Population Projections: Revealing multifaceted sources of their immanent uncertainty

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I Introduction

Population projections are relevant for several societal aspects like planning finance in economic, political and healthcare systems.

Some scientists distinguish between projections and forecasts with respect to their objections. Projections intend to analyze which assumptions or outcomes result from initially predetermined outcomes or assumptions. Therefore, projections are a kind of model calculation that investigates the population development’s consequences of a certain presetting. Contrary to projections, forecasts suppose to compute the most likely future population. Nevertheless, in this paper the terms projections and forecasts will be used synonym.

II Sources of uncertainty in several steps of a projection process

Population projections (with intention to project the most likely future population) are uncertain by their very nature, as the prediction of human behavior concerning demographic events, like births or migration, relies on complex individual decision processes. Besides the projection-immanent uncertainty when generating assumptions, every step of a projection process adds various sources of uncertainty.

For instance, the first step in a projection process includes an accurate definition of what has to be projected. Here, an important source of uncertainty is a misconception of certain demographic technical terms between the prognosticator and the client. The determination of the conceptual framework influences all further steps decisively, like the formal specification of the projection model, the collection of relevant data, the generation of assumptions, the execution of a certain projection, and the evaluation and application of its outcomes (on the basis of Armstrong 2001; Cruijsen and Keilman 1992; Willekens 1990). Commonly emerging sources of uncertainty are, e.g., model misspecification as erroneous functional relationships between several model parameters (like age and sex specific fertility or mortality rates), bugs in the software to calculate the projection model, lack of relevant data, availability of incomplete or false data, the occurrence of unexpected (political, economic, social or environmental) events that influence vital events, the predetermination of number and type of methods to generate assumptions for model parameters, calculation errors, and the misinterpretation of the outcomes.

III Evaluation criteria

There are two important questions in this context: First, what does a good projection look like, and, second, how can it be measured? A popular criterion is accuracy, measured by deviances between projected and observed outcome. Commonly used error measures for accuracy are constructed for deterministic rather than probabilistic population projections. Since error measures for deterministic projections can not easily be applied to probabilistic ones, specific error measures for probabilistic projections need to be developed. The easiest way measuring accuracy of probabilistic projection outcome is to check whether the observed value is in the outcome range or not. A more sophisticated method could be the computation of a weighted mean of forecasting errors of every trial's outcome depending on their occurrence probabilities. This method can only be applied if several trials are computed with randomly chosen (or generated) assumptions like in the Probabilistic Population Projection Model (PPPM). Moreover, a comprehensive evaluation of a projection model requires considering other important criteria like usability, consistence, validity, verification, user-friendliness, parsimony, transparence, and reliability as well (Long 1995; Ahlburg 1995; Rogers 1995; Booth 2006).

IV Capturing revealed uncertainty sources in the PPPM

The PPPM copes with some of the revealed uncertainty sources in a population process as certain properties in model specification and assumption generation try to eliminate them. For instance, various assumptions can be generated for each model parameter with no predetermined method. Additionally, correlations between model parameters of different (1) demographic components and/or (2) subpopulations (like locals and migrants) can be freely adjusted over two alternative variants of the PPPM: The Open Type and the Limited Type (Bohk and Salzmann 2006). Furthermore, an occurrence probability will be assigned to each assumption via expert judgment. Therefore, the various more and less likely future population developments can be modeled and considered. Consequently, these mentioned (and further) model features can capture a projection's uncertainty to a great extend. Despite the consideration of relevant uncertainty sources, the presented methods - counter-intuitively - do not always necessarily narrow down the resulting confidence intervals.

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