Ways to project fertility – how do European countries project fertility and what are their perceptions of current practices?

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Abstract

Norway is currently considering changing the way we project fertility. This paper aims to describe the different ways various European countries project fertility in their national population projections, to establish a solid basis for deciding the way forward. Data is collected in two steps: First, the Offices of National Statistics (ONSs) in Europe were asked to respond to a questionnaire regarding their current practices. These results were summarized qualitatively. For a quantitative overview, the different methods used by the participating countries were categorized into four broad groups: 1) Model-based, deterministic projections 2) Model-based stochastic projections (frequentist and/or Bayesian approaches); 3) Expert-based projections; 4) Other methods. A descriptive analysis of similarities and differences was performed to assess which methods were most common, how satisfied the ONSs were with their method, the public availability of documentation, and the extent to which the accuracy of the projections was assessed short- and long-term. Second, eight countries were selected for a more in-depth analysis. The countries represent a variety of ways of projecting fertility, to illustrate the range of options available and in use across Europe. We examined readily available information and documentation online, as well as reports and journal articles. For comparison purposes, this study also includes the fertility projection methods utilized by Eurostat and the UN. Strengths and weaknesses associated with the different methods are presented, discussing both the comments and feedback from the ONSs, as well as those emerging in a broader perspective based on the comparisons made in this study.

Introduction

Population projections are widely used by governments, policy makers, planners, and organizations around the world because they provide a "…picture of what the future size and structure of the population by sex and age might look like" (Insee, 2019). Population projections are made by national governments in many countries around the world, as well as by international organizations like the United Nations (UN) and Eurostat who both project population at global and national levels.

Three components are important when projecting population of a geographic area; fertility, mortality, and migration, and the interaction between these three components create population growth or decline. Thus, assumptions about fertility, mortality, and migration, in combination with past trends, comprise a basis for projecting population trends for years to come (Insee, 2019). Over the past years, (international) migration has become perhaps the most challenging component when creating population projections as it is more difficult to project compared to fertility and mortality (PRB, 2019). Migration changes are often a result of "short-term changes in economic, social or political factors that are hard to predict or quantify" (PRB, 2019).

However, fertility continues to be a much-debated topic as "close to half of all people globally live in a country or area where fertility is below 2.1 births per woman over a lifetime" (UN WPP, 2019, p. 2). Total Fertility Rate (FTR) can be defined as "the average number of children a woman would bear if she survived through the end of the reproductive age span, experiencing at each age the age-specific fertility rates of that period" (Alkema et al., 2011, p. 816). The impact of fertility projections is substantial, as the cumulative effect over generations can have huge consequences for a country as "…slightly higher fertility will

play out over several decades" (UN DESA, 2013, p. 2) and vice versa when projected fertility levels are set slightly lower. Thus, it is of great importance to utilize well-tested and well-assessed methods for projecting future fertility.

In general, population projections tend to become less accurate the further away they are from the date of the projection. Thus, when projecting fertility for the next 50 years, the likelihood is that the projected numbers for 2050 will be less accurate than the projected numbers for 2025. However, because of the great variation in methods that exists for population projections, the accuracy and margin of errors varies. Regardless of method there will always be potential errors when projecting fertility for future years, but an important reasoning behind a chosen method should be to increase the likelihood of projecting numbers that are as accurate as possible. When explaining and comparing fertility, one can look at either period-fertility or cohort-fertility (Rowland, 2003). However, past research highlights challenges when trying to choose a method for projecting fertility as little information exists on *how* to choose among the methods available (Bohk-Ewall, Li, & Myrskylä, 2018). As period-fertility is utilized in most national projections, this study is limited to the assumptions made to project period-fertility.

Statistics Norway is currently considering changing the way in which we project fertility. The aim of this study is to explore the different methods employed to make assumptions about future fertility and to project fertility by countries across Europe, to assess their strengths, and weaknesses. The present study is a mixed-methods study, consisting of two-parts. The first is a document review based on the available information on current practices across Offices of National Statistics (ONSs) in Europe, as well as the UN and Eurostat. The second part of the study comprises a survey regarding current practices, benefits, and potential suggestions for changes in how fertility ought to be projected. The survey has currently been piloted in the Nordic countries and will be distributed to the rest of the Eurostat countries in November 2019. An underlying goal of the study is to enable both Norway and other countries to use this explorative study to help evaluate whether their current methods for fertility projection are adequate or if other approaches might be worth considering.

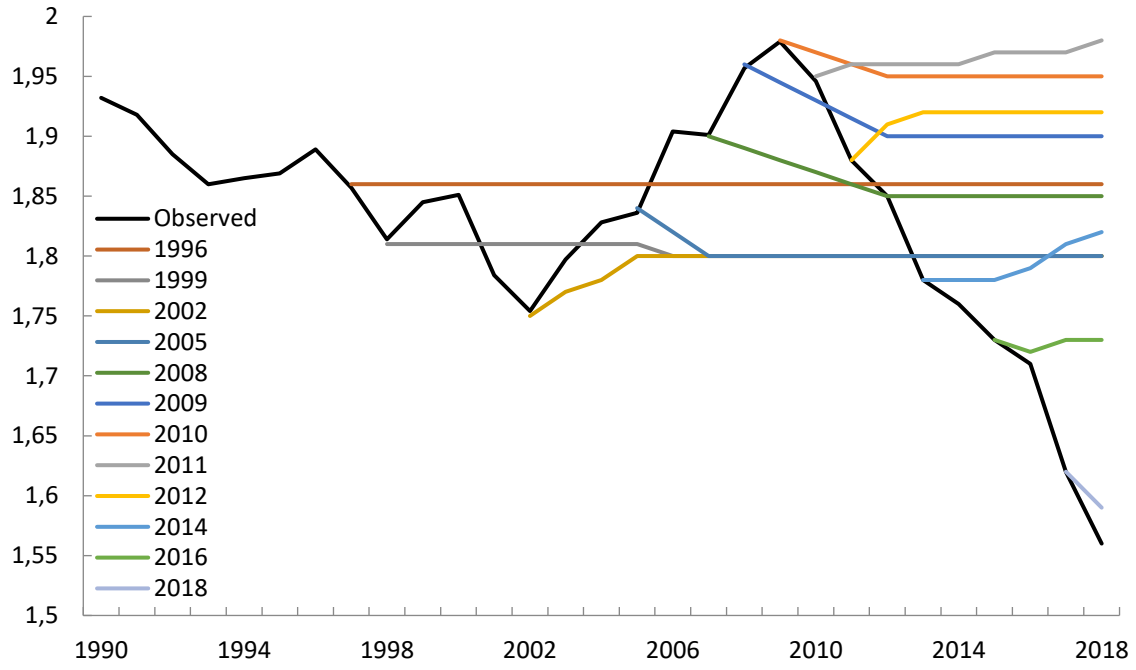
Norway – current method

Future population development in Norway is projected by Statistics Norway using the cohort-component method. The projections are deterministic and a total of 15 alternatives is produced, differing in their combinations of assumptions for the components of life expectancy, fertility, internal migration and international migration. The main alternative (MMMM) uses a medium level for all components. For the national projections, fertility is projected for 16 different groups of women, depending on country group of origin (4 groups) and for immigrants, length of stay in Norway (5 groups) in Norway (Statistics Norway, 2018). Three different scenarios are calculated for the fertility assumptions: low, medium (main alternative), and high. In practice, three annual factors are determined, one for each alternative. This factor raises or lowers the fertility of native women to a level determined after analyses of historical developments and expert consultations with a multidisciplinary advisory group consisting of fertility researchers (Statistics Norway, 2018, p. 41). The respective annual factor is applied to produce assumptions of future fertility by multiplying it with the current age-specific fertility rates. The same factor is used also for the 15 other groups of immigrant women, but because their age-specific fertility rates vary, the total TFR differs between all groups. Since the distribution of native and immigrant women varies across the projection period, the total TFR for the country as a whole is a result, rather than an assumption, in our set-up. The fertility assumptions and projections are published biennially. Currently, the fertility is projected up to the year 2100.

Norway – how does past projections compare to observed?

When examining past fertility projections in Norway, there has been great variation in the preciseness of the projected fertility. Certain years, especially following the second world war, the projected TFR was too low, while the projected fertility for the 1970s and 1980s was too high (Rogne, 2016). Research indicates that population projections in developed countries often have had too generous fertility projections in the past (Keilman, 1991; Texmon, 1993; Texmon & Keilman, 1991). In a study examining projected and observed population changes in Norway in the years between 1996 and 2005, Rogne (2016) found that the deviations between the medium projected alternative and observed TFR did not follow a clear pattern (p. 67). However, there seems to have been a tendency of projecting fertility at a similar level as that observed the year prior to the production of the population projections, i.e. the baseline year (see figure 1.). Thus, the medium fertility has been projected too high during years with periods of high or increasing fertility, while projected fertility during years with lower or declining fertility rates have been too low.

Figure 1. Projected and observed total fertility rate (TFR)



Source: Statistics Norway.

Present study

Because of the great variation in methods used across countries that project fertility as part of their population projections, this study aims to examine the different methods utilized among European countries, as well as the methods used by Eurostat and the UN. The goal is an overall comparison of these methods, their strengths and weaknesses, and how accurate they are when projecting fertility. We also want to understand how ONSs regard their methods, including their usefulness, their ease of use, their accuracy and how they are communicated to the public.

This summary will enable Statistics Norway to compare their current practices with other methods that potentially might be a better option for projecting fertility. In addition, there are other countries that have indicated a need to improve their fertility projections, such as Luxembourg (Peltier, 2018). Thus, our hope is that this examination will be useful not only

for Norway, but also for other countries that are considering changing their methods or who are interested in a broader comparison of the different methods used by other countries when making fertility assumptions and projecting fertility.

Data and Methods

This is a mixed-method study, utilizing both qualitative and quantitative data and analytic techniques. First, the ONSs in Europe were asked to respond to a survey regarding their current practices. Some examples of questions asked were "Do you currently use a formal statistical model to project fertility?"; "In the data you use, what type of information is available?", and; "If you could choose freely, do you have any suggestions of changes to the way your country projects fertility?" The survey was piloted in the Nordic countries and relevant adjustments were made based on their feedback. The survey will be distributed to the ONSs in Europe in November 2019. When their responses have been received, approximately eight countries will be selected for a more in-depth analysis in the second part of this study. The survey responses will be compared and complemented with an examination of readily available information and documentation online, as well as published reports and journal articles. For comparison purposes, this study also includes the projection methods utilized by Eurostat and the UN.

For the pilot study, a total of 5 questionnaires were sent out to the Nordic countries (Sweden, Denmark, Finland, Faroe Islands, and Iceland). A total of 4 questionnaires were completed and submitted (as of November 1st, Finland's response is incomplete). Based on the responses and feedback, the survey has been adjusted. Below are the preliminary results based on the pilot study.

Results – document review

For the purpose of this extended abstract, the countries included in the document review are the countries participating in the pilot study, as well as the UN and Eurostat. For the final article, this section will highlight approximately eight of the participating countries. The countries will be chosen to represent various ways in which to project fertility, but will also be selected based on the availability of detailed documentation of their projection methods, as examples of "best practices", in addition to the UN and Eurostat.

United Nations

The UN Department for Economic and Social Affairs have produced 26 rounds of the World Population Prospects (WPP), projecting future population trends related to fertility, mortality, and international migration. Currently, data from more than 230 countries or areas are included. This review is based on the most recent WPP, published in 2019. It includes estimates of TFR going back to 1950, as well as fertility projections until 2100 (UN DESA, 2019a). The most recent revision of the WPP includes ten different projection variants that combined illustrates "…the sensitive of the medium-variant projection to changes in the underlying assumptions" (UN DESA, 2019b). Five of the ten variants differ with respect to the level of fertility. These are low, medium, high, constant-fertility, and instant-replacement-fertility and the comparison between. According to the UN, these five variants allow an assessment of the effects that different fertility assumptions have on other demographic parameters (UN DESA, 2019b). The main alternative used by the UN is the medium variant, in which the fertility assumption is a medium fertility level based on probabilistic methods which provide 80 and 95% prediction intervals (UN DESA, 2019b). The UN generates assumptions about future age-specific fertility rates for most countries by projecting forward the overall TFR and then converting the overall levels to age-specific rates taking into account

changing age patterns for fertility (Raftery, Alkema, & Gerland, 2014, p. 60). More details on the methodology used for the WPP 2019 will be included as soon as it is released.

The fertility projection model in the most recent WPP had three major updates, first to "…include the experience of a larger number of countries currently with low levels of fertility (UN DESA, 2019a, p.1). Second, the model utilized to "…project the age patterns of fertility was also updated to include new empirical evidence. The projection model combines past national trends of the age pattern of fertility with a trend leading towards a global model age pattern of fertility" (UN DESA, 2019a, p. 1). Lastly, the level of fertility projected for countries with fertility below 2.1 live births per woman was adjusted "…to smooth the transition between a recent downward trend in fertility and an expected future increase" (UN DESA, 2019a, p. 1). To illustrate the uncertainty of the fertility projections, UN utilizes probabilistic methods (Bayesian) that take into account the past experience of each country, while also reflecting uncertainty about future changes based on the past experience of other countries under similar conditions (UN DESA, 2019c).

Eurostat

Eurostat, the statistical office of the European Union, produces population projections every three years using data on births, deaths, and migration reported by countries in the EU, the European Economic Area (EEA), current EU candidates, as well as countries that are part of the European Neighborhood Policy (ENP-countries). Data on population demography such as fertility is reported by the individual countries to Eurostat every year. The most recent population projections published, EUROPOP2018, was published June 2019 and provides national estimates for 31 countries (Eurostat, 2019c).

To project TFR, Eurostat utilizes a statistical model that combines "…a country-specific trend extrapolation and the convergence assumption" (Eurostat, 2019b, p. 3). The convergence assumption has been assessed on past trends of fertility (Lanzieri, 2009) and can be summarized as "…socio-economic differentials among EU Member States are expected to be fading out in the very long term" (Eurostat, 2017, p. 3). Thus, it is assumed that the countries are following a similar pattern of demographic development and the model combines this assumption with an extrapolation of four parameters using Schmertmann's (2003) model for age specific fertility rates. The trend extrapolation has full weight for the years before and including 2020 (Eurostat, 2019b). After 2020 "…the convergence assumption starts operating, with linearly increasing weight towards the end of the projections period. Country-specific trend extrapolations are obtained from a constrained ARIMA(1,0,1) applied to the time series 1950-2017. Missing Eurostat TFR data have been replaced with data extracted from the Human Fertility Database. Convergence is modelled by assuming a tendency of fertility in all countries towards an ultimate value never reached during the horizon of the projections, namely equal to 1.83. This value represents the maximum TFR that UN's World Population Prospects 20194 project for 2100 for the countries included in EUROPOP2018" (Eurostat, 2019b).

Denmark

Denmark published their first population projection in 1963 and has produced projections annually since 1978. From 2010, Statistics Denmark has made their projections in cooperation with DREAM (The Danish Research Institute for Economic Analysis and Modeling), an independent semi-governmental Danish research institution. Each February, Statistics Denmark update DREAM with the most recent data on immigration, emigration, births, deaths, and change in citizenship. DREAM utilize this data to run "the actual projection model for the whole of Denmark" (Statistics Denmark, 2019, p. 2) and provides Statistics Denmark with the data used to publish the national population projections (Statistics

Denmark, 2019). Statistics Denmark used to have an expert panel for fertility projections, but that was terminated in 2019. The fertility assumptions are now calculated using two formal methods; the Richards Curve for the convergence for the short-term towards the long-term development and the Cubic Spline Smoothing to calculate the trend in the age-related fertility. Denmark's population projections are deterministic (based on historical experience) and creates only one scenario utilizing one set of assumptions (Statistics Denmark, 2019).

Finland

Statistics Finland published the first population projection in 1934 and are currently publishing projections biennially. Statistics Finland utilizes a demographic component method and "…future population number and structure are calculated by means of age-specific birth rate, mortality and migration coefficients" (Statistics Finland, 2019). The coefficients for fertility are calculated "on the basis of demographic statistics for the last few years" (OSF, 2019). To predict fertility, both number of births as well as age-specific fertility rates are calculated. For the latest fertility productions (published in 2019), the number of births were calculated by grouping municipalities "into 74 fertility areas on the basis of the total fertility rate in the years 2014 to 2018." (OSF, 2019). Age-specific fertility rates are calculated for the aforementioned fertility areas and each area have identical fertility coefficients. When projecting fertility, the rates are kept "constant throughout the projection period" (OSF, 2019). In their latest fertility projection (2019), Finland made national projections up to 2070 and provide only one alternative, in which the TFR is constant.

Iceland

Iceland publishes population projections on an annual basis, utilizing a combination of the cohort model and "certain expert assumptions on some components" (Calian & Harðarson, 2015, p. 3). For the expert assumptions on fertility, they have three variants (Calian & Harðarson, 2015, p. 9). Because of its small population size, Iceland faces certain challenges when calculating fertility rates and is therefore utilizing a functional data approach based on Hyndman et al. (2007). The fertility projections are created "using functional models with time series coefficients according to [the] functional data method" (Calian & Harðarson, 2015, p. 3). The long-term fertility projections "are constrained to converge to fixed values given by expert assumptions… the (independent) assumptions are very close to the estimated confidence interval bounds given by the model" (Calian & Harðarson, 2015, p. 4). Statistics Iceland obtain both short- and long-term projections, and for the long-term fertility projections a total of three alternatives are created; low, medium (main), and high. The low and high represents prediction intervals, resulting from probabilistic methods.

Sweden

Statistics Sweden is responsible for the population projections in Sweden and publishes population projections on an annual basis. Sweden has a long history of producing population projections. Sweden does not utilize a formal model for projecting fertility. Instead, fertility is projected using a cohort model with a parity component for the Swedish-born women. No parity-specific assumptions are made for foreign born women, instead, foreign-born women are divided into six groups based on country of birth (Nordic countries, non-Nordic countries of the EU27, non-EU27 countries in Europe, or a non-European country grouped by the UN Human Development Index; high, medium or low). When making fertility projections for foreign-born women, Statistics Sweden uses annual age specific fertility rates that have been projected for each country in the birth group. Several deterministic alternatives are provided, as well as stochastic prediction intervals. The fertility assumptions are revised every third year based on advice and viewpoints from an expert reference group.

Results - survey

Below is a preliminary comparison of the countries from the pilot study, in which the Nordic countries were invited to participate (Sweden, Denmark, Finland, Iceland, and the Faroe Islands). Four of these countries have participated as of November 1, 2019. The survey will be distributed to the countries that partake in the Eurostat collaboration in November this year, and the results will be analyzed and included in the final article which we hope to present at the EPC2020 in June 2020.

In this study, the Faroe Island is viewed as being distinct from Denmark as they make their own population projections. It should be noted that the population composition and size vary between the four pilot countries, ranging from the Faroe Islands with around 49,000 people (2017) to 10,1 million people in Sweden (2018), which impacts the type of methods they utilize for their population projections, as well as the resources available.

Use of formal statistical models

Three of the four, Iceland, Faroe Islands, and Denmark, are currently using formal statistical models to project fertility. While Iceland is utilizing a functional modelling approach, stochastic population forecasts using functional data models for fertility, as well as integrated long-term expert assumptions, Denmark is using Cubic Spline Smoothing and the Richards Curve for the convergence from the short- to the long-term development. As in Iceland, the Faroe Islands are also utilizing a stochastic fertility model. Only Swedish fertility assumptions are based on deterministic methods. All countries, except Denmark, provide several alternatives. The Faroe Islands updates their fertility projections most often (monthly), while the three other countries make updates annually. While Sweden and Iceland rely on a panel of expert assumptions, Denmark eliminated this as of 2019.

Evaluation of most recent population projections

When asked to evaluate the most recent population projections, three countries answered that the information available for making the fertility projections were adequate, while Denmark are currently exploring whether they can elaborate on the input used in the fertility calculations and part of this exploration involves testing whether their current method is adequate or not. All four countries felt that enough time is spent on fertility projections and that the frequency of updates is adequate. While Sweden explained that the number of scenarios/levels provided are not detailed enough, Denmark is currently testing this. Denmark is also currently evaluating whether their fertility projections are adequate, while the three other countries answered that they view the fertility projections as adequate as of now. Iceland mentioned that they are currently experimenting with Bayesian methods, with the goal of improving small population estimates of rates and to incorporate expert assumptions into the models in a more nuanced way.

Discrepancies between projected and observed fertility

In regard to discrepancies in trends between projected and observed fertility, Denmark reported that because fertility varies, it is challenging to grasp these variations in their calculations and thus the projected fertility is currently a little higher than the observed fertility. While the Faroe Islands reported that the results look reasonable, Iceland reported that for the past two years, the point estimate forecast fertility was above the true value, but the true was contained in the 80% prediction interval. Sweden has seen a decline in fertility since 2010, resulting in an overestimate of the projected fertility. However, for some groups of foreign-born, they have underestimated the fertility because fertility is higher during the first years in Sweden, i.e. immigrants with short lengths of stay.

Preliminary conclusions

Based on the pilot study, the four countries seem to view their methods for fertility projections as adequate, but with certain challenges. Although the challenges differ, the countries are experimenting and testing whether certain changes can improve their models and the projected fertility. A common trend seems to be a slight overestimation of predicted fertility levels over the past years in all countries except the Faroe Islands. This might be a result of the observed decline in fertility in the Nordic countries during the past decade, perhaps stronger than foreseen, in line with the conclusions for Norway in the review by Rogne (2016).

If we consider the document review, readily available documentation in English of the fertility assumptions and projections is limited to some degree, in various manners, for most countries, Norway included. Iceland is an exception, with available information online as well as in published articles. While Denmark and Finland provide information readily available in English, the Swedish documentation is thorough, but primarily available in Swedish. Faroe Islands is a small area, and limited information was publicly available in English.

To conclude, the Nordic countries are likely to benefit from increased interaction and exchange of ideas and views regarding fertility projections, and efforts to increase such collaboration have been initiated by the ONS of Denmark later this year. Furthermore, the meetings and seminars organized by Eurostat appears to be welcome, as further exchange of information outside the Nordic area appears warranted to improve fertility projections and learn from countries and organizations that do well in this area. It is our hope that this paper, once finished, can be a helpful resource – and to increase learning and the exchange of ideas across European countries to a greater extent than what is the case today.

The conclusions will be finalized by January 2020.

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