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Policy-based Population Projections for the European Union: A Complementary Approach*

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Abstract: We present new population projections out to 2100 for the countries of the European Union and for the EU as a whole under a wide range of fertility and migration scenarios. As policy-based projections rather than forecasts, they aspire not to maximize predictive success regarding future demographic developments, but to accurately show the impact of different migration and socio-economic policy choices on population numbers. Our chief aim is to clarify those policy choices for European citizens and policymakers. We show that demographic policies have the potential to markedly increase or decrease future populations across the EU. Migration policy offers greater scope for influencing future population numbers than policies aimed at influencing national fertility rates. In countries with particularly low fertility rates or high emigration levels, egalitarian economic and family support policies have the potential to limit future population decreases to a significant extent, especially in combination. In most cases, EU nations are well placed to stabilize or slowly reduce their populations by continuing status quo policies or with moderate changes. Thus they are well placed to achieve one of the necessary conditions for creating ecologically sustainable societies.

Keywords: Population projections · European Union · Fertility · Migration · Population policy

* This article contains supplementary material in the form of three online appendices: Detailed Discussion of Projection Scenarios (appendix I) DOI 10.12765/CPoS-2019-15en, Projection Parameters (appendix II) DOI 10.12765/CPoS-2019-16en, and Population Projections for all EU countries (appendix III) DOI 10.12765/CPoS-2019-17en:
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1 Introduction

In this paper we present new, complementary population projections for the 28 member countries of the European Union and for the EU as a whole. These projections, building on the work of Eurostat and numerous individual demographers, differ from previous national and region-wide projections primarily in projecting a wider range of fertility and migration scenarios farther out into the future than has typically been done and in linking these scenarios explicitly to policies. As policy-based projections rather than forecasts, they aspire not to maximize predictive success regarding what will happen, but to accurately show the long-range demographic impacts of different policy choices, so as to clarify those choices for Europe's leaders and citizens.

Our central claim is that these new projections clarify the population impact of a wide range of current policy choices better than recent projections from the UN, Eurostat, and national statistical bureaus. In addition, we ask these research questions:

1) How much can feasible family-support policies increase or decrease European populations?
2) How much can alternative migration policies do so, particularly over the long term?
3) Do changes to family-support policies or immigration numbers have the bigger potential to influence future population size within the European Union?
4) What regional differences exist among EU countries in terms of population futures and policy choices?
5) What policies might best mitigate excessive population decreases in extra low fertility or high emigration countries?
6) How can migration and fertility policies affect the extent of aging in the EU?

These new projections can also show which demographic policies lead toward stable or slowly decreasing populations in the densely populated EU and which toward higher ones – important information for citizens concerned to create ecologically sustainable societies. In what follows, we review recent efforts to project European populations (Section 2), describe our own scenario choices (Section 3) and projection methods (Section 4), present results and discuss answers to our research questions (Sections 5 and 6), and offer our main conclusions (Section 7).

2 Background

Successful countries need to make well-informed policy decisions. Today the nations of the EU face policy choices that will influence their long-range demographic development, leading to a wide range of possible population futures. But we live in a rapidly changing world, including sudden fluctuations in migration levels, with

unexpected demographic surprises, such as persistently low fertility rates in some developed nations. Aware of this demographic uncertainty, national statistical bureaus tend to be leery of projecting more than a few decades into the future, and their alternative scenarios, if given at all, are usually narrowly constrained. This limits the usefulness of their projections for long-range policy analysis, or for informing their citizens about the full range of policy options.

For example, the report presenting the most recent national population projections from Germany to a general audience shows only two fertility scenarios (1.4 TFR and 1.6 TFR) and two migration scenarios (annual net migration of 100,000 and 200,000) with higher fertility and migration scenarios relegated to model assumptions beside the main variants (*Federal Statistical Office of Germany* 2015). Such a small variation in the total fertility rate arguably does not capture the fertility changes possible through changes to family support programs or other economic policies (see discussion below). Similarly, the two immigration scenarios hardly account for the range of policy choices facing a country where annual net immigration has averaged 259,000 over the past twenty years and varied widely (from – 56,000 in 2008 to 1.2 million in 2015) and where there is widespread support both for greatly increasing immigration (Social Democrats, *Die Grünen*) and greatly decreasing it (Christian Democratic Union, *Alternative für Deutschland*). The report makes no attempt to explicitly link different fertility rates and immigration numbers to particular policies. In addition, the projections only go out to 2060, with longer-term demographic impacts left unexplored.

It is easy to lose sight of the goal of policy clarification while pursuing predictive rigor. Probabilistic population forecasts have begun to supplant traditional cohort-component projection methods, based on superior accuracy and their ability to quantify uncertainty (*Wilson/Rees* 2005; *Azose et al.* 2016). Recently the Italian national statistical bureau took this approach, using stochastic models to estimate future fertility, mortality and immigration trends, which they present with 90 percent confidence intervals (*Istat* 2018). Stochastic projection models may provide superior short-term forecasts, but an unremarked consequence of using them is that median scenarios with confidence intervals tend to displace presentation of a variety of alternative scenarios – thus breaking any explicit connection between future numbers and current policy choices. *Il Futuro Demografico Del Paese* provides readers with a single median projection (with 90 percent confidence intervals) of Italy's future population out to 2065, with no alternative scenarios (*Istat* 2018). But fertility, mortality and migration trends can develop in different ways due to policy choices, and it would have been helpful to clarify these.

When we turn to region-wide projections, their value for policy clarification also may be limited. Eurostat's 2015 EU population projections run to 2080 and helpfully provide several alternative migration and fertility variants. Baseline scenarios are projected from recent trends by nowcast, convergence and trend models. TFRs for all countries are assumed to converge moderately to strongly around those of the highest fertility EU members, while net migration levels are assumed to converge relatively quickly around much lower levels (from ½ to ¼ of current levels by 2080) (*Lanzieri* 2017). Sensitivity tests are then provided for lower and higher migration

(+/- one third of the baseline net migration level) and for lower fertility (shrinkage of national fertility rates by 20 percent), but not for higher-than-baseline fertility. The projections provided in online tables (*Eurostat* 2019) are not clearly related to particular policy choices, nor do they cover the range of plausible alternatives, nor are the results explained in accessible summary publications. The resulting projections provide readers with little sense of how increases or decreases in net migration or fertility could impact future population numbers.

The most recent UN projections run to 2100 and use a probabilistic approach, resting on probabilistic fertility and mortality projections but deterministic migration projections (*Raftery et al.* 2014; *United Nations* 2017a). They assume generally constant levels of net migration until 2045-2050, which then gradually decline, reaching 50 percent of 2045-2050 levels by 2095-2100. Whatever the merits of this long-term forecast globally, it seems dubious for European countries, where migration pressures are strong and are projected to grow stronger during this century (*Lutz et al.* 2019). Only one alternative migration scenario is presented, the zero net migration variant; this allows readers to estimate the impact of status quo migration levels to future population numbers through 2050, but not much more. Regarding fertility, the UN follows the tradition and adds projections for +/- 0.5 of base TFR. Combined with a "constant fertility" scenario, where fertility rates remain at 2010-2015 levels, this provides some sense of how future fertility rates might influence future national population numbers. However, this information is not presented perspicuously in summary publications (see *United Nations* 2017b). In any case, for low-fertility developed nations like those in the EU, a more fine-grained series of fertility and migration projections would be valuable – as well as some attempt to connect particular fertility and migration scenarios to particular policy choices.

The public typically regard any population projection as a forecast designed to predict the future (*Booth* 2006). However, several recent efforts helpfully project alternative futures without emphasizing the superior likelihood of any of the alternatives projected. Such scenario-based projections emphasize that demography is not destiny and that policies can decisively influence demographic outcomes. The DEMIFER project (Demographic and Migratory Flows Affecting European Regions and Cities) is one effort to clearly link policy choices to demographic consequences using scenario designs (*De Beer et al.* 2010; *Rees et al.* 2012). Reasoning that future demographic changes would be influenced less by specific demographic policy choices than by overall economic trends (which in turn influence policies), researchers developed four general scenarios. The complex scenarios depict more or less robust economies and more or less economic inequality within and between European regions. Researchers then calculated expected changes to fertility and mortality rates and immigration levels under each scenario. Their focus on NUTS2 regions provides a more fine-grained analysis than national projections and their holistic approach arguably captures well potential changes in fertility rates, given the fact that societies' overall support for family formation influences these rates more strongly than one-off policy initiatives (*Frejka* 2008). But the approach fails to model European immigration policy choices, since future immigration levels, like current ones, will be set primarily by European governments rather than by economic trends.

The recently updated global projections from the International Institute for Applied Systems Analysis provide the most ambitious approach we have seen linking policy choices to future population numbers. Building on the "shared socio-economic pathways" developed for climate change analysis, (*Lutz et al.* 2018) develop three scenarios representing slow, medium and rapid socioeconomic development, each with associated fertility, mortality and migration levels. They then split their medium scenario into three based on different migration levels: zero net migration; continuation of the average net migration level between 1960 and 2015; and double that average. All five of the ensuing projections are run out to 2100. The result is the most explicit picture we have seen of the potential for different migration levels to influence future EU population numbers. Unfortunately, the potential impact of family support policies on future numbers is obscured, since their scenarios assume an implausibly large influence for increased education on future EU fertility levels, not taking into account already high European education levels and recent evidence for *increased* fertility among more educated women (*Hazan/Zoabi* 2015). They also mix changing fertility rates with changing migration and mortality levels in such a way as to render the impacts of family support policy choices opaque.

3 Scenarios

In general contrast to the approaches discussed above, our EU projections disaggregate the demographic impacts of fertility-focused policies and migration policies, presenting separate projections with multiple policy scenarios for each. We set the parameters for fertility rates and annual immigration numbers with reference to recent rates and numbers in status quo scenarios. Then we build additional scenarios by phasing in plausible changes to these rates and numbers, directly related to particular policy choices.

Our scenarios are informed by reference to recent policy choices made or advocated in the political sphere, and by analyses of the effectiveness of these policies in the recent demographic literature. Given the wide range of policy proposals currently under discussion in the public sphere, we have opted to consider a wider rather than a narrower range of projections.

3.1 Fertility scenarios

All European countries have completed the demographic transition to small families with long-lived members (*Frejka* 2008). While there is considerable variation (from a current TFR of 1.34 in Italy and Spain to 1.92 in France), no European country is at or above replacement fertility (Table 1).

Although a few analysts see low fertility and smaller populations as part of the natural evolution of successful societies (*Matanle* 2017; *Götmark et al.* 2018), most policy-makers see them as problems to be fought (*European Commission* 2014). Low fertility rates have induced EU nations to make a variety of attempts to raise them, including bonuses and tax breaks for having more children, and more gener-

Tab. 1: Fertility rates in 2016 for EU countries according to Eurostat, divided into three groups

Lower fertility countries TFR < 1.5 TFR		Medium fertility countries 1.5 < TFR < 1.7		Higher fertility countries TFR > 1.7	
Italy	1.34	Austria	1.53	Latvia	1.74
Spain	1.34	Hungary	1.53	Denmark	1.79
Portugal	1.36	Bulgaria	1.54	United Kingdom	1.79
Cyprus	1.37	Finland	1.57	Ireland	1.81
Malta	1.37	Slovenia	1.58	Sweden	1.85
Greece	1.38	Estonia	1.60	France	1.92
Poland	1.39	Germany	1.60		
Luxembourg	1.41	European Union	1.60		
Croatia	1.42	Czech Republic	1.63		
Slovakia	1.48	Romania	1.64		
		The Netherlands	1.66		
		Belgium	1.68		
		Lithuania	1.69		

Source: Eurostat database, "Fertility indicators" table

ous provision of child care services. Such efforts have been extensively studied. Despite mixed evidence in the literature (*Gauthier et al.* 2013), by now policy-makers have a fairly clear sense of what works best for permanently raising fertility levels in developed nations: comprehensive Nordic-style policies that make work-life balance easier for women and couples, combined with strong economic safety nets and more egalitarian societies (*Thévenon/Gauthier* 2011; *Balbo et al.* 2013; *Pollmann-Schult* 2018). We have also learned which policies do not work, or which only provide a short-term boost to fertility rates by influencing the timing of child-bearing, rather than completed fertility. These include isolated payments to encourage larger families within unchanged contexts of economic or career insecurity (*Kalwij* 2010; *Kim* 2014, although see *Hong/Sullivan* 2016 for some contrary evidence for the effectiveness of fertility subsidies.)

Given this general understanding, we have developed the five family support policy scenarios summarized in table 2 below. In the status quo policy scenario, we imagine nations continuing their existing economic and family support policies. Under this scenario, we hold TFR steady for higher fertility countries (see Table 1) and phase in small fertility increases for lower and medium fertility countries, in line with prevailing trends and other recent projections. Then in our two egalitarian policy scenarios, moderate and strong, we visualize countries enacting policies that make it easier for couples to form and sustain families, or creating more generous economic safety nets and doing more to redistribute wealth, so as to sustain a relatively egalitarian economic structure, or both. In contrast, in our two neo-liberal policy scenarios, moderate and strong, we imagine countries retreating from their

Tab. 2: Projection assumptions made under different family support scenarios. The impact on fertility is always phased in by 2036

Scenario	Policy changes	Impact on fertility rates
(1) status quo economic and family support policies	Continue existing level of family support, existing economic safety net, existing levels of economic equality and equality between the sexes	Lower fertility countries: + 0.2 TFR Medium fertility countries: + 0.1 TFR Higher fertility countries: no change in TFR (2016 value)
(2) moderate egalitarian policy shift	Improve economic safety net, decrease economic inequality within society, increase policies that support family formation, commit to equality between the sexes	All three categories: status quo TFR + 0.15
(3) strong egalitarian policy shift	Greatly improve economic safety net, greatly decrease economic inequality within society, greatly increase policies that support family formation, strongly commit to equality between the sexes	All three categories: status quo TFR + 0.3
(4) moderate neo-liberal policy shift	Reduce economic safety net, accept growing economic inequality within society, decrease support for family formation, ignore inequality between the sexes	All three categories: status quo TFR - 0.15
(5) strong neo-liberal policy shift	Greatly reduce economic safety net, accept greatly increased economic inequality within society, greatly decrease support for family formation, ignore inequality between the sexes	All three categories: status quo TFR - 0.3

Source: own design

current levels of family support, cutting their economic safety nets, or encouraging greater economic inequality – or some combination of all three

A key question regarding these scenarios is the extent to which policy changes in one direction or the other will influence national fertility rates. There is much disagreement among demographers about the effectiveness of policy in influencing fertility (*Luci-Greulich/Thévenon* 2013). Yet that they have some influence seems undeniable. *Hilgeman/Butts* (2009: 113) found that improved access to childcare increased European fertility rates, predicting that if "Italy were to increase its enrollment from 6 percent to 64 percent, to match that in Denmark, the realized fertility

per woman would be predicted to increase by an average of 0.97 children." (*Adsera* 2004) concluded that the gap between desired and achieved fertility was lower for Spanish women with more secure public sector jobs than for those with less secure private sector jobs. Although *Gauthier et al*. 2013 argue that this "gap" is often overestimated and should not be used as evidence for the potential impact of family-friendly policies, it is often cited as evidence at least for their possible impact (*European Commission* 2005). One summary found small yet significant increases in developed nations' fertility rates under a wide range of policy interventions (*OECD* 2011).

Acknowledging the uncertainty around this issue, we assume a relatively small but not insignificant space for family support and general economic policies to increase or decrease future fertility rates in the EU: plus or minus 0.15 TFR for our "moderate" policy change scenarios and plus or minus 0.30 TFR for our "strong" scenarios. This range is broadly in line both with studies that have looked at the impacts of particular policies in particular EU countries and with the idea that the range of fertility rates exhibited among EU countries is partly but not wholly a function of different national policy choices. See appendix I for additional discussion.

3.2 Migration scenarios

Regarding migration, we develop a similarly wide range of policy-dependent scenarios, recognizing the greater uncertainty around future migration numbers compared to future fertility rates (*Azose et al.* 2016). Migration numbers vary widely across the EU, as illustrated by table 3, showing individual countries' average annual net migration over the past twenty years.

In recent decades, many EU countries have evolved from relatively low to relatively high immigration regimes. More recently, high immigration levels have produced a strong populist reaction and some attempts to reduce these numbers, but whether this leads to permanently reduced immigration in the future remains to be seen. On the one hand, many EU citizens would like to see immigration reduced for social, economic, or political reasons (*Connor/Krogstad* 2018). They perceive current immigration levels offering few benefits and considerable harms. On the other hand, many citizens (sometimes the same ones) feel a humanitarian obligation to help their poorer neighbors to the south and east by allowing more immigration. Many business leaders see increased immigration as the solution to the potential problem of shrinking numbers of workers and consumers (*Legrain* 2014; *d'Albis et al.* 2018), a view echoed by EU policy-makers (*European Commission* 2005, 2014).

The situation is fluid and the sheer range of immigration policies advocated by European political parties is impressive. We seek to capture this range in our projections, with the following five migration scenarios for those countries (20 out of 28) that have averaged net positive migration over the past twenty years:

We build the *status quo net migration scenario* by averaging annual net migration into a country for the past twenty years and projecting it out to 2100 (note that our status quo net migration scenario is identical to our status quo fertility policy scenario). Such a lookback period roughly mirrors contemporary policies and con-

Tab. 3: Average annual net migration (1998-2017) of EU countries

Countries with positive average annual net migration				Countries with negative average annual net migration	
European Union	1,188,235				
Spain	270,112	Ireland	21,645	Slovakia	-305
Germany	259,316	Czech Republic	18,747	Estonia	-942
United Kingdom	230,107	Denmark	16,778	Croatia	-4,259
Italy	229,093	Hungary	13,652	Poland	-12,552
France	100,525	Portugal	12,262	Latvia	-14,362
Sweden	50,024	Finland	11,104	Bulgaria	-21,052
Belgium	42,575	Greece	8,390	Lithuania	-27,212
Austria	40,547	Luxembourg	6,967	Romania	-103,807
The Netherlands	26,427	Cyprus	5,855		
		Slovenia	4,128		
		Malta	3,642		

Source: calculated from Eurostat database,"Population change – Demographic balance and crude rates at national level" table

ditions, while smoothing out yearly fluctuations. We then build four further scenarios around the status quo scenario: 2X and 4X status quo scenarios, which increase immigration, and a zero net migration scenario and half status quo scenario, which decrease it. See appendix I for further details.

We treat the eight EU countries where emigration has exceeded immigration on average over the last two decades somewhat differently. For these countries, which are all in Eastern Europe, we have built a *status quo net migration scenario* around continued negative net migration, again taking the average annual net migration level for the past twenty years as a starting reference but linearly increasing it to zero in 2100 (in this way, gradually increasing net migration compensates for a decreasing total population that could not support large constant negative net migration levels). We then project a *zero net migration scenario*, reaching equal numbers of emigrants and immigrants by 2026, and three positive net migration scenarios built around applying a multiple of the average annual net migration rate for the EU as a whole during the past twenty years to the countries in question, out to 2100. These higher net migration scenarios thus assume convergence in migration patterns across the EU, as Eastern countries catch up to Western ones by being more open to immigration from outside the EU while fewer of their own citizens emigrate.

As with our fertility scenarios, we believe our migration scenarios well capture the range of policy choices facing EU countries today. These two sets of five alternatives present the full gamut of policy choices on immigration: from drastically curtailing it to drastically expanding it; from the Sweden Democrats to Sweden's Green Party. Several readers of this study in manuscript have questioned the feasibility

Tab. 4: Projection assumptions under different migration scenarios for countries with net positive migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) status quo net migration	Continuation of the country's average annual net migration level for the past 20 years for the rest of the century	TFR the same as under status quo fertility scenarios
(2) 2X status quo net migration	2X average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR + 0.05 by 2036
(3) 4X status quo net migration	4X average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR + 0.2 by 2036
(4) half status quo net migration	½ average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR - 0.025 by 2036
(5) zero net migration	Zero net migration by 2026, held stable for the rest of the century	Status quo TFR - 0.05 by 2036

Source: own design

of the zero net migration and 4X net migration scenarios for positive net migration countries. We agree that these more extreme scenarios are less likely to occur than the more modest policy changes characterized within the range of our half status quo to 2X status quo scenarios; that is why we graph them with dotted lines rather than straight lines in our projections. Yet given the overriding goal of these projections – to clarify the potential demographic impact of current policy choices – we believe these policy options should be included in our analysis.

A long-term zero net migration scenario for high-immigration countries in western and northern Europe is unlikely. Yet "no international migration" scenarios are included in the population projections of many national statistical bureaus and academic demographers, serving as reference scenarios to decompose the impacts of internal population changes and international migration. Similarly, migration levels equal to 4X these countries' recent net migration are highly unlikely to be sustained for many decades. The 4X net migration scenario thus is best seen as a "what if" scenario, allowing us to ask: "what might the demographic results be if a country persisted in allowing very high levels of immigration?"

Several EU governments allowed unprecedented immigration for a time in 2015 and 2016; in the case of Germany, this resulted in even higher net migration in 2015 than would occur under our 4X status quo migration scenario. Exploring the possible demographic impacts of persisting in such a course is valuable, even if such

Tab. 5: Projection assumptions under different migration scenarios for countries with net negative migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) status quo net migration	Linear increase from average annual net migration for the past 20 years to zero by 2100	Status quo TFR
(2) zero net migration	Zero net migration by 2026, held stable for the rest of the century	Status quo TFR
(3) EU status quo net migration rate	Net migration level equal to the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR + 0.05 by 2036
(4) 2X EU status quo net migration rate	Net migration level equal to 2X the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR + 0.1 by 2036
(5) 4X EU status quo net migration rate	Net migration level equal to 4X the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR + 0.2 by 2036

Source: own design

persistence is unlikely. Similarly, for other countries, the 4X status quo net migration scenario allows us to ask: "what might the demographic results be if a country allowed open borders?" Europe's Green parties explicitly advocated an open borders immigration policy in the 2019 European parliamentary elections (*European Greens* 2019a/b), and many EU social democratic parties have joined them in resisting efforts to set numerical limits to refugee admissions into the EU while simultaneously pushing for a much more expansive definition of refugees (*Žižek* 2016). Truly open borders are hard to model, but the 4X status quo scenario seems to us a good proxy for such an unlikely but possible course of action, showing its possible demographic impact. See appendix I for further discussion.

Finally, we note that family support and migration policies can and will change simultaneously. For that reason, we also project several combination scenarios in an attempt to better understand the full range of potential demographic futures facing EU countries and the impacts that policy choices may have on them. We describe these combination scenarios in section 5 of appendix I. We present them, along with all our scenario projections, in appendix III.

4 Methods

Our population projections employ the deterministic cohort-component method. We used DemProj program version 5.71, part of the Spectrum policy development and planning tool developed by Avenir Health (*Stover/Kirmeyer* 2007; *Stover et al.* 2010). The program requires information on population numbers by age and sex in the base year (2016 in all scenarios), as well as current year data and future assumptions about total fertility rate (TFR), age distribution of fertility, life expectancy at birth by sex, the most appropriate model life table, and the magnitude and pattern of international migration. In order to calculate dependency ratios, median age and proportion of 65+ population throughout the projections, we also used the DemProj module of Spectrum.

Our source for baseline 2016 data on population numbers by sex and single age (0-80+), national TFRs, life expectancy at birth and net migration figures, is the European Statistical Office (Eurostat). We use 2016 as our base year because at the time we made the projections, that was the most recent year for which actual TFR figures were available. Age specific fertility rates follow the United Nations' most recent world population projections' country specific fertility distribution data (*United Nations* 2017a). For changes to life expectancy, we use the sex specific assumptions of the baseline scenario of the Eurostat 2015 population projections until 2080, then hold these constant through the end of the century. In order to work with age-specific mortality rates, we use the UN's country specific model life tables.

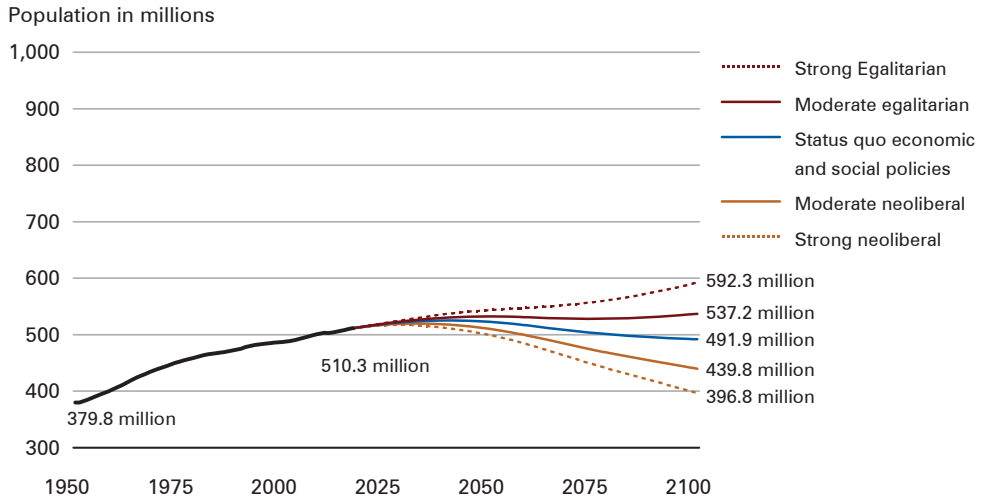
To model the impact of changes in migration levels, we constructed status quo scenarios by averaging Eurostat's annual national net migration figures for 1998 to 2017, then built alternative scenarios on multiples of that base. As we were not forecasting but building what-if policy scenarios, a model using readily available net migration level data was satisfactory for our purposes, although we are aware that multiregional models such as MULTIPOLES (*Kupiszewski/Kupiszewska* 2011) based on immigration levels and emigration rates are more accurate and methodologically elegant (*Rogers* 1990). Similarly, we did not attempt to model regional, sub-national migration, nor to classify different migration flows by motive, such as employment versus asylum seeking, nor did we distinguish between immigrants coming from EU countries or outside the European Union. Such approaches may provide a more fine-grained picture. But our focus in this study was squarely on national net migration levels, since a primary goal was to model the future demographic impacts of migration policy, which is made primarily at the national level. Concerning "net migrants," we assume equal proportions between the sexes and the DemProj program uses the UN's country-specific migration age distributions.

All changes to TFR in our scenarios assume a linear change phased in between 2016 and 2036, while all changes to net migration rates are phased in between 2016 and 2026. Appendix II provides tables showing the projection parameters (life expectancy, fertility rates and net migration levels) set for all scenarios across all countries in the study. Appendix III provides detailed population projections for all EU member states and the EU as a whole, in chart and table form.

5 Results

To begin summarizing our results, consider our projections for the European Union as a whole. The current 28 countries in the EU had a combined population in 1950 of 379.8 million and 510.3 million in 2016. The region's current (2016) total fertility rate is 1.60 and its annual net migration level over the past 20 years (1998-2017) averaged 1,188,235.

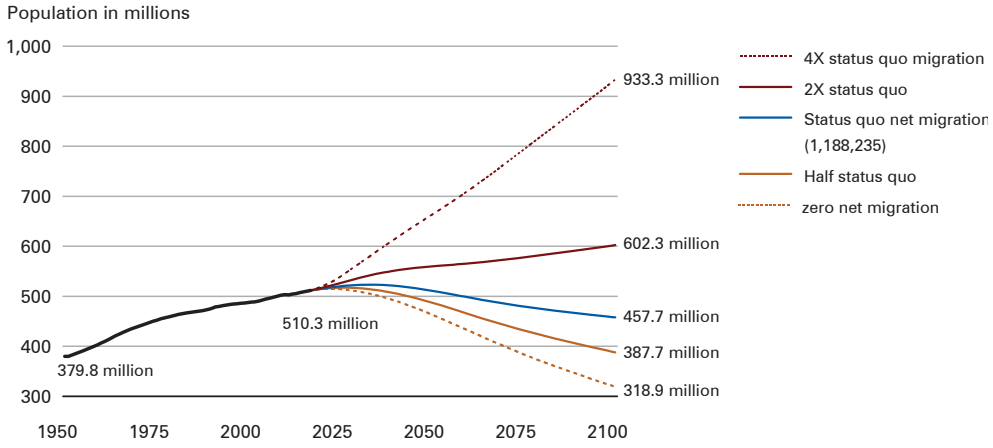
Fig. 1: European Union population projections under five fertility scenarios. All scenarios assume the continuation of the past 20 years average annual net migration on the EU level



Source: own calculations

Under a continuation of status quo family support and economic policies and an extension of current immigration levels in every country, we can expect a 3.6 percent decrease in the EU population (Fig. 1). This would hardly be overwhelming, spread out over eight decades. A relatively modest turn toward less generous support for family formation, under the moderate neoliberal scenario, would accelerate population decrease, leading instead to a 14.2 percent population decline. On the other hand, more generous support for workers and their families, under the moderate egalitarian scenario, would increase fertility rates sufficiently to avoid any population decline, even adding 27 million people to the total EU population. Given wide disparities among EU countries in economic support systems, commitments to egalitarian relations between the sexes and financial support for having children, there seems sufficient scope for enacting such policies and thus avoiding a decline if that is desired. The full range of fertility-related policy scenarios (dashed lines on figure 1), from strong neoliberal to strong egalitarian policies, leads to populations ranging in 2100 from 396.8 million (a 22 percent decline) to 592.3 million (a 16 percent increase): almost a 200 million spread.

Fig. 2: European Union population projections under five fertility scenarios. Status quo migration is the continuation of the past 20 years average annual net migration level (1,188,235). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs



Source: own calculations

Altering immigration levels provides much greater scope for increasing or decreasing the total EU population, compared to changing fertility-related policies on the country level – an important result that also holds for most individual countries (Fig. 2). Cutting net average migration in half would reduce the EU population by an additional 70 million people, or an extra 14 percent compared to the population loss under the status quo scenario, for a total drop of 24 percent by 2100. Doubling net migration, conversely, would switch the EU's population from declining by 52.6 million (10 percent) under the status quo to growing by 92.0 million (18 percent). That's a swing of 214.6 million people across our most likely range of immigration policy changes. The spread across the full range of policy choices is much greater: over 600 million people, from swelling to 933.3 million in 2100 in the case of quadrupling status quo net migration numbers (an 83 percent increase), to contracting to only 318.9 million by reducing net migration to zero (a 38 percent decline).

Our combination scenarios add further detail to the picture (see appendices I and III for details). Doubling recent average net migration levels across the EU while improving family support through egalitarian social and economic policies leads to a 38 percent population increase by the end of the century. In contrast, cutting immigration in half and cutting back on social and economic support for family formation leads to a population decline of over two hundred million people (a 40 percent decline). Interestingly, halving recent net migration levels combined with strong improvements in family support leads to a relatively stable population (decreasing

only 3.6 percent by the end of the century). This might be a particularly appealing policy combination on a continent where support for mass immigration has waned while concerns about low fertility levels remain strong.

5.1 Regional differences

Despite their shared experience passing through "the second demographic transition," EU nations all face somewhat different population futures and policy choices. In particular, it is worth highlighting the substantial differences among four regions of the EU.

Central and Eastern Europe

Under status quo policies, many low fertility and/or net emigration countries in this region are on track for steep population declines this century.[1] These include Romania, facing a 74 percent decline by 2100, Bulgaria (60 percent), the Baltic states (between 38 percent and 86 percent) and Hungary, facing a decline of 29 percent by 2100. However, egalitarian economic and social policies could mitigate population declines among this group by increasing fertility rates and (potentially) decreasing emigration numbers. In tandem with modestly increased immigration, much of the projected depopulation could be avoided. For example, under a combination scenario of zero net migration fused with strong family support policies, Romania's population decline shrinks to 22 percent by 2100, while under the same scenario over the same time-frame, Bulgaria's population only decreases 28 percent. Add positive net immigration at the current EU level and these populations would instead increase, Romania by 17 percent and Bulgaria by 6 percent.

Hungary, which has had small positive net migration over the past twenty years, could limit its population decline to 11 percent by holding net migration steady and embracing strong family support policies. Instead, its current government has proposed the sort of pro-natalist policies that have proven ineffective in the past, such as subsidies to encourage families to have three or four children. More effective, both narrowly in terms of increasing fertility and broadly in terms of social well-being, would be policies to help young couples have the one or two children many of them want, without having to sacrifice their careers or go into poverty.

Southern Europe

Low fertility/high net migration countries in this region are propping up population numbers through high immigration levels under status quo policies. Without heavy immigration, Spain's and Italy's populations would already be declining, since their TFRs have been below replacement rate since the early 1980s and are now well below it. Under zero net migration scenarios, Spain's population decreases by 46 per-

[1] *Sobotka* (2003) argues that the countries of Central Europe and Eastern Europe are following somewhat different paths, the former moving toward western European norms of later child-rearing and the latter shifting toward larger proportions of one-child families.

cent and Italy's by over 50 percent by 2100. These countries cannot cut back significantly on immigration without either embracing egalitarian economic and family support policies to increase fertility rates, or accepting significant population declines this century.

Greece and Portugal, averaging more modest positive net migration over the past twenty years, instead face steep population declines in coming decades under status quo scenarios and all projected fertility scenarios. Their choices going forward are somewhat similar to Italy's and Spain's, however: accept higher net migration numbers, boost support for family-formation and create stronger economic safety nets for common citizens in order to maintain their populations, or accept rapid population decline. Interestingly, for Italy and Spain, the status quo scenario and a scenario combining half status quo migration and a strong egalitarian shift in family support policies lead to relatively similar results, coalescing around a fairly stable population, while for Greece and Portugal this combination scenario leads to significantly less population loss. A combination of increased support for family formation and decreased immigration might be appealing to many residents of these countries, especially given relatively high unemployment rates throughout the region.

Northern European countries

With high fertility and high immigration levels these countries will see signifcant population growth this century under status quo policies, and some growth under most plausible policy scenarios. An example is Sweden, which is on track to increase its population 52 percent by 2100 under status quo fertility and immigration policies. Increases in immigration levels could lead to much larger populations throughout northern Europe, as seen in the table below:

Tab. 6: Percentage change from current population by 2100, under different immigration scenarios in Northern Europe. Scenarios leading to > 50 percent population increase are shaded

	Zero net migration	½ status quo	Status quo migration	2X status quo	4X status quo
Denmark	- 19	- 2	16	54	142
Finland	- 35	- 22	- 11	15	71
Sweden	- 9	23	52	124	276

Source: own calculations

With wealthy societies, low population densities (by European standards) and a post-war tradition in some countries of taking in large numbers of refugees, significant increases in immigration levels are a real possibility – although there is also considerable opposition to such increases, as demonstrated in recent elections.

Western European countries

With medium to high fertility and high immigration levels, these countries are mostly on track for relatively stable to moderately increasing populations under status quo policy scenarios (Table 7). While increases in immigration levels could lead to much larger populations, such as increases of 186 percent in Belgium and 167 percent in the UK under our highest immigration scenario, decreases could lead to significantly smaller ones, such as a 38 percent decline in Germany and a 24 percent decrease in the Netherlands at zero net migration. As in the rest of Europe, policy-induced changes in fertility rates could also change future population numbers substantially, albeit to a lesser extent.

Tab. 7: Percentage increase from current population by 2100, under different immigration scenarios in Western Europe. Scenarios leading to > 50 percent population increase are shaded

	Zero net migration	½ status quo	Status quo net migration	2X status quo	4X status quo
Austria	-36	-9	16	72	195
Belgium	-23	>-1	26	74	186
Czech Republic	-37	-25	-14	8	61
France	-9	2	13	35	88
Germany	-38	-19	-2	37	123
Ireland	-6	23	51	111	245
Luxembourg	-33	50	117	267	600
The Netherlands	-24	-12	-2	25	82
United Kingdom	-18	3	24	68	167

Source: own calculations

5.2 Impact on population aging

Fertility and migration policies will have only a moderate influence on the pace of future population aging, with migration policy changes having a stronger potential impact. For the EU-28 population, the proportion of the population 65 years and older and the dependency ratio will be higher in 2100 than they are today under all scenarios (Table 8), so some aging is inevitable. Of all the scenarios, increasing long term average net migration 4 times would do the most to slow the pace of aging, with the dependency ratio increasing 10 percent instead of 17 percent as under the status quo scenario, while increasing the proportion of the population 65 years + by 2.2 percent instead of 7.2 percent. But in exchange for these modest improvements, these immigration policy changes would add an extra 475 million people to the total EU population (933 million instead of 458 million under the status quo scenario).

Pursuing the strong egalitarian family policy scenario would improve the dependency ratio roughly as much as under the 2X status quo migration scenario. In the other direction, the strong neoliberal family policy scenario would increase the

Tab. 8: The impact of five migration and five fertility policy scenarios on three measures of societal aging in the EU as a whole

Year	Migration scenarios					Fertility scenarios			
	Status quo Scenario	Zero net migration	Half status quo	2X status quo	4X status quo	Strong neoliberal	Moderate neoliberal	Moderate egalitarian	Strong egalitarian
					Working age population (%)				
2016	65.3	65.3	65.3	65.3	65.3	65.3	65.3	65.3	65.3
2050	57.8	56.4	57.1	58.9	60.4	58.7	58.2	57.4	57.0
2100	58.8	56.5	57.9	60.1	61.3	57.3	58.2	59.3	59.6
					Dependency ratio (%)				
2016	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2
2050	73.0	77.3	75.0	69.7	65.5	70.5	71.7	74.3	75.5
2100	70.0	76.9	72.8	66.5	63.2	74.5	71.9	68.6	67.7
					Population 6 5 + (%)				
2016	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
2050	27.7	30.0	28.8	25.7	22.5	28.9	28.3	27.1	26.5
2100	26.4	29.9	27.9	24.3	21.4	30.8	28.5	24.4	22.7

Source: own calculations

percentage of the population 65+ by an additional 4.4 percent in 2100, comparable to the zero net migration scenario, while it would increase the dependency ratio by an additional 4.5 percent, comparable to cutting immigration to one quarter of current levels. But once again, the impacts on total population numbers would dwarf the impacts on aging.

5.3 Comparison with other studies

Our fertility and migration scenarios give projection results that are roughly comparable to the results from other recent European-wide studies, while linking those results more clearly to available policy choices. Compare in this regard our migration scenario projections to recent projections from *Eurostat* (2015), the *United Nations* (2017b) and the *Wittgenstein Centre for Demography and Global Human Capital* (2018) in figure 3 below.

Results from our zero net migration, status quo and 2X status quo scenarios are broadly comparable to the no migration, median or "most likely," and high migration projections from these other studies. The clear outlier is our 4X status quo scenario which graphs a much higher sustained high immigration level than any major study to date. The justification for providing this scenario has already been provided. Note that the supply is already in place, with hundreds of millions of young people in the developing world living in rapidly-growing societies that struggle to provide them with the jobs and material well-being they desire. Whether EU countries (or the EU as a whole, under a strengthened centralized government) will enact policies that increase immigration this much is doubtful, yet possible.

6 Discussion

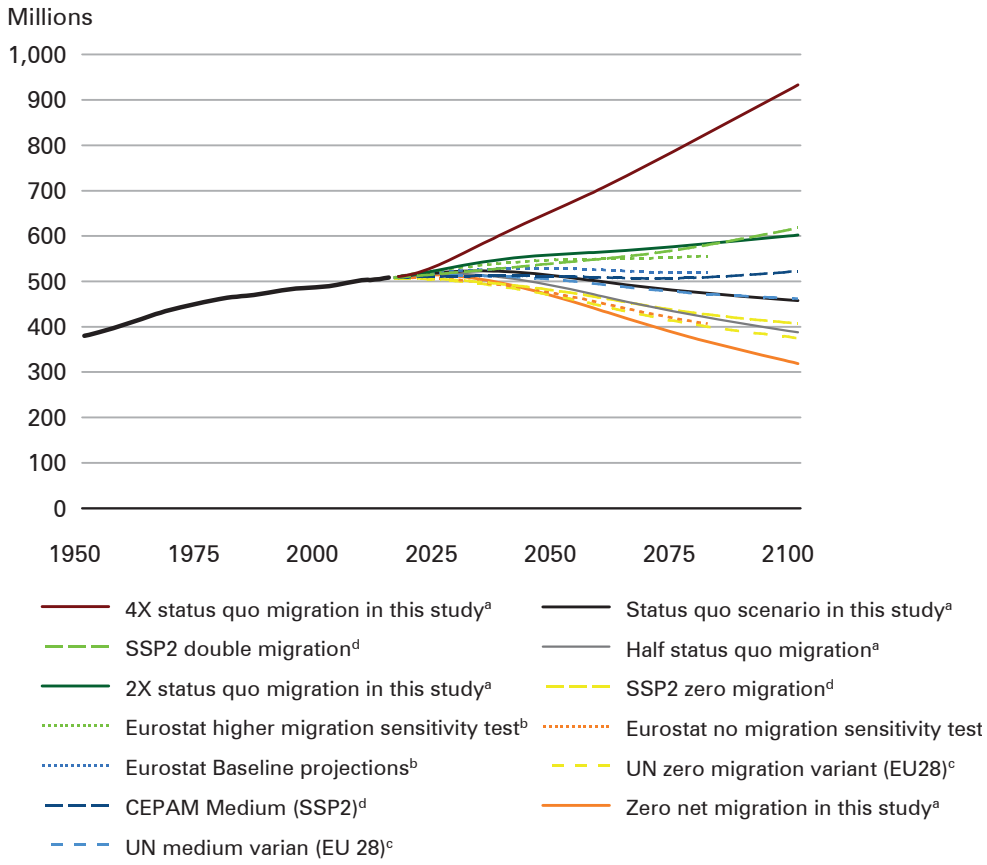
What conclusions can we draw from these projections regarding our main research questions? We would direct attention to five key points.

(1) Migration policy offers greater scope for influencing future population numbers than changes to family support policies, or changes to other fertility-related economic policies in the EU.

Changing fertility does influence population size. But in a context of relatively low-fertility regimes where policy changes' impacts on fertility are often fairly small, changes to national immigration levels could have a much greater impact going forward.

For Germany, Europe's most populous country, the more likely scenarios for fertility variation range between 1.55 TFR and 1.85 TFR, leading to a potential difference of 15.4 million people in 2100 (72.9 million versus 88.3 million) (figure 4). In contrast, the three more likely net migration scenarios generate a 3X greater spread, ranging across 46.6 million people (Fig. 5). Considering the full range of fertility change scenarios, including less likely but still possible low and high scenarios of 1.4 TFR to 2.0 TFR, doubles the potential range across Germany's 2100 population to 31.1 million. But considering the full range of possible migration scenarios in-

Fig. 3: Comparing the policy-based migration scenarios for 28 EU member states in the present study with the migration scenarios in other published region-wide or world-wide studies

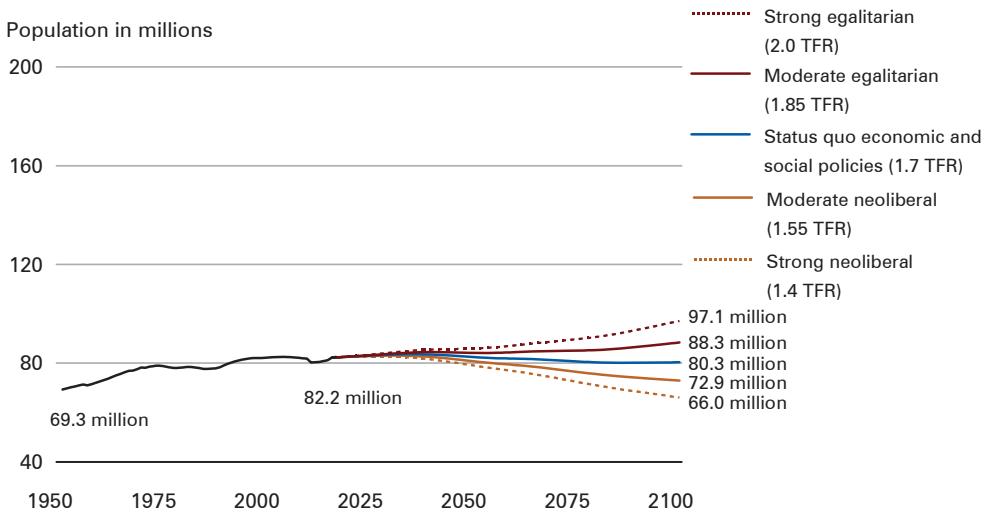


Sources: [a] – own calculation; [b] – *Eurostat Database* 2015; [c] – *United Nations Population Prospects* 2017; [d] – *Wittgenstein Centre for Demography and Global Human Capital* 2018.

creases the 2100 population spread by over 100 million more. While the full range of fertility scenarios all lead to populations in 2100 that are broadly commensurate with Germany's present population of 82.2 million (80 percent to 118 percent of current numbers), the extreme migration scenarios would lead to much more drastic changes: from 62 percent of the current population under the lowest scenario to 223 percent under the highest. Similar results, with much higher ranges across migration scenarios than fertility scenarios, obtain for most EU countries and for the EU as a whole, as we saw earlier.

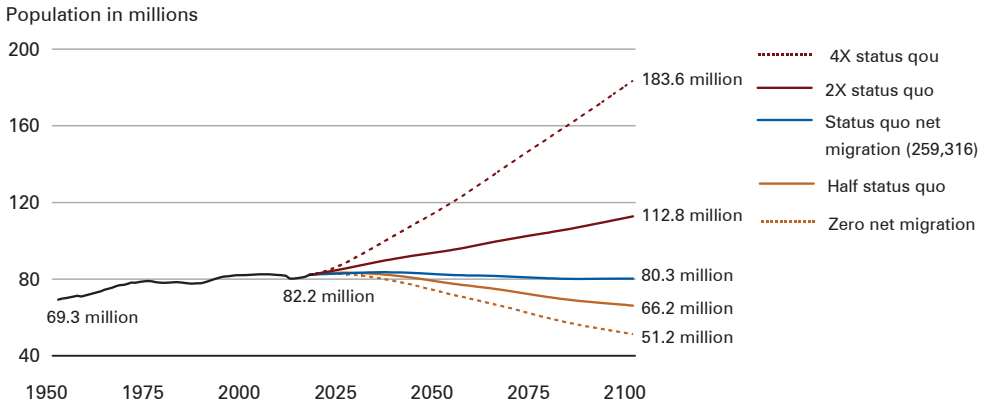
(2) *Egalitarian economic and family support policies and increased net migration have significant potential to mitigate excessive population decreases in the EU's lower fertility countries.*

Fig. 4: Germany population projections under five fertility scenarios: All scenarios assume the continuation of the past 20 years average annual net migration level (259,316)



Source: own calculations

Fig. 5: Germany population projections under five migration scenarios: Status quo migration is the continuation of the past 20 years average annual net migration level (259,316). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs



Source: own calculations

Several eastern European countries with low fertility levels and high emigration rates are on track for rapid depopulation this century. While the dangers of small population decreases are often overblown, too large or too quick decreases could

cause social problems in these societies (*Rees et al.* 2012; *Jakovljevic/Laaser* 2015). So it is good to know that part of this potential decrease could be avoided by adopting the economic and family support policies that have proven so successful at boosting fertility rates and improving lives in northern Europe. Consider Poland, the most populous EU country facing significant population decline (see projections in appendix III).

Under status quo policies that provide little support for women who want to combine careers with creating a family (*Mishtal* 2009), Poland's population is set to decline 44 percent by the end of the century. Combining increased net migration up to the current EU status quo net migration rate with a strong increase in support for family formation would instead increase Poland's total population 4 percent by 2100. Similar reflections apply to Romania, Bulgaria, Italy, Portugal, Greece and other countries in eastern and southern Europe that could see significant population losses over the next 80 years. It is particularly noteworthy that some of the same economic policies that could raise national fertility rates would also increase economic security, possibly decreasing emigration by younger workers. While these policies, such as improved child-care programs and paid family leave for workers, are expensive, they hold out hope for a slow, manageable population decrease rather than a precipitous decline in these countries (*Frejka/Gietel-Basten* 2016).

(3) In most cases, EU nations are well placed to stabilize or slowly reduce their populations–thus achieving one of the necessary conditions for creating ecologically sustainable societies.

We can see this in many of the status quo scenarios, which tend to stay relatively flat throughout the 21st century: often within 10 percent of current population figures (Holland, Italy, Germany) and if not, then within 20 percent of current numbers (France, Spain, Denmark, Czech Republic). In replenishing their populations, these countries have room to shift the balance somewhat between immigration and births to citizens, either in one direction or the other, while still keeping their populations stable or moderately declining. This can be seen by comparing the status quo fertility and migration scenarios with the ½ net migration/strong family support policy combination scenarios in Table 9.

A few countries, like Belgium and the United Kingdom, are set for larger population increases this century under a continuation of status quo fertility and migration policies. Such increases could be mitigated by decreasing immigration levels, which would likely be more popular than decreasing fertility rates by cutting economic safety nets or support for family formation. On the other hand, higher net migration levels could lead to much high population growth across the continent.

(4) An egalitarian shift in family support policies or increasing immigration levels are not effective remedies for population aging in the EU.

In accordance with other recent studies (*Craveiro et al*. 2019; *Lutz et al.* 2019) and contrary to many political discussions, encouraging more immigration from external countries into the EU or increasing fertility rates by means of successful government initiatives will not significantly slow population aging in the EU. Even increasing net migration levels 4 times would do little in the long-term to reduce the dependency ratio or the proportion of the population 65 years or older (see

Tab. 9: Percentage change from current population by 2100, under four policy scenarios, for the EU's ten most populous countries. Scenarios resulting in relatively stable populations (+/- 15 percent) highlighted

	Status quo migration & status quo family support	½ status quo migration & strong egalitarian policy shift	2X status quo migration & status quo family support	2X status quo migration & strong egalitarian policy shift
Germany	-2	0	37	58
France	13	28	35	59
UK	24	29	68	90
Italy	-8	-13	34	54
Spain	19	5	83	107
Poland	-26[a]	---	12[b]	36[c]
Romania	-5[a]	---	31[b]	59[c]
The Netherlands	-2	11	25	46
Belgium	26	23	74	105
Greece	-36	-25	-25	-11
EU total	-10	-4	18	38

[a] Shows the EU status quo migration rate & status quo family support scenario

[b] Shows the 2X EU status quo migration rate & status quo family support scenario

[c] Shows the 2X EU status quo migration rate & strong egalitarian policy shift scenario

Source: own calculations

Table 8). This is due to the fact that immigrants, like non-immigrants, age and retire, requiring social benefits and medical care. The fertility scenarios discussed in the present paper show an even smaller impact on aging measures than our migration scenarios. Meanwhile fertility and especially immigration increases show a much greater capacity for increasing total population numbers.

In exchange for a small improvement in dependency ratios in 2100 (66.5 instead of 70.0 under the status quo), doubling net immigration into the EU over that period would add 145 million more residents to the total population (602 million rather than 458 million). Increasing immigration 4X would improve the dependency ratio slightly more, to 63.2. But that would still be a full ten points higher than today's 53.2 and in exchange the EU would have to support 475 million more people than it would under a status quo migration scenario – with all the increased environmental demands (*Marques et al.* 2019) and social contention (*Harmon* 2018) that such increased numbers imply. The moral is that to the extent aging societies create economic problems, the most effective remedies will involve increasing labor-force participation and other systemic changes, rather than increasing either net migration or fertility rates (*Götmark et al.* 2018).

(5) Demographic policies have the potential to significantly raise or lower future populations, and hence to make it harder or easier for EU nations to create ecologically sustainable societies.

In a world where the population growth rate is slowing down and most future population growth is projected for the developing world, it is easy to overlook the importance of demographic policies to *developed* countries' futures. Arguably this is misguided. Many western and northern European nations are pursuing population policies that could significantly increase their populations in the coming years and hence increase their countries' total ecological footprint, which is a function of the size of their population and their per capita consumption of resources (*Lin et al.* 2019). *Ceteris paribus*, more people mean more consumption and pollution, more greenhouse gases emitted, etc. (*IPCC* 2014; *Díaz et al.* 2019). There is abundant evidence that humanity's current biophysical demands are already far in excess of what is ecologically sustainable (*Ripple et al.* 2017) and this problem must be tackled both by decreasing overconsumption and ending population growth.

Other EU countries, whose fertility levels could lead to shrinking populations and hence help lessen their environmental footprints, are instead bolstering their populations through historically high immigration levels. Germany, Italy and Spain are important examples. Spain, with a current TFR of 1.34, is on track to increase its population by 8.5 million by 2100. With the same low current TFR, Italy's population will decrease by only 3.5 million people this century under the status quo. Accepting rapid population decline is probably not to be expected of any nation's leaders. But accepting some population decrease in wealthy, crowded societies may be advisable, given the environmental benefits of smaller populations (*Matanle* 2017; *Pilling* 2018).

7 Conclusion

In developing new policy-based population projections, we have shown that some policy choices have the potential to substantially increase future European population numbers. Both family support and migration policies will influence these numbers, with migration policies likely having the greatest impact. The potential increases under more expansive policy scenarios would not be as large, either as a percentage change or in absolute numbers, as those that occurred in India and China during the past century, or those being predicted for Africa during this one. This fact should not mislead us. Increasing Europe's population by even 100 million more people would be a very big "ask" on nature; decreasing it by 100 million people would be a substantial gift. As a matter of *de facto* environmental policy, demographic decisions will be at least as important as any other policy courses charted by EU nations this century, since they impact all aspects of a country's environmental situation. In a recent working paper, we use these projections to explore population policies' potential impacts on future efforts to reduce the EU's greenhouse gas emissions and preserve its biodiversity (*Cafaro/Dérer* 2018).

Precisely how demographic policies impact such efforts demands further study (*Rust/Kehoe* 2017). So do population policies' impacts on economic equality and social solidarity. By tying our population projections more explicitly to actual policy options than previous efforts, we hope to facilitate other researchers' efforts to ask and answer such questions. By providing a full range of population projections for all the countries of the EU, we believe we have made it easier for concerned citizens from these countries to do so, as well.

According to the UN Human Development Index, European nations are among the world leaders in terms of health and longevity; in wealth and sharing that wealth equitably; in securing honest governments that serve their citizens and uphold the rule of law; and in promoting tolerance and ensuring human rights (*United Nations Development Programme* 2018). But the EU's demographic challenges and opportunities are complex. Which population policies will best sustain flourishing societies remains to be determined. Getting this right is important in Europe – and beyond. A world caught up in an economic system built around the uncritical pursuit of growth and bumping up against ecological limits (*O'Neill et al.* 2018) needs to see that the socio-economic challenges of aging and shrinking societies are inevitable but manageable (*Götmark et al.* 2018) and that international solidarity can be combined with demographic responsibility (*Cafaro* 2015).

As we have shown, most EU countries are well placed to stabilize or slowly reduce their populations. Europeans' great contribution in the twenty-first century could be to model successful societies that do not depend on continued growth, but that instead prioritize societal well-being and an acceptance of limits (*Kallis* 2018). We hope these population projections are a useful tool for exploring such questions and ultimately for imagining and creating such societies.

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