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ABSTRACT

Fertility in High-Income Countries: Trends, Patterns, Determinants, and Consequences

High-income countries have generally experienced falling fertility in recent decades. In most of these countries, the total fertility rate is now below the level that implies a stable population in the long run. This has led to concerns among economists, policymakers, and the wider public about the economic consequences of low fertility and population decline. In this contribution, we aim to i) describe the main determinants of low fertility in high-income countries, ii) assess its potential economic consequences, iii) discuss adjustment mechanisms for individuals and economies, iv) propose a simple economic framework to analyze the long-run economic impact of low fertility, and v) draw lessons for economic policymakers to react appropriately. While the economic challenges of low fertility are substantial, a thoughtful and consistent policy response can mitigate most of the adverse consequences.

JEL Classification: J11, J13, O11

Keywords: low fertility, below replacement fertility, depopulation, economic consequences of population decline, long-run economic growth, economic policies to address low fertility

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1 Introduction

In recent decades, fertility rates have decreased steadily in all high-income countries. Across the Organisation for Economic Co-operation and Development (OECD) countries, the total fertility rate (TFR), which is the number of children that a woman can expect to have given current age-specific fertility rates, has dropped from 3.29 children per woman in 1960 to 1.63 children per woman in 2019 (World Bank, 2023). Based on United Nations (2022) data, Table 1 depicts the development of the TFR for individual OECD countries during this time span. We observe that i) in all countries the TFR has fallen (column 4), and ii) with the exception of Israel, the TFR in 2019 is below the replacement rate of 2.1 children per woman. Absent migration, a fertility rate below the replacement level implies a shrinking population and a shrinking workforce in the long run.[1]

We use 2019 as a reference year for the TFR because behavioral responses to the COVID-19 pandemic may influence the TFR beyond 2020. This means that in column 3, a COVID-19 effect may alter the secular long-run falling trend. Overall, however, we observe that the change in the TFR between 2019 and 2021 is rather small and lacks a consistent sign (see also our discussion of the effects of COVID-19 on fertility in Section 2.6).

The causes of the long-run decline in fertility are manifold, and many different aspects have caught the attention of researchers (see Lesthaeghe, 2020; Doepke et al., 2023, for recent overviews). For example, growing wages and increasing labor force participation of women — who continue to spend more time on childcare on average than men — have increased the opportunity costs of raising children. This may have influenced the decision of households to have fewer children or no children at all. More directly, increases in tuition and in the rental prices of living spaces have reduced the ability of many families to bring up children in conditions that guarantee them a "good childhood." Because a tension exists between having many children (quantity) and spending more resources per child (quality), quantity-quality trade-offs may have strongly shifted toward quality in recent decades. Changing social norms toward smaller families, marriage ages, and dating habits may all have contributed to the decline in fertility. Apart from these socioeconomic considerations, medical reasons have also been discussed. For example, reductions in biological fecundity and, in particular, in male sperm count that have been observed over recent years is another plausible reason for low fertility, albeit the extent of the effect remains unresolved to date.

Low fertility has many economic implications. Lower fertility has already led to a slowdown of workforce growth and even implies a decline in the absolute size of the workforce in many high-income countries. Some are afraid that this will cause labor shortages and pose serious challenges for companies in finding qualified staff. Moreover, falling fertility as such is the main driver of population aging, with a stronger influence than increasing life expectancy and changing migration patterns (see, e.g., Weil, 1997; Bloom and Luca, 2016; Prettner and Bloom, 2020). The phenomenon of population aging has already instigated concerns about our future economic prospects. For example, the World Economic Forum (2004) stated that "we face the prospect that the historical rates of improvement in standards of living might slow or even decline"; *The Economist* has devoted several special reports to the topic, claiming that the economic costs of population aging will be much greater than those of the Global Financial Crisis in 2007-2009 (cf. The Economist, 2009, 2011a,b); and some have even gone as far as calling global aging a "threat more grave and certain than those posed by chemical weapons,

[1]The fact that the long-run replacement rate is slightly more than 2 is due to i) child and youth mortality such that not all children will progress through the childbearing years and ii) a slightly higher number of boys being born than girls.

Country	TFR in 1960 (1)	TFR in 2019 (2)	TFR in 2021 (affected by COVID-19) (3)	Secular decline (1960-2019) (4)
Australia	3.45	1.67	1.60	-1.78
Austria	2.70	1.46	1.47	-1.24
Belgium	2.54	1.59	1.58	-0.95
Canada	3.90	1.45	1.46	-2.45
Chile	4.70	1.55	1.54	-3.15
Colombia	6.74	1.76	1.72	-4.98
Costa Rica	6.71	1.63	1.53	-5.08
Czech Republic	2.10	1.71	1.70	-0.39
Denmark	2.54	1.70	1.72	-0.84
Estonia	1.98	1.67	1.68	-0.31
Finland	2.72	1.36	1.39	-1.36
France	2.73	1.83	1.79	-0.90
Germany	2.38	1.54	1.53	-0.84
Greece	2.31	1.32	1.37	-0.99
Hungary	2.02	1.55	1.58	-0.47
Iceland	4.26	1.75	1.73	-2.51
Ireland	3.78	1.78	1.77	-2.00
Israel	4.05	3.22	2.98	-0.83
Italy	2.38	1.26	1.28	-1.12
Japan	2.01	1.29	1.30	-0.72
Latvia	1.95	1.61	1.58	-0.34
Lithuania	2.63	1.61	1.62	-1.02
Luxembourg	2.29	1.35	1.39	-0.94
Mexico	6.76	1.92	1.82	-4.84
Netherlands	3.12	1.58	1.64	-1.54
New Zealand	4.24	1.85	1.77	-2.39
Norway	2.87	1.54	1.50	-1.33
Poland	3.03	1.45	1.46	-1.58
Portugal	3.16	1.42	1.36	-1.74
Republic of Korea	5.95	0.91	0.88	-5.04
Slovak Republic	3.04	1.56	1.57	-1.48
Slovenia	2.19	1.61	1.63	-0.58
Spain	2.78	1.23	1.28	-1.55
Sweden	2.18	1.72	1.67	-0.46
Switzerland	2.44	1.49	1.49	-0.95
Turkey	6.38	1.97	1.89	-4.41
United Kingdom	2.72	1.63	1.56	-1.09
United States	3.55	1.69	1.66	-1.86

Table 1: Total Fertility Rates (TFRs) of OECD Countries in 1960, 2019, and 2021

Notes: We use United Nations (2022) data. We calculate the change in the TFR between 1960 and 2019 because COVID-19 may have influenced the TFR beyond 2020.

nuclear proliferation, or ethnic strife" (Peterson, 1999).

In more measured terms, economists have voiced concerns that are, for example, summarized by Bloom et al. (2010) and various articles in *The Routledge Handbook of the Economics of Ageing* (cf. Hurd and Rohwedder, 2023; Kuhn, 2023; Sánchez-Romero and Prskawetz, 2023). These relate to the sustainability of social security systems and retirement schemes in the face of low fertility (Gruber and Wise, 1998; Bloom et al., 2007; Breyer et al., 2010), potentially lower productivity and lower labor supply of an aging workforce (Skirbekk, 2008; Mahlberg et al., 2013; Cooley and Henriksen, 2018), and a potential decline in innovation when an older population demands fewer innovative products or is less capable of innovation (Canton et al., 2002; Borghans and ter Weel, 2002; Aksoy et al., 2019). Most recently, Jones (2022) has modeled declining innovation and reduced economic growth as consequences of low fertility. Jones claims that negative population growth can become entrenched and lead to a stagnation of living standards, and, eventually, to a vanishing economy in terms of an "empty planet."

However, counteracting forces also exist that would help to deal with the potentially negative economic consequences of low fertility and population decline. For example, when fertility falls, the ratio of dependents starts to shrink initially because of fewer children, opening a time window to reap the benefits of a "demographic dividend"; labor force participation (particularly of women) tends to rise, which leads to an immediate increase of the labor force; and families tend to invest more in the education of each child because more resources are available if they need to care for fewer children. This, in turn, implies higher productivity among these children when they enter the labor market. For a recent contribution that is on a more cheerful side regarding the effects of low fertility see Skirbekk (2022).

In this survey, we describe the main determinants of low fertility in high-income countries in Section 2, assess the potential economic effects of low fertility in Section 3, discuss adjustment mechanisms for individuals and economies in Section 4, propose a simple economic framework in Section 5 that allows for incorporating some of the channels discussed and that helps to explain why the relationship between fertility and economic growth in the data tends to be negative rather than positive on balance, and draw some lessons for economic policymakers in Section 6. Finally, in Section 7, we conclude.

2 Determinants of fertility decline

In the following, we describe the main causes of fertility decline in rich countries.

2.1 Rising income

Malthus (1798) was perhaps the first to point out a positive income effect on fertility. In his view, rising income was the driver of population expansion up to the point at which a limited supply of land and food would lead to stagnation or crisis and a subsequent decline in fertility. During industrialization and throughout the first part of the 20th century, the Malthusian view was no longer borne out by the data, which instead presented a negative relationship between TFR and GDP, as is well documented in Doepke et al. (2023). Seeking an explanation, Willis (1973) and Moffitt (1984) were among the first to show that an increase of (particularly women's) earnings tends to reduce fertility (see Hotz et al., 1997, for a survey of this literature). The reason is that increasing wages imply higher opportunity costs of the time spent on childcare because this time is no longer available for formal labor supply and earning a wage income. Considering more recent data from the second part of the 20th century, Doepke et al. (2023) argue that the relation between per capita GDP and fertility has become more complex over time. In some countries and for high income levels, the correlation has reversed its sign again so that fertility once more starts to rise with income.[2]

[2]A related theory of changing fertility over time posits that it is a cyclical phenomenon and depends on generational crowding. If a large cohort exists due to high birth rates, standard labor market considerations would imply that the members of this cohort tend to have lower wages than the members of previous cohorts that were relatively smaller. Thus, they could have difficulties finding partners, which leads to later marriages, higher crime, and difficulties financing the expenditures related to having children (Easterlin, 1966; Bloom et al., 1988; Pampel and Peters, 1995). The pattern

These developments can only be understood (i) by disentangling income effects from other drivers of fertility that are correlated with GDP growth; and (ii) by isolating the direct income effect on fertility from indirect and concomitant effects in the microeconomic data. Regarding (i), Doepke et al. (2023) argue that the negative correlation between per capita GDP and fertility has been broken mainly through four channels: family policies such as the availability of parental leave and, particularly, the availability of public childcare (Bauernschuster et al., 2016); a stronger involvement of fathers in childcare (Doepke and Kindermann, 2019); more favorable social norms that make it more acceptable for women with children to work and, thus, not to forego wage income (Kleven et al., 2019); and more flexible labor markets where switching between part-time and full-time employment is easier (Del Boca and Sauer, 2009). Regarding (ii), ample evidence supports a positive direct effect of income, as, e.g., picked up by male earnings in a setting in which childcare is mostly performed by women (Ermisch, 1989; Heckman and Walker, 1990). By contrast, an increase in female earnings compounds the income effect with a "substitution" effect in the sense that female earnings raise the opportunity cost of having children, and the latter effect may, indeed, dominate.[3]

2.2 The quantity-quality trade-off

One key consideration in the context of fertility choices is how the cost of raising children trades off against parental aspirations in respect to their children's well-being. Here, children's education plays a major role.[4] As long as education is less important for individual economic prosperity (for example, in agriculturally dominated economies), children are much less expensive than in a service- or high-tech environment in which many parents strive to provide a university degree for their children as a means for them to secure a reliably high income. Over the last two centuries, investing in the education of children became increasingly important because of the structural transition from agriculture to manufacturing (see, e.g., Galor et al., 2009), followed by the transition to the service economy in which many jobs are skill intensive. When parents spend more on the education of their children, one way of affording these expenditures is to reduce the number of children. This idea, which came to be known as the quantity-quality trade-off, was first expressed by Becker (1960) and further elaborated upon by Becker and Lewis (1973), Becker and Tomes (1976), Barro and Becker (1989), and Doepke (2005).[5]

More recent evidence points to a weakening of the quantity-quality trade-off in high-income settings (see Doepke et al., 2023, for an in-depth discussion). This reflects a much diminished need

that emerges from these considerations would be cyclical wherein fertility is high for a generation and then low for another. While this cannot explain the low and shrinking fertility rates we have observed over the past decades, the theory has some explanatory power when it comes to the baby boom as a cyclical departure from the long run trend of declining fertility (Hill, 2015).

[3]Ermisch (1989) shows, however, that the negative impact of female wages on fertility is reduced and possibly overturned when childcare is available and affordable to the household. He thus provides early evidence on one of the mechanisms that are prone to reverse the negative GDP-fertility correlation (see also Butz and Ward, 1979).

[4]An additional cost of children arises from additional housing requirements. Recent evidence shows that housing booms tend to bear positively on the fertility of homeowners through a wealth effect but they tend to depress fertility (intentions) of renters (e.g., Atalay et al., 2021; Meng et al., 2023).

[5]In the last two decades, the idea of the quantity-quality trade-off has led to a highly successful strand of the macroeconomic literature that explains the transition from Malthusian stagnation with high fertility and low economic growth to a modern growth regime with low fertility and high economic growth (cf. Galor and Weil, 2000). During this transition, the quantity-quality trade-off played a crucial role because with technological progress parental investment in the education of their children became ever more desirable as fertility fell. This process reverses the positive effect of parental income on fertility observed in the Malthusian regime (Malthus, 1798), which mainly explains why early or insufficient technological progress cannot lift an economy out of poverty. Overall, while the decline in fertility caused by the quantity-quality trade-off enabled a take-off toward sustained economic growth in the past, it also led to the current situation of low fertility and population decline.

for adolescents to contribute to family income, or to support themselves (Hazan and Berdugo, 2002; Doepke, 2004); expansions of public education that soften or eliminate the trade-off between number and quality of children [see, e.g., Omori (2009) and Yew and Zhang (2013) for theoretical treatments; and Black et al. (2005) and Angrist et al. (2010) for empirical evidence]; and a greater scope for high-income earners to purchase childcare on the market (Furtado and Hock, 2010; Furtado, 2016; Bar et al., 2018). Notably, the ability to purchase childcare can explain the observation that the decline in fertility has abated, in particular, among educated high-income earners (Doepke et al., 2023), while a decline continues to take place among people in lower-income strata.

2.3 Women's opportunities and family policies

One key component of the total cost of children relates to the time parents need to invest in their children and the related opportunity cost in terms of foregone earnings. In traditional societies, women largely assume the role of child rearing and caring, implying that it is their labor income that should be accounted for. Doepke et al. (2023) provide an extensive review of theory and evidence in this respect, confirming that during periods of increasing female education and empowerment in many countries, increasing labor market opportunities led to a reduction in fertility. This result also holds when accounting for career dynamics, where motherhood breaks come with an additional penalty due to foregone experience-related earnings increases (see, e.g., Caucutt et al., 2002; Adda et al., 2017) and skill depreciation (Mincer and Ofek, 1982; Blackburn et al., 1993). Here, fertility is delayed but whether or not it can be recuperated depends on the socioeconomic and policy context (see, e.g., Sobotka, 2004; Frejka et al., 2010; Beaujouan, 2020; Hwang, 2023).

Over the past decades, evidence has begun to accumulate suggesting that the trade-off between female employment and childbearing, too, has weakened and, to some extent, reversed in many countries (Doepke et al., 2023). This tendency can essentially be attributed to four causes: (i) increasingly effective family policies (see Olivetti and Petrongolo, 2017, for a survey), in particular, in the areas of public childcare (Bauernschuster et al., 2016; d'Albis et al., 2017), family leave (Lalive and Zweimüller, 2009; Raute, 2019), taxation (Bick and Fuchs-Schündeln, 2018), and benefit schemes (Riphahn and Wiynck, 2017; González and Trommlerová, 2023); (ii) technological enhancements that relieve the trade-off among child bearing, rearing, and employment (Greenwood et al., 2005, 2017); (iii) fathers assuming a stronger role in childcare, which, through a more balanced time allocation within the household, relaxes the trade-off in employment at the household level (e.g., Brodmann et al., 2007; Feyrer et al., 2008; De Laat and Sevilla-Sanz, 2011; Fanelli and Profeta, 2021) and (iv) more agreement on fertility choices within couple bargaining (Testa et al., 2014; Doepke and Kindermann, 2019). Changes in social norms play a further role, as Section 2.5 discusses in greater detail.

2.4 Uncertainty, insurance, and intergenerational transfers

Fertility decisions are deeply entangled with issues of uncertainty. This is because the decision to bear and bring up a child is subject to multiple risks, while, at the same time, children can be viewed as insurance against the risk of poverty and lack of support in old age (see Cain, 1983; Trinitapoli and Yeatman, 2018; Bellani and Arpino, 2022).[6] Three dimensions of uncertainty receive particular attention: (i) the risk of child mortality, (ii) risks related to old-age dependency, and (iii) employment and other income risks.

[6] Assessing whether children are perceived more as a risk or as insurance, Bellani and Arpino (2022) provide evidence from Italy in support of an insurance role, in particular, among the less educated.

The risk of losing children during infancy has been shown to induce precautionary fertility (e.g., Kalemli-Ozcan, 2003; Doepke, 2005; Fioroni, 2010). Medical improvements and generally better living conditions during the early parts of the 20th century have curbed both child mortality and precautionary fertility. Although the net effect is an increase in surviving children during the initial phase of this transition (e.g., Doepke, 2005), the precautionary motive for fertility is no longer considered to play a role in advanced economies with well-developed health care systems.

The social security motive for having children includes insurance against income shocks over the life cycle that may lead to old-age poverty. Social security is also a means of transferring wealth into old age in economies that do not readily allow for transfers through private savings or the accumulation of public pension entitlements. Caldwell (1976, 2005) proposes a theory of fertility decline that is based on such intergenerational wealth flows. In poor societies with inadequate social safety nets and an early age at which children start working, the net flow of resources across generations is from young to old. Thus, according to this theory, it is economically beneficial for parents to have a relatively large number of children. By contrast, in modern societies with pension systems and strong social safety nets, resources typically flow the other way because parents support their children until a comparatively older age. During the transition from poor to rich societies, the flow of wealth therefore reverses and this could have contributed to the fertility decline (see also Willis, 1979). Empirical evidence tends to show that children and savings act as substitute instruments for old-age security (e.g., Banerjee et al., 2014; Filoso and Papagni, 2015; Cigno, 2016; Lugauer et al., 2019).[7] Additional consideration needs to be given to public pensions as a third vehicle. Much of the empirical research on the impact of public pension schemes on fertility (see Cigno, 2016, for a summary) confirms the social security motive and suggests that the expansion of old-age security as part of modern welfare states is one of the channels behind fertility decline. Building on Caldwell (1976, 2005) and calibrating the model to a set of modern countries, Boldrin et al. (2015) show that old-age security and access to private capital markets account for a sizeable part of the fertility differences across countries and over time within their simulation. According to recent evidence in Shen et al. (2020) and Danzer and Zyska (2023), similar findings apply to the introduction and expansion of social security within two newly industrialized countries, Brazil and China, both of which experienced fertility declines. Bau (2021) shows that the introduction of social security also has the power to soften traditional family norms on co-residence, which comes, however, at the expense of lower educational investments.

An extant body of literature studies how unemployment and labor market uncertainty affect fertility (see Buh, 2023; Doepke et al., 2023, for recent surveys). In principle, unemployment leads to offsetting fertility stimuli, a positive one due to relaxation or elimination of the labor-related opportunity cost of fertility and a negative one due to a reduction in period income and a downward assessment of the expectation of future income flows. The majority of studies shows that the life-cycle income effect tends to dominate, implying that deteriorating employment conditions lead to reductions in fertility. Indeed, Del Bono et al. (2012, 2015) show that the deviation from a career-track rather than unemployment per se lowers fertility. Related research finds that differences in exposure to globalization across industries imply fertility decline among individuals working in industries that are negatively affected and vice versa for those working in industries that are expected to benefit (Autor et al., 2019; Giuntella et al., 2022). Social and policy context matters as well: Matysiak et al.

[7] Filoso and Papagni (2015) provide the more nuanced empirical finding that, while the general development of private capital markets reduces fertility, access to credit increases it by allowing to cover the resource needs of child rearing at an early point in the household life cycle when savings have not yet accumulated. The issue of private saving is further discussed in Section 4.

(2021) find that the Great Recession has strengthened the decline in fertility for most European countries. The impact was most pronounced in Southern and Eastern Europe, and muted in Western and especially Northern Europe. Moving beyond employment risks, Gozgor et al. (2021) confirm that a general index of economic uncertainty is negatively related to fertility. Against the backdrop of a general tendency toward more unstable career trajectories, as implied by the rise of self-employment (Boeri et al., 2020) and, more recently, the "gig economy" (Vallas and Schor, 2020) in many industrialized countries, this may well explain some of the continued decline in fertility in spite of policy efforts toward mitigating the employment-fertility trade-off.

2.5 Social norms

Choices on fertility are not made in isolation but rather in the context of (broader) families and networks of friends, neighbors, and colleagues. Thus, a literature has emerged that studies the impact of the social norms held within relevant peer groups on fertility. Prettner and Strulik (2017) show that a change away from traditional to modern norms, the latter supporting contraception and smaller family sizes, can lead to strong social dynamics toward lower fertility. de Silva and Tenreyro (2020) employ a calibrated overlapping generations model with human capital investments and social norms to quantify numerically the role of social norms and policies aimed at fostering norms in favor of smaller family size. They find that global fertility decline is particularly well explained by the impact of policy change on social norms. At the micro level, social norms have been shown to have more varied effects. Changes in social norms that honor fathers' engagement with children and make the role of "working mom" more acceptable or even turn it into a role model (Fernández and Fogli, 2006, 2009) may help to contain fertility decline, which is in line with Arpino et al. (2015) who report a U-shaped relationship between norms toward gender equality and fertility. Norms have been shown to be both contagious across space (Spolaore and Wacziarg, 2022) and persistent across socioeconomic peer groups (e.g., Bauernschuster and Rainer, 2012; Chabé-Ferret, 2019). Finally, Ferrara et al. (2012) highlight the role of mass media, such as soap operas in Brazil, in the transmission of low-fertility norms even beyond the immediate influence of peer groups.

2.6 Emerging trends

Childlessness: Doepke et al. (2023) report an increasing tendency toward childlessness for several developed countries. Childlessness may be unintended due to lack of resources or biological sterility or it may be voluntary. With respect to unintended childlessness, Giuntella et al. (2022) report that exposure to import competition tends to increase childlessness, in particular among less-educated men. There are strong indications that biological sterility in industrialized economies is increasing among both women and men due to environmental factors (see Skakkebæk et al., 2022; Levine et al., 2023, for a survey). At the same time, the ongoing postponement of childbearing to ages at which fecundity declines naturally leads to a further increase in childlessness (Beaujouan, 2020; Hwang, 2023). While scope exists for assisted reproduction to realize fertility intentions at older ages, the extent to which this will offset the loss in fertility is unclear (see, e.g., Doepke et al., 2023; Lazzari et al., 2023). Finally, a recent debate centers on the effect of climate change on fertility. While findings indicate that climate-related extreme weather events tend to depress fertility (Sellers and Gray, 2019), evidence on whether climate anxiety leads to voluntary childlessness remains inconclusive to date (Schneider-Mayerson and Leong, 2020).

New partnership platforms and patterns: That partnership patterns have shifted away from lifelong marriage to much more diverse forms is well established (see, e.g., Seltzer, 2019a); however, the advent of social media and dating platforms has also changed the matching market as well as fertility choices and opportunities. According to recent evidence from the United States, matching tends to be positively affected at the point at which individuals are willing to engage in a partnership (Sironi and Kashyap, 2022). However, the impact on fertility choices is both age- and context-dependent. Evidence for the United States suggests that internet access, in general, has curbed the teen birth rate (Guldi and Herbst, 2017) but has raised fertility among highly-educated women aged 24–39, presumably by alleviating the trade-off between childcare and employment (Billari et al., 2019). By contrast, evidence from China shows a negative impact of internet access for all education and age groups (Nie et al., 2023).

Fertility beyond the Great Recession and COVID-19: Since the advent of the new millenium, two global events, the great recession and the COVID-19 pandemic, had the potential to disrupt fertility patterns. Recent research has investigated whether these events had lasting impacts. Seltzer (2019b) finds that U.S. fertility has not recovered from the bust during the Great Recession and attributes this empirically to continued structural change to the economy. This finding aligns with evidence that robotization, as a proxy for the more general digitilization of employment contexts, is associated with lower fertility in European settings (Matysiak et al., 2023). Following the pandemic, which featured a short-term fertility bust in many countries (Aassve et al., 2021), most of these countries have experienced a rebound even beyond pre-pandemic levels (Sobotka et al., 2023).

More generally, the outlook on fertility remains mixed. While some evidence points to a flattening or reversal of the (originally negative) correlation between GDP and fertility at the macro level (Doepke et al., 2023), especially in contexts in which social change, policies, or a high income level allow for a reconciliation between female employment and childbearing, these developments do not universally translate into a reversal of declining fertility at the aggregate level. With some evidence pointing to a reversal of fertility decline at high levels of development (Goldstein et al., 2009; Myrskylä et al., 2009; Fox et al., 2019), other work shows more inconsistent patterns (e.g., Myrskylä et al., 2013; Lesthaeghe, 2020). Notably, over the recent past, fertility has begun to dip in the Scandinavian countries although family policies and social norms support gender equity (e.g., Hellstrand et al., 2021). Thus, as Doepke et al. (2023) point out, an understanding of how the income-fertility nexus is emerging may be more conducive to understanding cross- and within-country fertility differences than understanding the secular decline in fertility.

3 Macroeconomic concerns about fertility decline

The macroeconomic consequences of fertility decline and low fertility are manifold. Many predominantly affect the supply side of the economy (e.g., labor shortages) and some predominantly affect the demand side (e.g., reductions in consumption expenditure growth and the associated repercussions on investment). In the following, we discuss the different concerns in more detail.

Labor supply: First, a fertility decline that is unaccompanied by increases in immigration or a decline in mortality leads to a reduction of population growth and — with a certain delay to allow for schooling and training — to a slowdown in the growth of the labor force. In settings with very low fertility, the workforce can even shrink, implying labor shortages. This has the potential to induce problems in the production of goods, supply chain disruptions, and even shortages of goods as many countries experienced during the COVID-19 pandemic and its immediate aftermath. In addition, upward pressures on wages emerge, which, in turn, cause upward pressures on prices such that inflationary spirals may be induced by demographic change (see, e.g., Lindh and Malmberg, 2000). Davis et al. (2022) study the impact of workforce shrinkage in a two-country open-economy model with productivity spillovers, where firms tend to locate and innovate in the country with a larger labor market. While adjustment patterns vary depending on whether population aging arises in the large or small economy, a numerical exercise based on the United States–European trade nexus shows that workforce shrinkage typically harms both economies.

Social security and pension systems: Related to the social security system and the funding of pension schemes, low fertility poses the obvious problem that it reduces the long-run support ratio (the number of workers per retiree). Many pension systems in different countries are built on a pay-as-you-go structure, where those who are currently working pay for the pensions of those who are currently retired (and no funds accumulate as they would in a fully-funded system). In a pay-as-you-go system, the decrease in contributors implies a shortfall of funding for given tax- and benefit rates. As a consequence, many countries have to support their pay-as-you-go pension or health care systems with a substantial part of their tax revenues (e.g., Breyer et al., 2010), which can no longer be invested in education, basic and applied science, public health, or infrastructure projects. At the same time, a declining population could lead to a shrinking tax base because fewer people have paid jobs. This exacerbates the problems of funding growth-promoting policies and, thus, leads to a slowdown of economic growth.

Innovation and technological progress: Some economists have expressed concerns that a decline in population growth or even depopulation has an underappreciated negative effect on innovation. First, as the number of working-age individuals decreases, so does the number of scientists in the long run (in the short run, a larger share of the population could become scientists and therefore compensate for the overall population decline). The reduction in the number of scientists, in turn, has negative effects on innovation and, thus, innovation-driven long-run economic growth in many prominent economic growth models (see, e.g., Romer, 1990; Jones, 1995, 2022; Segerström, 1998; Aksoy et al., 2019).

Consumption and saving: Kuhn and Prettner (2018) show that in an overlapping generations model with realistic demography, a reduction in the birth rate tends to depress aggregate consumption growth and thereby (domestic) demand. This, in turn, implies deflationary tendencies, a reduction in investment by firms and, consequently, downward pressure on the equilibrium interest rate. Summers (2015) and Eggertsson et al. (2019) argue that the demographic developments in high-income countries over the past decades contributed to secular stagnation, which is how they interpreted the sluggish recovery from the global economic and financial crisis in 2008-2009. By pointing out the role of market size for research and development (R&D), Desmet and Parente (2010) hint at a channel through which a reduction in local demand may inhibit an economy's innovation efforts. Overall, however, concerns related to demand-side restrictions may be muted at the moment because — at the time of writing in 2023 — inflation rates are high because of supply chain bottlenecks, the energy and food price shocks due to the Russian invasion of Ukraine in 2022, and the demand-side stimuli of expansionary fiscal policies in Europe and the United States in the aftermath of COVID-19 induced lockdowns.

Fertility decline and socioeconomic inequality: Against ample evidence of socioeconomic gradients in fertility (see Doepke et al., 2023, for a review), (differential) fertility change is prone to shape socioeconomic inequality by changing the population distribution across socioeconomic strata. Generally, the concern is that higher fertility among the socioeconomically disadvantaged may exacerbate inequality (e.g. Daruich and Kozlowski, 2020) and dilute average human capital (Vogl, 2016). In that respect, the evidence reported by Doepke et al. (2023) that fertility decline is dampened, in particular, among the better educated is reassuring to the extent that it suggests a limitation of such a process.

Regional imbalances: Many high-income countries continue to face considerable internal migration especially from rural to urban areas, leading to a tendency of unbalanced spatial economic development (see, e.g., Rosenbaum-Feldbrügge et al., 2022). In many cases, this involves the selective migration of young (and educated) women into urban areas with better employment prospects (Fuchs-Schündeln and Schündeln, 2009). While the depopulation process may turn into a vicious cycle for the home regions with lower population densities leading to a slowdown in economic activity and investments in public infrastructure, the departure especially of females in their childbearing ages tends to hasten the downward spiral, as the reduction in local childbearing diminishes the region's future prospects. One particular measurement problem here is that a region that faces selective outmigration of young women may not exhibit a decline in its TFR, as long as those women in childbearing ages who are left behind do not reduce or (due to lacking employment prospects or lower education on average) even increase their fertility. Thus, TFR in itself would not signal a problem here.

4 Compensatory mechanisms

While some direct effects of low fertility may raise concerns about adverse long-run economic outcomes, several counterveiling accounting and behavioral adjustments could help ameliorate them. In the following, we discuss several pathways in greater detail.

Demographic dividends: When fertility rates fall, the immediate effect is that the ratio of young dependent individuals to the working-age population starts to decrease. This opens the window for a "demographic dividend" (Bloom and Williamson, 1998; Bloom et al., 2003; Lee and Mason, 2010; Ashraf et al., 2013; Mason et al., 2016), where, for a certain duration, the support ratio increases, which allows for an increase in per capita GDP. The gradual ageing and retirement of workers translates into a subsequent decline of the support ratio, implying that the boost to per capita GDP is not a permanent long-run driver. This notwithstanding, a more permanent dividend can be reaped if the additional resources that become available during the demographic window of opportunity are invested in growth-promoting areas.

In addition, as Mason and Lee (2006) argue, a second demographic dividend becomes available to the extent that individuals or the state on their behalf increase savings to finance old-age support when fewer children or workers, more generally, are available. These savings would either boost investment in the domestic capital stock or generate claims on foreign production, e.g., in countries with higher fertility (Krueger and Ludwig, 2007). In simulation exercises, Lee and Mason (2010), Ashraf et al. (2013), and Mason et al. (2016) study the impacts of an exogenous fertility transition on GDP growth in various country settings. Their findings suggest that if the demographic dividends are strategically re-invested (e.g., in education, population health, research and development etc.), strong positive knock-on effects on economic growth can be expected (Bloom et al., 2017), which has been observed in many East Asian countries (Bloom and Finlay, 2009).

Female employment: With decreasing fertility, the labor force participation rate tends to increase, particularly that of women. This boosts employment further as compared to a situation with a high fertility rate. This effect is particularly strong in the short and medium run, but the growth effect tends to level off over time, because it is a one-time shift. Bloom et al. (2009) and Ashraf et al. (2013), among others, have analyzed the channel of rising female labor force participation and its growth effects.

Savings response: As discussed in Section 2.4 above, access to capital markets for old-age savings may depress fertility. Conversely, fertility decline could boost savings and, thereby, compensate for a declining labor force through investments in physical capital, human capital, technology, and knowledge. At the microeconomic level, a body of literature, much of it based on the quasi-experimental nature of the introduction and recent relaxation of China's one-child policy (Banerjee et al., 2014; Ge et al., 2018; Choukhmane et al., 2023), has emerged that finds consistent evidence of a strong negative effect of fertility on savings. Curtis et al. (2015) employ structural modelling in partial equilibrium to show that the fertility decline in China explains about 50 percent of the increase in aggregate savings, a finding that must be corrected downward when taking into account general equilibrium feedbacks (Banerjee et al., 2014).[8] These findings are broadly consistent with theoretical predictions, which show that an increase in the birth rate lowers capital accumulation and economic growth both in the two-period overlapping generations (OLG) framework (Diamond, 1965) and in the continuous-time OLG model (Blanchard, 1985; Buiter, 1988). While d'Albis (2007) shows that, within a continuous-time OLG model with age-specific (rather than constant) mortality, fertility has an ambiguous effect on capital accumulation, subsequent work by Lau (2009) and Sánchez-Romero (2013) shows that, for a plausible calibration, the effect of fertility on capital accumulation is negative even in models with a realistic demographic structure. While these findings generally support the notion that the savings response to fertility decline should at least partially offset the reduction in labor supply, Sánchez-Romero et al. (2013) show that this also depends on the policy context. Studying the impacts of the baby boom and bust in Spain, accounting for the concomitant expansion of the public pensions system, and allowing for bequests, they find that the boom-bust sequence may well have depleted capital, both because of the negative saving incentive of public pensions for the boom cohort and the subsequent reliance of the bust cohort on generous bequests. Similarly, Cavallo et al. (2018) find in a comparative analysis that the correlation between demographic factors and domestic savings holds in Southeast Asia but not in Latin America.

Human capital: When families have fewer children, they tend to invest more in the education and health of each child (Lee and Mason, 2010; Prettner et al., 2013; Strulik et al., 2013). Better-educated children are more productive when they enter the labor market, which has a positive effect on economic growth. Several studies have analyzed this behavioral response to declining fertility (Ashraf et al.,

[8] Studying the demographic transition in a partial equilibrium setting, Lee and Mason (2000) arrive at a similar result. Curtis et al. (2017) extend the structural model to study the comparative impact of demographic changes on household savings in China, India, and Japan and find a tight link.

2013; Strulik et al., 2013; Kotschy and Sunde, 2018; Baldanzi et al., 2021; Marois et al., 2021; Strulik, 2022) and confirm it to be an important mechanism. The growth-promoting effect of better education is well established theoretically (Lucas, 1988; Strulik et al., 2013) and empirically (Cohen and Soto, 2007; Lutz et al., 2008; Hanushek and Woessmann, 2012, 2015). Similarly, investments in health (Weil, 2007; Bloom et al., 2019a) and women's health, in particular (Bloom et al., 2020), have been shown to further enhance growth. Moreover, the described behavioral effect is reinforced by an accounting effect in the education sector. A shrinking cohort of children means that a given government education budget is distributed among fewer pupils. This raises the resource intensity of schooling for each child and has the potential to raise economic growth (Prettner, 2014).

However, the extent to which human capital improvements offset population aging or population decline is unclear. Kotschy and Sunde (2018) identify strong cross-country heterogeneity in the extent to which educational expansion compensates the decline in the working-age population and find that for many countries, population aging will have negative consequences in the foreseeable future. Siskova et al. (2023) find that human capital investments only partially offset reductions in fertility, implying a decline in the aggregate human capital (or "effective labor force") of many countries, an effect that is even more pronounced for countries facing population decline. Studying a macroeconomic model with human capital investments following a quantity-quality trade-off that is calibrated to the Chinese economy, Gu (2021) concludes that responding to declining fertility through increased human capital investments cannot fully offset the negative impact of a smaller labor force on aggregate income.

Investments in infrastructure, institutions, and technology: Saving and investment can also promote growth if they flow into infrastructure (Barro, 1990; Canning and Pedroni, 2008), basic and applied research (Jones and Williams, 1998, 2000; Prettner and Werner, 2016; Huang et al., 2023), and institutional improvements (Acemoglu and Robinson, 2010). Societies that experience declining workforce growth and population aging generate a particularly strong return to investments in technologies that are productivity increasing and labor saving. For standard forms of technological progress, this has been shown theoretically and empirically by Gehringer and Prettner (2019). As far as automation is concerned, this has been established by Acemoglu and Restrepo (2017, 2022), Stähler (2021), and Abeliansky and Prettner (2023). Overall, these papers show that demographic factors explain a large part of the increase in "robot density" (the number of industrial robots per worker) that has been observed over the past decades.

5 A simple model to reconcile theoretical predictions and empirical findings

In this section, we propose a simple extension of a semi-endogenous growth model that can be used to analyze the effects of declining fertility on economic growth and that features some of the previously described mechanisms. The model is capable of generating a negative effect of fertility on economic growth and, thus, seems to be more in line with cross-country data (see, e.g., Ahituv, 2001; Herzer et al., 2012). The framework can be extended in future research to include channels we have described but have not (yet) included in the formulation below.

We assume that time t evolves discretely because including a realistic human capital accumulation process in the model is then straightforward. In Jones (1995), long-run economic growth is determined by technological progress that is generated in a knowledge production sector. The stock of technologies is denoted by A_t at time t, and its change depends positively on the number of scientists, $L_{A,t}$, and their productivity, δ_A. The specific knowledge production function reads

$$A_{t+1} - A_t = \delta_A A_t^{\phi} L_{A,t}^{\lambda}, \tag{1}$$

where λ is an inverse measure of the stepping-on toes externality (i.e., that different researchers work on the same idea and, thus, duplicate efforts) and ϕ measures intertemporal knowledge spillovers (i.e., the extent to which past innovation raises the productivity of scientists in generating new ideas in the future). It can be shown that the long-run balanced growth rate of the economy is driven by population growth and given by

$$g_A = g_y = (1+n)^{\frac{\lambda}{1-\phi}} - 1, \tag{2}$$

where g_i denotes the growth rate of variable i, y refers to per capita GDP, and n is the growth rate of the population. Clearly, a slowdown of population growth as driven by declining fertility would reduce per capita GDP growth. Jones (2022) goes one step further and shows that the consequences of entrenched below-replacement fertility are long-run depopulation and economic stagnation.

However, in general, the sheer number of people is not what matters for knowledge creation but the presence of well-educated scientists who often have decades of training in the fields in which they work. Thus, the human capital of scientists is what should feature in the knowledge production function as the main determinant of technological progress and economic growth. This was already acknowledged by Romer (1990), although he did not model the human capital accumulation process explicitly. Strulik et al. (2013) endogenize the human capital accumulation process based on a Beckerian child quantity-quality trade-off effect as described previously (see also Galor and Weil, 2000). Here, we provide a simplified exposition of this model.

In so doing, we assume that the production side of the economy is the same as in Jones (1995), except that the knowledge production function features the human capital embodied in the scientific workforce instead of the number of scientists. Denoting the aggregate human capital stock by H_t, which is the product of individual human capital h_t and the size of the workforce L_t, it can be shown that the long-run growth rate of the economy now depends on the growth rate of human capital g_H such that

$$g_A = g_y = (1+g_H)^{\frac{\lambda}{1-\phi}} - 1. \tag{3}$$

On the consumption side, households derive utility from consumption (c_t), from the number of own children (n_t), and from the education the children enjoy (e_t), reflecting intergenerational altruism. Utility is increasing in all of these arguments but with a decreasing marginal effect. The easiest way of capturing this is a logarithmic utility function of the form

$$u(c_t, n_t, e_t) = \log(c_t) + \alpha \log(n_t) + \eta \log(e_t), \tag{4}$$

where α is the utility weight of the number of children (relative to the utility of consumption) and η is the utility weight of children's education. For meaningful results, a hierarchy of needs has to hold according to which households prioritize first consumption, then procreation, and finally education. This is ensured if $1 > \alpha > \eta > 0$. If the second inequality were not to hold, households would end up with a positive demand for their children's education, although they would not have children in the first place.

The wage rate is denoted by w_t and the costs of children are modeled as foregone parental labor income due to the time spent on childcare. Assuming that each child requires ψ units of parental time, normalizing parental time endowment to 1, and denoting the price of education by ξ, we have the following household budget constraint:

$$w_t h_t (1 - \psi n_t) = c_t + \xi e_t n_t. \tag{5}$$

The left-hand side is parental income earned by supplying h_t units of human capital during the available time net of childcare on the labor market for the wage rate w_t.

Solving the optimization problem yields the following first-order conditions:

$$c_t = \frac{h_t w_t}{1+\alpha}, \qquad n_t = \frac{\alpha - \eta}{\psi(1+\alpha)}, \qquad e_t = \frac{\psi \eta h_t w_t}{\xi(\alpha - \eta)}, \tag{6}$$

where consumption and education expenditures increase with income, whereas fertility stays constant with income. We immediately observe the quantity-quality trade-off:

- If parents want to have more children (higher α), fertility (n_t) rises, and education (e_t) decreases;
- If parents want to have better educated children (higher η), fertility (n_t) decreases, and education (e_t) rises;
- If the time required for raising children increases (higher ψ), fertility (n_t) decreases, and education (e_t) increases.

This pattern contains the quantity-quality trade-off described in Subsection 2.2. Notably, in the single-gender version of the model, an increase in earnings has no impact on fertility. This is because for a logarithmic utility function, the pure income effect exactly offsets the substitution effect, related to a greater opportunity cost of children. A version of such a model that distinguishes between women and men in terms of time spent on childcare and time spent on formal labor generates plausible effects of earnings increases that are in line with Subsection 2.1. If women spend more time on childcare and less time on formal labor supply than men (as has been the case historically and still is the case in many countries), such a gendered model generates a positive impact on fertility of male earnings but a negative impact of female earnings (Bloom et al., 2020).

Next, we assume that education expenditures of parents are used to pay teachers who educate the children and thereby translate parental education expenditures into children's human capital. Then aggregate expenditures for education are

$$\xi e_t n_t L_t = \frac{\psi \eta h_t w_t}{\alpha - \eta} n_t L_t. \tag{7}$$

Denoting the number of teachers by L_{E_t} and recognizing that teachers earn the current wage rate w_t, the wage bill in the education sector is

$$w_t h_t L_{E_t}. \tag{8}$$

Equalizing expenditures on education (7) and costs of education (8), we can solve for the education resources invested per child as

$$w_t h_t L_{E_t} = \frac{\psi \eta h_t w_t}{\alpha - \eta} n_t L_t \qquad \Leftrightarrow \qquad \frac{L_{E_t}}{n_t L_t} = \frac{\psi \eta}{\alpha - \eta}, \tag{9}$$

where $L_{E_t}/(n_t L_t)$ is the teacher-pupil ratio. Assuming that the human capital of children increases with the education resources per child and denoting the productivity of teachers by κ, we get the following law of motion for individual human capital:

$$h_{t+1} = \frac{\psi \eta \kappa}{\alpha - \eta} h_t. \tag{10}$$

Using $H_t = h_t L_t$ and computing the growth rate of aggregate human capital, we get

$$g_H = \frac{\eta \kappa}{1 + \alpha} - 1. \tag{11}$$

From this expression and the result for the fertility choice of households (6), we can show that

$$\frac{\partial g_H}{\partial \eta} > 0, \qquad \text{whereas} \qquad \frac{\partial n_t}{\partial \eta} < 0,$$
$$\frac{\partial g_H}{\partial \alpha} < 0, \qquad \text{whereas} \qquad \frac{\partial n_t}{\partial \alpha} > 0.$$

We can therefore state the following result.

Result 1 *In the semi-endogenous growth model with human capital and an endogenous education and fertility choice, aggregate human capital growth decreases when fertility increases (and vice versa).*

Considering the expression for the long-run growth rate (3) and recognizing that $\lambda/(1 - \phi)$ is constant, we finally arrive at

$$\frac{\partial g_y}{\partial \eta} > 0, \qquad \text{while} \qquad \frac{\partial g_y}{\partial \alpha} < 0.$$

This, together with Result 1, establishes the following crucial result.

Result 2 *The semi-endogenous growth model with human capital and an endogenous education and fertility choice exhibits a negative effect of population growth on economic growth.*

Overall, we have shown that the semi-endogenous growth framework with endogenous human capital accumulation can replicate the stylized cross-country pattern of the relation between economic growth and fertility (Ahituv, 2001; Herzer et al., 2012; Strulik et al., 2013).

This model captures mainly the quantity-quality trade-off as a compensation mechanism for a fall in fertility because this is the effect that prevails in the long run. In the medium run, however, a positive effect of falling fertility on parental labor force participation occurs through the term $(1 - \psi n_t)$. This has a growth effect on per capita GDP in the medium run, which translates into a positive level effect of falling fertility on income in the long run.

Many extensions of such a simple framework are possible. For example, endogenous savings could be another channel by which households react to falling fertility (see, e.g., the model of Strulik et al., 2013, that includes an optimal saving choice). In addition, health is another aspect that increases human capital and productivity. Baldanzi et al. (2021) augment the model with children's health in addition to children's education and show that both have an important effect on the growth of aggregate human capital and, thus, on long-run economic growth. Lehmann-Hasemeyer et al. (2023) include an endogenous institutional setting that fosters scientific inquiry and show how it interacts with declining fertility and increasing education. Finally, Hashimoto and Tabata (2016) augment the model to account for increasing life expectancy and its effects on fertility. A similar framework could be adopted to address later retirement and its potential to compensate for a fall of fertility, at least during the transition to the long-run balanced growth path.

6 Discussion and policy implications

What can policymakers do to address low fertility, population decline, and their macroeconomic consequences? Fortunately, demography is not destiny, and many different policies can either help to address falling fertility as such or contain its economic repercussions.

The encouragement of immigration is one possibility for countering a decline in the workforce (Marois et al., 2020). It takes advantage of the fact that demographic cycles are out of phase across countries. This could be done by allowing for special visa quotas differentiated by occupations or skills. In addition, the emigration incentives of in-country workers with the required skills could be countered by increasing the attractiveness of their occupations, i.e., in terms of special legal regulations, potential tax breaks, or fringe benefit packages. Of course, migration policies can only go so far because i) every immigrant in one country is an emigrant from another one so that other countries may suffer from such policies — however, this becomes an increasing problem to the extent that population aging triggered by fertility decline spreads into lower- and middle-income countries; ii) the levels of immigration required to fully compensate for the low fertility rates observed in many countries would be very high; and iii) political and public resistance against immigration is common. Sound immigration policies need to consider these constraints.

Family-friendly policies are another avenue that is often suggested to raise birth rates. Policies in this area range from direct monetary subsidies for each child via tax reductions for (large) families, generous parental leave regulations, and public provision of childcare, to various other policies that enable parents to balance work-related and family-related responsibilities. Here, direct payments and tax breaks have been shown to be less effective in terms of raising fertility than policies related to childcare (Doepke et al., 2023). In this context, it is important to note that if fertility rates rise after such policies are enacted, the number of dependents as compared with the working-age population will initially increase. This would lead to a "reverse demographic dividend" in the short to medium run, and the positive effects of increasing fertility on workforce- and economic growth will start to materialize after roughly two decades.

Greater investment in general education and specialized training (or retraining of workers whose skills are no longer in high demand) would help to reduce demographically-induced labor market shortages. In addition, a better-educated workforce is more productive, which would increase output and income, and more versatile, which would be helpful in finding new jobs after crises or after older jobs have been made obsolete by technological change (Prettner and Bloom, 2020, chapter 7). An analogous argument holds for investments in population health, which also tend to raise the productivity of workers (Bloom et al., 2019a,b). Also, spending on infrastructure can be helpful in this regard, not only by increasing productivity but also by raising the attractiveness of a country for immigrants and for foreign investors.

A critical aspect to counter the economic challenges of low fertility is raising investment in basic and applied research to foster technological progress as the main driver of long-run economic growth (Jones and Williams, 1998, 2000; Prettner and Werner, 2016; Huang et al., 2023). Productivity improvements can go a long way in compensating for a declining labor force. In addition, countries facing more severe demographic challenges invest more heavily in technologies that substitute for workers such as industrial robots, 3D printers, and artificial intelligence (Abeliansky et al., 2020; Abeliansky and Prettner, 2023; Gehringer and Prettner, 2019; Acemoglu and Restrepo, 2022). Boosting research into labor-saving or labor-enhancing technologies may therefore be an important complement to educational investments in ensuring long-run economic prosperity in the face of population decline.

Another lever to cope with a declining workforce is to raise the statutory and actual retirement ages. Because life expectancy has increased in all rich countries in the past decades, people spend more and more time in retirement. While optimal individual retirement tends to rise with life expectancy, regulations and implicit subsidies are in place that induce people to retire at the statutory age or even earlier (Bloom et al., 2007, 2010; Prettner and Canning, 2014; Kuhn and Prettner, 2023). More flexibility in the system to accommodate voluntary extensions of the working life could be helpful for mitigating the negative effects of low fertility on the workforce.

No policy in isolation will be a panacea; rather, a mutually reinforcing combination of different policies is more likely to be effective. For example, if education and health investments raise the productivity of workers and allow them to work to older ages, an increase in the retirement age is likely to be more effective than without better health and education (Kuhn et al., 2015; Sánchez-Romero et al., 2016). An unhealthy population may just not be capable of postponing retirement. Analogously, while immigration can mitigate some of the demographic effects of low fertility, it is unlikely to fully compensate them. Policies aimed at achieving a more desirable balance between family and work responsibilities could help to increase fertility and raise labor force participation. Combining migration, family, and education policies could reduce the extent of population decline. Finally, investments in education and investments in science and technology would be complementary in raising the productivity of workers.

Aside from the due consideration of synergies across policy domains and the implications for the design of balanced policy mixes to address the implications of fertility decline, further thought needs to address how the given sets of policy options relate to the socioeconomic consequences of digitalization, which generate challenges and opportunities in regard to production, consumption, and the processes of social interaction that may ultimately drive changes in fertility itself. Indeed, these processes imply a need to consider whether entirely new policy designs are necessary to channel digitalization toward fostering its positive and containing its negative consequences. Finally, policymakers may need to understand how the ongoing socioeconomic transformations come with changes in individual preferences and social norms and what the implications are for policymaking. This includes the proviso that fertility decline and the accompanying transitions should be considered and addressed from a perspective that centers on social welfare more broadly rather than on economic growth alone.

7 Conclusions

The steady decrease in fertility rates across high-income countries in recent decades has led to population aging and in some countries even to population decline and a shrinking workforce. We argue that these trends could have negative economic consequences, in particular, increasing pressures on social security and pension systems, a less innovative society, a slowdown of economic growth, and reduced consumption possibilities for much of the population. These economic consequences of fertility decline have received much attention in the literature and from the media. Here, we argue that economic and social reactions to low fertility such as better education of children, increased labor force participation (particularly of women), increased investments in labor-saving technologies, and later retirement will compensate some potentially negative economic consequences. In particular, policymakers have scope to react to declining fertility with carefully designed economic policies that utilize complementarities and synergies, including policies that allow families to square family-related responsibilities with work-related responsibilities; policies that ensure socially optimal levels of immigration – with safeguards to protect against undue brain drain; increased investment in education and health of the next generation, who will be in the workforce over the coming decades and whose productivity is vital in guaranteeing economic prosperity; and investments in productivity-enhancing areas such as infrastructure and basic and applied research.

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