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With a Whimper: Depopulation and Longtermism

"Future people count. There could be a lot of them. We can make their lives go better." This is Will MacAskill's elegant and compelling introduction to longtermism for a popular audience in *What We Owe the Future*. It is the starting point of an argument for prioritizing the wellbeing of the near-endless stream of future people. Or, more specifically, people who may exist if humanity can evade the nearer term existential risks that threaten it. In this chapter, we consider an important other possibility: There might not be a lot of them, after all. The entire population science community predicts the global population to begin shrinking within the lives of children born today. Once this decline begins, it may happen fast.

The goal of this chapter is to bring facts from population science and population economics into dialogue with the community of longtermists who are thinking about wellbeing into the far future. To eventually achieve a flourishing far future, it is valuable that over the coming few centuries a complex global economy endures and the number of people does not become small enough to be highly vulnerable to extinction from a threat that a larger population could sustain. We review population projections and other social scientific facts that show that fertility rates that are normal in much of the world today would cause population decline that is faster and to lower levels than is commonly understood, threatening the long term future.

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"Future people count. There could be a lot of them. We can make their lives go better." This is Will MacAskill's elegant and compelling introduction to longtermism for a popular audience in *What We Owe the Future*. It is the starting point of an argument for prioritizing the wellbeing of the near-endless stream of future people. Or, more specifically, people who may exist if humanity can evade the nearer term existential risks that threaten it. In this chapter, we consider an important other possibility: There might not be a lot of them, after all.

MacAskill's book contains a striking diagram: If you have the book, go look at page 15. A series of small stick-figures, each representing ten billion people, stretches for five pages. Nine-hundred and fifty-four stick-figures dramatize the possible future of human lives yet to be lived. (MacAskill reports that, if he were not abbreviating to save paper, he would ideally include five million figures over twenty thousand such pages.) He computes this number as the straightforward multiplication of ten billion people living on Earth for each of five hundred million years.[2]

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[1] We are grateful for written comments on drafts of this chapter from Kathleen Broussard, Diane Coffey, Aashish Gupta, Kevin Kuruc, Melissa LoPalo, Sangita Vyas, and Gage Weston.

[2] MacAskill is not the only philosopher embracing longtermism, and his are not the only arguments and explanations, but it is hard to overstate the traction that this presentation has received as a representation of one of Longtermism's core ideas. At the time of our writing, the Wikipedia entry for Longtermism had exactly two diagrams–both variations on the same idea as MacAskill's stick figure diagram, these produced by Our World in Data (Rosen, 2022). Newberry (2021) presents similar computations in a working paper.

We hope that so many excellent lives happen. But the population science community projects something else to happen. The possibility of these lives may become closed off.

What sort of plague or apocalypse is responsible for this forecast? Only that people continue, for a few centuries, to have the sort of fertility rates that are now normal for most of humanity. With a high degree of scientific certainty, the human population size will begin shrinking soon, within the lifetime of children alive today. What happens after that is less certain, but sustained depopulation is a likely possibility. Two-thirds of people now live in a country where fertility rates are not high enough, on average, to prevent depopulation.[3] By depopulation, we mean that the number of people alive exponentially declines, generation after generation. The dividing line that separates population growth from depopulation is whether fertility is consistently above or below 2 children per adult woman, on average globally. Below that critical threshold, the next generation will not replace the last. Nearly all rich countries are already below 2. The most populous poor and middle-income countries are as well. And in the few holdouts where fertility rates are still high today, fertility is falling.

To give a concrete numerical example: Consider the US, where fertility is not especially low by rich-country standards: 1.66 children per woman. Europe, China, Japan, and a set of other countries together amounting to 38% of the world population all already have fertility below this level. What if the whole world converges to the fertility rate that is normal in the US today? (At the risk of over-emphasizing, this would mean an *increase* in fertility in many countries where fertility is already lower than in the US.) How many stick-figures would be needed to represent the count of all future human lives in that case? How many of MacAskill's five million figures would remain?

Three figures. If the whole world reaches and sustains a fertility rate like the US has now, then there would be fewer than 30 billion future human births, ever (Spears et al., 2023). There have been about 120 billion human births so far, since the beginning of our species. So that would mean that humanity is now four-fifths over, only one-fifth remaining. This outcome would not require low fertility to be sustained for millennia, or even for more than a few centuries. By 2350 CE, there would be only 20 million births per year compared to around 140 million in 2022. The last time so few people were born was sometime in the 9th century. The Mayan civilization was waning then. The Vikings were just getting started.

Longtermism (understood broadly as a body of scholarly arguments focused on making things go well for future people, because there could be a lot of them) typically focuses on the risk that the future goes out with a bang, due to a disaster like a pandemic, a supervolcano, an asteroid, or losing a war with AI (Ord, 2020). This chapter encourages longtermists to include on their research agenda the neglected possibility that we go out with a whimper–generations of exponential decay in population size over a few centuries until there are only a few million or

[3] Later in What We Owe the Future, in the contexts of economic stagnation and value lock-in, MacAskill mentions the risk of depopulation. Here we offer an expanded treatment of this risk–its trends, its causes, and its consequences–drawing on our research in economics and demography.

few hundred million of us. At that point, it might not require a huge disaster to close off our flourishing future.

The goal of this chapter is to bring facts from population science and population economics into dialogue with the community of longtermists who are thinking about wellbeing into the far future. Our maintained assumption is that most longtermists would agree that, to eventually achieve a flourishing far future, it is valuable that over the coming few centuries a complex global economy endures and the number of people does not become small enough to be highly vulnerable to extinction from a threat that a larger population could sustain. We review population projections and other social scientific facts that show that fertility rates that are normal in much of the world today would cause population decline that is faster and to lower levels than is commonly understood, threatening the long term future.[4]

We proceed in four sections. Section 1 presents demographic projections. We take the UN's projection to 2100 and then extend it using standard tools from population science. The result is that, on the timetable of a few centuries, depopulation could happen very fast, even if global fertility rates are not far below two children per woman, on average.

Section 2 responds to the question "How can you be so sure?" As you will see, we are not. That uncertainty is itself important. Like all threats to long-term flourishing, depopulation is a risk, not a certainty. Raftery and Ševčíková, for example, compute that there is a 90% chance that global fertility remains below the stable replacement level out to 2300. In other words, they forecast a 90% chance of sustained depopulation—which implies a 10% chance of a fertility reversal that would also reverse depopulation. The historical cases of low fertility populations offer precisely zero examples of rebound to sustained fertility rates high enough to prevent depopulation. But we won't rule out a reversal. The uncertain possibility is sufficient to make understanding depopulation an urgent cause.

Section 3 briefly tours the consequences of depopulation for longtermist goals. Maybe a much smaller global population could sustain a complex, modern, information-based economy. Maybe not. We review arguments from macroeconomics and other social sciences that it might not. None of our arguments require fertility rates to stay low forever to threaten longtermists goals. Timing is often neglected in discussions of long run population, as if any population path might lead us to the same bright future. But it shouldn't be, as we discuss in Section 3: Whatever future longtermists hope for, they should not be confident that progress towards these outcomes would not be closed off by a much smaller population in the next several hundred years.

Section 4 asks about possible policy responses. Plausible responses would require a clear understanding of why fertility is declining basically everywhere, but nobody really knows yet.

[4] Unfortunately, this chapter cannot do its job, within its word limit, and also be an essay about population ethics, gender inequality, or expanding our moral circle to include potential people in the near term future. But these issues are important to us. We have written about them elsewhere, and we touch on them briefly.

There are no shovel-ready solutions to reverse this phenomenon because the basic science is incomplete. We describe how, contrary to popular myth, fertility policy has rarely (and possibly never) been effective at making and sustaining large changes to population-level fertility rates.[5] In this sense, responding to depopulation is not yet tractable at the level of policy and culture, even though the present neglect of the underlying scientific issues makes it particularly ripe for progress. The population science of depopulation is today where climate science was a half-century ago: It was important then that scientists were measuring carbon concentrations, recognizing the system-level problem, and sounding the alarm, even though we had neither the computing power to produce an integrated climate assessment model nor the technological foundations for a clean energy infrastructure. This chapter is intended as a rousing call to more research and better understanding of depopulation.

1. Living in Strange Times: History and Projections

Why do we project the future to contain only a few more stick figures, while MacAskill would draw five million, each representing ten billion lives? Because we are answering a different question. MacAskill's stick figures describe what could happen, if humanity overcomes all barriers to sustaining a population of 10 billion for 500 billion years, until the Earth becomes uninhabitable because of changes in the Sun. His illustration is not intended to ask who would conceive, gestate, and parent so many babies.

Our demographic projections, in contrast, do ask a stylized version of this. Our computation uses a cohort-component-model projection from population science. Such a model quantitatively tracks each hypothetical birth cohort as they age, have children, and die off along the way.

With this model, we answer the question of what would happen if the world follows the UN demographers' medium projection until 2100, and then each country converges over the following few decades to a level of low fertility that is already common–for example, fertility like the present average fertility of the United States (or of South America, or Europe, or East Asia)?[6] Although we present our own long-term projections that we have made with coauthors (Spears et al., 2023), we are not the first to document what would happen if fertility rates stay

[5] Perhaps this is surprising. But to tell you what the history and social science says: Governments sometimes try to coerce people to have babies; governments sometimes try to coerce people not to have babies. It is typical, with such policies, to wreck people's lives, wreck the economy's human capital, and wreck society's compact between the governed and the government. And yet, the evidence is far from clear, despite the popular myths, that such coercive policies have managed to change fertility much from the course it would have followed without coercion. As we will explain below, nobody yet knows of a policy response that could actually do much to change fertility. So it is time for longtermists to join the search for a better understanding.

[6] This is the most recent year available. It is probably not very impacted by COVID because most of the babies born in 2020 would have been conceived before COVID changed people's behavior in spring 2020, but none of our conclusions would be meaningfully different if we used the 1.71 figure from 2019 or the 1.73 figure from 2018, rather than the 1.66 from 2020. There is something odd about assuming that the set of countries is unchanged over 30 years, but because our mechanical projections assume that demographic rates converge, this does not matter.

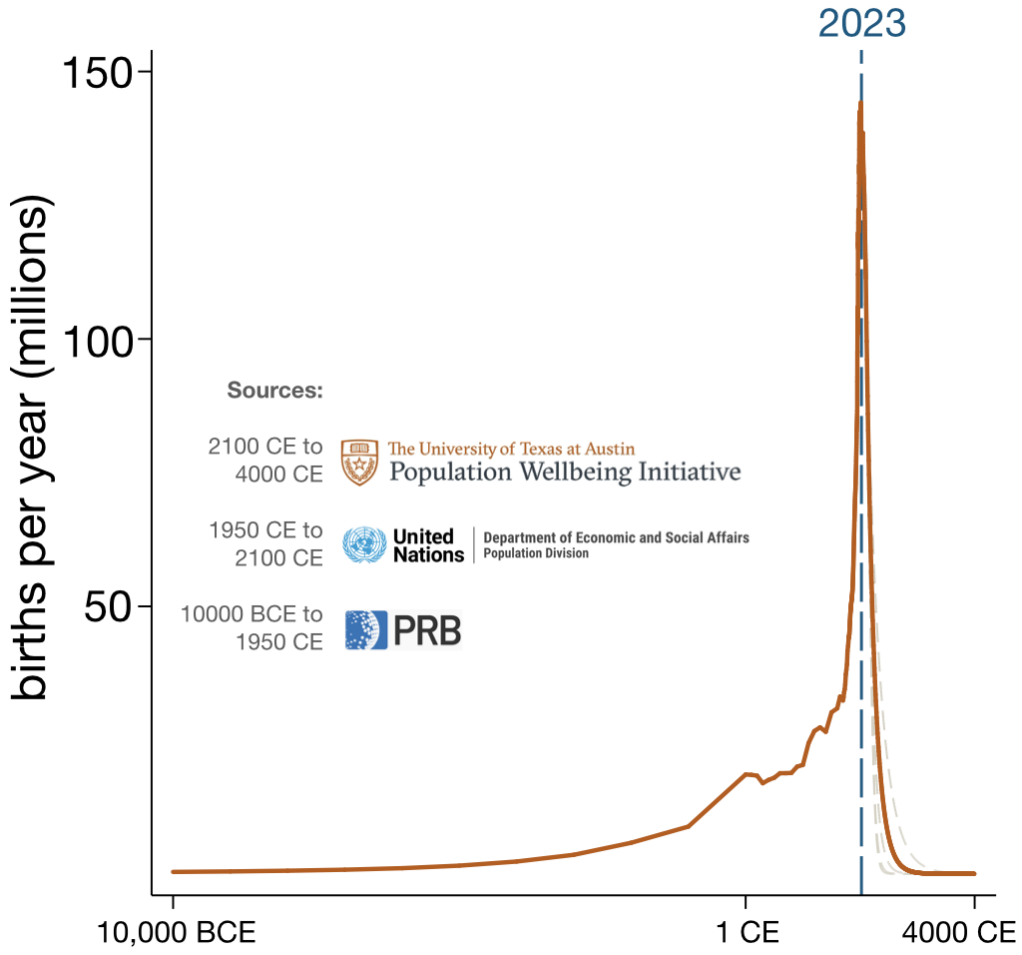
low. Our results are broadly consistent with those of Basten, et al. (2013) and Raftery and Ševčíková (2023), who also quantify uncertainty out to 2300.

Figure 1 is the answer to our question of why the future could be so small.[7] We call it the Spike. It plots the number of births in each year for a long time into the past and a short while into the future. Focus, for now, on the solid line, which makes our focal, illustrative assumption of a future where global fertility is like current US fertility: a total fertility rate (TFR) of 1.66–meaning 1.66 children per woman, on average. As we will verify in Table 1 below, from our zoomed-out, longtermist vantage, the example of 1.66 will be informative of anything in the ballpark. Whether we consider 1.66 or 1.8 (present South America) or 1.2 (present East Asia) simply does not matter for our conclusions.[8] It would be an error to focus too much on the particulars of any of these numbers and miss that they all imply the same broad pattern.

[7] Figure 1 repurposes the projections from Spears, et al. (2023), where they were first circulated; we are grateful for the support of our coauthors Gage Weston and Sangita Vyas in producing these projections. For earlier research consistent with our results, see Basten, et al. (2013). Data for years before 1950 is our construction from Table 1 of Kaneda and Haub (2022).

[8] 1.66, in particular, is not a prediction we are making: There is no reason to believe that future global fertility will just so happen to be numerically like the country where we happen to be writing in the most recent data year available when we happen to be writing. We simply take 1.66 children from the US in 2020 as a non-outlandish illustrative example: Out of nine women, for instance, one has no children, two have one, five have two, and one has three kids.

Figure 1: The Spike:
If fertility rates stay low, then peak births per year has already passed



Notes: Figure 1 plots historical estimates up to the present and cohort-component model projections for the future. Any such projections are conditional on a scenario for future fertility rates. The bold line assumes that future fertility converges to a TFR of 1.66; gray lines assume alternative below-replacement scenarios for future fertility, detailed in Table 1.

The area under the Spike describes the total number of human lives ever lived. Given the emerging new normal of low fertility, Figure 1 conditionally projects 150 billion lives will ever be lived. 120 billion of them have been born in the past.

If so, humanity is four-fifths over.

Of course, there is something silly about following the projection down forever. We do not think there is much chance that the math would hold until the last couple has only one child. Using this projection is merely a way of quantifying: *Humanity's numbers could quickly get small enough to be vulnerable to something bad.*

The Spike shows us that our times could be very strange, relative to the rest of human history, past and future. Although it may be hard to see, given the millenia-wide scale of Figure 1, we (you, the reader, and we, the authors) have already lived through the peak. Total global births per year crested in 2014. According to the UN's historical records and central projection, for as long as they project, there will never again be as many babies born in a year as there were in 2014. The world is already on the downward slope of the Spike.

The population size peak will happen after the births peak, but that is in our near-term future as well: The expert opinion of the population science profession is that, in a few decades, global fertility is very likely to fall below an average of two births per woman. That triggers a shrinking population. The UN projects a global total fertility rate of 1.86 in 2100, as its central estimate, and believes that the size of the world population will peak in the 2080s. Wolfgang Lutz and colleagues at IIASA project 1.67 babies per woman in 2100 and place the peak in the 2070s. IHME at the University of Washington projects a similar 1.66 for 2100 and a peak in the 2060s. The authors of these various studies and reports have good reason to care about the fine details that separate their work from one another's. But for our purposes here, these numbers are no different from each other: Each group expects a future of fewer than 2 babies per woman within the coming decades.[9]

Why is 2 children per woman (or a little more than that–actually 2.05 or so) the important dividing line between exponential growth and exponential decay? Because, when artificial sex selection is absent, human biology yields about 100 female births for every 105 male births. If, on average, 100 adult females produce fewer than 205 births (plus one or two more for the few babies in a low-mortality population who will not survive to reproductive ages) then they have not reproduced themselves (100 females) in the next generation. So, when fertility is above 2 per woman, each generation is larger than the last. When fertility is below 2 per woman, each generation is smaller than the last. And the rules of exponential growth and decay govern the population size, so growth or shrinkage compounds across generations.

Table 1 provides another illustration of what would happen if fertility falls below two, as demographers predict, and if it stays below two, under various assumptions.[10] The columns offer five scenarios of hypothetical asymptotic fertility (corresponding to the dashed lines in Figure 1). The bottom row of Table 1 reports the year in which the world would again have as few as 10 million births per year under each scenario. 10 million is an arbitrary marker,[11] meant to help us

[9] This is the advantage of counting in the coarse units of ten-billion-birth stick figures. If you disagree with our particular open-ended decay, then your alternative equations to end the model and ours would have to differ by five billion births not to agree on the rounded count of figures.

[10] In 2011, Gietel-Basten, et al. (2014) solicited the opinions of expert population scientists about a plausible long-run asymptotic fertility rate. This exercise settled on 1.75, which is within the range of our Table 1. We conjecture that this subjective expectation would be even lower today, after 12 further years of subsequent fertility decline. Raftery and Ševčíková (2023) project statistical distribution with a median global total fertility rate of 1.72 for both 2250 and 2300, strikingly in line with Gietel-Basten's estimate.

[11] 10 million is an arbitrary round number which turns out to be about 7% of the number of births that will occur this year. If you think the number that matters instead is twice or half as many as our focal 10 million example, ok. All the logic here still applies, just a handful of decades sooner or later.

imagine a scenario in which economic and technological complexity might, we imagine, face meaningful constraints or risks—low enough, we propose, to be a risk to longtermist goals. The last time there were only 10 million births per year was around 800 BCE, about the same time as what may be the first account of a sundial (in the book of Isaiah)—before the first instructions to make glass appear in cuneiform tablets, before cast iron, and before stirrups.

An important lesson of Figure 1 and Table 1 is that change could come very quickly. The population would shrink rapidly, to less than 10 million births per year, in just a few centuries under any of these possible global total fertility rates. So fertility does not have to remain below two forever to be a threat to longtermist goals—merely for these next few centuries.

What is striking about both Figure 1 and Table 1 is that it makes little difference to the shape of the Spike or to the final number of stick figures in humanity's future whether one assumes that fertility will converge to what is now normal in the Americas or to what is now normal in Europe or East Asia. For some challenges, like strained social welfare systems due to inverted age pyramids, the difference between a TFR of 1.4 (Japan) and 1.7 (US) is massive. But for the question of how many humans may yet be born, anything much below 2 leads to a very similar end: Only 20 or 30 billion lives yet to be lived.

Table 1: The robustness of our conclusions to alternative future fertility rates

hypothetical asymptotic fertility:	1.8	1.66	1.5	1.2	1.0
(example 2023 country or region, according to UN)	South America	US	Europe	East Asia	South Korea
% of 2023 world population in countries at or below this fertility rate	43%	38%	25%	19%	1%
% of all human lives which would have been already born	77%	82%	85%	86%	86%
% of all human lives which would remain yet to be born	23%	18%	15%	14%	14%
number of future stick figures (future births ÷ 10 billion, rounded)	3	3	2	2	2
year birth count falls below 20 million	2495	2345	2275	2240	2235
year birth count falls below 10 million	2660	2445	2345	2280	2270

2. How can we be so sure?

You may be asking: How can we be so sure that global fertility rates will fall below two and stay there for centuries?

Our first answer is: We are not sure, of course! No one should pretend to be sure that without intervention, destructive AI will be invented or that an asteroid will cross earth's path or that the supervolcano below Wyoming will erupt, nor when. But longtermists take these risks seriously. We should take the uncertainties of low fertility seriously, too.

Our second answer is that, even though we cannot be sure, the evidence of social science is aligned with two demographic facts. One fact is that falling fertility is found in essentially every population and subpopulation, even places with different economic, social, and policy environments. "Falling" here does not mean *towards* two children per woman (the dividing line between exponential growth and decay); falling means right through two and below. The other fact is that, empirically, fertility rates that have fallen and stayed well below replacement levels so far have never rebounded to levels that would avoid depopulation.

Declining fertility is nothing new: Even as the population size has been growing (due to reductions in early-life mortality), fertility rates have long been declining in richer and better-educated countries. Fertility in France has been falling since the 1700s. Fertility in England and Wales has been falling since the 1800s. Fertility in Sweden, where records have long been high-quality, has never since matched its 1715 local peak, nor its 1822 local peak, nor its local 1901, 1946, nor 1991 peaks. Fertility rates can fall for centuries and then stay low. We know that because they have.

The Human Fertility Database organizes comparable fertility statistics from the national data of countries with high-quality records. The key number for our purposes is the average number of children that women have over the course of their life. If this lifetime average is computed for a "birth cohort" of women born in the same year, it is called "completed cohort fertility." Since the 1950 birth cohort, there have been 27 countries with trustworthy statistics where the lifetime average of children per woman has ever fallen below 1.9. (Estonia and Hungary both bounced around this range for women born in the 1940s before turning decisively down.) Whether or not worldwide completed cohort fertility stays below 2 is more or less the same question as whether or not the human population will shrink.

Never, in any one of these 27 countries, has the average ever yet risen above 2 again. Not in Canada (now 1.8), not in Japan (1.4), not in Scotland (1.7), not in Taiwan (1.5).[12] In some of these countries, governments believe they have policies to promote and support parenting. But none of these policies have ever, in fact, achieved a return to fertility levels that would stabilize the population. Zero-for-27, so far.

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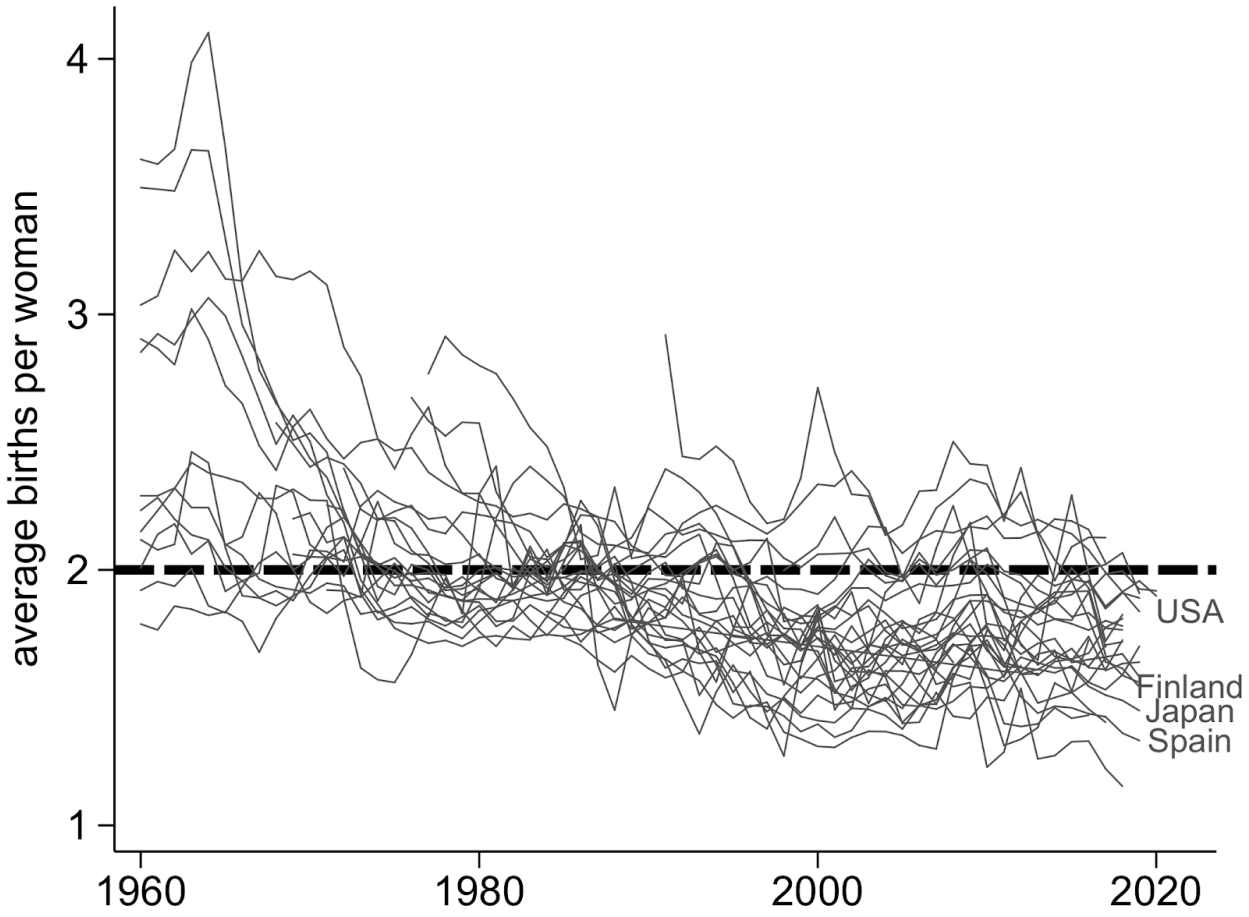
[12] Notice, incidentally, that completed cohort fertility numbers will tend to be higher than period total fertility rates (such as the 1.66 for the US that we described above) at this point in history because women are shifting their fertility to later ages, known as a "tempo effect" in the population science literate. It is completed cohort fertility that ultimately matters for population growth or decay, so the fact that even these (typically greater) summary statistics remain below two is particularly telling.

More examples and more detail will require going beyond the ideal statistic (that is, going beyond completed cohort fertility) because not all countries collect adequate records and because completed cohort fertility is only available for cohorts old enough to be out of their childbearing ages. We cannot know how many children the women who were born in 2000 will have, on average, until about 2045 or 2050.

But other measures of fertility exist and tell the same story. Figure 2 is drawn using the same Human Fertility Database core data. It shows tempo-adjusted period fertility rates, for countries where fertility has fallen below two. These are period rates, meaning descriptions of a point in time, rather than a cohort of women's observed fertility. Tempo adjustment incorporates the recognition that if births are being pushed to older ages, observing very few births among 20-year-olds today will underestimate total births over a lifetime. Tempo-adjusted period rates allow us to draw the graph farther into history (up to the present), but depend somewhat on the quality of the adjustment. They tell the same story that unadjusted period total fertility rates tell and that completed cohort fertility statistics tell: Unreversing decline is found everywhere, even in countries with dissimilar societies, economies and policies.

Most importantly, Figure 2 shows that two children per woman—the essential dividing line between population growth and decay—is no special stopping point as fertility rates decline. So far, every population that ever encountered the dashed line in Figure 2 just blew right through it. But of course they would. A population-level average of two is merely a theoretically interesting quantity in a demography textbook. A family can choose its own size–and may choose 2 (or 0 or 1 or 6), but It is in nobody's power to choose 2 for the population average.

Figure 2: Tempo-adjusted total fertility does not stop at two: It keep falling

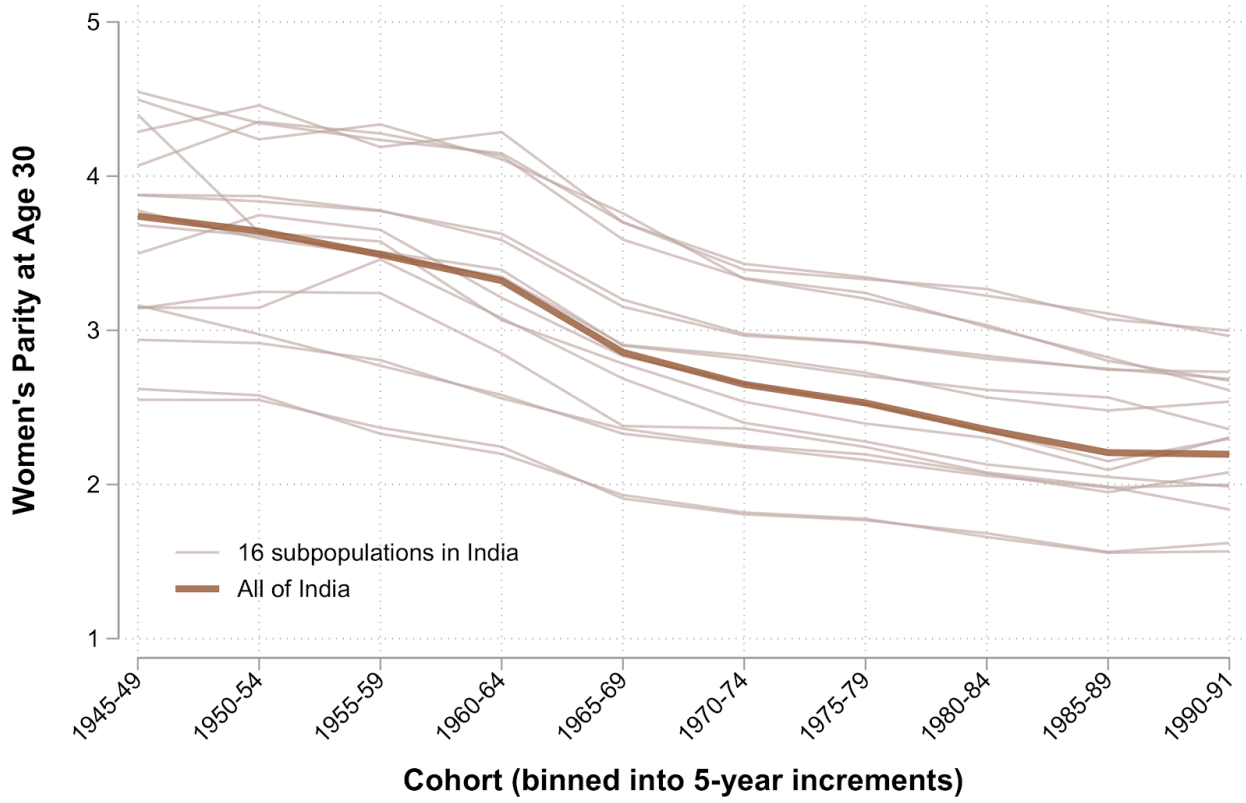


Source: Authors' drawing from the Human Fertility Database

Figure 3 makes a similar point by focusing on India, a country that was the focus of "overpopulation" rhetoric in the 20th century. The vertical axis plots parity at age 30, an analogue of completed cohort fertility that computes the average number of children a birth cohort of women has had by the time they are 30 years old.[13] Figure 3 updates a graph that we first published with coauthors in Arenberg, et al. (2022), now to include an additional, later round of survey data. The pattern is the same with the updated data as it was in our prior publication: All sixteen lines slope downwards. Each line is a demographically relevant group, split by education, geography, and religion. Fertility is falling; the gap between high and low fertility is narrowing; and several sub-populations are already below two children per woman.

Figure 3: Fertility is falling for high and low fertility sub-populations: One example is 16 sub-populations of India

[13] This allows us to go later into history than completed cohort fertility would, because it lets us include birth cohorts that are only 30 years old at the time of the most recent survey. However in India childbearing tends to happen at young maternal ages and babies born to mothers over 30 are uncommon, so little is lost by using this measure here.



Source: Authors' computations from the Demographic and Health Surveys for India, updating a figure in Arenberg (2022)

Other places match this pattern. Fertility in China has never since been as high as in the mid 1960s. In the early 1990s, China's period total fertility rate fell below 2 and has never since exceeded it, according to UN statistics. It stands now, 30 years later, at an average of one and a quarter children per woman. Fertility for Latin America and the Caribbean, combined, has been falling for at least five decades, also in UN summary data, and is now below two. Sub-Saharan Africa is the only major region where average fertility still exceeds two, but there, too, it has been falling for decades; improving education and declining mortality promise continued fertility decline there, too (Kebede, et al. 2019).

So the social scientific facts are consistent with continued fertility decline. We may not be able to be confident about all of the quantitative details of depopulation, but we saw in Section 1 that those matter little on a longtermist timeline.

And we can probably be more confident about demographic projections over the coming decades than you might think. In 1990, the UN projected that there would be 8.5 billion people in 2025. Now, 35 years later, it appears this will be off by only 3.6%. The 1968 projection for 2000 was only wrong by 4.6%. (We wonder what other projections, predictions, or forecasts on other issues of concern to longtermists, could hope for such accuracy. Not many, we wager.)

So why do different teams of demographers agree with each other, and how were those projections so accurate over a decades-long projection window? Population change turns out to be a simple dynamic system, in its biggest picture. Today's babies will grow up to be tomorrow's parents, but not for a few decades, so the progression of babies to adults is baked into population projections; the certainty that this fact creates is called "population momentum." This makes the nearer term time path of population growth and decline amenable to precise forecasting.[14]

At this point, you might be thinking of one or more objections. Perhaps you are thinking: Couldn't we just solve any problem with migration from high-fertility countries? Nope, not if those countries happen to be on Earth.[15] Or maybe you are thinking: won't governments just sort this out if and when it becomes a problem? We'll explain in Section 4 that no government ever has, nor does any government currently have any plausible plan for doing so.

Another common response is: Won't fertility rates equilibrate to two, so that population size stabilizes? We reply: But why would that happen? There is no magical force to balance the number of births to the number of deaths. Right now, births exceed deaths. Soon, deaths will exceed births. No known equilibrating force will cause fertility rates to rise. Total fertility rates of 2 are the dividing line between exponential growth and exponential decay. But none of the complex set of personal motivations and economic and cultural forces that drive individual decision-making generate a tendency to hold at 2. Ask the demographic experts of Japan, where TFR has been below replacement for 50 years, whether they've encountered evidence of this mysterious equilibrating force. So no, and Figure 2 has already shown that it hasn't happened in the countries that have so far experienced low fertility.

Another version of this is: Won't this just fix itself someday? This question has all of the hand-wavy dismissiveness of *Won't fertility equilibrate to two?*, but doesn't mask its lack of a theoretical or empirical basis behind fancy words like equilibrating. We hope that this problem is fixed some day. But if it is, it may be in the same way that the climate problem may be fixed: After decades of research and advocacy, after many careers devoted to overcoming challenges, and after many political fights debating whether anything is a problem or priority at all, we might manage to avert the worst version of the disaster. But not without attention and investment.

But what, you might ask, about heritability (intergenerational transmission of high-fertility cultural practices)? Won't the Amish or some other high-fertility, perhaps religious, sub-population

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[14] The key equation in determining the size of the population is the number of deaths each year and the number of births. As mortality rates continue to decline, they are bounded below by zero, so declining average mortality implies declining variance in the projection of mortality. The only major quantitative uncertainty that remains is the pace of the decline in fertility rates. Different population scientists disagree about this, but these disagreements do not make a huge difference at the scale of the Spike over the next century. And even if fertility rates (the flow of people) are a little different than somebody thinks, the population stock will not be very different than expected, on a scale of decades.

[15] We, the authors of this chapter, are all for freer migration. Migration might help some countries mitigate their near-term fiscal challenges. But this chapter is about *global* depopulation, so migration will not help.

expand to be as many as we need? For several reasons, no.[16] We have addressed this question at more length in Arenberg (2022).[17] In the very long run (i.e., potentially after the coming few centuries of decline), two facts would have to be true for heritability to be a solution: First, fertility in a high-fertility sub-group would have to be high enough (certainly above two, for example). We've already seen above that the "high fertility" of high fertility subgroups has been declining over the decades. High fertility used to mean 6 children per woman. Now it means 2.5. Before long, it may mean 1.8. Second, the children of high-fertility parents would have to be very likely to remain in their high-fertility cultural group. Where researchers have studied the empirical magnitude of these intergenerational correlations as they have played out in actual practice, they have found them to be positive, but small–too small, in fact, for the high fertility group to make much of a dent in overall population.[18] It turns out your kids might choose not to inherit your cultural practices and beliefs. (If you have had a teenage child, you will not be surprised about what social scientists have documented in their studies.)[19]

Yes, it is theoretically possible that–against all historical precedence and against contemporary evidence and high quality forecasts–a sticky high-fertility emerges to stabilize the population. It is also theoretically possible (and simpler!) that, under an unprecedented social change, a new high-fertility norm could sweep the globe. Our claim is that it would be imprudent for longtermists to neglect this risk. In light of global socioeconomic change and ubiquitous declining fertility, treating self-correcting fertility rates as more than a conceptual possibility does little more than assume a solution. More than that, it assumes a solution in direct opposition to the historical patterns of evidence and other well-documented social scientific facts.

3. Consequences

Why should a longtermist should be concerned about the scenarios like those consistent with what demographers expect to happen in the next 100 years? Our own study of long-term population projections is ultimately motivated by a population ethics that values the lives and experiences of each person who might get to live a good life (rather than merely appreciating

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[16] Raftery and Ševčíková cite Warren (2015) on the timeline of heritable fertility: "For fertility, Warren (2015) has argued that a small subpopulation might become dominant over time if its members had consistently very high fertility, eventually leading to much higher than replacement fertility for the world population as a whole. His simulations showed, however, that it would require in the region of seven centuries for something like this to have a major global demographic impact, and its effect would likely still be modest in 2300, even if it started to happen immediately."

[17] Arenberg (2022) responds to arguments that applied population formulas from the mathematical biology literature to human demography. A fundamental reason why human fertility is different from, and less subject to tidy mathematics than, non-human animal population dynamics is that human fertility reflects intentional choices, technological change, culture, economic incentives, and other social influences. That is why we have this chapter to write, after all.

[18] Vogl (2020) summarizes: "In populations with [total fertility rates] less than 3, differential fertility raises [the total fertility rate] by 4% on average." This would not be enough to escape depopulation.

[19] Why, one might ask, would such a group remain cohesive and remain high-fertility, generation after generation, even as everyone else behaves differently? How would the social forces that keep a small social band in lockstep continue to discipline individual behavior when the group grows to no longer be a small band, but instead a group of hundreds of millions? And where, outside of their traditional geographies, would the growing group's members all live without changing their ways?

them instrumentally on the path to a longer-term future). But we set that population ethics perspective of ours aside for this chapter.

We also set aside what we believe might be an important instrumental reason to be concerned about nearer term depopulation (but one that doesn't connect to the economic and demographic facts at the core of this essay): If we cannot create a culture that values and invests in the lives of potential people who may live over the next hundred years or so, when our children and grandchildren will live and share the planet with them, what could give anyone with longtermist priorities confidence that longtermism as a movement will muster the political will to invest in the lives of potential people thousands of years from now? We conjecture that it would be difficult to expand humanity's a moral circle to include the trillions of lives in the far future if longtermists are unwilling to fight for the billions in the nearer future. That's a squishy conjecture, and we can offer no proof. So instead we will focus on the instrumental economic facts, for which the evidence is clear.

Why might a small population in 2300, 2400, or 2500 threaten valuable and widespread flourishing in millennia thereafter? Our simple thesis, informed by population forecasts and economic theory and evidence, is this: Achieving the long and bright future that longtermists hope for might require a large number of people over the next few hundred years working to deliver it.

We mean the "might" sincerely. Some optimistic longtermist might hope that artificial robotic wombs and synthetic nannies could someday substitute for the work that humans do to create life and raise children, or might believe that intelligences not housed in human bodies will do the living and feeling that matters in the distant future. Fine. But should anyone be confident that it will happen in the next 300 years, before the world's number of scientists and engineers has spiraled downwards? Or confident that progress towards these outcomes would not be slowed or halted entirely by a much smaller population in the near term? The timing matters. We may be racing towards a technologically enabled superabundance. But depopulation could win the race. We, Mike and Dean, are not confident of anything except that exponential decline is the unavoidable mathematical consequence of fertility below 2.

If it does matter how many people live in the nearer term—whether because of population ethics, or economic growth, or environmental sustainability,[20] or extinction risk—then this would

[20] Calls to reduce the size of the human population are commonly heard, especially in popular media, as a suggested tool for decarbonization. Would depopulation be an effective tool of climate mitigation, that is, of reducing carbon emissions? No. Climate scientists have determined that humanity should seek to decarbonize in the next few decades. For example, the Biden White House has announced a strategy for the US to reach net-zero carbon emissions by 2050, which is 27 years from now. This is simply too soon for changing fertility rates to make a difference. This is because of the process described above that demographers call "population momentum": Even if fertility rates changed significantly, the size of the population would maintain its trajectory for decades as today's stock of children and babies grow up into the coming decades' potential parents. A baby born yesterday will not have any children for decades (perhaps for 27 years or more), whatever fertility rates might be at that point. So fertility change is simply too slow to be a credible response to the urgency of decarbonization. Because of population momentum, low fertility is not a constructive response to climate change. This argument was first made, to our

be what economists call an “externality,” meaning that no one individual, no one country, and no one generation has the incentives to make the choices that would be best, all things considered.

Externalities are economists’ classic cases where markets fail. Nobody—no country and no family—has an incentive (nevermind ability) to individually solve this collective problem. So leaving an externality to run its course would make things worse, not better. Carbon emissions are a classic externality, so the solution is policy, public action, subsidized technological change, and coordination. If depopulation is indeed an externality that requires a public policy response, then there would be advantages to understanding the situation sooner than later. As Wolfgang Lutz and other demographers (2006) have argued, once cultures, economies, and everyone’s preferences organize around low fertility being normal, it may be hard to get out of a “low fertility trap.”

There would be economic consequences of depopulation, which the economics of scale effects warns are likely to be negative for average global living standards. Various mechanisms from macroeconomics suggest that a larger population would also be likely to have higher living standards, on average. These economic mechanisms mean there is not an aggregate quantity-quality tradeoff: Despite all of the theoretical attention to the “repugnant conclusion” of population ethics which trades-off numbers of lives against quality of life, macroeconomists teach us that we should expect a larger population to be better-off both on average and in total.

This is not a fringe view in academic economics: Peters (2022) begins an abstract in a top journal with the summary that “virtually all theories of economic growth predict a positive relationship between population size and productivity.” (Productivity here means on average, not in aggregate total.) If the totalist approach to population ethics (which says that more good lives is better) is correct, then the macroeconomics of scale effects tells us that we might reap those benefits for free.

A less productive economy with lower living standards may be less able to reach a flourishing future, or even to protect itself against certain types of risks. We review three economic mechanisms of scale effects from the literature: specialization, innovation, and fixed costs.

Specialization and trade. Romer (1987) summarizes: “The idea that specialization could lead to increasing returns is as old as economics as a discipline.” Specialization and trade is a core tool of modern economies. None of us reading this volume produces our own food, caretaking, medicine, electricity, clothes, transportation, software, or scholarly argumentation without any input from others. Specialization allows tasks to be done by individuals who are good at them. Over time, specialization allows people to become experts who are good at something, which economists call human capital. Specialization also prevents wastage and inefficiency in task-switching.

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knowledge, by Bradshaw and Brook (2014) and further developed by Budolfson and Spears (2021). For the detailed population and climate modeling supporting this argument quantitatively, see our paper with coauthors Kevin Kuruc, Sangita Vyas, and Mark Budolfson (Kuruc et al. 2022).

A modern economy and its products are simply too extensive for one person to have the expertise, tools, and resources to produce everything. As Paul Romer wrote, economists have recognized the importance of specialization in creating “the wealth of nations” at least since Adam Smith published this observation under this title in 1776. You might be feeling confident that even a much smaller economy could continue to produce toasters. But would it produce lifesaving new drugs, like the novel mRNA vaccine technology delivered just in time for combatting COVID? No one can know. But we can know with high certainty that a world with orders of magnitude fewer people will have fewer molecular biologists. We can know that a smaller economy would be less complex, all else equal, and could not store its human capital across so many human brains, all else equal, which would limit our experts’ ability to specialize.

Whatever technological breakthroughs you hope for that might usher in a new era of human flourishing, the economics of specialization tells us to not be confident that our shrinking world will produce it before we become too small to produce complex things.

Innovation and non-rival ideas. A second economic mechanism for scale effects is innovation. This mechanism is studied in the macroeconomics of endogenous economic growth, initially formalized by Romer (1986), developed further by Jones (2022), and a cornerstone of theories of humanity's escape from poverty (Kremer, 1993; Galor and Weil, 2000). The fundamental idea is that ideas, technologies, concepts, and strategies are non-rival. Non-rival is a technical term in economics which means that one person using a resource does not deplete the amount available for somebody else. Jones gives the example of the Pythagorean theorem: However often a builder consults the 3-4-5 triangle to build a right angle, the information remains fully intact, undepleted for somebody else to use.

The fact that ideas are non-rival generates scale effects because every person could potentially generate ideas that could then be used by everybody thereafter. On this view, it is no coincidence that humanity’s huge expansion in technology coincided with its huge expansion in population. And if humanity depopulates, Jones has recently worked out in mathematical detail, technological progress and economic growth could end.[21]

Fixed costs, variety, and extinction risk. The final economic mechanism that might cause a small future to close off a bright future is fixed costs, which are featured in trade and geographic economics (Krugman, 1991). The costs of economic activities are divided in microeconomic theory into two costs: variable costs, which scale with the quantity produced, and fixed costs, which do not. Product differentiation and fixed costs are important reasons why real economies are not the perfectly competitive economies of introductory textbooks. In particular, fixed costs can be a barrier to market entry for a new firm, if there will not be enough customers to cover the fixed costs of the new business.

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[21] Indeed, depopulation could be even worse than in Jones’ model because Jones does not incorporate depreciation of technology (Eden and Kuruc, 2022). This means that Jones does not include a cost of keeping ideas and knowledge in existence and available in useable form. Maybe such knowledge-depreciation would happen slowly enough that rapid improvements in information technology would more than make up for the losses due to depopulation. Or, maybe not.

Fixed costs do not merely apply to businesses. Consider greenhouse gasses. Imagine the year after humanity reaches the point of net-zero annual emissions. Going forward from that point, there will be a fixed amount of greenhouse gasses in the atmosphere, accumulated since the start of the industrial era. Intentional "negative emissions" technology, such as planting forests or sequestering carbon underground, could reduce that fixed stock of greenhouse gasses at an economic cost, if somebody chooses to pay it. A larger total economy, which could be achieved by having a more populous total economy, would have more resources that it could choose to devote to the fixed cost of negative emissions. Of course, it is a further economic and political question whether future decision-makers will choose to do this.

Some existential threats take such a fixed cost form.[22] They are exogenous to human population size and would arrive at a historical time that is independent of human activity, such as, perhaps, a large asteroid or supervolcano. Consider the following simple model of such a situation:

> An exogenous threat has arisen which will kill all humans (however many) unless a large cost is paid to deflect it (such as by deflecting the asteroid) within a certain time period.

This large cost is fixed, in the microeconomic sense, because it must be paid to deflect the asteroid, whether "killing all of us" means killing 10 billion or killing 10 million. The cost of avoiding the disaster does not scale with population size. And here is where population scale effects come in. Which do you think would be more likely to successfully pay the fixed cost in time: the larger population and economy or the smaller one? Probably the larger one: After all, if both societies were equally rich per capita (and they wouldn't be; we're handicapping the larger population here, relative to what the macroeconomic-growth literature teaches us), then the larger society could out-produce the smaller society in rockets or anything else needed to avoid disaster. In the larger economy (10 billion of us), a 0.1% tax levied to fund the response effort would outstrip a 50.0% tax levied in the smaller economy (10 million of us). At least some existential risks would be more likely to be survived by a larger population.

There are several reasons to stop neglecting depopulation risk now, rather than waiting a few decades. First, as we discuss in the next section, humanity presently has no policy or technology that could reverse the decline if that turned out to be desirable. It's time to make progress on understanding possible responses so there is an option of action. Depopulation could be very fast (counting in centuries), and there might not be much time to course-correct, if it turns out to be a bigger problem than you think. Second, it might be hard to ever convince most people of the positive externalities of scale–that the optimal number of people to have around is more than whatever they are used to believing. So decline might be a one-way ratchet. Perhaps the best humanity can ever do is stabilize. If so, stabilizing soon, at a higher level, means many more stick figures in humanity's future.

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[22] Other threats may be less likely or more likely to arise if more people are alive at a time; we ignore those threats here.

4. Responses

To know how and whether to respond to depopulation, we need to know two things: first, why so many people in such different societies are choosing low fertility, and second, what policy options might be available, given the reality of human societies and their governments.

Start with the first: Why is sustained fertility decline seen everywhere? Our understanding of the available claims and evidence is that nobody really knows. There are a range of theories. These are roughly divisible into economic theories and cultural theories. Economic theories of fertility decline emphasize that, in richer societies, children change from being a source of economic support for their parents to being an expensive consumption good for their parents, especially in economies where there are large benefits of many years of expensive investments in education and human capital. Cultural theories point, instead, to a change in values, away from family or traditional roles as a motivating factor in life and towards adults' own fulfillment or enjoyment (Lesthaeghe, 2010). A more specific version of this is the "incomplete gender revolution" theory, according to which the driving force is the fact that women are increasingly both free to and, in some cases, economically required to pursue education and paid labor market work, but do not receive support from partners and other family members in the work of parenting (Esping-Andersen, 2009).

There is something to learn from each of these theories. But no theory is yet widely accepted and no theory fits all of the facts (Doepke, et al. 2022). For example, the economic theory of the quantity-quality tradeoff, where parents have fewer children in order to invest more in the education of each one, cannot immediately explain societies where many people choose to have *no* children. Similarly, differences across US states in the economic costs of children do not explain differences in the pace of fertility decline (Kearney, et al. 2022).

Most importantly, fertility decline is a convergent phenomenon, happening in many places. Theories of female paid labor force participation as a binding constraint cannot explain India, especially south India, where fertility rates are below replacement even though only a minority of women work in the paid labor force (Gietel-Basten, et al., 2022).

Accounts that focus on social policy have a hard time fitting the facts of international comparisons. Welfare states are larger in Europe than in the United States, but fertility is lower in Europe, on average. Rightly or wrongly, US progressives hold up Sweden as a model of what pro-parent policy-making could be. But the average woman in Sweden in 2018 had children at a pace of 1.76 over a lifetime, compared to 1.73 in the US. In 2019, both countries fell to 1.70, by chance matching Denmark. Norway and Finland, in case you don't trust these examples, dropped in 2019 to 1.53 and 1.35, respectively. These four European countries each spend twice the fraction of GDP that the US spends on family benefits. The sort of $3,600 child tax credit that was briefly implemented, debated, and then eliminated in US politics over the past few years is small relative to benefits in these countries, is small relative to the costs of parenting and extra child, and is unlikely to make much of a difference in aggregate outcomes.

Figure 4: Living standards have expanded as fertility has declined

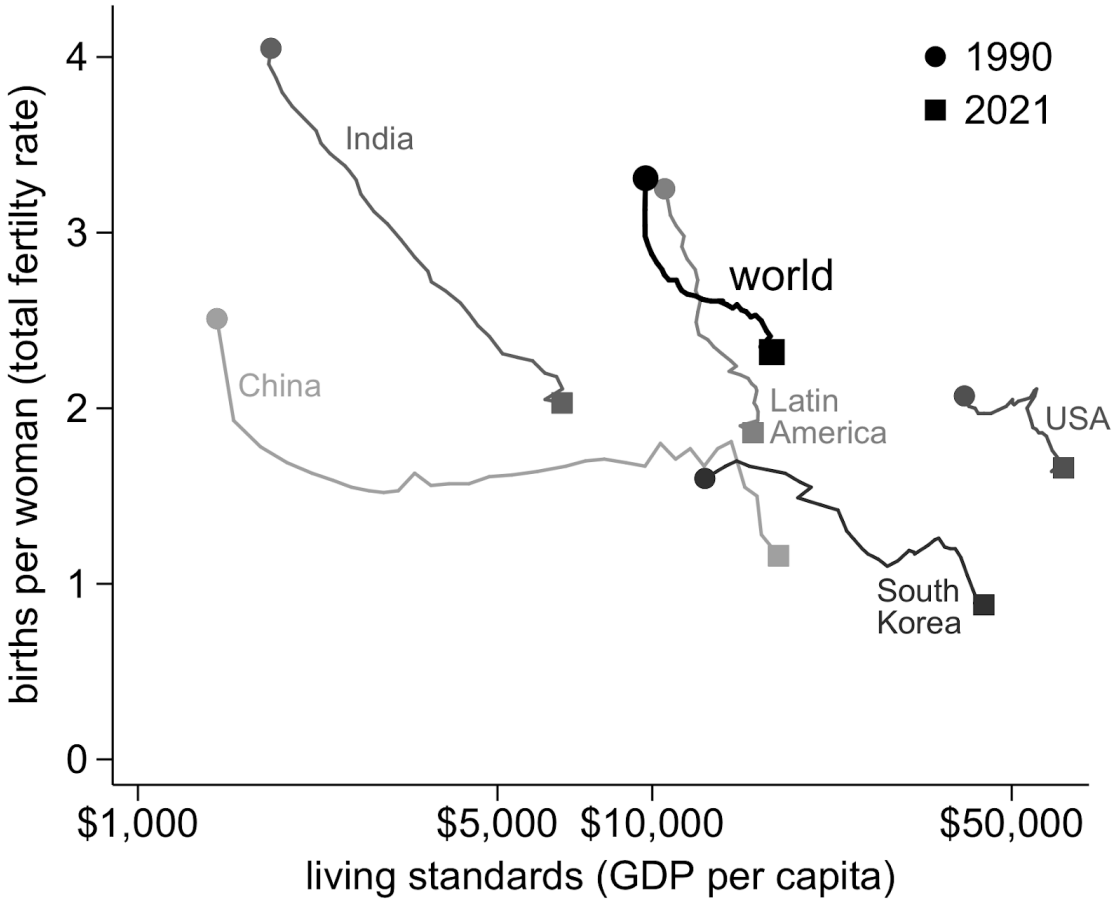

Figure 4 summarizes what we see as one of the most important facts: Because declining fertility has accompanied rapid global economic growth, average living standards have expanded radically over the same decades that average fertility rates have been falling.

One conclusion that Figure 4 teaches is to be skeptical of overly simple economic theories that children are less affordable than they used to be: Although our point is not that anyone should, families could choose a 1990 consumption bundle and a 1990 fertility level and still have more money left over and better things (better devices, better houses, better health care, safer cars…) than 1990 people did.

The second question to ask about responding to low fertility is what policies and programs might be feasible and might be good ideas. Here, too, we have much to learn. There are no tried-and-tested, ready responses: Consider the many European and East Asian countries with much-publicized pro-natalist policies. Consider also that these countries have retained enduring low fertility rates (Gietel-Basten, 2019).

The lessons humanity has from its experience with fertility policy are both strong and negative. Governments in some times and places have tried to compel people to have children they don't

want to have; governments in some times and places have tried to compel people not to have children they want to have. These policies have done terrible harm to people's lives without changing aggregate fertility rates. If you would like to learn more, read Betsy Hartmann's (1987) Reproductive Rights and Wrongs: The Global Politics of Population Control or Matthew Connelly's (2010) Fatal Misconception.

It is not within the scope of this essay to adequately review the social science and history of population policy. But because we are often confronted with people who seem to believe that governments can choose fertility rates as easily as the Federal Reserve Bank chooses interest rates, we'll merely note that the widely-cited one child policy from China is widely misunderstood. In particular, birth rates fell dramatically over the decade prior to the policy (there was a different fertility policy at that time, too). The total fertility rate in China was nearing two and a half when the one child policy was adopted in 1980.

Yes, China's population policy was a harmful repression of the freedom of individuals to choose their lives. And, in the other direction, anti-abortion policy elsewhere has been and is harmful and repressive, too. But, as Susan Greenhalgh (2018) and others have documented, China was also experiencing large socioeconomic changes of the sort that are known to have contributed to fertility decline elsewhere. Such changes combined with coercion to shape fertility outcomes in China, and we should not believe the official Chinese Communist Party claims that the policy prevented 400 million births.

Up to now and in any foreseen future, all children are birthed by pregnant females.[23] This fact alone makes reproduction unequal, without even considering the gender inequality that our societies and economies layer on top of what biology has endowed us with. No understanding of or response to low fertility can ignore gender inequality. If society does not share the burden of producing the next generations, lifting the burden on mothers and other caretakers, then we should not be surprised if they do not take it up. If a flourishing next generation is a public good, an economist might say, too many men have been free riding on women's contributions. Perhaps if more of the powerful men of the past spent many nights exhausted, soothing an upset baby who couldn't quite figure out how to eat or sleep, we would already be making more progress on constructing a society that can offer a combination of parenting with prosperity, freedom, and wellbeing for parents and children.

So what then should we do? The next step is to learn more about low fertility and depopulation: the causes, the consequences, and the possible responses. This requires investment in basic science.

[23] There is a tension between, on the one hand, recognizing the gender inequality that puts so much of the burden of care work and parenting on women and, on the other hand, celebrating the growing freedom in gender identities, which recognizes that not all pregnant people identify as women. We refer the reader to Foster's (2020) discussion of this tension in *The Turnaway Study* and follow her use of "women."

Depopulation is projected to begin in about sixty years. About sixty years ago, in President Lyndon Johnson's administration in the US, the White House recognized that carbon dioxide, from burning fossil fuels, is an important pollutant that would change the climate by changing the atmosphere. We, now, do not know what to do about depopulation, just as the best climate scientists of Johnson's time could not have directed today's energy policies. But they knew some big facts—in particular, that emitting carbon dioxide would eventually warm the earth. And we know some big facts—in particular, that sustained below-replacement fertility would depopulate the earth at an exponential pace. Climate policy is achieving more, today, than it otherwise would be if the research and debates of the past sixty years had not gotten started, even without having all the answers. Following their example, longtermists and others should turn more of their attention and research to depopulation. We will never achieve shovel-ready projects to address this challenge if we do not begin the work of basic scientific research to understand this problem and potential responses.

5. Conclusion

Because this brief chapter is intended to invite longtermists and population scientists into dialogue, it did not have enough to say about some important issues. It did not have enough to say about gender inequality. Nor about population ethics. Billions of good lives that might have been lived over the next few centuries will not be if we do not begin work to address depopulation. Some who do not follow the strongest versions of longtermism should find this an important reason to make better understanding of depopulation a research priority—just like, for example, animal welfare and global health.

There may be many future people. Or there may be strikingly few. We hope that the world begins investing serious attention to depopulation so that someone can someday know what to do about it. We are skeptical that anyone yet knows. And there are risks of reckless action. When we shared the ideas behind this chapter with a public health colleague, she warned us: "But you know what is going to happen," meaning that the political proponents of social inequality and coercion will use the threat of depopulation as motivation for another round of repressive politics (using arguments like ours as cover). This concern comes from a place of wisdom and deserves our attention and respect.

We do not know what is going to happen. One possibility is an unprecedented reversal in fertility trends, perhaps bolstered by unprecedented policy investments in children, gender equality, care work, and the freedom to parent or not to parent. Another possibility is that sustained low fertility is one more thing to fight over, that our colleague is correct, and that humanity depopulates with cruelty.

A third possibility is that we end with a whimper.[24] It is easy to imagine that, instead of supporting one another, future people comfort themselves with art and culture and stories to tell one another that depopulation is good.

You might hope that fertility rates in the future will increase without attention or directed resources. You might wonder if humanity will move on, one way or another, from parenting in nuclear families and women carrying fetuses. You might hope that humanity might pass the baton of wellbeing to artificial intelligences that will experience wellbeing and be just the population that an excellent future needs. In any of these cases, human depopulation over the coming centuries might be no big deal. But are you sure? It is time to invest in a better understanding of the risks of depopulation.

Perhaps we risk political naïveté to hope that human politics can construct a response to depopulation that expands people's freedom and options, respects their autonomy, and supports more of those who want to have more children to choose to have more children (and raise them safely and healthily) while also supporting those who want not to choosing not to—all while balancing the many other worthy demands on our politics and policy. Can we really hope to find our way to doing radically more to support humanity's caregivers, so caregivers are better-off and so people choose to be caregivers? It would not do the causes supported by longtermists or (any other good cause) any favors to ignore the political risks and history. But in the face of the Spike, we do hope.

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[24] Here is a speculative question: Could low fertility be a general response to the Fermi paradox? It seems plausible that replacing evolutionary motivation with chosen, intentional fertility would be a common step for other technologically advancing civilizations. A lesson of the Spike is that a quantitatively small overcorrection (against evolved high fertility) could have large consequences quickly.

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