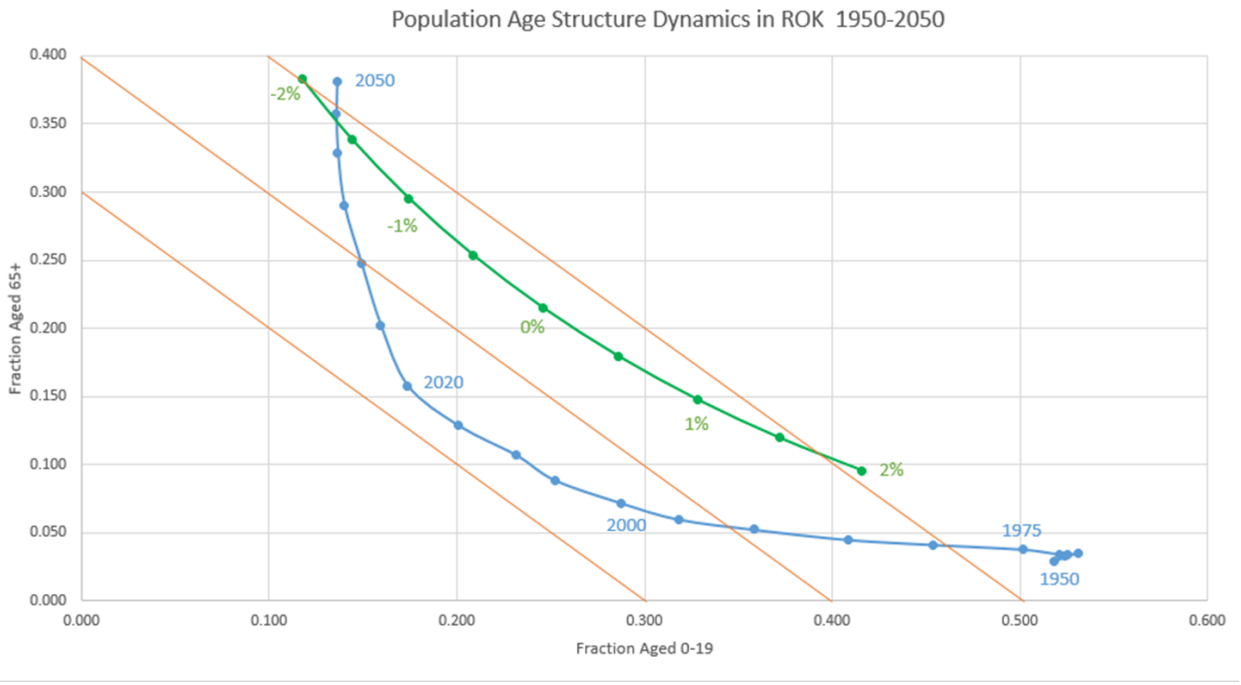
$$g_{GDP\ per\ capita} = g_{GDP\ per\ worker} + g_{workers\ per\ capita}$$

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.

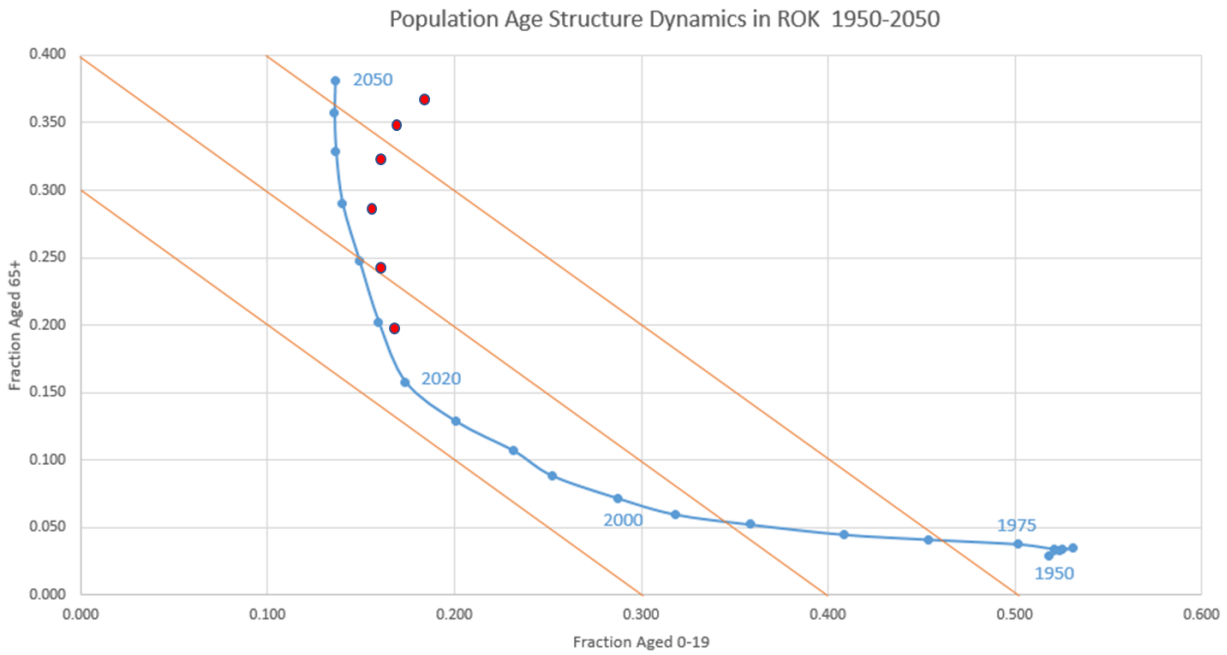


This analysis captures the simple intuition for why many commentators think that population aging brought about by low fertility is bad for the economy: we can see that the old-age dependency burden is rising, and this directly impacts consumption. However, such a conclusion misses the point that the aging taking place in many developed countries is really just the end of the decades-long demographic dividend, i.e. the period following 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 the figure below, 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).



A further implication of this model is that raising fertility will lead to a temporary period of dependency that is even higher than it would have been (shown as red dots in the figure below). This is the reverse of the demographic dividend, and I will call it the “demographic deduction:” a period of several decades following a rise in fertility, characterized by lower consumption as the economy transitions to a younger age structure. It is relatively easy to do calculations comparing, say, consumption per capita in Korea if it follows current fertility projections vs. an alternative in which fertility rises back to replacement. Consumption along the alternative path would be lower than along the baseline projection path for something like four decades. Thus 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 whose time horizons tend to be relatively short.



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. 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. (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.)

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 (see 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 capital (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. The journalist Jonathan Last has suggested 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.

Beyond Dependency: Technological Progress, the Environment, and Debt

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

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

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 growth. 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.[12] 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. 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 to be exogenous. That optimum corresponding to zero population growth would still be a knife-edge case.

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.[13]

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 above, a rise in fertility would have a negative impact on the government's budget for a period of many decades.

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[12] 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.

[13] 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.

So breeding up a large generation of future taxpayers is unlikely to be a viable policy option for governments faced with heavy debt burdens.

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. In the limit, one could say that establishing the institutions that incentivize fertility, the government should be taking into account the wishes of these potential people.

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 worrying about the impact of fertility now on technological change, resource depletion, or the size of the population in the distant future is simply not that important. 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.

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