

24 February 2017

English only
(A summary document
carrying symbol
ECÉ/CES/2017/7 is available
in English, French and
Russian on the CES 65th
plenary session webpage)

Economic Commission for Europe

Conference of European Statisticians

Sixty-fifth plenary session

Geneva, 19-21 June 2017

Item 7 (f) of the provisional agenda

Population projections

Recommendations on communicating population projections

Prepared by the Task Force on Population Projections

Summary

The document presents for your comments the *Recommendations on communicating population projections* prepared by the UNECE Task Force on Population Projections.

The deadline for the reply is **24 March 2017**. Please send your comments using the attached feedback questionnaire to paolo.valente@unece.org.

Subject to the positive outcome of the consultation, the Recommendations will be submitted to the 2017 CES plenary session (Geneva, 19-21 June) for endorsement.

ACKNOWLEDGEMENTS

The present Recommendations have been prepared by the UNECE Task Force on Population Projections, which consisted of the following members: Patrice Dion (Statistics Canada, chair of the Task Force), Suzanne Dunsmith and Dan Horscroft (Office for National Statistics, United Kingdom), Nora Galbraith (Statistics Canada), Victor Garcia Vilchis and Felix Velez Fernandez Varela (INEGI, Mexico), Mehmet Dogu Karakaya and Neriman Can Ergen (TurkStat, Turkey), Raymond Kohli (Swiss Federal Statistics Office), Giampaolo Lanzieri (Eurostat), Lena Lundkvist (Statistics Sweden), Graça Magalhaes and Claudia Pina (Statistics Portugal), Marco Marsili (Istat, Italy), François Pelletier and John Wilmoth (United Nations Population Division), Paolo Valente and Fiona Willis-Núñez (UNECE).

In addition to the members of the Task Force, the following persons have been involved in the realization of the recommendations: Stacey Hallman (Statistics Canada) and Enver Tasti, Sebnem Bese Canpolat, Metin Aytaç (TurkStat, Turkey), and everyone who completed the user and NSO surveys produced for the purpose of this document. The Task Force wishes to acknowledge with much appreciation their contribution.

Finally, the Task Force expresses its deepest gratitude to everyone who kindly accepted to review preliminary versions of the recommendations: Lina Bassarsky, Jakub Bijak, Dalkhat Ediev, Patrick Gerland, Danan Gu, Nico Keilman, Ronald D. Lee, Mark Wheldon and Frans Willekens. The Task Force is also grateful to the people who attended the presentation and discussion of the preliminary recommendations at the Eurostat/UNECE Work Session on Demographic Projections in April 2016.

PREFACE

The Conference of European Statisticians (CES) provides a platform for coordinating international statistical work among its member countries. Its main objectives are to improve national statistics and their international comparability, to achieve greater uniformity in concepts and definitions across national statistical offices, and to discuss and adopt statistical standards.

Each year the CES Bureau reviews selected statistical areas in depth to improve coordination among statistical agencies, to identify gaps and address emerging issues. These reviews conclude with concrete recommendations and may result in the establishment of a Team of Specialists to carry out specific tasks related to these recommendations.¹ One such in-depth review concerned the topic of population projections. Following this review, the CES Bureau decided in October 2014 to establish a Task Force to evaluate the communication of population projections. The objective of the Task Force was two-fold: to provide a series of good practices and recommendations on communicating population projections and to develop a database of existing population projections in UNECE countries. The present document responds to the first objective of the Task Force.

¹ In-depth reviews can be consulted at <http://www.unece.org/stats/ces/in-depth-reviews/poppro.html>.

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INTRODUCTION

The objective of this document is to provide a series of good practices and recommendations how to effectively communicate the results of population projections, in line with the Task Force's terms of reference. Here, communication encompasses not only the means by which projections should be disseminated to users, but also what should be communicated. Consequently, a substantial portion of this document aims to improve the coherence between what is produced by National Statistical Offices (NSOs) and what is needed by users, planners and decision-makers. The document does not address questions of methodology except on rare occasions where methods are discussed as ways to produce desired outputs.²

The good practices and recommendations come from various sources, such as practices of NSOs, the preferences of users, consultations among members of the Task Force and developments by academics and researchers in the field of population projections. While the opinions and practices were not always in consensus, efforts were made to represent all point of views and to clearly identify where agreement may be lacking.

When possible, examples of various NSOs' practices are provided. While these examples relate mainly to population projections by age and sex using the cohort-component method (by far the most commonly used), the good practices are broad enough that they encompass all kinds of projections (such as projections of households or projections of the population with certain characteristics) and methods (simple extrapolations, cohort-component method, cohort-progression methods, microsimulation, etc.). Similarly, the document does not specifically address issues or challenges related to subnational projections made for planners at local and sectoral levels, although it promotes an ongoing dialogue with users of population projections which is critical for ensuring that the projections respond adequately to the specific needs of these users.

Lastly, while it is not expected that NSOs and projection-makers in general will adopt all good practices and recommendations from this document, it is hoped that they will value them as general guidance and lines of reflection for possible improvements. Users of population projections may also find it instructive, as it details various ways that projection data can help decision-making.

The document starts with a methodology section in which a description is provided of the methods used for data collection, and some terms are defined. A series of good practices is then presented in four chapters, formulated as broad recommendations, and each tackling a distinct aspect of population projections: Provide pertinent results (chapter 1), Cultivate transparency in population projections (chapter 2), Address uncertainty explicitly (chapter 3), and Foster relationships with users (chapter 4). The document concludes by identifying areas for future development.

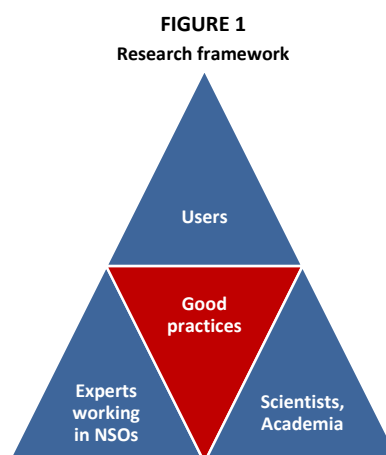
² Methodological aspects of population projections have been partially covered in a report provided by a panel of experts convened in 1998 by the National Research Council's Committee on Population (see NRC 2000). The panel was asked to examine the scientific foundation of the methodology and assumptions of recent population projections and to review their accuracy. While the exercise was focused mainly on world population projections, the report provides several recommendations that apply in large part to national and sub-national population projections.

RESEARCH FRAMEWORK AND METHODOLOGY

While population projection results appear simple on the surface—future population figures broken down by some characteristics (mainly age, sex and geography)—their speculative nature and the complexity of the process undertaken to build them require supplementing them with assessments of their uncertainty and thorough documentation. There are important challenges associated with these tasks, including often a poor understanding of user needs and/or perceptions and the general challenge of disseminating complex scientific ideas. In fact, the general concepts of forecasts or projections, and what can be expected from such exercises, are often themselves misunderstood.

These difficulties are not unique to demographers alone, but to scientists in general. In recent years, crafting adequate communication of complex science-related topics such as climate change or pharmaceutical research to non-expert audiences has proven especially difficult, with the acute danger of developing mistrust in science when unsuccessful. In fact, the difficulties in communicating science to the public have long been recognized and constitute a field of study in itself, most often referred to simply as *science communication*.

Inspired in part by some work in the field of science communication (e.g.: Bruine de Bruin and Bostrom 2013, Fischhoff 2013), the research framework developed to guide the production of this document aims to integrate several points of view: those of the experts working to produce population projections (NSOs), those of projections users, as well as the viewpoints of scientists or academic experts (Figure 1). This approach is also consistent with the United Nations Fundamental Principles of Official Statistics which recommends maintaining regular dialogue with users and consulting the scientific community to ensure the relevance of statistical programmes (United Nations 2015a).



This document compares and contrasts the three viewpoints – users, experts and NSOs – in order to identify possible sources of conflict. In particular, an attempt was made to better understand the information that users need and to comprehend their pre-existing interpretations and their decision-making processes. Indeed, as Fischhoff and Davis (2014 p.13,668) explain: “Science communication is driven by what audiences need to know, not by what scientists want to say”.

Various tools were designed and implemented to collect data about these three viewpoints: a survey of the users of national population projections, a survey of NSOs which produce national population projections, a consultation with a number of experts working in academic or other (non-NSO) capacities in the areas of population projections and science communication, and a literature review. These tools are described below.

User survey

One of the recommendations suggested by the National Research Council’s panel of experts convened to examine the methodology and assumptions of population projections is to investigate how projections are used in order to propose improvements in presentation (NRC 2000). In line with this recommendation, the Task Force developed a user survey. It consisted of approximately 20 questions, covering topics including: the user’s associated organization, the reason for using population projections, the importance and evaluation of various elements of dissemination

materials, whether users had contacted the NSO in the past for information and their associated level of satisfaction with that interaction, and what aspects of the communication of projections produced by their NSO could be improved upon, in their view. The user survey was sent to a sample of users of national and, in some cases, international population projections in June 2015. Data was collected during the summer of 2015. In total there were 151 respondents to the user survey. The content of the questionnaire of the user survey is presented in Appendix A.

Results of the user survey were very useful, but require careful interpretation due to limitations in the sampling methods used. In short, because only a limited number of NSOs were involved in the identification of projection users (essentially those represented in the Task Force), and because the sample nearly exclusively consisted of users who had previously contacted these NSOs for information (as most NSOs had no other ways to identify users), it is not possible to determine how representative the sample of users is. Responses indicate, for example, that the majority of user respondents considered themselves to have “high” or “intermediate” as opposed to “low” familiarity with population projections.

NSO survey

Building upon a previous endeavour by Eurostat (Lanzieri and Giannakouris 2006), an additional survey was developed and sent to NSOs from UNECE member countries (covering Europe, North America and Central Asia). The survey, consisting of approximately 30 questions, asked the producers of national population projections some basic questions about their projections, the information that is disseminated in their publications, their approach to communicating uncertainty, their level of interaction with users and what they see as the main challenges in communicating projections to users. The survey was sent to respondents in the month of June 2015. The content of the questionnaire sent to NSOs is presented in Appendix B. While individual NSOs may have at times inquired as to the needs of their own users in various manners, the Task Force was not aware of large initiatives in this regard. Indeed, it became clear in the NSO survey responses that most NSOs have a very limited idea of who their users are.

The responses to this survey provided a means of discovering more about the practices of the NSOs, as well as their perceptions, capacities and limitations. It was also informative about what types of information NSOs feel it is necessary to communicate to users. In total there were 32 respondents to the NSO survey.

Expert consultation

A third tool consisted of external evaluations of the good practices and recommendations proposed in this document by several experts working in the field of population projections. The aim was to incorporate more formally the point of view of scientific experts, as a complement to the analysis by the Task Force of existing literature relevant to the topic.

Various steps were undertaken to achieve this objective. Firstly, in April 2016, a preliminary version of this document was presented at the Eurostat/UNECE Work Session on Population Projections, to an audience composed mainly of representatives from NSOs of UNECE member countries (with some exceptions), from international organizations as well as researchers in the field of population projections. The Work Session offered a good forum for thorough discussions on the content of the document. Updated versions were then reviewed by external experts: first, in September 2016, by a group of demographers from the United Nations Population Division composed of Lina Bassarsky, Patrick Gerland, Danan Gu and Mark Wheldon, and later, in November 2016, by a number of experts selected by the Task Force for their contribution to the field of population projections, namely Jakub Bijak, Dalkhat Ediev, Nico Keilman, Ronald D. Lee, and Frans Willekens.

Overall, the consultation process has been extremely helpful in identifying sound good practices for communicating population projections, evaluating the consensus around them, and equally representing the viewpoints of users, projection-makers and experts. The consulted experts generally found the final version of the document to be balanced, comprehensive, and a valuable resource for projection-makers and users. It should be clear, however, that the views expressed in this document are those of the Task Force, and do not necessarily reflect those of the persons consulted during its production.

Literature review

Finally, a literature review supplemented the analysis, further highlighting the contrasting perspectives of users, NSOs, and experts. It covered scientific articles in several fields such as psychology, communication, and demography, as well as the publications released by NSOs. The literature review also provided key insights about effective ways to communicate complex scientific results.

Terminology

Before entering the core of this document, it is necessary to establish clear definitions for a number of key terms related to population projections. The goal here is not to propose a universal glossary, although a more uniform utilization of these terms by agencies globally could facilitate clearer, more precise communications.

Projections and forecasts

Estimates published for future reference dates are most often referred to as *projections* or *forecasts*. Results from the NSO survey shows that most NSOs (25 out of 32) use solely the term *projection*, but six NSOs also use the term *forecast*. Those that provided reasons for using *projection* indicated a desire to convey less certainty than the term *forecast* does. It also appears that the term *projection* is used to encompass the plurality of approaches taken to envisage the future development of a population in the literature (as is done in this document).

As Romaniuk (1976, 1994, 2010) noted, the distinction between the two terms has much to do with the epistemological posture adopted in regard to our knowledge of the future. To generalize, projection-makers want to accentuate the fact the projections are not predictions, whereas forecast-makers seem to assume more boldly, within some limits, a capacity to predict.³ This distinction poses some difficulty since, as noted by Keyfitz (1972), assumptions constituting a projection are usually conceived with a concern for realism, without which the projection would have no real value. Hence, the notion of “predicting the future” can rarely be removed from any projection exercise. In accordance with Keyfitz, Hoem (1973, p.13) noted: “it seems that most of the advance calculations actually made, can be placed somewhere in the area bordered by real projections on the one hand and pure forecasts on the other hand.” In an effort to clarify some ambiguities, and in broad accordance with the most current contemporary practices and usages in the literature (although interpretations of the terms often differ), the following definitions are proposed⁴:

- Following Demœpedia (2016), the term population projections is defined as “calculations which show the future development of a population when certain assumptions are made

³ Note that each of these viewpoints has dominated at different points from the 18th century to the present, from the use of predictive laws of population growth to a more sober approach that emphasizes the complexity of the forces governing population growth (Romaniuk 1976, Le Bras 2008).

⁴ Recognizing that some terms do not have exact equivalents in some languages.

about the future course of population change, usually with respect to fertility, mortality and migration.” It refers to the calculation of some estimates at a future date. Thus the term “projection” is a general term that encompasses different types of approaches to estimation at future dates. Note however that there can also be projections towards the past, usually labelled as 'retro-projections' or 'backward projections'.

- A projection can be deterministic, or probabilistic. A deterministic projection can be summarized in a single value, obtained from a series of projection assumptions. No measures of uncertainty are usually associated with a deterministic projection result. In contrast, a probabilistic projection is summarized in a set of values or a probability distribution. The rationale is that since all variables used in a projection are random variables (variables that cannot be predicted with certainty), and that not all assumptions are equally likely, a probability distribution of plausible values is required. The distribution is the basis for the estimation of the distribution of demographic indicators such as total fertility rate (TFR), life expectancy and future population size. The variance of the distribution also yields an appropriate measure of uncertainty about which of the plausible values are (most) likely.
- When a projection is to be interpreted as the most probable development of a future population, it should be labelled a forecast.^{5,6} The expression “most probable” implies that a projection is considered the most probable outcome among a set of possibilities, but since the set of possibilities is technically infinite, any single trajectory has a probability measure of zero (or close to it). Accordingly, in a probabilistic framework, a forecast does not coincide with any simulated trajectory, but rather reflects the whole probability distribution (e.g., the median outcome among all outcomes). The term forecast, in this context, refers to the expected value of a model outcome.^{7,8} The term forecast is also used sometimes in the context of deterministic projections. However, given that no likelihood is provided, a “most probable” outcome does not technically exist, and it may be preferable to speak of a “most indicative” outcome. The likelihood, in this case, most often reflects a judgment made by the projection-makers, perhaps guided by statistical methods. In many cases, projection-makers will not label any outcome as a forecast, but that does not prevent a user from doing so. For example, users will interpret the result of a middle variant as being the most likely when more than one projection scenario is provided (Keyfitz 1981).

Other definitions

Some other terms used in this document can be defined as follows:

Scenario: the description of the background context in which the population is projected/forecasted. It usually refers to the main assumption(s) adopted for those specific projections/forecasts (e.g.,

⁵ Note that the term forecast has different definitions depending on the field. It has a more strict definition in time series forecasting for example, where it represents the prediction of future values on the basis of values observed in the past.

⁶ Forecasts have variable projection horizons. However, because the uncertainty of a forecast increases considerably over time, short-term horizons are usually preferred (Demœpedia 2016).

⁷ Compare, for instance, the expected value when you throw a fair die: 3.5, but you will never observe this value.

⁸ At the same time, the distinction between probabilistic projections and forecasts is somewhat blurred, since using probabilistic methods implies making a statement on the (relative) likelihood of different trajectories.

demographic transition, trends, economic growth, convergence, etc.). It is basically the storyline of the components of population change, the conceptual framework which is adopted. For instance, assuming that a country will undergo a demographic transition is a theoretical frame of reference, depicting the broad changes expected to happen in fertility, mortality and migration and possibly their rationale. A scenario is qualitative in its nature. It is – according to its dictionary meaning - a description of possible actions or events in the future.

Even though the description of a scenario may give an indication about the expected evolution of the various projection components (e.g., decrease of mortality first, followed by a decrease of fertility), the way such evolution takes place may have relevant repercussions on projection outcomes (for instance, fertility may fall more or less quickly to different levels). Projection-makers may then provide alternative values for the quantification of a scenario, indicated by terms such as variant, or sensitivity variant/test. This is here indicated by the following wording:

Variant: the quantitative implementation of the theoretical assumptions formulated in the scenario of reference. A variant, following the dictionary meaning, implies the existence of a 'standard', from which it varies. The word 'variant' should not be used as indication of the likelihood of outcomes, and thus should not be used for forecasts.

Sensitivity variant/test: a special case of variant where only one component is modified to show how much the outcome would change with a single variation in the assumptions (other things being equal).

Prediction interval: A prediction interval is an interval associated with a random variable yet to be observed, with a specified probability of the random variable lying within the interval. While similar in construction to a confidence interval, the latter term is used mainly in a frequentist approach to convey uncertainty related to the fact that an unobserved parameter was estimated from a sample.

CHAPTER 1 - PROVIDE PERTINENT AND ACCESSIBLE RESULTS

Introduction

As the Internet Era has become firmly entrenched in society, user expectations for highly detailed, flexible and easily accessible information have grown stronger and such demands are likely to continue to grow in the future. Regular evaluation of dissemination procedures, with a view to improving the interpretability, accessibility and relevance of projection results, becomes essential in this context.

The results of the user survey were mixed with regard to the level of detail desired by users of population projections. While close to three-quarters (73 per cent) of the respondents think that the projection data are adequately detailed, about two-thirds (66 per cent) think that projections of characteristics other than age, sex or region are important or very important. However, when asked about aspects that could be improved, only four respondents mentioned more disaggregated results (spatial breakdowns 2, ethnicity 1 and education 1). In contrast, respondents to the NSO survey did not appear to view more detailed projection data as an area of user concern. It could be that while users could benefit from more detailed variables, most are generally satisfied with the projections offered by NSOs. It is also possible however that NSOs underestimate or are unaware of the desire of many users for more detailed information on all aspects of the projections.

In terms of accessibility of the data, 71 per cent of the respondents answered that the projection data were easily accessible. However, access to the dissemination materials was mentioned as an area of improvement by 10 per cent of all respondents. In 60 per cent of these cases, answers were elaborate enough to pinpoint difficulties in finding the desired information on the NSOs' web sites. As for NSOs, help in accessing the data was a request received by 14 per cent of respondents.

The following good practices and recommendations provide some guidance on how to communicate effectively the results of a population projection.

Good practices

1.1 *Communicate results in clear and simple language*

Projection users are a diverse group, differing in their level of familiarity with statistical and demographic concepts and techniques, as well as having varying motivations for consulting projection disseminations. Users were asked whether they considered the language used in the projection dissemination to be "too simplistic", "appropriate", or "too technical". It is noteworthy that while the large majority of user respondents felt the language was "appropriate" (83%), there were more instances of users finding the language "too technical" (8%) than "too simplistic" (1%).

Suggested strategies for reaching the widest possible audience are:

- Use plain, simple language in order to ease interpretation for different types of projection users. Choose words with a single definition or connotation and be consistent with word use.
- Include a glossary with clear definitions in order to further clarify important terms (particularly those that are more technical in nature).
- Include in the dissemination an introductory text box or chapter for users which sets proper expectations for the use of the projections and explains in a high-level manner their key caveats and limitations.

- Pre-test draft dissemination materials on a small group of non-expert users to ensure that terms have been clearly defined and will be interpreted as intended (Centers for Disease Control and Prevention 1999).
- Offer short courses for non-professional users such as journalists or state employees who are not involved in the projections.

1.2 Introduce information in a progressive manner

An efficient strategy for communicating information of different technical levels to a variety of users is to release it in different layers of increasing complexity. This approach, often referred to as *progressive disclosure of information*⁹, helps create an efficient instructional design by minimizing the load on the working memory and segmenting complex explanations into intelligible portions (Kalyuga 2011). The *progressive disclosure of information* also allows uncertainty to be communicated in a gradual and repeated manner by integrating it as part of the message in the various layers of the communication (Kloprogge et al. 2007, Wardekker et al. 2008). As noted by Kloprogge et al. (2007), users differ in their preferences for specific forms of presentations; repeating messages using different forms (verbal, numeric and graphical) may result in better understanding and increase the chance that the user will notice and correctly interpret the information.

Many NSOs tend to follow more or less consciously the approach of *progressive disclosure of information* by releasing their projection results in several distinct layers, aiming for a large coverage by a variety of audiences. For instance, an NSO might publish, in parallel to a detailed report, press releases, shorter communications intended for media, or shorter articles summarizing the results. These shorter communications are often those that have the greatest exposure in the public and are often the only medium by which the larger public will be informed about a given topic.

Another frequently-used strategy is to provide a separate technical report to present the methods and assumptions. However, several studies show that readers tend to spend limited time reading such detailed reports (Kloprogge et al. 2007). It is therefore essential that general statements about the limitations of projections permeate the primary layers of the communication of population projection results, and are not only found in a detailed technical report. Good practice 3.1 further discusses the importance of situating statements about the uncertainty of population projections in high-level dissemination materials.

1.3 Provide results for both short-term and long-term horizons, making clear that the uncertainty of projection results increases with the length of the projection horizon

The needs of users regarding projection horizons are varied. As seen in Table 1, while respondents to the user survey most frequently expressed a need for a projection horizon of 10 years, considerably lower than the modal horizon of 50 years disseminated by respondents to the NSO survey, horizon needs among users ranged from as short as one year to as long as 150 years in the future.

⁹ The concept of *progressive disclosure of information* has its origins in computer application engineering where it is used for improving interactions between humans and computers. It is also used in journalism.

TABLE 1					
Projection horizon disseminated (NSO survey) and used (user survey)					
	Projection horizon in years				
	Mean	Mode	Min	Max	> 50
NSO (disseminated) (N=32)	54	50	25	100	12
User (needed) (N=140)	31	10	1	150	14

The tendency for user respondents to favour a considerably shorter projection horizon than those actually produced by NSOs raises the question of whether NSOs should consider shortening the length of their projection horizons (from an average of 50 years to an average of 30 years, for example). Indeed, it is well documented that accuracy tends to decrease with time elapsed since the projection.¹⁰ The report provided by the panel of experts convened by the National Research Council's Committee on Population to review different aspects of population projections suggests that beyond a period of 50 years, projections involve so much uncertainty that they should not be produced (NRC 2000). High uncertainty associated with certain demographic components can be a motivating factor for not extending the projection horizon too far. For example, fertility assumptions become increasingly perilous beyond 25 to 30 years, the mean length of a generation, after which the uncertainty of the numbers of potential mothers in the population compounds the uncertainty of associated birth rates (Lutz et al. 1994, Leridon 2015). Likewise, Bijak and Wiśniowski (2010) found that after a five- to ten- year horizon, prediction intervals for international migration become too large to be very helpful to decision-makers.¹¹

While projection-makers must exercise caution in the choice of a projection horizon, results of the user survey suggest that consideration of both short- and mid-term intervals within that horizon will benefit a large array of users. For instance, if it is thought that immigration will decrease in the long term, variations in the short term should also be taken into account and discussed in disseminations, as this will respond to the needs of users interested in short-term projections.

Nonetheless, some users do require longer-term projection horizons for planning. For example, studies of the long-term viability of pension plans typically require horizons of 75 years or more. More globally, long-term projection horizons are also used by earth scientists in the context of climate change modelling (e.g., IPCC 2013). Recognizing the disparity between a reluctance of projection-makers to go beyond a certain time horizon and the expectations of some users, Lutz et al. (1994) recommended making clear distinctions between projections made for short- or mid- term horizons and those made for longer horizons (typically for more than 30 years). However, the provision of a long-term projection should not be a problem as long as it is accompanied by an appropriate relevant estimate of its uncertainty. As Lee (1998) points out, the increasingly wide uncertainty over time will inform users about the risks of using projection results for long horizons (see chapter 3).¹²

¹⁰ See for example George et al. (2004) and. Keilman (2007).

¹¹ There are of course other sources of increasing uncertainty over time in projections; Lutz et al. (1994) provided a summary of the impacts of possible other sources of uncertainty in relation to projection horizon.

¹² In some cases, users may require 'infinite horizon' projections, that is, projections over a very long horizon produced for the calculation of some measures of imbalance in pension systems and the evaluation of the long-term sustainability of some fiscal regimes (e.g. Lee and Anderson 2005). Such projections are often called 'routine' or 'business as usual' projections, since they tend to exclude shocks to the system, likely to occur in a very long period (ibid.). Very long projection horizons are sometimes used to obtain a stable population, at which point the population structure depends only on demographic rates and is independent of the initial

1.4 Disseminate projection results by single age and year whenever possible

Population projections are typically produced by single years of age and 1-year steps (1x1), or by 5-year age group and 5-year steps (5x5). Other configurations are possible when interpolation techniques are used. For example, a projection-maker can publish projections by 5-year age groups and 1-year steps (5x1), where the years in-between 5-year steps are interpolated. Interpolation can also be used to break down 5-year age groups into single years of age.

The vast majority (87 per cent) of respondents to the NSO survey reported that they disseminated their projections by single years of age, and 81 per cent by single projection year. Responses to the user survey suggest that this is a good practice. Indeed, 84 per cent of respondents to the survey felt that it was important or very important for them to obtain projection results by single year and age. Providing projections by single year also offers users more flexibility in terms of projection horizon. This is especially important with very short-term projections, which, as highlighted in good practice 1.2 above, are needed by some users.

Finally, interpolation of coarser-grained projections can offer a good alternative to projections by single age and year built from the ground up, but the results may not always be satisfactory, especially when performed over both the age and time dimensions.¹³ Therefore, it is advisable for projection-makers to test their single-year projections for smoothness of outcomes (e.g. absence of undesirable features such as saw-toothed patterns, irregularities, etc.). It is also desirable to inform users when an interpolation method is used and about its possible limitations.

1.5 Update the projections on a regular and predetermined basis or when important demographic changes affect the pertinence of the assumptions

Most NSOs update their projections on a regular basis, often when new or revised data become available. This is a good practice as inaccuracies in the baseline data can be a non-negligible source of projection errors, sometimes the most important one in countries with generally low quality data, especially with short- or mid-term horizons (Keilman 2001). New projections can also be produced on an ad hoc basis to reflect important demographic changes. Among NSOs, projections were most frequently updated on a five-yearly basis, ranging from a minimum of one year to maximum of 10 years (Table 2).

TABLE 2
Update frequency of projections among
NSO respondents (N=31), in years

Mean	Mode	Min	Max
3.8	5	1	10

conditions prevailing at the start of the projection. Stable states are useful to reveal the long-term demographic equilibrium of a series of demographic parameters subjects of analysis, especially in comparative studies (Blanchet 1998). For such requests, projection-makers may consider advising users on how to extend their projections if they are so inclined, for example by holding constant their end-of-projection vital rates.

¹³ Bermúdez and Blanquero (2016) discussed the difficulties associated with disaggregating population data grouped in age ranges into individual age while processing several consecutive years. They used optimization models to obtain results that are coherent both longitudinally and transversally (that is between populations of consecutive ages in consecutive years).

Results from the user survey show that most users (65 per cent) found the update schedules of population projections to be adequate, although a sizeable proportion (28 per cent) felt they were not frequent enough (Figure 2).

Other results from the survey show that the majority of users (68 per cent) found frequent updates to be important or very important (on a scale from 1 to 5, where 1 is “of no importance” and 5 is “very important”) (Figure 3). Only 6 per cent of respondents found that regular updates were not important at all or not very important.



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It is difficult to propose an ideal update schedule, as the pace at which the demographic context changes varies over time and geographically. A more sensible suggestion is provided by Romaniuk (1994), who wrote: “While respecting certain periodicity, as a matter of policy, the revision of the existing projections or development of new ones should be based on analytical considerations, when, for example, the demographic situation has changed to justify a new round of projections.” Akin to this proposition, a revision policy based not only on frequency of update but also on the level of correspondence between projected and observed data would mitigate against large discrepancies between projected data and observed trends, at least in the short-term.

Still, Romaniuk’s ‘analytical considerations’ can appear somewhat vague without some guidance to determine how large a discrepancy can be tolerated. To assess whether the projection differs from observed trends because of random fluctuations or because of or systematic deviations, within some level of confidence, requires the utilization of a statistical model. Another option is to use predetermined rules for deciding when a projection should be updated. For example, the Turkish Statistical Institute follows a revision policy stating that an update must be produced if the correspondence between projection data and administrative data falls below 99 per cent in total

population, below 99 per cent in total 15-64 aged population, or below 95% in any of the total population of NUTS 2 regions of Turkey (see Turkish Statistical Institute 2016a).

Finally, because the same period in the future can be covered by several consecutive editions, projections are uniquely subject to confusion regarding which edition is the most current. To ensure the relevance of the results, it is preferable that only the most recent edition of the projections be used by media and other prominent users (unless in exceptional cases). Good strategies in this context include:

- Ensuring that search capabilities of the website will lead to the most recent results;
- Clearly labelling and categorizing as “ARCHIVED” (or an equivalent term) material related to past editions within the NSO website, with a hyperlink to the current edition on the same page;
- Advertising the dissemination of new population projections through media (see chapter 4).

1.6 *Make electronic dissemination materials accessible and easy to navigate*

Most users will access disseminated materials through the NSOs’ websites. It is therefore crucial to ensure that the materials are easy to access. A good practice in this context is to regularly evaluate the ease of use and accessibility of the data and all dissemination materials. NSOs should look for means of improving the user experience of the population projection web pages, including search capabilities within the broader NSO website, data retrieval capabilities and navigational ease for users. Typically, such improvements would involve the whole NSO, and not only the persons responsible for producing population projections, since most NSO websites have common look-and-feel guidelines or other restrictions in terms of the format of web content.

1.7 *Offer customizable/interactive projection data to users in tabular or graphical formats*

As noted by Morgan and Henrion (1990), if users can be actively involved in the selection and design of graphics to suit their special interests and skills, their experience is likely to be more motivating and educational than in the traditional, passive modes of communication. Data from the user survey shows that more than three-quarters (77 per cent) of respondents felt that it is important or very important to have access to customizable data tables. Some examples of the provision of customizable projection data can be found in Box 1.

Undoubtedly, the construction of an interactive application and its continuing updates are resource-intensive for NSOs. The desire of users to access different data or tables than what is available should nevertheless be acknowledged, and an alternative for NSOs is to be easily accessible and to offer to produce the requested information themselves (see chapter 4 for good practices about fostering relationships with users).

Finally, some (three) respondents to the user survey expressed the desire for more flexible and interactive projection data, in which the user could select the desired combination of assumptions from a given list and potentially generate their own custom scenarios. In principle, offering a tool such as this to users could improve their understanding of the sensitivity of projections to assumptions and/or the degree of population inertia, and possibly also generate new or deeper interest in projections. However, precautions should be taken to minimize the risk that custom-made projections be erroneously identified as an ‘official’ publication of a NSO because they were made from an application it provides.

Box 1: Examples of customizable projection results

Statistics Norway

Statistics Norway offers a tool for the creation of custom tables and graphs. It is possible to select different variables (e.g. population, various components of the growth, life expectancy, etc.), and values for these variables (e.g. specific ages). It is also possible to select various scenarios for comparisons. The outputs can be saved in a large number of formats.

REFERENCE: Statistics Norway (2016).

Eurostat

Eurostat's database offers rich possibilities to create customized tables. Users can select various kind of outputs and demographic indicators for different variants. It is also possible to view assumptions (e.g. age-specific mortality rates).

REFERENCE: Eurostat (2016).

United Nations

The web site for the 2015 Revision of the United Nations' *World Population Prospects* offers multiple possibilities for viewing the results, including maps, data tables, graphical representations of various outputs and key demographic indicators. Users can choose results for selected countries.

REFERENCE: United Nations (2015b).

CHAPTER 2 - CULTIVATE TRANSPARENCY

Introduction

Transparency is a basic principle of good scientific practice. Providing detailed and clear information about how the projection was produced allows users to develop a more accurate interpretation of the results, and to understand more fully their limitations and the context in which they were built. The importance of transparency is recognized in the United Nations Fundamental Principles of Official Statistics: “transparency on the sources, methods and procedures used to produce official statistics as well as data quality assessments readily available to users will enable them to judge the fitness of use of the data. Transparency therefore contributes greatly to increase the confidence and trust of users in statistics and thereby increasing use of statistics as evidence in decisions.” (United Nations 2015a). However, a report prepared by the Panel on Population Projections of the National Research Council’s Committee on Population concluded that “users would benefit from clearer presentation of the underlying methodology and assumptions”. (NRC 2000 p.12).

Users appear to place high value on this ‘background’ information, with a large majority of respondents to the user survey clearly indicating that receiving information about such elements was important or very important to them, including information about the current demographic context (90 per cent of users agreed), assumptions (86 per cent), methodology (78 per cent) and quality of underlying data sources (76 per cent). These percentages are higher even than the proportion that considered detailed analysis of results to be important (70 per cent). However, a sizeable percentage of respondents to the user survey felt that there was not enough detail in the information about the current demographic context/trends (21 per cent), the projection assumptions (29 per cent), the methodology (24 per cent) or the underlying data sources (22 per

cent).

For their part, NSOs seem also to consider information about how the projections were produced to be a key element of their disseminations: respondents to the NSO survey dedicated on average over one-quarter of their total disseminations to describing projection assumptions, the highest share of any projection element. Yet, among the various dissemination elements, it was with projection assumptions that the highest proportion of respondents to the user survey expressed dissatisfaction in the level of detail disseminated by their NSO. Moreover, as shown in Figure 4, the most common requests for technical assistance received by NSOs have to do with explanation of data, assumptions and the methodology in general.

Thus, while NSOs appear to be dedicating a substantial portion of their disseminations to the discussion of projection assumptions, improvements could potentially be made in the focus and content of those descriptions to make them better suited to user needs for both qualitative, contextual information and detailed quantitative data. The following good practices provide general recommendations and advice on how to communicate population projections in a transparent manner.

Good practices

2.1 *Provide descriptions of the data, methods and assumptions*

As described in the introduction to this chapter, users value highly the background information accompanying projection results. This is for several reasons. As noted by de Beer (2011 p.215), adequate descriptions of the methods and assumptions “[...] make it possible for the user to determine how to interpret the outcomes of the calculations.” Also, a clear description of the assumptions and methods allows users to make their own decisions regarding whether a projection is adequately adapted to their needs (Armstrong 2001). Morgan and Henrion (1990) noted that scientific research reports should provide descriptions of their procedures and assumptions to a level of detail sufficient for others to undertake a replication of the results. Although this can be difficult to do in practice, the documentation should be prepared with the ideal of reproducibility in mind.

Provision of detailed descriptions of the model, the data and the methods used is therefore a good practice. Some possible strategies to help projection-makers achieve this goal are:

- Clearly identify the data sources used and comment on any major quality issues and their associated impact on the quality of the projections. Information on the evaluation procedures and any adjustments of the initial data for the projection should also be provided.
- Make clear the logical links between descriptions of the current demographic context and projection assumptions. As de Beer (2011) explains, the arguments underlying the choices of assumptions and methods and their consequences should be provided. In the case of data extrapolation methods, for example, the impact of the choice of a reference period should be described, especially when it is sensitive or particularly consequential.
- If necessary, provide a brief description of the procedure followed to obtain the base population. In several countries, this population is essentially derived from the last population census or from the population register. However, adjustments (for coverage and other factors) are almost always made and should be noted in disseminations. The same could be done with other data used for the projections, such as those used to build the assumptions (e.g. immigration figures, vital statistics data, etc.).
- Provide a description of the methods that were used to compute the parameters of the projections. An efficient strategy is to publish a separate technical report, distinct from the results (e.g. Aase et al. 2014, Bohnert et al. 2015, United Nations 2015b). Alternatively, projection-makers can produce a series of technical papers addressing particular topics of the projections following the release of the results. This option gives more time for NSOs to produce the report, but it has the disadvantage of offering the technical information in a less punctual manner.

- Provide a general description of the projection model, along with its strengths and limitations. It may often not be necessary to dedicate a large part of the dissemination material to this purpose if some pre-existing documentation can be referenced (e.g. George et al. 2004, Preston et al. 2000).
- Disseminate projection inputs (for example, age-specific fertility rates) in the same level of detail as was utilized in the building of the projection.¹⁴ However, this may not always be possible given the amount and level of details of the inputs to be published. A good strategy in this context is to be willing to engage in direct communication with users regarding data and methods and to provide input data upon request.¹⁵

Finally, a good practice would be to dedicate a portion of dissemination materials to the publication of key information about the projections. Many NSOs have a section of their website dedicated to providing information about their various statistical programmes. However, the formats used are often not of much relevance for population projections that differ from most other statistical programmes, such as surveys or administrative data collection programmes for example. The adoption of a standard format adapted to the specific nature of population projections would improve the accessibility of key information about the projections. This would be particularly true if NSOs use a similar, standard way of reporting this information. Appendix C provides a template to help NSOs achieve this goal. In addition, for NSOs, a large portion of the information contained in this template should also be reported in the (forthcoming) UNECE database on population projections metadata once new population projections are published.

2.2 Acknowledge any relevant stakeholders and describe the process and outcomes of all consultations

Population projections, like official statistics in general, intend to serve the information systems of democracies for better decision-making. Independence and impartiality of population projections are preconditions for fulfilling this demanding role (United Nations 2015a). Users of population projections expect results that are independent and impartial, and these principles are generally followed by NSOs. However, a transparent approach in this domain can certainly help to preserve and even promote these principles. A good strategy in this context is to provide in the dissemination materials a description of any major stakeholders, particularly those who may have had an influential role in the production of the projections, whether because they provided some degree of funding or for other reasons. When possible, the impact of stakeholders on the production of the projections (for example, changes in assumptions) should be specified.

Whether or not stakeholders have been involved, most NSOs appear to engage in some form of consultation in the process of creating their projections. Data from the NSO survey show that two-thirds of NSOs had noted some or all of their consultations in their disseminated products (Table 3).

¹⁴ Examples of NSOs providing detailed projection inputs can be found in: Eurostat (2016), Statistics Norway (2016), Statistics Portugal (2016) and Statistics Sweden (2016).

¹⁵ Data from the NSO survey show that they tend to comply with requests for input data from their users. Indeed, 83 per cent of NSOs in the survey answered that they would distribute detailed parameter/input data to allow users to reproduce the projections, or similar projections, upon request.

TABLE 3

Q21. If you consulted any bodies during production of the projections, were these consultations noted in disseminated products?	
All of the consultations were noted	11
Some of the consultations were noted	8
No, the consultations were not noted	10
Not applicable (there were no consultations)	2
NR	1

Documentation of consultations may help contextualize why some decisions were taken in the production of the projections. Such descriptions can also reveal the areas where there is general consensus and those where it may be lacking, or where there may be greater uncertainty. Good examples of thorough documentation of the expert consultation process can be found in Appendix D.

2.3 *Clearly define key terms used in dissemination products*

To be properly understood, communications must use clear and well-defined terms. Accordingly, key concepts should be defined as they are introduced in the dissemination material. One recommended way to achieve this practice is to include a glossary of key terms in the dissemination materials. In particular, key terms associated with projections such as projection, forecast, scenario or variant, should be defined and it should not be presumed that users share the same understanding of these terms as the projection-maker.

2.4 *Describe how the new projections differ from previous editions*

NSOs produce frequent updates of projections, most often following a predetermined schedule, usually after the updating of the base population (e.g., when new census data becomes available), or due to some important demographic changes that may have occurred or are at risk of occurring. Each update requires users to become familiar with a new set of assumptions, results and methods. A good practice in this context is to communicate any key changes in approach from previous editions.¹⁶ For regular users who are familiar with projections, such information can greatly facilitate the learning process. Finally, users would benefit from being aware of the periodicity of new releases and to be notified in a timely manner about any upcoming reviews outside of the pre-established periodicity. The key factors that may lead to such ad hoc updates or revisions also constitute relevant information.

2.5 *Assess the performance of previous projections*

Many NSOs have adopted the practice of analyzing the performance of their past projections, sometimes supplementing the publication of new projections with an in-depth analysis of the performance of past projections. Repeated comparison of projected values with historical estimates reveals the limitations of population projections and informs users about what can reasonably be expected from them. Engaging in this exercise is also a means for NSOs to reflect on the sources of past inaccuracies, serving as a basis for improving future projection assumptions and methodologies (Wilson and Rees 2005). Measurements of past errors have also been used to produce prediction

¹⁶ An example of the documentation of changes from previous editions can be found in Vandresse (2016). The paper highlights how the projections are dependent on hypotheses, which themselves reflect changes in the demographic trends in the country and internationally. Major changes in methodology are also described.

intervals around new forecasts in the production of probabilistic projections (e.g. Keyfitz 1981, Stoto 1983), and are essential for calibration of probabilistic forecasts.

Such exercises should nevertheless be undertaken with some caution. The fact that population projections are not perfectly accurate does not render them totally useless. Indeed, as Romaniuk (1994, 2010) observed, the future is not only something to be discovered, but can also be seen as something to be created. He adds that projections can be instrumental as planning tools when peers and users recognize their analytical credibility. Besides, an inevitable limitation of such analysis is the fact that projections are used as means to influence the future, and thus can trigger outcomes that will prove them wrong; the problem of self-defeating prophecy. Another caution is that a projection is never perfectly comparable to the previous ones as there can be changes in the methods and in the demographic context. These caveats should be kept in mind and communicated to users in any relevant dissemination materials.

While an in-depth analysis of previous projection performance is ideal, NSOs may not necessarily need to undertake such exercises with each new edition produced. A single assessment of the most recent projection is not very useful since it implies that projection errors are computed for short durations only, and because random fluctuations in important parameters may have caused substantial gaps between projected and observed data. A better practice is therefore to evaluate a series of historical projections. At a minimum, it is recommended that disseminations make some reference to the performance of previous editions, linking the discussion logically to a larger acknowledgement of the uncertainty of projections.¹⁷

¹⁷ Some examples of communication of the past performance of projections are: National Research Council (2000), Shaw (2007), Statistics New Zealand (2008), Dion and Galbraith (2015), Office for National Statistics (2015a), Majérus (2015) and Statistics Sweden (2012).

CHAPTER 3 - ADDRESS UNCERTAINTY EXPLICITLY

Introduction

The urgency and the significance of issues that scientists are currently being asked to tackle have begun to move the question of uncertainty¹⁸ from the periphery to the core of scientific methodology (Funtowicz and Ravetz 1993). For population projections, this means that not only are the most likely sizes and structures of future populations of interest for planning, but so is the uncertainty of their projected future values.

Organizations engage in risk management exercises in order to measure and manage the consequences that internal or external factors could have on the realization of their objectives. Typically, risk management provides an evaluation of risks, defined as the effect of uncertainty on an organization (ISO Guide 73:2009) and measured in terms of the impact of uncertain outcomes on the organization's objectives taking into account their probabilities of occurrence. For example, the International Organization for Standardization (ISO) provides a formal framework for risk assessment in order to determine whether the magnitude of risks is acceptable or tolerable (ISO 31000:2009).

Another reason for communicating uncertainty is that responses to uncertain events often differ from responses to more certain events. In some cases, uncertainty may lead to postponement of action, or to precautionary measures or policies that can be adapted as the future unfolds (NRC 2000). For example, the *precautionary principle* suggests the use of mitigation or preventative measures when it is impossible to assess – scientifically and with sufficient certainty – the risk of an action.¹⁹ This guiding principle has been adopted in several domains internationally, including the environment (Kriebel et al. 2001), health (WHO 2004), and more generally in economics and politics (Commission of the European Communities 2000).

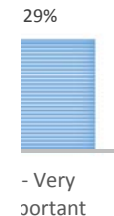
In addition to being a critical tool to assist decision-making, the communication of uncertainty promotes users' confidence, helps users to manage expectations and truthfully reflects the state of the science (WMO 2008).

Results from the user survey highlight the importance of conveying measures of uncertainty when disseminating population projections. Although very few agencies provide quantification of uncertainty²⁰, the majority of user respondents (69 per cent) felt that quantification of the uncertainty of projections was either important or very important, while very few (1 per cent) felt that it was not important at all (Figure 5).

¹⁸ In this chapter, following Knight's (1921) distinction, uncertainty can be aleatory, that is when it comes from randomness, or epistemic, when its source is our lack of knowledge. In the case of population projections, the question of whether uncertainty comes from the fact that the future is not completely specified by the past (inherent randomness) or because of epistemic limitations (including imprecisions in the data) is a metaphysical one as the result is the same: our knowledge of future population growth is uncertain (de Beer 2001). In the end, as Morgan and Henrion (1990, p.63) relate, "you see a quantity as random if you do not know of any pattern or model that can account for its variation."

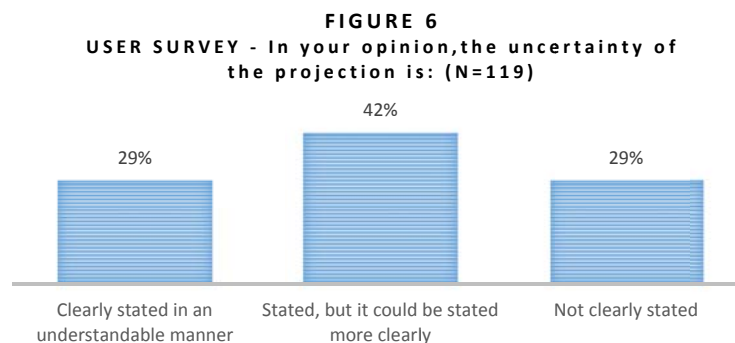
¹⁹ A working definition of the *precautionary principle* has been written by UNESCO (2005): "when human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm."

²⁰ Most agencies publish a series of scenarios which are supposed to represent a plausible range of outcomes, as shown in Figure 7 later in this report.



Results from the user survey also show that a majority of users thought that communication of uncertainty could be improved (Figure 6). Asked about the information present in the most recent edition of the population projections used, a third of respondents (29 per cent) felt that the uncertainty was stated clearly and in an understandable manner.²¹ The same proportion said that it was not clearly stated, and about two-fifths said that it could be stated more clearly. The fact that the majority of user respondents were interested in understanding the uncertainty of population projections illustrates the demand for such information and could motivate NSOs to invest resources in improving the communication of uncertainty.

There is a general sentiment among demographers that the treatment of uncertainty in population projections is an area of work that remains underdeveloped.²² O'Neill et al. (2001) noted that



accurately characterizing the associated uncertainty is critical to ensuring that a population projection is used appropriately, yet there is no generally-accepted approach for characterizing such uncertainty. The speculative nature of population projections makes it difficult to assess uncertainty, especially in quantifiable terms. Indeed, the future is not an experiment from which we can collect

²¹ Note that all respondents were from countries whose national population projections contained more than one scenario.

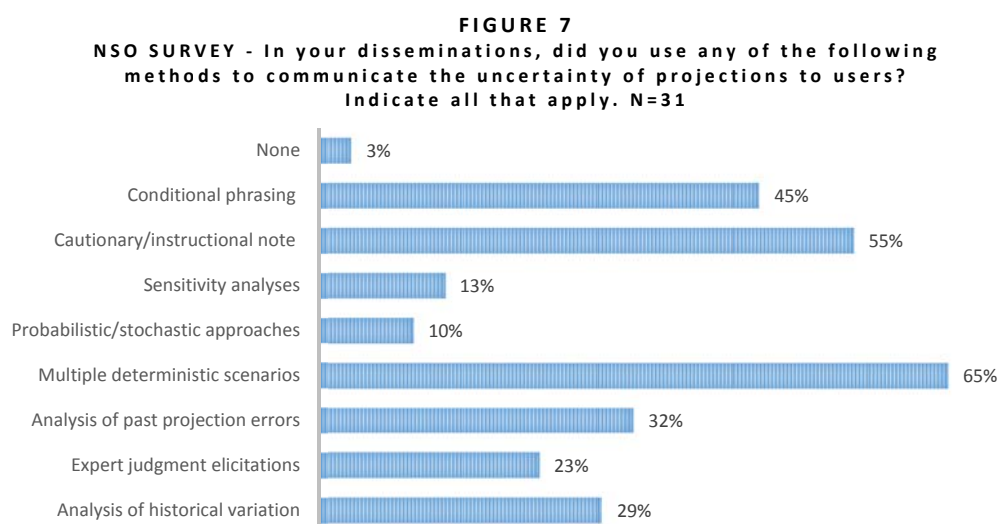
²² Adequate measurement of uncertainty in population projections has been identified as an area severely requiring improvement in several studies in recent decades, including: Keilman et al. 2002; Keilman 2008; NRC 2000, de Beer 2000; Lee 1998; Keyfitz 1981; Stoto 1983. This is also a conclusion of the report prepared by the Panel on Population Projections of the National Research Council's Committee on Population, which stated "official projections have neglected the important issue of the uncertainty surrounding forecasts." (NRC 2000 p.12).

data. Nevertheless, as noted by Keyfitz (1981, p.579), “the user of a population forecast has no less need to know its error than the user of a yield estimate or of an estimate of unemployment.”

Many techniques for estimating the uncertainty of forecasts have been developed, including a vast literature on probabilistic models for time series. Demographic problems have also driven the development of forecasting methods, such as the Lee-Carter model for mortality (see Lee and Carter 1992). Smith (1997) and O’Neill et al. (2001) observed that efforts made to consider how best to express uncertainty and convey this information to users should be a priority for research, as it is key to improving the quality and usefulness of population projections. This point is important, since, as Jenkins (1982) pointed out, forecasts or projections may fail to achieve their objective not because of poor quality, but because insufficient attention was paid to the relationship between forecasting and decision-making. Campbell (2011 p.4892) provided a good description of the quandary faced by scientists with regard to uncertainty, noting that “the values of openness and transparency in communication to stakeholders and publics, not to mention a modicum of due humility, necessitate an explicit acknowledgement of scientific uncertainties. But this obligation flies in the face of a strong concern that expressed uncertainties can themselves undermine public trust. Resolution of this contradiction depends on the context and on how you tell it”.

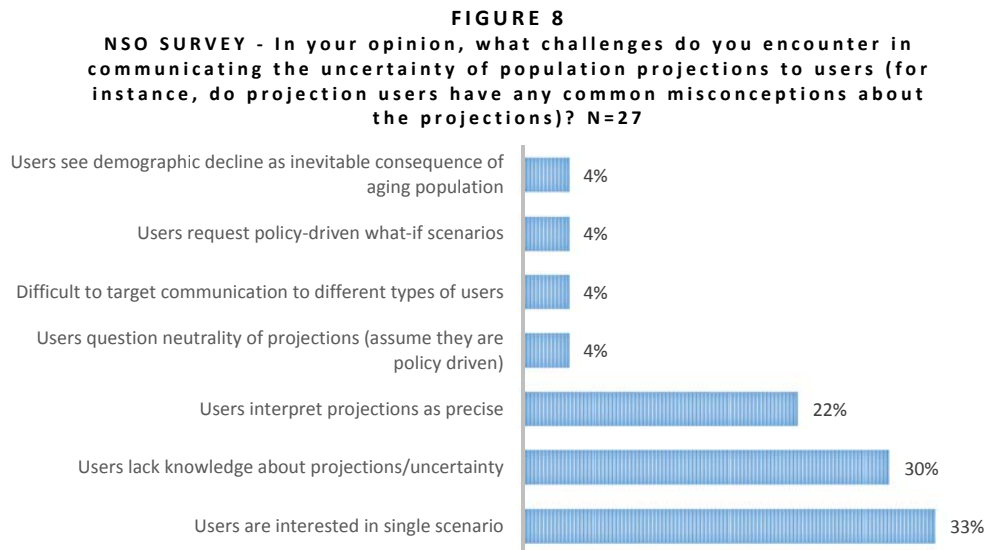
Current practices

An examination of current practices reveals an unevenness in the commitment of statistical agencies to communicate the uncertainty of population projections and in the approaches used. As an example, Figure 7 shows the proportion of NSOs that utilized various methods to communicate uncertainty in their disseminations. While the majority utilized multiple deterministic scenarios and cautionary or instructional notes, fewer than half used conditional phrasing, a simple and effective means of indicating the uncertain nature of the results.



Survey findings also revealed variations in the number of scenarios produced and in the information and language used to characterize them. For example, some NSOs disseminate a ‘most likely’ scenario or only a single scenario while others provide multiple scenarios without assessment of their likelihood of occurrence. Even the use and definition of basic terminology, such as the difference between a ‘forecast’ and a ‘projection’, varies considerably across NSOs. This disparity of practices has increased with the publication in recent years of probabilistic projections providing specific prediction intervals.

Reluctance to express uncertainty is not confined to producers of population projection but touches scientific communication in general. Fischhoff (2012) identified some causes for this reluctance on the part of experts: uncertainty is seen as giving misplaced or exaggerated imprecision; uncertainties may not be understood as intended; experts can be disparaged for communicating uncertainty; and perhaps most fundamentally, experts in many cases do not know how to express or accurately measure uncertainty. Results from the NSO survey confirm some of those challenges: approximately one-third of NSO respondents indicated that they felt users were interested in a single scenario or lacked knowledge about projections or uncertainty in general, making it challenging to communicate information about projection uncertainty to them (Figure 8).



The different strategies used by projection-makers to communicate uncertainty can be grouped into two main approaches: the production of deterministic scenarios and probabilistic projections (O'Neill et al. 2001, Lutz and Samir 2010). These two approaches are summarized below.

The deterministic (scenario) approach

Users of population projections will often be interested in a single most likely outcome (Lutz et al. 1994), and will tend to interpret the result of a middle variant as being the most likely when more than one projection scenario is provided (Keyfitz 1981). Despite these tendencies, most NSOs have attempted to acknowledge the uncertainty of population projections through various means. By far the most common practice among NSOs is to provide a series of alternative deterministic variants in which the demographic components are combined in such a way as to maximize the range of results in terms of population sizes alone. For example, a low-growth scenario can be constructed by combining assumptions of low fertility, high mortality, low immigration and high emigration. The method is simple and fairly transparent to users.

The scenario approach, as Willekens (1990) explained, “[...] is a method for dealing with uncertainty. Its goal is not to predict the future, but to provide the user with alternative, internally consistent futures against which decisions can be tested and actions planned.” The approach allows users to make comparisons and to understand the sensitivity of the projected results to variation in assumptions about vital rates (with some assumptions being more-or-less plausible, and others being implausible but still instructive as hypothetical cases in policy-driven discussions). Such comparisons provide a form of sensitivity analysis, and may be useful to guide potential

interventions or policy development. Indeed, as noted by Sanderson et al. (2003), policy-makers are used to thinking in terms of alternative scenarios; to evaluate, for instance, what the outcomes of different policies could be. The plurality of scenarios highlights the uncertain nature of population projections by making it clear that there is not just one possible outcome for the future but rather multiple possibilities.

Romaniuk (1994, 2010) described the usefulness of the scenario approach in terms of *prospective analysis*: as a way to explore the future and for managing the future. Prospective analysis stands between *predictions*, aiming to predict the future, and their opposites, *simulations*, aiming either to show the consequences of given conditions (process-oriented) or to find the conditions leading to a given outcome (goal-oriented), without any concern for the analytical credibility of the assumptions.

In addition, several projection-makers reject the idea of producing forecasts or publishing measures of probabilities (as in the probabilistic approach, summarized in the next section), because such practices may convey a misleading sense of precision, and may not be justifiable in view of past performance of projections (Lutz et al. 2004).

However, the scenario approach has often been viewed as an unsatisfactory way to deal with the assessment and communication of the uncertainty of population projections (e.g., Lee 1998, de Beer 2000, NRC 2000, Keilman et al. 2002, Bijak et al. 2015). Some of the noted limitations of the scenario approach are the following:

- The scenario approach does not adequately reflect the uncertain nature of population projections (NRC 2000, Bijak et al. 2015).
- In its most common application, namely the high-growth versus low-growth configuration, the scenario approach is designed to provide plausible variations only in terms of population sizes. Nothing ensures that the variations projected for other demographic indicators are plausible nor probabilistically consistent, that is, that the variations in these indicators are of the same size and order as those of population size. For example, the high-growth versus low-growth configuration tends to yield very narrow variations for the old-age dependency ratio, in contrast to variations of population sizes (Lee 1998, Lee and Edwards 2002, Keilman et al. 2002). Comparisons with probabilistic projections results suggest that these intervals are too narrow (Lee 1998, Lee and Edwards 2002, Keilman et al. 2002). For the scenario approach to provide plausible results, it must be tailored to the outcome for which one wants to assess uncertainty (Lee *ibid.*). For example, an analysis centred on the old-age dependency ratio could compare two scenarios, one proposing high mortality and high fertility and a second one combining low mortality and low fertility. The issue gets more complicated when variations are needed for more than one outcome, as there will be no consistency in all scenarios.
- There can be several ways of combining levels of fertility, mortality and migration that yield similar ranges of population sizes. By comparing only a small number of scenarios, the scenario approach is unable to capture the infinite ways in which the various components of growth can combine (Lee 1998).
- Because no probabilities are associated with the different parameters of the inputs, it is not possible to provide a probabilistic interpretation of the results of deterministic scenarios. It is also not possible, without revising the specification of the scenarios, to modify the width of the high-low interval for some specific purposes. These characteristics may limit the usefulness of deterministic variants for planning purposes.

- To avoid providing statements about the likelihood of their projections, some NSOs provide a plurality of projection variants without providing the likelihood or probability of each variant. This is in contradiction, however, with the way in which population projections are usually produced. Indeed, as Keyfitz (1972) noted, most projection-makers build their assumptions based on what they think the most likely outcomes are, since without such assessment, any possible variant would as good as any other, and there would be no special value to any scenario. Besides, the fact that a projection-maker does not want to consider the projection as a forecast does not prevent users from doing so themselves. Deprived of any 'most probable' outcome, planners often have no other choice. However, in practice, many decision-makers may be willing to accept any kind of information about how reliable the projection will likely be, even a subjective but informed opinion. For de Beer (2000 p.26), "to let users make their own choice does not seem an optimal use of expertise." Similarly, Keyfitz (1981) observed that in practice users depend on demographers for assessing the likelihood of different outcomes, and that if this cannot be done by those specializing in the subject, then no one can do it.
- The scenarios themselves may also be difficult to interpret. Indeed, the scenario approach implies several kinds of high or perfect correlations that do not represent highly plausible outcomes (de Beer 2000, Keilman et al. 2002). For example, in a single variant, perfect correlation is assumed over time for a given component and between components (e.g. constant high mortality and low fertility). High correlations can also be found between scenarios, especially when designed specifically for providing a range of outcomes for some variable (e.g. population size).

The probabilistic approach

In recent years, an increasing number of researchers have advocated for a paradigm shift in population projections in order to solve the inconsistencies and address the caveats associated with the scenario approach described above. For these researchers, uncertainty should be characterized using the language of probability, and measures of uncertainty should be provided through the use of probabilistic methods.

Fundamentally, probabilistic projections result from the borrowing of methodologies developed for *uncertainty analysis* in other domains of science and their application to population projections.²³ Uncertainty analysis consists of quantifying the uncertainty in the results of a model (Saltelli et al. 2008). A general procedure for uncertainty analysis contains the following steps: 1) define the measurement process, 2) develop the error model, 3) identify the error sources and distributions, 4) estimate uncertainties, 5) combine uncertainties, and 6) report results of the analysis. Methods used for uncertainty analysis can also be used for sensitivity analysis, which can be defined as "the study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to uncertainty in the different inputs to the model" (Saltelli et al. 2004 p.45).^{24,25}

²³ Although simplified alternatives have been developed to bring some of the benefits of probabilistic projections into the scenario approach framework (e.g. Bertino et al. 2012, Goldstein 2004).

²⁴ This is the definition retained in the context of this report. However, as noted in Saltelli et al. (2004), the term *sensitivity analysis* may have different interpretations depending on the setting or the technical community.

²⁵ This is often done without the machinery of probabilistic projections. For example, one could run two scenarios with the low and high values of an 80 per cent prediction interval for fertility to obtain a range of outputs associated strictly with variations in fertility. The results would reflect the differences given an 80 per

In a probabilistic projection, the parameters do not have single values but rather take on a range of possible values in accordance with a probability distribution. Such projections have been built using time-series extrapolations, expert elicitation, analysis of past forecast errors, or a combination of these methods. By sampling parameter values from the associated probability distributions for the various components of population change, an infinite number of trajectories can be produced. This approach allows the integration of the uncertainty associated with each component of population change in a consistent manner (even though they may be summarized by non-comparable indicators, such as the total fertility rate, life expectancy at birth, etc.). As a result, for any outcome variable (population size, the size of individual age groups, indicators of age structure, etc.), users can identify a single forecast, usually set equal to the median result from a large number of simulated trials (or trajectories), surrounded by a prediction interval corresponding to a selected probability (usually 80 or 95 per cent).

When outcomes have associated probabilities, it becomes obvious that some outcomes are more likely than others. Indeed, the vocabulary used to describe probabilistic projections suggests a predictive goal, reflected in the use of terms such as “forecast error”. As Alho and Spencer (2005 p.244) have noted, “In general, a forecaster must be prepared to describe a stochastic or probabilistic forecast as representing his or her subjective views of the likelihood of future developments”. This subjective approach to probabilities is natural in a Bayesian framework, embraced by several probabilistic projection-makers (see Appendix G for more details).

Because it allows one to incorporate more information about uncertainty and to better mimic the uncertainty propagation over time than the traditional deterministic projections, probabilistic projections are seen as providing more authoritative assessments of uncertainty. However, to be considered as such, several conditions need to be met. Clearly, probabilistic projections have numerous benefits as well as limitations. These are described at length in the literature and are summarized here in Appendix E. Appendix F shows how uncertainty analysis and sensitivity analysis have analogues in the domain of population projections. Finally, Appendix G shows an application of decision-making using results from probabilistic projections.

Good practices

3.1 *Develop an explicit strategy for characterizing and communicating the uncertainty of population projections*

NSOs should think of the quantification of uncertainty as a valuable result in itself. This would naturally lead to the development of a comprehensive and explicit strategy for the communication of uncertainty. Moreover, a clear exposition of such a strategy would allow users to understand its strengths and limitations, and the multiple sources of the uncertainty inherent in population projections.

An explicit strategy should entail the selection of some specific key outcomes (e.g., population size, components of change, and indicators of the age structure) for which it seems particularly important to communicate information about the uncertainty of the projections. For example, in industrialized countries, indicators of population ageing will likely be sought. Other indicators that decision-makers could look for might be estimates of the size of future cohorts of students at various ages or the number of people entering the labour force. This approach would be preferable to what is the most

cent prediction interval in assumptions. However, an 80 per cent prediction interval obtained from a probabilistic projection with varying levels of fertility could show different results in the presence of non-linear interactions between fertility and the other components of growth (if the projection model allows for them).

current strategy used by NSOs, a rather mechanistic application of the high-growth/low-growth configuration in the scenario approach, which, as mentioned earlier, possesses some flaws, especially when used for outputs other than population size.

A comprehensive strategy could also include the use of different methods to assess uncertainty in population projections. An exhaustive approach, for example, could include reporting the expected main sources of uncertainty in the projections, qualitative assessments by independent experts of the assumptions, estimation of model uncertainty through comparison of various models, production of different scenarios for sensitivity analysis for some results deemed sensitive or important and the production of prediction intervals via probabilistic methods. This example may look somewhat extreme, and mainly serves to illustrate the variety of methods that NSOs can use to communicate uncertainty. That said, such comprehensive strategies have been used in other domains such as the studies of future climate change (e.g. IPCC 2013). Subsequent good practices in this chapter discuss some of these methods in more details.

3.2 Identify and acknowledge the major sources of uncertainty

There are obviously innumerable sources of uncertainty in population projections. It is a good practice to identify the major sources of uncertainty in population projections, recognizing that some sources are not known even to the projection-makers. The most important sources could be the topic of a more in-depth analysis when possible, following an explicit strategy as suggested above. In probabilistic projections, the uncertainties that are unquantifiable but potentially relevant can be identified and evaluated with regard to overall importance. Such practices would reinforce the observation that population projections are not predictions while also enhancing the transparency of the resulting projections. The various sources of uncertainty in population projections have been described in several papers and books (e.g., Hoem 1973 p.14, Lee 1998 p.157, de Beer 2000 p.2, Alho and Spencer 2005 p.238), and are summarized in Box 2.

Finally, although population projections usually perform well within limited time horizons thanks to demographic momentum and also in situations with little variation in vital rates²⁶, their accuracy is adversely affected by unpredictable events such as war, economic crises, or natural catastrophes. For example, a sudden surge in the number of births (the ‘baby boom’) and its abrupt termination two decades later (the ‘baby bust’) were largely unforeseen (Keyfitz 1981, Reher 2015). One might argue that such events are unlikely to be missed today because the techniques of population projection have greatly improved over time. There is, however, no clear evidence that this is indeed the case nor that substantial improvements in the accuracy of forecasts will occur in the future (Keilman 2008). It seems foolhardy to believe that demographers will not be surprised by other unforeseen demographic events in the future.²⁷ Noting the disastrous records of forecasters in other domains such as finance, Taleb (2012 p.9) warns against “the (unscientific) overestimation of the reach of scientific knowledge”. He observes that because of structural limitations and an inevitable blindness with respect to randomness there are areas where the possibility of rare but very

²⁶ For example, projections of population ageing in most industrialized countries can be considered as robust in the short and mid-term given their current age structures.

²⁷ For example, some Mediterranean countries experienced decreases in fertility in the second half of the 1980s and the first half of the 1990s that were similar in proportion to the post-war baby-boom and baby-bust. Those changes had also not been anticipated (Alho and Spencer 2005 p.232).

consequential events simply cannot be assessed (Taleb 2010). These limitations should be made explicit to the users of population projections.²⁸

Box 2: Main sources of uncertainty in population projections

- **Uncertainty related to data:** This uncertainty includes the imprecisions in the data used for constructing the projection such as the baseline population and the observed vital rates used for choosing the assumptions. Reviewing world projections published by the United Nations since 1950, Keilman (2001) noted that the importance of projection errors due to inaccuracies in baseline data tends to decline over time, but may nevertheless remain the dominant source of projection errors for as long as 10 years after the projection in countries with particularly poor quality data. Keilman also found that poor quality of birth and death data contributes to errors in the projection of total fertility or life expectancy (ibid.). Lutz et al. (2007) provide an example where uncertainty in the current demographic conditions can be found in probabilistic projections of China.
- **Uncertainty of the future:** This is uncertainty about whether the assumptions used in making the projections will accurately reflect future demographic trends. This type of uncertainty increases with time. It includes uncertainty about whether events will occur, such as the implementation of policies affecting demographic levels and trends. Due to the absence of precise information about the future, these questions must be framed in terms of probability and plausibility.
- **Structural uncertainty:** This refers to uncertainty related to limitations in our understanding of population dynamics and in our capacities to model them. Experts tend to underestimate the magnitude of the structural uncertainty that is inherent to complex systems and processes (Morgan et Henrion 1990). Typically, parts of the population projection methodology are immune to structural uncertainty. For example, in a cohort-component model, the demographic equation consists of exact relationships between population growth and the components of growth (births, deaths and migrations). Structural uncertainty, however, comes into play when modelling these components and projecting them into the future.

Possible sources of structural uncertainty are:

- Lack of scientific knowledge
- Limitations/boundaries of the modelling processes
- Events with low probability that are not considered in the modelling process
- Limitations of indicators used in the modelling process.

3.3 *Clearly state the uncertain nature of the projection results in high-level dissemination materials*

The uncertain nature of population projections can be described in a simple, clear and candid manner as part of any high-level or summary dissemination materials (Wardekker et al. 2008). The consumers of the projections cannot be expected to understand the nature of their uncertainty if it is not explained and summarized for them in a convenient manner (Campbell 2011, Fischhoff 2013). Discussing the concept of uncertainty and how it affects the interpretation of the results can be especially useful for a lay audience. Including a statement about uncertainty in high-level

²⁸ Demographers are mostly aware of this, as illustrated by the current common practice among NSOs of publishing a warning or cautionary note that the projections are the result of plausible assumptions but do not account for unpredictable events or circumstances such as economic crises, wars, or natural catastrophes (see Appendix H). Also, as noted in NRC (2000), the occurrence of some of these events would change the world so significantly that the original planning the projections were intended to inform would largely lose its relevance.

dissemination materials increases the chances that journalists may pick up on the topic. A statement on the uncertainty of the projections does not require a specific quantity or measure. On the contrary, the message should be short and accessible, helping to inform the public of the speculative nature of projections. Box 3 provides some examples of simple statements on uncertainty that can be included in a press release or other high-level dissemination materials.

In addition, a short introductory section of this nature could explain how uncertainty affects the results, and how it is dealt with in the context of a given projection, guiding readers through the various sections where uncertainty information is disclosed. Such a section could also include an assessment of what is known and what is highly uncertain, and a summary of the main sources of uncertainty, which could be discussed in greater detail elsewhere in the dissemination materials, employing the technique of progressive disclosure of information, as discussed in chapter 1 (good practice 1.2).

A review of the most recent disseminations by NSOs indicated that many have already embraced, to varying degrees, the practice of producing high-level summary information on the uncertainty of projections. The references listed in Appendix H offer numerous good examples from NSOs of tactics for communicating the uncertainty of population projections. Some of the most useful approaches include:

- Noting that projections are not intended to be predictions about what will happen in the future nor do they describe an inevitable outcome;
- In cases where multiple deterministic projection scenarios are published, encouraging users to consider a range of projection results rather than a single result, by comparing multiple scenarios;
- In cases where probabilistic projections are produced, publishing prediction intervals, possibly at different levels (e.g. 80 per cent and 95 per cent). Also, showing one or a few trajectories (iterations) is helpful to illustrate how the uncertainty may propagate over time over time in the projections and facilitate the understanding of the approach (e.g. United Nations 2015b);
- Noting that the accuracy of a projection depends on a number of factors that are difficult or impossible to anticipate, such as economic crises, wars or natural catastrophes;
- Noting that projections are uncertain and become increasingly so with the length of the projection horizon (e.g., projection uncertainty is much greater for the characteristics of cohorts who have not yet been born, as these require assumptions about future fertility patterns);
- Offering answers to common questions from users, e.g., “which series should I use?”, which provides an opportunity to explain that using several scenarios yields a more realistic picture of possible future trends;
- Noting the key differences between population estimates and projections;
- Observing that certain components of a projection contain more uncertainty than others and explaining why this is true (e.g., assumptions about future net migration are highly uncertain, since immigration levels can be volatile as a result of economic and policy changes, while knowledge of emigration levels may be very poor due to data quality issues).

Box 3: Examples of good practice in communicating uncertainty in high-level dissemination materials

Federal Statistical Office of Germany

Press release

In this example, a portion of a press release was allocated to state the uncertain nature of population projections, mentioning that many variants were published and how they were produced. This practice can certainly increase the likelihood of receiving more accurate press coverage.

“WIESBADEN – [...] As the President of the Federal Statistical Office (Destatis), Roderich Egeler, stated at a press conference to present the results of the 13th coordinated population projection, the country's 2013 population of 80.8 million was expected to increase, depending on the assumed extent of net immigration, over a period of five to seven years and to decline afterwards. He continued that the population figure would be below 2013 levels not before 2023. In 2060, the population size would be 67.6 million according to a lower and 73.1 million according to a higher immigration variant.

However, long-term population projections are not forecasts. They provide 'if-then statements' and show how the population and its structure would change based on certain assumptions. The results shown here were obtained by two of the total of eight variants included in the 13th coordinated population projection. These variants describe the development until 2060 based on the assumptions that the average annual birth rate will be 1.4 children per woman, with the average age at birth rising; life expectancy will increase by seven years (men) and six years (women); and migration will develop according to two different assumptions. [...]”

REFERENCE: Federal Statistical Office of Germany (2016).

World population stabilization unlikely this century

Article in *Science*

This example shows how, in probabilistic projections, it is possible to demonstrate the uncertain nature of population projections results very simply by using the language of probability.

“The United Nations (UN) recently released population projections based on data until 2012 and a Bayesian probabilistic methodology. Analysis of these data reveals that, contrary to previous literature, the world population is unlikely to stop growing this century. There is an 80% probability that world population, now 7.2 billion people, will increase to between 9.6 billion and 12.3 billion in 2100. This uncertainty is much smaller than the range from the traditional UN high and low variants. Much of the increase is expected to happen in Africa, in part due to higher fertility rates and a recent slowdown in the pace of fertility decline. Also, the ratio of working-age people to older people is likely to decline substantially in all countries, even those that currently have young populations.”

REFERENCE: Gerland et Al. (2014).

3.4 Dedicate space within disseminated materials to promote a better understanding of uncertainty and its interpretations

The uncertain nature of population projections calls for at least a minimal understanding of related concepts such as assumptions, scenarios, plausibility and uncertainty itself, all of which are complex topics. The concept of a forecast or a projection, and what we can reasonably expect from such an exercise, is often misunderstood. Even among demographers, such topics continue to be a subject of lively debate. This fact is not surprising, however, since the conceptualization of ideas such as chance and uncertainty has been challenging ever since Bernoulli's seminal thinking on the subject of probability in the early eighteenth century (Fischhoff 2013 p.69).

While it is useful to have all concepts related to uncertainty included in an accessible glossary within the disseminated materials, another good practice is to dedicate a section of these materials to a discussion designed to educate people on how to understand uncertainty more accurately and in

greater depth.²⁹ This section could also be the occasion to engage in a more direct and informal dialogue with users on the communication of uncertainty and other relevant topics. Showing not only expertise but also a desire to teach and a sense of care about users is likely to reduce the distance between experts and the lay public and to increase the public's trust in the experts and in the information they provide. Lastly, the use of graphs can be very helpful to portray uncertainty simply and effectively (e.g. Spiegelhalter et al. 2011). Box 4 provides examples of good practice in the communication of concepts of uncertainty related to population projections.

Box 4: Examples of good practice in the communication of concepts of uncertainty related to population projections

United Kingdom

Postnote Number 438: Uncertainty in Population Projections.

This note, published by the Parliamentary office of science and technology in United Kingdom, provides a description of how population projections work, a short assessment of past projections, a discussion of the limitations of various models of projections and guidance in terms of how to manage uncertainty in a policy context.

REFERENCE: Parliamentary Office of Science and Technology (2013).

Population Reference Bureau

Policy Brief, July 2014: Understanding Population Projections: Assumptions Behind the Numbers

In this brief, the authors encourage policymakers and planners to understand how projections rely on assumptions about the future and the implications of uncertainty for successful planning. They examine the population projections produced by the United Nations (World Population Prospects: The 2012 Revision) in order to describe how uncertainty comes from a variety of sources and how it increases over time. The authors also debunk some myths about projections (e.g. the growth of a country does not stop immediately once its fertility reaches replacement level).

REFERENCE: Kaneda and Bremner (2014).

3.5 Pay close attention to verbal expressions of uncertainty

Words can be an effective way of conveying a general idea of uncertainty. In general, verbal expressions are more easily remembered than numerical expressions and are better adapted to lay audiences (Kloprogge et al. 2007). Qualitative assessments and evaluations can be appropriate when quantitative measurements are impossible to provide (IPCC 2010). They are especially relevant when communicating degrees of consensus among experts.³⁰ Some simple strategies for communicating uncertainty in words include:

- Describe the results of multiple variants rather than a single estimate (in the case of deterministic projections) or a prediction interval (for probabilistic projections);
- Use conditional phrasing so as to integrate uncertainty within the message. This is particularly important for probabilistic projections given that the language adopted may tend to exaggerate the predictive capabilities of the projection-makers;
- Emphasize that the results are not predictions and that the report contains additional information regarding the uncertainty of the results;

²⁹ For example, Woloshin et al. (2007) found that when provided a booklet describing how to understand the risks and the possible benefits or harms from an intervention, data interpretation skills among patients were improved considerably.

³⁰ Projection-makers can also find some inspiration for the assessment of their methods in protocols developed in science for integrating qualitative and quantitative dimensions of uncertainty and communicating them efficiently, such as the NUSAP (Numeral, Unit, Spread, Assessment and Pedigree) notational system (e.g. Funtowicz and Ravetz 1993).

- Draw attention to differences of opinion regarding the main assumptions and explain how such choices can influence the results;
- Demonstrate how a given result could change if there were a deviation from assumptions or an unexpected event (e.g.: population ageing may be likely across a range of plausible scenarios, but its magnitude could be lessened by higher than-expected levels of fertility or immigration).

The benefits of verbal expressions can also be achieved in the case of probabilistic projections by using fixed scales in which calibrated language is used to express probabilistic estimates. For example, IPCC (2010) used a likelihood scale in which linguistic qualifiers like “virtually certain” and “very likely” were associated with ranges of probabilities such as greater than 99 per cent, and 90 to 99 per cent, respectively.

Some disadvantages of fixed scales are that the terms are imposed upon users, and do not necessarily match how they would intuitively have used them, and that like numerical expressions, they are not well adapted to uncertainties that are difficult to quantify (Kloprogge et al. 2007). Verbal expressions may also be consistent with various interpretations, depending on the context (Morgan and Henrion 1990). However, as noted by Renooij and Witteman (1999), this also occurs in the case of numerical expressions.

3.6 Solicit and publish expert opinion

Asking experts for their best professional judgment is often the only viable option when a decision must be made in the absence of empirical data, or when the required data are limited, unreliable, or prohibitively expensive (Allan et al. 2010, Runge et al. 2011). In the context of modelling uncertain events, elicitation of expert opinion can be used to translate professional judgment about uncertain events into something that can be usefully modelled (Gosling 2014).

Yet, expert elicitation should not be viewed merely as a ‘last recourse’, as it offers several benefits. An important feature of expert elicitation in a statistical framework is that the expert uncertainty is explicitly included in the modelling process in a formal way, reflecting the differences of opinions between the experts (e.g., Bijak and Wiśniowski 2010). Indeed, when properly structured and documented, expert elicitation characterizes uncertainties in a transparent manner. It is also a relatively quick and inexpensive method to undertake as compared to intensive research or data collection (ibid., Gosling 2014). Furthermore, in some cases, expert elicitation may be preferable over other methods, such as time series extrapolation, if it takes into consideration additional information beyond what was previously observed. According to Lutz et al. (1998), this argument is especially pertinent in the case of population projections, as demographic trends are highly affected by social changes and policies that can be difficult to predict based only on historical trends.

There are limitations to expert elicitation, however. One is that it can be difficult for experts to articulate their views (Gosling 2014), especially when they are asked to assign probabilities to specific events. Indeed, it has been found that humans in general, whether experts or not, are not good at estimating probabilities (Morgan and Henrion 1990, Garthwaite et al. 2005, Kynn 2008). Faced with such tasks, individuals resort to heuristic devices that can lead to biased outcomes.³¹

³¹ More details about these possible biases can be found in: Morgan and Henrion 1990, Hoffman et al. 1995, Kynn 2008, Lutz et al. 1998 and Martin et al. 2011.

Projection-makers who utilize expert elicitation should be aware of such limitations. Various protocols have been created to facilitate the processes of expert elicitation.³²

3.7 Provide uncertainty analysis

As indicated in the introductory part of this chapter, uncertainty analysis is a standard practice in science. Its application to population projections, yielding probabilistic projections, provides a means to translate the uncertainty estimated for each component of the growth, and possibly the baseline data, into uncertainty of the results (see Appendix F for an illustration). Equipped with probabilistic projections, users can acknowledge and integrate the uncertainty associated with projections of future population trends into an analysis using projections as inputs for research on various topics or for other types of forecasts.

Results from the user survey provide some support for the provision of probabilistic projections, suggesting that users desire some quantification of the uncertainty of population projections. Indeed, as previously mentioned in Chapter 1, more than two-thirds of respondents (69 per cent) felt that it was either important or very important to provide a quantification of the uncertainty of the projections, while very few (1 per cent) felt that this was not important at all.

Uncertainty analysis, and probabilistic projections more specifically, provides a means for projection-makers to communicate the range of errors that can reasonably be expected in a particular demographic forecast. This is typically done by publishing results in the form of prediction intervals. A good practice is to avoid very large intervals, which are not very useful, and very narrow ones, which exaggerate the precision of the forecast. A reasonable choice for publication in this context, often selected by the purveyors of probabilistic projections, is 80 per cent. However, an application that allowed users to select their own prediction intervals would encourage them to think about risks associated with unexpected outcomes. Projection-makers might also consider posting a database containing the full set of sample paths to allow a user to calculate their own statistics (e.g., a prediction interval for the size of the labour force in the future).³³

Methods used to produce probabilistic projections should be tested with historical data and re-calibrated if necessary. It is expected, for instance, that observed values would be contained in an 80 per cent prediction interval, on average 80 per cent of the time (Raftery 2014). Calibration can be achieved by using sequences of retrospective forecasts where a past period is forecasted using data available at the beginning of the forecast.³⁴ By measuring how a forecast methodology performs in past contexts, retrospective forecasts also provide an indication of they could likely perform in the future (Kirtman et al. 2013). Results from cognitive research show that calibration tends to improve trust in the forecasts (Raftery *ibid.*).

It must be clear that given the speculative nature of such an exercise, evaluating the uncertainty of population projections will remain a difficult task, whatever the methods used. However, the

³² Examples or summaries of such protocols can be found in Morgan and Henrion (1990), Hoffman et al. (1995), Collopy et al. (2001), van der Sluijs et al. (2004), Garthwaite et al. (2005), Scapolo and Miles (2006), Aspinall (2010), Knol et al. (2010), and Fischhoff and Davis (2014), among others.

³³ For example, results of stochastic household forecasts were made available on the Internet in the context of MoPAct, a project that aims to provide the research and practical evidence upon which Europe can begin to make longevity an asset for social and economic development (see MoPAct 2016).

³⁴ Back testing of models, or retrospective forecasts, have been used intensively in the fields of meteorology and oceanography, where they are also termed as 'hindcasts'.

machinery of probabilistic projections, when properly executed, can help projection-makers to provide an assessment of uncertainty that is deemed authoritative, at least by comparison with what can be obtained with other methods, or, put differently, one that in the current state of knowledge should constitute a valid standard for comparison by which other methods should be judged.

In light of the benefits and limitations of disseminating probabilistic projection results (summarized in Appendix E), a well-guided approach is for NSOs to evaluate carefully their capacity to implement such methods without compromising the overall quality of their projections (including the plausibility of the median trajectory in probabilistic projections).³⁵ In particular, explicit measures of uncertainty should be provided only when projection-makers are confident of their capacities to build scientifically sound confidence intervals, relying on robust data, solid expertise, and methods that are at least partially standardized, to the extent that a standard method has been agreed by consensus.

When probabilistic projections are produced, it is crucial to explain clearly how the prediction intervals were computed and to what they refer (i.e., which demographic components were allowed to vary in order to quantify the uncertainty in future population). Probabilistic projections, like deterministic ones, also require that certain assumptions be made by projection-makers. Also, most applications of probabilistic projections so far have treated only some components of the growth in a probabilistic manner. These details should be communicated to users.

Finally, users should be made aware that the probabilities attached to a forecast are also projections and have their own uncertainty. A suggestion, proposed by Lutz and Goldstein (2004 p.3) is “[...] to clearly tell the users that the stated uncertainty ranges should not be seen as precise objective probabilities but rather as indicative ranges depending on the specific model and parameter assumptions made according to the best judgement of the producers.” At the current time, probabilistic projections remain relatively rare and recent initiatives. Hence, thorough evaluations of their performance are practically non-existent.³⁶

3.8 Provide sensitivity analyses

Most NSOs have used the scenario approach to convey a sense of uncertainty about their projections, often describing it as a sensitivity analysis. It is useful, however, to distinguish clearly between these two practices. As described earlier, the goal of sensitivity analysis is not to represent a range of possible assumptions, which is generally the goal of the scenario approach (discussed in the following good practice), but rather to understand how a particular input in the model can influence the results.

The relevance of sensitivity analysis will be greatest when tackling societal concerns. It is particularly useful to recognize and understand the main drivers of an outcome such as population growth or population ageing as this may help policymakers to devise policies targeting the key factor(s) for a

³⁵ See Dunstan and Ball (2016) for a series of recommendations to projection-makers envisaging to develop probabilistic projections, including: engaging with users, collaborating with other organisations and adopting a gradual approach (e.g., publishing probabilistic national projections before extending to subnational projections).

³⁶ Examples of probabilistic projections can be found in: Alho and Spencer (1985), Stoto 1983, Lee and Tuljapurkar (1994), Lee (1998), National Research Council (2000), Lutz et al. (2004), Tuljapurkar et al. (2004), Statistics Sweden (2006), Keilman (2008), Abel et al. (2013), Statistics New Zealand (2014), United Nations (2015b).

given objective. For example, in industrialized countries, numerous sensitivity analyses have shown that contrary to conventional wisdom, immigration has limited potential as a means of moderating population ageing, especially when compared to the long-term impact of an increase in fertility (e.g. United Nations 2000).

Probabilistic population projections do not eliminate the need for sensitivity analyses, as they do not reveal the consequences of a specific change in an assumption for a given scenario (Lutz and Goldstein 2004). Nonetheless, probabilistic approaches do not preclude the use of sensitivity analysis either. For example, Statistics New Zealand published probabilistic projections in conjunction with deterministic ‘what-if’ scenarios (see Statistics New Zealand 2104), an approach that Dunstan and Ball (2016) described as useful for users and pragmatic from the point of view of projection-makers. Sanderson et al. (2003) showed how the various simulations from probabilistic projections can be combined in distinct groups based on their projected levels of fertility and mortality to obtain probabilistic analogues of deterministic scenario analysis.

3.9 Provide a range of plausible assumptions

In contrast to providing a forecast that only reflects the most likely outcome, the scenario approach, when properly implemented, aims to retain all assumptions that seem plausible (Lachapelle 1977). When implemented as such, the scenario approach provides valuable insights about the uncertainty of population projections. First, the publication of multiple deterministic scenarios underlines the fact that there is not one single path for the future. Second, it provides a simple way to communicate the plausible range of future demographic trends given what is currently known (Romaniuk 1976). Quoting Romaniuk (2010) about projections in general, “By properly exploring the future, we may have been able to narrow its blind spots”. Hence, even deprived of likelihood assessments, the plurality of scenarios remains useful to stimulate reflection and guide actions leading towards a more desirable future (Romaniuk 1994, 2010, Isserman 1992).

To be effective, however, the scenario approach should follow a carefully thought out and comprehensive strategy for communicating uncertainty (as described in good practice 3.1), one that comprises multiple facets of the results, such as population sizes, geographical distribution, various indicators of age structure, etc. It will be difficult in practice to consider all possible aspects of the results, so the choice of outcome variables should be guided by specific policy preoccupations in the country at hand, such as population ageing, renewal of the labour force, the magnitude of migration flows, etc. Additionally, NSOs should communicate clearly which aspects were considered and which ones were left out of the analysis.

CHAPTER 4 – FOSTER RELATIONSHIPS WITH USERS

Introduction

Good science communication must begin with aiming to understand audience needs and how to address them (National Academy of Sciences 2014, Bruine de Bruin and Bostrom 2013, Fischhoff 2013). Interactions with users provide an opportunity to determine whether or not the communication is well understood, and can lead to improvements when it is not. Interactions can also help to determine whether the communication approach responds well to the needs of users in general, and can trigger important changes in this regard. Furthermore, scientists are more and more being asked to help solve important policy issues with high stakes and highly uncertain information (e.g. climate change). Funtowicz and Ravetz (1993) called for an approach favouring a dialogue between all legitimate participants and the recognition of different perspectives, especially as regards environmental, societal and ethical aspects. For all these reasons, it is increasingly being recognized that effective scientific communication must be a two-way process.

One way to approach the public is through the media. Media coverage involving both traditional and new media can be helpful to communicate messages effectively and to reach new audiences. It is therefore critical to understand how media in all forms work and to cultivate good relationships with journalists.

The attitudes and the actions of the experts working in NSOs have a large part to play in the communication process, as they are the ones entering into contact with the public (Davies 2008). The following good practices should help NSOs to foster their relationships with users, which should improve users' experience with the products and enhance the utility of the projections.

Good practices

4.1 *Provide a clearly-identifiable means for users to obtain answers from projection-makers*

Requests for technical assistance from users can shed light on areas for improvement in disseminations. Among the respondents to the user survey who had previously contacted their NSO for information requests, 90 per cent felt that their NSO provided an adequate response to their request(s). This suggests that generally, interactions between NSOs and users are fruitful and productive from the user point of view, and therefore should be encouraged on the part of NSOs.

It is therefore recommended that NSOs consider taking the following interrelated actions in relation to fielding requests from users:

- Provide on the NSO's website a clearly-identifiable means for users to ask questions and provide feedback to projection producers, and respond to requests in a timely manner;
- Identify common themes in customer queries and provide responses to frequently asked questions or items known to be less understood in the dissemination material.

4.2 *Consider developing and offering 'outreach activities' to engage directly with users in a substantive manner*

NSOs may wish to consider engaging in outreach activities involving direct contact with users such as instructional workshops, training sessions, or online chat sessions in order to improve user understanding of projections. In terms of successful strategies for communicating with users, several

respondents to the NSO survey mentioned that the use of outreach activities such as these proved to be the most successful strategy for communicating with their users. The use of more in-depth, interactive communications provides an opportunity to reveal misconceptions or misinterpretations that users may have about the projection results, identifying in more specific and clear terms areas where communication improvements could be made and highlighting users' needs in terms of projection content. There is in fact some evidence from the literature that direct instruction by scientists generates positive reactions among members of the public (National Academy of Sciences 2014).

Outreach activities can also help to boost the credibility of projection-makers and NSOs in general. Indeed, activities such as discussing, teaching, and simply sharing information express trustworthy intentions, which is paramount since trust is, along with expertise, the main component of scientific credibility (Fiske and Dupree 2014).

4.3 *Provide notices of forthcoming projection releases to media and frequent projection users*

A good practice for NSOs is to distribute notices to the media and frequent projection users informing them of forthcoming projection dissemination releases. The popular media in particular play a vital role in communicating science to the public; indeed, the majority of citizens gain knowledge about scientific findings through the media (SIRC undated).

4.4 *Embrace traditional and new media*

For scientists, communicating with the public is often negatively perceived as a difficult and perilous duty (Davies 2008). However, popular media should be seen as a major channel for scientists to perform their responsibility of communicating with the public (ECCR 2007). Indeed, the quality of press releases has been shown to have an impact on the quality of subsequent news reporting (Schwartz et al. 2012). A proactive approach in this domain can help provide an accurate and balanced picture to the public and avoid possible pitfalls and misunderstandings, which could hinder trust from the public.

In addition to traditional media such as print, radio and television, projection-makers should direct efforts towards embracing 'new', internet-based media forms including social media. As noted by Brossard and Scheufele (2013), the new norm is for the public to use the internet to seek information about scientific issues, and new media science coverage may reach audiences not typically targeted by traditional media. While best practices in terms of online science communication are lacking at this time (Brossard 2013), projection-makers should prioritize the investigation of using new media such as social networking sites, blogs and online forums to communicate dissemination materials, as they provide more opportunities for potential users to be exposed to the information (ibid).

4.5 *Investigate and document the needs of users*

Several of the previous good practices may serve not only to provide information to users but also to gather information about what users need and what could be improved. Thus, interactions with users should be seen as opportunities to document their unmet requirements, identify good practices to maintain, and more generally as a way to constantly gauge the pertinence of the projections.

One particular area where unmet needs are typically frequent is for projections at subnational levels or for some given regions. Most NSOs provide some results not only at the national level but also for some smaller geographic levels, but they may be unaware of the specific needs of planners at more regional levels in terms of geographical disaggregation, time horizon and projected characteristics. NSOs can decide to produce custom projections for specific needs, possibly on a cost-recovery basis, or alternatively, offer guidance for the production of such projections.

Encouraging interactions with users can be challenging in practice. It is easier for users to contact the projection-makers than for projection-makers to contact users. Indeed, for the most part, users simply download projection materials from the NSO's website in an anonymous way, and there is no way for NSOs to know who has accessed or viewed their materials unless the user contacts them with an inquiry. Often, the best information NSOs have about their users is the number of web hits and/or downloads.

There are some practices that can be used to maximize the collection of information from users. Here are a few:

- Provide means for users to contact experts through the NSO's website (see good Practice 4.1 above);
- Engage in outreach activities such as conferences, seminars, workshops (see good Practice 4.3 above) ;
- Establish a working group (with knowledgeable users) that can help inform methodological changes, and also keeps the users involved;
- Maintain relationships with known users;
- Conduct consultations (formal or informal);
- Invite feedback whenever possible (e.g. at events, in publications, in signatures at the end of emails).

CONCLUSION

The field of population projections has seen important developments in recent years, with a particular focus on how it can contribute to better decision-making, a trend observed before in other scientific areas such as climate change forecasting, mathematical modelling and engineering. More developments in this area are expected and desirable, but progress in other spheres is also conceivable. For example, algorithmic modeling techniques (i.e., machine learning) appear particularly useful in forecasting in the absence of theories or models to elucidate the relationships between explanatory variables and when rich datasets are available (Breiman 2001), and some researchers are currently exploring the potential of these techniques for population forecasts (e.g., Bandyopadhyay and Chattopadhyay 2006). It is unclear at this stage how such developments, focused exclusively on predictive accuracy, most often at the cost of transparency, will contribute to better communication in population projections.

In view of these developments, projection-makers are often called upon to revise their methods, and even to develop new ways of conceiving their tasks, a burden that may be difficult to fit into tight production schedules. This document aimed to portray the current state of knowledge in population projections and to act as a bridge between users, researchers and NSOs. While it would be almost impossible for a projection-maker to implement all the good practices and recommendations contained in this document, it is hoped that projection-makers will find in it ideas that contribute to improving the usefulness of their projections and guidelines as to what should be published and how.

In the course of the preparation of this document, the Task Force strived to attain a balance between the views of the users, the NSOs and the experts, perhaps with a positive bias for responding to users' needs. The user survey constituted a rare occasion to explore what information users utilize and how they use it. However, despite this noble effort, the concept of 'users' needs' remains a complex one, difficult to circumscribe. One problem is that in some cases, users may be looking for information that supports a particular ideology or policy option. Furthermore, and perhaps more importantly, users may be unaware of certain ways in which they could benefit from projections. For example, users would find no special value in probabilistic projections if they are unaware of how to use the extra information about uncertainty. Indeed, as Lee and Edwards (2002) observed, users tend to conceive probabilistic projections as improved high-low prediction intervals, despite the fact that they can support more detailed and sophisticated analyses. Consequently, it is doubtful that the provision of probabilistic projections will lead to markedly better decision-making if not accompanied by an increase in knowledge about how to use such projections. Although classic examples involving *decision theory* (such as the one provided in Appendix G) are instructive, this question likely deserves a more thoughtful treatment.

The documentation and promotion of better practices for decision-making clearly emerges as an area for future development. This is particularly true considering the urgency and significance of societal concerns in which expected population sizes and characteristics constitute key variables, such as climate change, viability of pension funds or sustainable development. The question would definitely merit a dedicated report or workshop. Resources could also be made available publicly in order to inform users of statistical data of the fundamental principles applicable to decision-making, perhaps similarly to what the Royal Statistical Society achieves with its *Initiative on statistical literacy* (see Royal Statistical Society 2016). Additionally, it could be imagined that in the not-so-distant future, most projection-makers would be apt and disposed to advise decision-makers on how to efficiently use this 'new' kind of information. In any case, better decision-making practices can only result from good interactions between projection-makers and users.

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APPENDIX A – QUESTIONNAIRE OF THE USER SURVEY

Introduction

Dear Sir/Madame,

This survey is the result of an important initiative of a recently-appointed Task Force on Population Projections* within the United Nations Economic Commission for Europe**. Its purpose is to obtain information about how national population projections outputs are used and user's perspective about various aspects of the projections.

If you did consult population projections for your country prepared by the National Statistical Office in recent years, we ask you to support this initiative by completing the present survey. Your responses will be used in the formulation of a collection of good practices on communicating population projections and will help identifying areas for improvement in that regard. As a result, your elaboration in as much detail as possible in the comment sections of the survey is greatly appreciated and strongly encouraged.

If you feel that other persons in your organization might be in a better position to respond to the survey, or they could simply provide an additional perspective, please invite them to participate in the survey by forwarding the participation link.

You are kindly invited to complete the survey by 30 June 2015.

If you have any questions or concerns about the survey, please contact the representative of your National Statistical Office that invited you to participate in this survey, or send a message to "social.stats@unece.org" at your earliest convenience.

Thank you in advance for your assistance in this endeavour.

Paolo Valente

Statistical Division

United Nations Economic Commission for Europe

Classification questions

INFORMATION ON THE COMPILATION OF THE QUESTIONNAIRE

- In order to navigate through the questionnaire please use the PREVIOUS and NEXT buttons located at the bottom of each page, and not the buttons on your browser.
- The questionnaire can be filled in more than one session.
- Clicking on the PREVIOUS and NEXT buttons at the bottom of each page saves automatically the data entered. However, the information entered can be corrected later, if necessary.

1. Please provide the following identification information (optional):

(To be used only for the purpose of this survey).

Name (optional):

Affiliation (optional):

Country:

Email address (optional):

2. How would you categorize yourself/your organization?

- ☐ Private sector
- ☐ Government (National)
- ☐ Government (Regional/municipal)
- ☐ Research group
- ☐ School/University
- ☐ Media
- ☐ Non-governmental organization
- ☐ Other (please specify below)

Please specify or provide comments:

3. How would you rate your level of familiarity with population projections?

- ☐ High
- ☐ Intermediate
- ☐ Low

4. For what purpose do you use projections?

Indicate all that apply.

- ☐ Planning
- ☐ Research
- ☐ Education
- ☐ Reference for building own population projections
- ☐ Reference for building own projections (of characteristics other than population)
- ☐ Other (please specify below)

Please specify or provide comments:

Core questions

5. Using a scale from 1 to 5, where 1 is “of no importance” and 5 is “very important”, please rate the importance of the following elements in regards to your use of population projections:

	1 - Of no importance	2	3	4	5 - Very important
Information about the current demographic context/trends	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information about the assumptions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information about the methodology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information about the quality of the underlying data sources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Detailed analysis of the results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Visual description of results (graphs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Customizable data table	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Summary information about the results (e.g., highlights)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The provision of a set of several different scenarios/variants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The designation of a “best” or “most likely” scenario/variant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Detailed projection data (e.g., data tables by single year)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Frequent updates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quantification of the uncertainty of the projections	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Projection of characteristics other than age/sex/region	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. Which of the following statements best characterizes your use of population projection data?

- ☐ You primarily use data from the variant/ scenario that was labelled as most likely by the projection makers.
- ☐ While the projection makers did not identify specifically a variant/scenario as the most likely, you primarily use data from the medium variant/scenario.
- ☐ While the projection makers did not identify specifically a variant/scenario as the most likely, you primarily use data from a variant/scenario that you considered to be the most likely result, based on the specifications of that variant/scenario.
- ☐ You primarily use data from a variant/scenario that you specifically chose as being the most useful for your specific needs, based on the specifications of that variant/scenario.
- ☐ You use data from several variants/scenarios to obtain a range of possible future outcomes.

Comments (optional):

7. What is the time horizon for which you usually need projected population estimates?
in years.

Please respond with reference to the most recent edition of the population projections that you used.

8. In your opinion, the information about the current demographic context/trends is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

9. In your opinion, the information about the projection assumptions is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

10. In your opinion, the information about the projection methodology is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

11. In your opinion, the information about the quality of the underlying data sources is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

12. In your opinion, the analysis of the results is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

13. In your opinion, the number of scenarios/variants provided is:

- ☐ Not detailed enough
- ☐ Adequate
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

14. In your opinion, the projection data are:

- ☐ Not easily accessible
- ☐ Easily accessible
- ☐ No opinion/Not applicable

Comments (optional):

15. In your opinion, the projection data are:

- ☐ Not adequately detailed
- ☐ Adequately detailed
- ☐ Too detailed
- ☐ No opinion/Not applicable

Comments (optional):

16. In your opinion, the uncertainty of the projections is:

- ☐ Not clearly stated
- ☐ Stated, but it could be stated more clearly
- ☐ Clearly stated in an understandable manner
- ☐ No opinion/Not applicable

Comments (optional):

17. In your opinion, the frequency of projection updates is:

- ☐ Not frequent enough
- ☐ Adequate
- ☐ More frequent than necessary
- ☐ No opinion/Not applicable

Comments (optional):

18. In your opinion, the language used in the projection dissemination is:

- ☐ Too simplistic
- ☐ Appropriate
- ☐ Too technical
- ☐ No opinion/Not applicable

Comments (optional):

19. Have you ever contacted the national statistical organization for more information about the projections?

- ☐ No
- ☐ Yes

Optional comments:

20. Do you feel the national statistical organization provided an adequate response to your request(s)?

- ☐ Yes
- ☐ No (please elaborate below)

21. In your opinion, could some aspects of the communication of the projections be improved?

- ☐ No
- ☐ Yes (please elaborate below)

End of the questionnaire

Thank you very much for your participation. If you want, you may provide below any comments on the survey, in particular if you found any problems in understanding the questions, or providing the answers, or if you would like to provide additional information on any of the questions.

Paolo Valente

UNECE Statistical Division

on behalf of the UNECE Task Force on Population Projections

APPENDIX B – QUESTIONNAIRE OF THE NSO SURVEY

Introduction

Dear Colleague,

You have been identified as the contact person for the population projections produced by your National Statistical Office.

We are contacting you on behalf of a recently-appointed Task Force on Population Projections* within the United Nations Economic Commission for Europe** (UNECE). The Task Force on Population Projections, which includes members from various countries along with representatives from Eurostat, UNECE and the United Nations Population Division (DESA), was created following the recommendations of an In-Depth Review of population projections commissioned by the Conference of European Statisticians (CES) in 2014.

The main objectives of the Task Force are to (a) promote the sharing of good practices on communicating population projections and (b) create mechanisms for collecting and disseminating metadata on national and international population projections.

As part of the Task Force's information-gathering process, we have developed a survey to be completed by national population projection makers. The purpose of the survey is twofold:

- Firstly, to obtain basic information about your organization's national population projections. Your responses will be used to populate a database containing metadata about the national population projections of all UNECE member countries. This database, to be updated on a regular basis, will provide a central information access point for projection users.
- Secondly, to obtain information about your organization's approach to communicating population projection to users. Your responses will be used, in conjunction with a parallel survey of a sample of projection users and the ongoing work of the task force, to develop a report containing a collection of good practices for communicating population projections.

Your participation in this survey is essential to the achievement of the Task Force's main objectives. It is hoped that the forthcoming database and good practices report will provide useful information for all national statistical agencies involved in the production of population projections.

We ask that you kindly complete the present survey by 20 June 2015. If you feel that another person in your organization might be in a better position to respond to the survey, please forward to this person the participation link.

If you have any questions or concerns about the survey, please send a message to

"social.stats@unece.org" at your earliest convenience. Thank you in advance for your assistance in this endeavour.

Paolo Valente
Statistical Division
United Nations Economic Commission for Europe

*<http://www.unece.org/statistics/about-us/statstos/task-force-on-population-projections.html>

**http://www.unece.org/stats/stats_h.html

INFORMATION ON THE COMPILATION OF THE QUESTIONNAIRE

- In order to navigate through the questionnaire please use the PREVIOUS and NEXT buttons located at the bottom of each page, and not the buttons on your browser.
- The questionnaire can be filled in more than one session.
- Clicking on the PREVIOUS and NEXT buttons at the bottom of each page saves automatically the data entered. However, the information entered can be corrected later, if necessary.

Contact information

1. Please provide the following contact information for any follow-up communications in the future:

Name:

Title/position:

National Statistical Organization:

Email address (for follow up communications):

2. Email address for direct contact by projections users (optional):

The United Nations Economic Commission is planning to create a publicly accessible database of metadata on population projections. Each NSO may indicate (on an optional basis) an email address at which users of this database would be able to send requests in case they need information or clarification about the national projections. Only this email address, if provided, will be included in the public database.

Email address:

General information on population projections

The following questions pertain to the most recent edition of national population projections produced by your organization.

3. Please specify the month and year of the dissemination of the projections and/or related datasets (if multiple products were published over a period, please indicate the earliest date, including web dissemination):
4. Please provide electronic hyperlink(s), if available, to the dissemination products (publications and/or datasets):
5. Please specify the start and end year of the projections (if different year-ends are used for different products, please provide the farthest):
Start Year:
End Year:
6. Please indicate the source of the data for the base population, its reference date (month and year) and information on adjustments, if any:
Source:
Reference date (month and year):
Adjustments (if any):

7. Please indicate what is the update frequency of your projections:
8. Which population characteristics, other than age and sex, were distinguished in your projections:
Indicate all that apply.
- ☐ Sub-national geography
 - ☐ Marital status
 - ☐ Household type
 - ☐ Citizenship
 - ☐ Country of birth or origin
 - ☐ Ethnicity
 - ☐ Education
 - ☐ Language
 - ☐ None
 - ☐ Other (please specify below)
- Please specify or provide comments:
9. Please indicate the number and type of scenarios/variants published:
- ☐ One scenario only
 - ☐ One scenario with surrounding confidence interval based on probabilistic/stochastic methods
 - ☐ Several scenarios/variants based on deterministic methods (please specify below the number of scenarios/variants). Please specify the number of scenarios/variants or provide comments:
10. Please specify what level of detail is disseminated for age:
- ☐ Single years of age, until age:
 - ☐ Five-year age groups, until age group:
11. Please specify what level of detail is disseminated for year:
- ☐ Single years
 - ☐ Every 5 years
 - ☐ Other (please specify below)
- Please specify or provide comments:
12. In your disseminations, did you use the term(s):
Indicate all that apply.
- ☐ Projection (please elaborate below why)
 - ☐ Forecast (please elaborate below why)
 - ☐ Other (please specify below and elaborate why)
- Please elaborate on choice:
13. Referring to the term(s) selected in the previous question, do you define this term(s) in your disseminations?
- ☐ Yes
 - ☐ No

14. In your disseminations, did you use the term(s):

Indicate all that apply.

- ☐ Scenario (please elaborate below why)
- ☐ Variant (please elaborate below why)
- ☐ Other (please specify below and elaborate why)

Please elaborate on choice:

Dissemination approach

15. Please indicate the approximate percentage devoted to the following elements in your disseminations:

If other please comment in the next question

Information about the current demographic context/trends:

Information about the assumptions:

Information about the methodology:

Information about the quality of the underlying data sources:

Analysis of the results:

Other (please specify in next question)

16. Comments on other specification in the previous question:

17. What information was disseminated in regards to projection outputs or results?

Indicate all that apply.

- ☐ Pre-defined data tables
- ☐ Customizable database
- ☐ Written summary/highlights of results
- ☐ Detailed written analysis of results
- ☐ Visual description of results (graphs)
- ☐ Other (please specify below)

Please specify or provide comments:

18. As part of your dissemination process, did you present the results of your projections:

Indicate all that apply.

- ☐ In press releases
- ☐ In press conferences
- ☐ In external professional meetings
- ☐ In scientific conferences
- ☐ Upon request
- ☐ Never
- ☐ Other (please specify below)

Please specify or provide comments:

19. Upon request, would you distribute detailed parameter/input data to allow users to reproduce the projections, or similar projections:

For example age specific fertility rates.

- ☐ Yes
- ☐ No
- ☐ Don't know

Comments (optional):

Communication – consultation

20. Please indicate which of the following bodies you consulted during the production of the projections, if any, and for what purpose(s) did you consult them:

Indicate all that apply.

	To develop assumptions and/or methodologies	To obtain feedback about assumptions (though you keep the final word on the assumptions)	To obtain feedback about assumptions (to which you must comply)	To inform them in advance of the official projection release with a primary focus on results	To inform them about the status of the production	NOT consulted
Senior management within the NSO	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other units within the NSO	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
National government agencies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sub-national government agencies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
International statistical agencies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
International bodies (e.g., international experts group)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Expert advisory group/panel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Frequent projection users, private sector	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Academic researchers other than formal expert panel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify or provide comments:

21. If you consulted any bodies during the production of the projections, were these consultations noted in disseminated products?

- ☐ All of the consultations were noted
- ☐ Some of the consultations were noted
- ☐ No, the consultations were not noted
- ☐ Not applicable (there were no consultations)

Comments (optional):

Interaction with users

22. Do you have some measures of usage of the projections?

Indicate all that apply.

- ☐ No
- ☐ Yes, electronic web hits/page views views/downloads
- ☐ Yes, other (please specify below)

Please specify or provide comments:

23. Can you identify the major users of your projections?

- ☐ No
- ☐ Yes, all of them
- ☐ Yes, some of them

24. Please indicate the major users:

Indicate all that apply.

- ☐ Government agencies
- ☐ General public
- ☐ Business/industry Media
- ☐ Academia
- ☐ Other (please specify below)

Please specify or provide comments:

25. Can users receive technical assistance on projections matters?

(For instance, technical explanation).

- ☐ Yes, they can directly contact the projection makers
- ☐ Yes, mediated by some user support service
- ☐ No

Comments (optional):

26. Are users explicitly informed of the availability of this technical assistance in dissemination products?

- ☐ Yes, in all dissemination products
- ☐ Yes, but only in some dissemination products

27. What are the most common requests for technical assistance that you received? Please elaborate:

For example, if most requests relate to methodological issues, what are the most common methodological issues requiring further explanation?

28. Can you provide approximately in which proportions these requests come from the following category of users?

Leave blank if unknown.

Government agencies:

General public:

Business/industry:

Media:

Academia:

Other (please specify in following question):

29. Please elaborate on *other* if used in the previous question:
30. In your opinion, which initiatives or strategies for *communicating population projections* (including results and methods) to users have been most successful for your institution?
31. In your opinion, which aspects of your projection publications would your users like to see expanded or improved, if any?

Communication of uncertainty

32. In your disseminations, did you use any of the following methods to communicate the uncertainty of projections to users:

Indicate all that apply.

- ☐ Analysis of historical variation Expert judgment elicitations Analysis of past projection errors
- ☐ Creation of multiple deterministic scenarios
- ☐ Use of Bayesian reasoning
- ☐ Use of probabilistic/stochastic approaches
- ☐ Sensitivity analyses
- ☐ Cautionary/instructional note on the uncertainty of projection results
- ☐ Conditional phrasing (e.g., 'would' instead of 'will'), please specify:
- ☐ None
- ☐ Other (please specify below)

Please specify or provide comments:

33. In your opinion, which initiatives or strategies for *communicating the uncertainty of population projections* to users have been most successful for your institution?
34. In your opinion, what challenges do you encounter in *communicating the uncertainty of population projections* to users (for instance, do projection users have any common misconceptions about the projections)?

End of the questionnaire

Thank you very much for your participation. If you want, you may provide below any comments on the survey, in particular if you found any problems in understanding the questions, or providing the answers, or if you would like to provide additional information on any of the questions.

Paolo Valente
 UNECE Statistical Division
 on behalf of the UNECE Task Force on Population Projections

APPENDIX C – SUGGESTED TEMPLATE FOR REPORTING METADATA ABOUT POPULATION PROJECTIONS

The following template has been designed as a tool to facilitate the task of projection-makers in reporting relevant information about their projections and to help users quickly find this information. Projection-makers are invited to modify the template, if necessary, to provide any information they deem relevant in the way they believe will be the most useful for users. A good practice would be to dedicate a portion of dissemination materials related to the projections to publishing the information contained in this template. In addition, for National Statistical Offices, a large portion of the information contained in this template should also be reported in the UNECE database on population projections metadata once new population projections are published.

<i>(insert title of the projections)</i> Descriptive summary sheet		
Country/ies to which the projection refers:		
Title of the projection:		
Organization:		
Stakeholders involved in the production: <i>(list the stakeholders who have had an influential role in the production of the projections)</i>		
Links to disseminated products:		
Who to contact for more information:		
General information		
Year/month of dissemination (YYYY-MM): <i>(if multiple products were published over a period of time, this refers to the earliest date, including web dissemination)</i>		
Projection start date (YYYY-MM-DD):		
Projection end date (YYYY-MM-DD): <i>(if different end dates are used for different products, this refers to the latest):</i>		
Production frequency (in number of years):		
Population concept (de jure / de facto):		
Target population: <i>(population covered by the projections)</i>		
General model of projection: <i>(e.g. cohort-component model, microsimulation, extrapolation, etc.)</i>		
Type of projection:	<u>Deterministic</u> Number and type of scenarios/variants:	<u>Probabilistic</u> Levels of prediction intervals:

Disseminated details	
Sub-national geography – availability and consistency with national geography:	<input type="radio"/> Not available <input type="radio"/> Available, not consistent with national geography <input type="radio"/> Available, consistent with national geography (bottom-up) <input type="radio"/> Available, consistent with national geography (top-down)
Age (multiple answers possible)	<input type="radio"/> Single years of age (calculated) <input type="radio"/> Single years of age (interpolated) <input type="radio"/> Age groups, please define:
Maximum age or age group:	
Years	<input type="radio"/> Single years (calculated) <input type="radio"/> Single years (interpolated) <input type="radio"/> Every 5 years
Households and/or family projections available:	<input type="radio"/> Households <input type="radio"/> Families
Other variables projected:	<input type="radio"/> None <input type="radio"/> Household type <input type="radio"/> Citizenship <input type="radio"/> Country of birth <input type="radio"/> Other(s), please specify:
Data sources	
Base population:	
Other data sources used:	
Methodology for handling uncertainty of the projections	
Measures taken to communicate uncertainty of population projections: <i>(Short description of the strategy used to communicate uncertainty of population projections, e.g. dissemination of various scenarios, publication of prediction intervals, etc. If no measures were taken, indicate "no measures taken".)</i>	
Other relevant information or details about the population projections:	

APPENDIX D – SOME EXAMPLES OF DOCUMENTATION OF CONSULTATIONS WITH EXPERTS

Central Statistics Office (Ireland)

In the assumption-building process for their 2011-based Population and Labour Force Projections, the Central Statistics Office of Ireland received input and advice from a large Expert Group. The associated report presents the projection assumptions including descriptions of the elements that the Expert Group considered most important, hence helping users to follow the thought process that led to the adoption of the final assumptions. The report (see Central Statistics Office of Ireland 2013) can be found on the Central Statistics Office's website: http://www.cso.ie/en/media/csoie/releasespublications/documents/population/2013/poplabfor2016_2046.pdf

Institut National de la Statistique et des Études Économiques (INSEE), France

In the assumption-building process for their 2007-based Population Projections, the INSEE received input and advice from a large Expert Group. The associated report presents the projection assumptions including descriptions of the elements that the Expert Group considered most important, hence helping users to follow the thought process that led to the adoption of the final assumptions. The report "Projections de population 2007-2060 pour la France métropolitaine : méthode et principaux résultats" can be found on the INSEE's website (in French): see Blanpain, N. and O. Chardon. 2009. http://www.insee.fr/fr/methodes/sources/pdf/proj_pop_2007_2060_F1008.pdf

Office for National Statistics (UK)

For their 2014-based National Population Projections, the Office for National Statistics (UK) published the complete minutes of their Expert Advisory panel meetings. This exhaustive rendering of the dialogue between experts and members from the ONS makes it possible to identify the topics that triggered greater discussion or for which there was less consensus. These minutes ("National Population Projections: 2014-based projections", Chapter 1, Annex A) can be found on the ONS website: <http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/compendium/nationalpopulationprojections/2015-10-29/backgroundandmethodology#appendix-a-minutes-of-expert-panel>

Statistics Canada

For their 2013-based National Population Projections, Statistics Canada surveyed the community of Canadian demographers in order to gather their opinions about future demographic trends. In the technical report on the methodology and assumptions that was released along with the report of the results, they describe the results of the survey, often using box-plots graphs that show mean responses as well as their spread. It is therefore easy to identify areas where consensus is lacking. The technical report (see Bohnert et al. 2015) can be found on Statistics Canada's website: <http://www.statcan.gc.ca/pub/91-620-x/2014001/chap02-eng.htm>

APPENDIX E – MAIN ADVANTAGES AND LIMITATIONS ASSOCIATED WITH PROBABILISTIC PROJECTIONS

The benefits of probabilistic projections have been described at length by many demographers, often showing the advantages they bring over deterministic projections (e.g., Lee 1998, NRC 2000, de Beer 2000, Keilman et al. 2002, Lutz et al. 2004, Lutz and Samir 2010, and Raftery 2014). Probabilistic projections also carry limitations, although these tend to be less well documented. These limitations are not insurmountable, but NSOs should be aware of them when evaluating the option of producing probabilistic projections. The main benefits and limitations of probabilistic projections are summarized below:

Main benefits:

- Because probabilities don't exist in nature – rather, they are created due to our lack of knowledge as a means to express uncertainty – expressing projection results in terms of probabilities contributes to constitute an honest representation of the limits of our predictive abilities (Silver 2012). While the measures of uncertainty are themselves uncertain, they exist and highlight the uncertainty associated with projection figures. As Dunstan and Ball (2016, p. 951) explained: “It is only possible for users to think about uncertainty if that uncertainty is conveyed to them appropriately”. For Bijak et al. (2015), an explicit and transparent forecast of uncertainty promotes values of honesty, humility and trust.
- The fact that a projection-maker does not want to consider the projection as a forecast will not prevent a user from doing so. In the end, as it is impossible to observe the future, decision-makers have no other option than to consider a projection as a prediction. In these circumstances, decision-makers may be willing to accept any kind of information about how reliable the projection will likely be, be it a subjective but informed opinion. Probabilistic projections offer a way to provide this information.
- One of the main practical benefits of the probabilistic approach is that it provides the ability to produce consistent bounds of uncertainty for non-linear population indices (e.g. the old age dependency ratio).
- Probabilistic projections are well suited to respond to different types of users and needs. With probabilistic projections, users can tailor a prediction interval according to their sensitivity to uncertainty (Keyfitz 1972, Raftery 2014).
- Probabilistic projections improve the capacity for users to make decisions according to their sensitivity to risk. When users are able to quantify a loss (or utility) function, it can be combined with probabilistic projection results to determine the optimal course of action or to choose between a series of finite choices (see Appendix G for an illustration).³⁷

³⁷ Although, as Raftery (2014) indicates, this contribution should not be exaggerated as users will often not be aware of their loss functions, or will refrain from using these methods because of the cognitive load they entail. Perhaps it cannot be expected that most users would be able to apply formal decision theory for decision-making based on population projections, but by providing the means to do so, NSOs would definitely encourage good practices. It is possible though, that as probabilistic projections become more widely available, they will be used (ibid.).

Experiments have shown that the provision of uncertainty in the form of probabilistic information contributes significantly to better decision-making (WMO 2008).

- Probabilistic projections offer a natural framework for evaluating the probabilities of policies to achieve different goals and for maximizing these probabilities (Tuljapurkar 2006). They have been shown to be very useful, for example, in settings that involve intergenerational transfers over long time horizons, such as fiscal or health expenditures planning (e.g., *ibid.*, Lee and Edwards 2002, Lee and Anderson 2005, Lassila and Valkonen 2008).
- Prediction intervals are a natural tool in the context of Bayesian statistics, which offer several methodologies for decision-making under uncertainty (Bijak 2010)
- In the scenario approach, deterministic projections require setting in advance the assumptions for all components of growth, and hence to assume perfect correlations between these components; usually a highly implausible assumption. Perfect correlations are not necessary in probabilistic projections. Assuming that appropriate assumptions are made about the temporal autocorrelations of demographic rates, probabilistic projections are well adapted to simulate how uncertainty is revealed over the course of the projection (Lee 1998).
- The prediction intervals can support the decision of projection-makers in selecting the projection horizon to be published, and can help users to determine the usefulness of projection data in a given horizon (Dunstan and Ball 2016).

Main limitations:

- Population projections are typically made to inform or even assist active policy measures. This is in sharp contrast with short-term weather forecasts where the response is more about adaptation than policy-making. Despite the rich amount of information that they provide, probabilistic population projections do not eliminate the need for sensitivity analyses that can assist policy-making (see good practice 3.8). However, most existing probabilistic population projections are not, in their current shape, addressing this aspect.
- The production of probabilistic projections tends to be data-intensive and requires research scientists' specialized knowledge to implement (Lutz and Goldstein 2004), two elements that may constitute impediments for NSOs often operating with limited resources. Clearly, the development of probabilistic projections may not fit well with the intensive pace of production of NSOs due to constant demand for recurrent updates, specific customer requests, and other obligations.
- Reflecting on the experience of Statistics New Zealand, Dunstan and Ball (2016) noted that there are non-trivial investment costs associated with the development of a probabilistic approach. However, they also noted that statistical agencies can reduce development costs by adopting methodologies and software developed elsewhere, and once the methodology is adopted, the ongoing costs of producing probabilistic or deterministic projections do not differ significantly (*ibid.*).
- The desire to produce probabilistic projections may lead projection-makers to focus on the assessment of uncertainty at the expense of the 'medium' or 'most probable' scenario. This would be problematic knowing that a large proportion of users will be interested only in values from that 'medium' scenario. In particular, projection-makers could be tempted to favour methodologies that provide some forms of uncertainty measurements (such as

extrapolations of time series) at the expenses of other methods that incorporate more substantive knowledge about the various components of the growth and their determinants (Lutz and Goldstein 2004).

- The added complexity of probabilistic projections may also be detrimental for the communication of assumptions, hindering the transparency of the projections. As Lutz and Goldstein (2004) noted, NSOs must not only make projections that are scientifically sound, but also must produce descriptions of uncertainty that will be easily understood by a broad range of users. In many cases, users may not be equipped to understand complex models and therefore could have a hard time judging the merits of the assumptions.
- While uncertainties related to measurement are present (e.g. errors in the estimation of the baseline population, imperfections in the data used to determine the projection assumptions, etc.), an important source of uncertainty in the model outputs is of another nature, related to the necessity of making assumptions about the future, for which no data exist. Indeed, the production of probabilistic projections presupposes the capacity to develop reliable estimates of the uncertainty associated with the projection assumptions. The ultimate test for a forecast is calibration.³⁸ For example, meteorological forecasts have been shown to be well calibrated, meaning for example that when predictions are made for a 40 per cent chance of rain, it will rain about 40 per cent of the time (Silver 2012). Note that contrary to demographers, meteorological forecasters benefit from large numbers of daily forecasts to help them check and calibrate their models. Producers of probabilistic projections can often use repeated cross-validations and out of sample prediction for short/mid-term validation of the performance of the modelling. However, a probabilistic approach may not be appropriate when it is difficult or impossible to calibrate the model (International Actuarial Association 2010).
- In addition to situations when calibration is not possible, probabilistic modelling may not be the best approach when the added complexity prevents the models from being thoroughly reviewed and validated, or when it is difficult or impossible to determine appropriate probability distributions for some variables (International Actuarial Association 2010).
- The difficulty of estimating uncertainty in the inputs of population projections can lead demographers to use a variety of (often imaginative) methods and data sources. However, the results are likely to vary depending on the choice of methods and other subjective factors in modelling.³⁹ While calibration may help to counter these problems, it could be difficult to perform in some circumstances, such as when uncertainty data comes from an expert elicitation process.
- Despite the numerous developments in recent years, more research is needed in some areas of probabilistic methods in order to make them more readily applicable for projection-makers. For example, Wilson and Rees (2005) noted that migration is rarely forecasted probabilistically, and that this component deserves more research.⁴⁰

³⁸ For an example of probabilistic projections where calibration has been used, see Raftery et al. (2012).

³⁹ For example, as reported in Lee (1998, p.186): “a comparison of the Alho (1997) and Lutz, Sanderson, and Scherbov (1996) probability distributions for essentially the same forecasts revealed huge differences.”

⁴⁰ There have, however, been some interesting developments in recent years (e.g., Azose et al. 2016).

- The provision of precise statements about uncertainty may lead users to infer greater precision than what is intended (Fischhoff and Davis 2014, Lutz and Goldstein 2004).⁴¹ It may lead users to think that projection-makers have more knowledge about how the future will unfold than they really do (Lutz and Goldstein *ibid.*). For example, measures of uncertainty will be appropriate only if the statistical model behind them is a (very) good approximation of the underlying processes they aim to simulate (and will continue to apply in the future), which is not straightforward to assess, especially for long-term projections. Dunstan and Ball (2016) recognize that probabilistic projections may be inclined to underestimate uncertainty, but noted that spuriously precise prediction intervals remain preferable to a spuriously precise deterministic projection.
- The interpretability of the probabilities associated with future outcomes is not straightforward.⁴² As Romaniuk (1994) observes, the theoretical foundation for probabilistic projections is not clear, stemming in large part from the elusive nature of uncertainty in population projections. In general, probabilistic projection-makers conceive probabilities as representative of a degree of belief that an event will occur, and use data such as divergences of opinions among experts, variability in past estimates or errors in past projections to compute them.⁴³
- Findings from behavioural research indicate that people have difficulty in interpreting intervals well enough to extract key information. There are, for instance, known biases in the perception and evaluation of uncertain outcomes (e.g. Kahneman and Tversky 1979).⁴⁴

⁴¹ Stoto (1988) objects to this, stating that the point is not one of estimation but of communication. In other words, prediction intervals may be wrong, but they serve to communicate more precisely the intentions of projection makers.

⁴² Such difficulties have been well documented in the field of meteorological forecasts. For example, the results of several surveys in the United States have shown that the public has difficulty interpreting probabilities of precipitation, even though such probabilities have been published since the 1960s (Morss et al. 2008): in a survey conducted in 2008, less than one respondent in 5 was able to find the correct interpretation of the sentence “There is a 60% chance of rain for tomorrow”. The correct interpretation is “it will rain on 60% of the days like tomorrow” (Morss et al. 2008).

⁴³ This is a Bayesian interpretation of probabilities. More on this can be found in Appendix G.

⁴⁴ On the other hand, there are also indications from cognitive research that probabilistic projections can generally be well understood by people and lead to better decision-making (Raftery 2014).

APPENDIX F – EXAMPLES OF UNCERTAINTY ANALYSIS AND SENSITIVITY ANALYSIS

The following example is taken from Saltelli et al. (2008), who aimed to provide a general framework to integrate the uncertainty coming from various components in any kind of models. Here, a general model of population growth replaces the original model in order to show how probabilistic projections are simply cases of uncertainty analysis applied to population projections.

Imagine a very simplistic model where the total growth of a single population at time $t+1$ depends on three parameters: the future number of deaths, the future number of births and the future net international migration. Thus, the model can be written simply as:

$$growth_{t,t+1} = bth_{t,t+1} - dth_{t,t+1} + net_{t,t+1}$$

Now, the values of the inputs come from assumptions about the future and are uncertain, and consequently, there should be some measurements available of their uncertainty. For example, one could forecast the future number of births using time series forecasting methods, and using the forecasted mean and variance and, assuming a normal distribution, obtain a predictive distribution for the number of births between t and $t+1$.

In *uncertainty analysis*, one wants to translate the uncertainty of inputs into uncertainty of the results. To do so, it is necessary to compute the propagation of error in the model and over time. When a model is linear or relatively simple, this can be done analytically through uncertainty propagation equations, partial derivatives, or by regression analysis. However, for more complex models, or as a mean to integrate the various sources of uncertainty (often from different kind of distributions), Monte Carlo simulations are often required (Booth 2006).⁴⁵ Monte Carlo simulations allow large number of iterations to be run in which the parameters can be sampled from various types of probability distributions associated with the inputs.

Using Monte Carlo methods, a number of iterations (for example, one thousand) would be run each time using different values for the number of births, deaths and for the net migration, sampled from their respective probability distributions. So all parameters could be seen to be contained in a matrix M , composed of 1,000 series of randomly-drawn parameters:

$$M = \begin{bmatrix} bth^1 & dth^1 & net^1 \\ bth^2 & dth^2 & net^2 \\ \vdots & \vdots & \vdots \\ bth^{1,000} & dth^{1,000} & net^{1,000} \end{bmatrix}$$

The result of the 1,000 projections is a vector of 1,000 values, which is the predictive probability distribution for the population growth between t and $t+1$:

$$G = \begin{bmatrix} g^1 \\ g^2 \\ \vdots \\ g^{1,000} \end{bmatrix}$$

⁴⁵ Note that this is almost always the case for population projections models in which the inputs are often correlated and where there is time autocorrelation (i.e. the projection at time $t+2$ is dependent on the projection at time $t+1$).

From this distribution, it is possible to compute a mean or a median scenario, and measures of variances (e.g. standard error or prediction intervals). Thus, the resulting probability distribution of g integrates the uncertainty of all parameters.

In *sensitivity analyses*, one generally wants to know how the output (the population growth between t and $t+1$), will vary given a change in one of the inputs. For example, one could be interested in knowing how the growth will be affected by some variation in the number of births. Depending on the objective, these variations can be specified in different ways:

- a) Using a general target, possibly inspired by a given policy target; a given percentage increase for example.
- b) Following some probability distributions that model the plausible fertility levels between t and $t+1$, in which case the variations would be defined specifically by choosing a prediction interval (e.g. 80 per cent).
- c) Alternatively, one could use Monte Carlo simulations in order to measure the sensitivity of the growth to fertility. One could obtain, for example, the upper limit of an 80 per cent prediction interval of population growth (simply the 80th percentile of the distribution).⁴⁶ Note that this is not the same thing as the previous item, running one single projection using the upper limit of an 80 per cent prediction interval of the probability distribution of the fertility parameters.
- d) Caswell and Sánchez Gassen (2015) use calculus and projection matrix formulation to conduct *prospective sensitivity analysis*, which consists in measuring the sensitivity of the output with respect to specifications of the model. While the calculations do not provide information about the uncertainty of the outcome⁴⁷, they "[...] formalize the intuitive notion that uncertainty in a parameter to which an outcome is very sensitive translates into a high degree of uncertainty in that outcome..." (ibid. p. 827). The method allows measurement of the sensitivity of any outputs (e.g. growth rates, population ratios, etc.) to perturbations in any set of vital rates without having to build alternative scenarios or specify modifications to projection parameters. Hence, one only needs the initial population vectors and the parameters of the various components of growth to perform sensitivity analysis, and access to the projection-makers' proprietary computer software is unnecessary. For this reason, Caswell and Sánchez Gassen urged agencies "to consider reporting the basis of their projections in the form of projection matrices." (ibid. p.829).

Some general notes:

1. The relative simplicity of Monte Carlo methods portrays a rather deceptive picture of the efforts necessary for the production of probabilistic projections. In most cases, the challenge really resides in drawing the probability distribution for each parameter (Saltelli et al. 2008). This usually requires a great deal of assumptions and modelling. Depending on the data

⁴⁶ The method allows sensitivity analysis to be carried out in order to evaluate the relative influence of different parameters on the future population size. It is possible, for example to plot the distribution of each parameter against the distribution of projected population and to compare the results (see Saltelli et al. 2008 for an illustration).

⁴⁷ In contrast to *retrospective sensitivity analysis* which focus on uncertainty of the parameters (see Caswell 2000 for a description of both types of analysis).

available, the uncertainty is estimated from time series methods, analysis of past projection errors, expert elicitation techniques or a mix of those. Bayesian techniques are often used to work around a lack of data or to incorporate more sources of information (e.g. United Nations 2015b, Abel et al. 2013, Billari et al. 2012, Bijak et al. 2010, Girosi and King 2008).

2. The uncertainty estimated from a model will be adequate only if the choice of the model is appropriate. Often, only after the fact can a glimpse of this uncertainty be measured through ex post errors (Keyfitz and Caswell 2005). However, for statistically-driven approaches, out-of-sample predictions can be used to guide the choice of a model. Alho and Spencer (2005 p.240) provided an approach for acknowledging variance due to choice of model. Abel et al. (2013) computed parameters from a range of models in order to assess uncertainty due to model choice.
3. Models have limitations in capturing uncertainty, especially in relation to rare events which, by definition, are often non-existent in time series data (Taleb 2010). Furthermore, extreme values (outliers) are sometimes removed in the modelling process. These limitations should be acknowledged.
4. In the example provided, the only output is total population size. Had population by age been projected instead, prediction intervals around some age structure indicators could also have been computed. Thus the method allows for a comprehensive and consistent estimation of the uncertainty associated with all outputs.
5. The correct modelling of the propagation of errors require sound specifications of the various correlations that exist in the model. The difficult part is often to estimate adequate representations of the various sources of covariance. However, to understand how correlations may exist in population projections, it is necessary to expand the example as a projection for more than one year. Here are three examples⁴⁸ of possible correlations in population projections:
 - a) Correlations can exist between the various inputs. For example, it could be preferable to assume that the future number of deaths in a given year is correlated with the number of births and the net migration forecasted in previous years given that the population at risk will be higher. In most population projections, the inputs are not number of births but birth rates applied to a population at risk, so the projected number of deaths would increase automatically with an increase in the number of births or in net migration, and it would not be necessary to specify autocorrelations between the components of growth. But even when the parameters are specified in the form of rates, correlations between components can exist. For example, it could be expected that a rise in fertility could be thought to follow a rise in immigration levels because of higher fertility rates among immigrant women. Note that taking such correlations into account adds substantially to the complexity of the process. To date, independence between the various components of the growth has been assumed in most applications of probabilistic projections.
 - b) Time autocorrelation is also present when considering a single input of the model because parameter values tend to move relatively slowly over time rather than exhibit radical movements from one year to the next. In this context, the parameter value at a given time $t+x$ is correlated with the values in previous periods. As illustrated in Lee

⁴⁸ A more complete rendition of various types of correlations in population projections is available in Lee (1998).

(1998), how time autocorrelations are specified is consequential in the projected variance of inputs over time. For example, assuming no time autocorrelation, parameter values over time would simply fluctuate around the mean, with no large deviations in the long run. Conversely, perfect time autocorrelations would yield a straight path in a projection from the beginning to the end, with no fluctuations.⁴⁹

- c) In an increasingly globalized world, different regions or countries may tend to follow similar paths. For example, the spread of medical technologies, but also of threats to life, may cause interregional correlations with respect to the evolution of life expectancy (Lutz et al. 2004). Interregional correlations have important consequences for the estimation of uncertainty in the various regions (Lee 1998). Fosdick and Raftery (2014) modelled between-country correlations for regional probabilistic forecasts of fertility as functions of time-invariant characteristics (although the method can be used for forecasting other components). Ways to deal with interregional correlations are discussed in Alho and Spencer (2005 p.292).

⁴⁹ A more technical note. Two distinct approaches are typically used to deal with time autocorrelation in population projections, the *random scenario forecasts* method and the *stochastic forecasts* method, as defined in Tuljapurkar et al. (2004) and Lee (1998). In the first method, the parameters represent a target in a given horizon and all intermediate years are interpolated from the launch year to the target year. This method would yield in our example 1,000 straight lines from start to finish. In the random scenario approach, the parameters for all the various inputs in a single iteration are perfectly correlated over time. However, it is not necessary to sample values for each year of the projection and to compute time autocorrelations that should restrain the random sampling process. The random scenario approach is useful when probability distributions are available only for a given horizon, such as when expert elicitation methods are used (e.g. Billari et al. 2012). In contrast, the stochastic forecasts method consists of drawing a value randomly each year from the parameter distributions. As a result, the 1,000 trajectories are no longer straight lines and instead can cross over time. The method provides a more realistic representation of how uncertainty propagates over time.

APPENDIX G – EXAMPLE OF THE USE OF PROBABILISTIC PROJECTIONS FOR OPTIMAL DECISION-MAKING

Imagine that some planners need to make a decision regarding the number and sizes of schools that need to be built in a given jurisdiction in order to accommodate population growth. Building schools and maintaining them is costly, so ideally, the number of new places offered would fit the demand perfectly. Aware that it is not possible to predict future population growth precisely, these planners would nevertheless appreciate having some approximate figures to support their decision-making process.

Fortunately, they can rely on available population projections. In particular, while population projection data are imperfect and uncertain, they constitute, when built in an independent and impartial manner, a neutral and objective source of information to support informed and open democratic decision-making. The simplest utilization of the projection data would be to base the number of new seats on the growth projected by the ‘most likely’ scenario, or a ‘medium’ scenario. But would that be the optimal decision?

The size of a future cohort is a stochastic variable, and ideally, its forecast should be accompanied by estimates of forecast error. So imagine instead that the planners are equipped with probabilistic forecasts. The planners will have to settle on a single number, but they will have some information available about the uncertainty associated with it. If the uncertainty is too high, it could lead to the suggestion of some precautionary measures, such as school designs that can be easily expanded if need be, in which case the probabilistic projection would give a plausible idea of what a necessary expansion could be.

However, using methods that arose from the development of the Bayesian theory of probability, the planners can go much further in their decision-making strategy by finding the optimal strategy that will minimize the potential losses caused by the inherent uncertainty of the future (Raiffa and Schlaifer 1961, Morgan and Henrion 1990, Alho and Spencer 2005, Bijak 2010).⁵⁰ The first step for them is to evaluate the *loss* function, in this case, how much a gap between the future number of students and the number of places available in schools will cost.

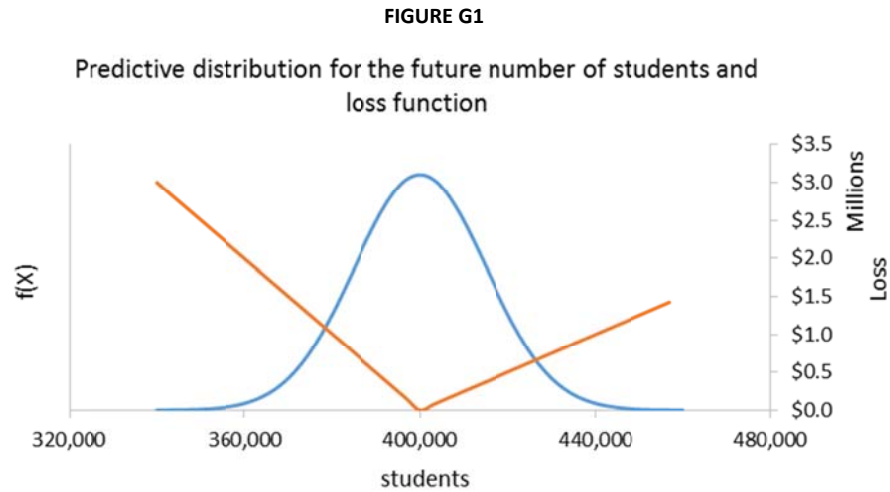
So imagine now that the planners were able to estimate that each overestimated student will cost about \$250 and that each underestimated student will cost about twice that amount (e.g. the planners may have realized that measures for adapting to surplus in the number of students are more costly than dealing with empty seats). In this case, the loss function can be described as *linear*, since the loss is a linear function of the ‘error’ in the number of students, and *asymmetric*, because it would cost twice as much to underestimate the demand than to overestimate it. Such a loss function could be written as:

$$l(d, x) \propto \begin{cases} c(d - x) & \text{if } d > x \\ \lambda c(x - d) & \text{if } d \leq x \end{cases}$$

where d is a decision, that is the target for the total number of seats to be available in the schools, x represents an estimate for the future number of students, c is a constant reflecting the cost of exceeding seats available and λ reflects by how much an underestimation is more costly than an

⁵⁰ Much of this example has been built from information provided in these references. Bijak (2010) in particular provides multiple examples in the context of population projections.

overestimation (and equals 2 in this example). Assume further that the predictive distribution of the number of students obtained from the probabilistic forecast, $f(x)$, can be approximated as normal with a mean of 400,000 and a standard deviation of 15,000: $X \sim N(400,000, 225,000)$. The resulting probability density and loss functions are illustrated in Figure D1. It can be seen that even though 400,000 seems a rational ‘guess’, it is not necessarily an optimal choice due to the uncertainty surrounding it. The optimal choice in fact should be located in the right tail of the distribution.



The optimal decision will be the one for which the expected loss will be minimized. The expected loss for a given choice d can be computed as:

$$c \int_{-\infty}^d (d - x)f(x)dx + \lambda c \int_d^{\infty} (x - d)f(x)dx$$

The minimum expected loss occurs when d equals the quantile of rank $\lambda/(\lambda + 1)$ of the cumulative distribution function of x . The optimal choice, d^o , is then the one for which the probability that $x \leq d^o$ equals $\lambda/(\lambda + 1)$. In this example, the value that would minimize the given loss function is 406,491 students (to be more precise, the growth would be 406,491 minus the current number of students).

Some general notes:

1. Note that the use of the term ‘Bayesian’ here does not refer not to the explicit use of Bayes’ theorem, but rather to an idea of probability that is strongly (but not exclusively) associated with the Bayesian approach, and that relates to a “state of uncertainty and not (only) to the outcome of repeated experiments.” (D’Agostini 2003 p.29). Essentially, in a Bayesian framework, there is a desire to “conceptualize some kinds of ignorance by characterizing our degrees of uncertainty in terms of subjective probabilities.” (Morgan and Henrion 1990 p.307). Bayesian decision theory offers a framework for explicitly incorporating uncertainty information into decision-making (Morgan and Henrion 1990, Bijak 2010, Bijak and Bryant 2016). In general, Bayesian methods tend to work better and more naturally for more complex or highly structured problems, and provide the possibility to describe multiple sources of uncertainty in a coherent way (Bijak and Bryant 2016).
2. Given what precedes, the method described here does not eliminate subjectivity. Still, it provides a mechanism to formalize preferences and judgments leading “[...] to decisions which are not only less arbitrary but actually more objective” (Raiffa and Schlaifer 1961

p.vii). In fact, the Bayesian approach brings transparency and coherence for decision-making but also for statistical demography in general (Bijak and Bryant 2016). Moreover, the subjective interpretation of probability in the Bayesian approach allows the emphasis of the subjective aspects of population projections in which probabilities do not reflect some frequency of occurrence as in the frequentist approach, or some equality of likelihood as in the classical interpretation, but rather the beliefs of the projection-makers given some data about the past and some views about the future.

3. Following the Bayesian framework, the planning problem can be described this way: the planners must make a decision d in a space of possible decisions \mathbf{D} ($d \in \mathbf{D}$), based on the size of the future population of students. While there is no way to determine this quantity with certainty, the planners are willing to use the results of a probabilistic population forecast, from which they obtain a plausible value x from space \mathbf{X} ($x \in \mathbf{X}$). The uncertainty about x is characterized by a probability distribution function $f(x)$. The loss function is then a function of the decision d and the state x : $L(d, x)$. Then, $E[L(d, x)] \equiv \int_{\mathbf{X}} L(d, x) f(x) dx$ is the expectation of the loss for the decision.
4. In forecasting, a loss function is often defined as the value to be minimized. The loss function is equivalent to the inverse of the utility. In this case, planners would want to maximize the utility.
5. Note that in cases where the loss function is linear and symmetrical, the optimal strategy would be to use the median of the probability distribution, as $\lambda/(\lambda + 1)$ would equal 0.5 (noting that the median is also the mean since a normal distribution was assumed in this specific case).
6. The *expected value of including uncertainty* (EVIU) is the expected difference in loss between a choice that would have been made without any estimates of uncertainty, d^{iu} , (here 400,000), and the optimal decision found with this information in hand, d^o :

$$\begin{aligned} EVIU &\equiv \int_{\mathbf{X}} [L(d^{iu}, x) - L(d^o, x)] f(x) dx \\ &= E[L(d^{iu}, x)] - E[L(d^o, x)] \end{aligned}$$

APPENDIX H – EXAMPLES OF HIGH-LEVEL COMMUNICATION ABOUT UNCERTAINTY

Bureau fédéral du Plan (2016), Belgium

Demographic projections, 2015-2060, (page 3) (translated from French)

Perspectives and not forecasts

“An important objective of the demographic projection is to serve as decision support, based on a scenario of unchanged policy and ‘social organization’, and not to predict the demographic future. The assumption of unchanged “social organization” does not involve freezing the value of different key parameters but to assume the long-term continuation of the trends that mark the current societal context, excluding breaks and upheaval. In the short term, the scenario also incorporates specific events that occurred in the recent past and likely to influence demographic trends.”

Statistics Canada (2014)

Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038), Cautionary note (page 5)

“The population projections produced by Statistics Canada's Demography Division are not intended to be interpreted as predictions about what will happen in the future. They should instead be understood as an exercise designed to investigate what the Canadian population might become in the years ahead according to various scenarios of possible future change. For this reason, Statistics Canada always publishes several scenarios and formulates several explicit assumptions regarding the main components of population growth. Accordingly, users are encouraged to consider several scenarios when they analyze the projection results.

It should also be kept in mind that the accuracy of the projections produced depends on a number of factors; various events - for example, economic crises, wars, natural catastrophes - that are difficult (or impossible) to anticipate can affect the growth and composition of the Canadian population. For this reason, Statistics Canada revises the population projections on a regular basis, so that the context in which they are developed is taken into account.”

Statistics Finland (2015)

Population projection 2015–2065 (page 2)

“Statistics Finland’s population projections are demographic trend calculations based on observations on past development in the birth rate, mortality and migration. The projections do not seek to estimate the effect of economic, socio-political regional policy and other such factors on population development.

The calculations mainly indicate the outcome from the present development under the assumption that it continues unchanged. Thus, they should not be interpreted as descriptions of the inevitable. The task of a population projection is to provide tools with which decision-makers can assess whether measures need to be taken to influence the development.”

Statistisches Bundesamt (2015), Germany

Statistics from A to Z: Population Projections

“How accurate are population projections?”

Population projections are based on hypotheses and therefore are subject to uncertainties. Their results depend, on the one hand, on the current number and structure of the population and, on the other, on the assumptions regarding fertility, life expectancy and migration. As the increasing distance from the base date makes it more and more difficult to predict the components' development, long-term population projections have a model character.

Calculating several scenarios makes it possible to illustrate the scope of potential change resulting from alternative assumptions on the development of the determinant components. When unforeseeable events occur, such as epidemics, wars or natural disasters, when there are unexpected changes in the generative behaviour of the population, such as the sudden drop in birth rates started by the pill in the mid-1960s, or when migration changes drastically, not even the calculation of alternative variants can increase the accuracy of population projections.

The ultimate purpose of population projections, however, is not to exactly predict future developments. They are rather intended to show how the population size and structure might change under specific conditions.”

Statistics New Zealand (2014)***National Population Projections: 2014(base)–2068, “Important advice for using projections” (page 2)***

“National population projections give an indication of the future population usually living in New Zealand. They indicate probable outcomes based on different combinations of fertility, mortality, and migration assumptions. Users can make their own judgement as to which projections are most suitable for their purposes.

These projections are not predictions. They should be used as an indication of the overall trend, rather than as exact forecasts. The projections are updated every 2–3 years to maintain their relevance and usefulness, by incorporating new information about demographic trends and developments in methods.

At the time of release, the median projection (50th percentile) indicates an estimated 50 percent chance that the actual value will be lower, and a 50 percent chance that the actual value will be higher, than this percentile. Other percentiles indicate the distribution of values (such as projection results or assumptions). For example, the 25th percentile indicates an estimated 25 percent chance that the actual value will be lower, and a 75 percent chance that the actual value will be higher, than this percentile.”

Tønnessen et al. (2016), Statistics Norway***Population projections 2016-2100: Main results – “Uncertainty in the figures” (page 10)***

“All projections of the future population, its composition and geographical distribution are uncertain. The uncertainty increases the further into the future we look, and the figures are even more uncertain in projections for small groups, such as the population of municipalities by sex and age in years. Future immigration is particularly subject to a large degree of uncertainty, but fertility, mortality, immigration and internal migration can also end up rather different than expected. The assumptions used in projections determine the outcomes of the different alternatives, as evidenced by the variations between the different alternatives and the disparities between projections by other institutions.”

Instituto Nacional de Estadística, (2015), Spain***Population Projections in Spain 2014-2064, Introduction (page 3)******“Methodology***

Demographic forecast shall express prospective trends based on the past and on highly likely scenarios for the future. This is very complex and subjective, since it depends on a much wider —and usually difficult to quantify— range of parameters (economic, social.....).

Demographic projections represent scenarios that would occur, should certain hypotheses take place, regardless of how plausible these hypotheses are. They can simply be useful to understand the consequences in the case that a certain hypothesis —even being improbable— is verified.

Thus, the Population Projections by the National Statistics Institute are not intended to be a ‘divination’ of the future, but a support tool for the decision- making based on a statistical simulation of the demographic course that the population resident in Spain would take in the next years, always under the hypothesis that the current demographic trends continued.”

Swiss Federal Statistical Office (2015)***Scenarios of evolution of the Switzerland's population 2015 – 2045, (page 5) (translated from French)***

“The new scenarios of evolution of the Switzerland's population describe plausible evolution regarding the permanent resident population of Switzerland during the coming decades. They are not forecasts, but possible evolutions that depend on the fulfillment of the proposed hypotheses.”

Turkish Statistical Institute (2013)***National Population Projections, 2013-2075, (translated from Turkish)***

“[...] Changes in the population of all the provinces between 2013 and 2023 were projected by analyzing the trends of the demographic events and population projections were produced for all provinces. On the other hand alternative population projections reflecting different fertility variants were also made. In Turkey, population projections are produced by using deterministic models, based on the so called “cohort component model” by using package program. The experience of other countries on fertility and mortality are utilized as well to formulate the assumptions.”

Office for National Statistics (2015b), United Kingdom
2014-based National Population Projections, Frequently Asked Questions

“How far ahead do the projections go?”

Projections are uncertain and become increasingly so the further they are carried forward in time. For this reason, analysis of the projection results mainly focuses upon the first 10 or 25 years of the projection period, which corresponds with the planning horizons of the majority of users of the projections, whilst recognising that uncertainty will be greater over a 25 year period.

However, some main users require projections over a longer period for modelling purposes, and the principal projection is also published for up to 100 years ahead. However, caution should be used when interpreting this longer-term projection as projections become increasingly uncertain the further into the future they go.”

Colby and Ortman (2014), United States (Census Bureau)
Projections of the Size and Composition of the U.S. Population: 2014 to 2060 – “Understanding the assumptions used to make population projections” (page 2).

“Projections illustrate possible courses of population change based on assumptions about future births, deaths, and net international migration. The projected values presented throughout this report are one possible outcome for the future that would occur only if all the assumptions hold true. All assumptions about the components of change are based on historical trends. Factors that might influence the levels of population components, policy decisions for example, cannot be predicted with any degree of certainty. Therefore, no attempts are made to incorporate these into the assumptions that produce the projections. Both the size and the composition of the projected population reflect the assumptions included in these projections. The accuracy of the projections will depend on how closely actual trends in fertility, mortality, and migration are consistent with these assumptions.”