

# Population Projections

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Population projections serve various actors at sub-national, national, and international levels as a quantitative basis for political and economic decision-making. Often, the users are no experts in statistics or forecasting and therefore lack the methodological and demographic background to completely understand the methods and limitations behind the projections they use for their analyses. Our contribution primarily targets that readership.

Keywords: demographic trends ; macroeconomic effects and forecasts ; labor force and employment size and structure ; forecasting and simulation: models and application ; stochasticity in forecasting ; frequentist and Bayesian methods

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## 1. Introduction

A population projection shows how a population will develop in the future under certain assumptions regarding its size and structure. It thus has a conditional character, i.e., it is based on if-then statements. Since demographic processes are generally slow, their true extent often only becomes apparent after many years<sup>[1]</sup>. This applies without restriction to fertility and mortality as long-term processes of natural population development. In this context, the inertia of demographic processes is sometimes also referred to<sup>[2][3]</sup>. Migration processes, on the other hand, can also be influenced very suddenly by, e.g., politically and/or economically motivated structural breaks, and are thus much more difficult to assess.

Population projections are usually of a long-term nature (usually over several decades), since planning based on them is also long-term, such as in infrastructural projects. Possibly problematic trends are to be identified at an early stage so that they can be counteracted if necessary. However, as the length of the projection horizon increases, so does the uncertainty, which further reinforces the hypothetical character of such population projections. Therefore, different scenarios are often calculated for better illustration of the range of possible developments or to highlight individual, realistic scenarios. Selected simulations can also be used to illustrate individual, stylized developments and their consequences, even if they are not expected to occur in this form in the future. For example, a simulation could be used to estimate how the population would develop if the total fertility rate reached a replacement-level of 2.1 children per woman<sup>[4]</sup>.

A population forecast, on the other hand, makes statements about the expected future population development and claims to predict this development “correctly”. Accordingly, the scientific literature repeatedly addresses potential sources of error in such forecasts<sup>[5]</sup> to further improve the quality of service for urban planners, for example. The time horizon of forecasts can be of a short, medium, or long-term nature, although the uncertainty of forecasts naturally increases with a longer forecast horizon<sup>[6][7]</sup>. Uncertainties in population forecasts are therefore often quantified in terms of the probabilities of occurrence of the possible development paths<sup>[7]</sup>.

## 2. Selected Areas of Application of Population Projections

Population projections serve as a quantitative basis for a variety of different applications and actors. In the coming decades, society is facing a radical macroeconomic structural change that will affect all important markets: the labor market in industrialized countries lacks young workers<sup>[8]</sup>, product markets must adapt to structurally changed consumer wishes and increasing longevity<sup>[9][10]</sup>, the housing market has to align the housing stock with the requirements and housing desires of older people<sup>[11]</sup>, and savings behavior and the demand for investments on the capital market are transforming<sup>[12][13]</sup>. In addition to the mentioned labor market trends, the social insurance systems face a greater financial burden on the expenditure side due to rising population figures in the higher and more vulnerable age groups<sup>[14][15]</sup>. Population projections thus form an important basis for many thematic fields. In this section, particularly relevant exemplary applications are highlighted, with no claim of completeness.

## 2.1. Labor Market

The aging of the population will have a strong impact on the labor market when the baby boomer generation retires and the ratio of senior citizens to people of working age will shift in favor of older people. Accordingly, the labor market will have to adapt to the emerging changes. A central area of application is therefore labor supply forecasts, which are based on population forecasts with assumptions on labor force participation<sup>[8][16]</sup>. Demographic transition in particular, along with other influences such as globalization, poses growing challenges for companies and their human resources management. The availability of qualified workers is increasingly becoming a decisive determinant for the future viability of individual companies as well as entire sectors and the competitiveness of entire economic areas<sup>[17]</sup>.

The need for information on future demographic development is correspondingly high and thus represents a basic prerequisite for estimating future labor market development at a small-area level. Planning requires knowledge of the future labor supply, since the emerging demographic change is leading to a decline in the population of younger people<sup>[7]</sup><sup>[8]</sup>. Regions are therefore increasingly competing for young and well-educated workers<sup>[18]</sup> because demographic development is unevenly distributed both at the regional level and across small areas and will have an unbalanced impact on individual regional labor markets<sup>[19]</sup>. The result will be competition for highly skilled workers which—with major regional differences—is already noticeable in some sectors of the economy [73]. The need for small-area population forecasts and labor market forecasts based on them is correspondingly high.

## 2.2. Housing Market

The labor market is closely intertwined with the housing market at the regional level. Large cities play a key economic role in regional development, as they provide a large share of all jobs<sup>[1]</sup>. However, a regional labor market is not exclusively characterized by the labor market center, but also by the surrounding area, which is mostly used as a residential location and from which workers commute to the centers<sup>[20]</sup>. Against the background of tight housing markets in large cities and university towns, a large number of projections of future housing requirements are currently being conducted globally<sup>[21]</sup><sup>[22][23]</sup>, which are based on population projections. Housing demand analyses are important because the planning horizon for the development of the housing stock is long-term. Knowledge of future demand for housing is therefore extremely important in the development of new construction projects<sup>[24]</sup>.

## 2.3. Economic Growth

At the national level, housing demand analyses and labor market projections serve as a quantitative basis for policy decisions. Thus, population projections and the future budget development derived from them form the basis for determining building requirements, which in turn make the existing need for action clear to politicians. In the case of projections of the labor supply side, projections of the demand for labor allow conclusions to be drawn about the development of the economy as a whole. For example, Grömling shows, based on Deschermeier's population forecast and Schäfer's projections of labor supply and labor demand, that the potential growth of the German economy up to 2035 will weaken noticeably due to the decline in the working population as a result of the aging of the society, despite increasing labor market participation. On such a basis, Bardt and Klös formulate recommendations to various policy areas for securing prosperity<sup>[25][26]</sup>. In general, the future size and structure of the population have a significant impact on the labor market, consumption, health, and in conclusion the productivity of an economy. The so-called demographic dividend is therefore an important factor for the socio-economic development of a country<sup>[27]</sup>, which makes demographic forecasts highly important for policy planning<sup>[1]</sup>.

## 2.4. Public Finances

A relevant policy area impacted by demographics is public finances. Beznoska and Hentze<sup>[25]</sup> use a combination of a population forecast and a microsimulation model to show that income tax revenue in Germany will decline significantly by 2035 as a result of demographic developments. The results show that the financial pressure on the public sector will intensify as government spending will increase, especially in social security and education. Kochskämper<sup>[25]</sup>, for example, illustrates this increase in social security spending. Based on a population forecast, the study projects the increase in spending due to population aging in the statutory pension, statutory health, and social long-term care insurance up to 2035. The results show that a constant level of benefits in all three classes of insurance by 2035 will probably require a 35 percent higher overall per-capita expenditure compared to the current level. Population projections thus serve as an information basis for fiscal and social policy<sup>[28][29]</sup>. Comparable trends can be found in large parts of the EU and the Schengen area, which significantly limits the opportunities for immigration of qualified workers among Schengen

countries. For example, the EU estimates a relative decline in its working-age population (defined as 15–64 year-olds) from 65.3% to 55.9% of the total population on average between 2016 and 2070, with a simultaneous increase in the very old (80 years and older) from 5.5% to 12.9%<sup>[30]</sup>.

## 2.5. Infrastructure

Population projections are a valuable source of information for issues of infrastructure planning<sup>[31]</sup>. For instance, Hyndman and Fan<sup>[32]</sup> conduct a 10-year forecast of electricity demand in Australia, using a population forecast as an input variable. Future population development is a key determinant for the development of new plants and the alignment of existing plants. Knowledge of the probable development of the number of students and school graduates helps school demand planning in capacity planning<sup>[1][33]</sup>, such as the creation of new jobs. Population forecasts provide information on the development of the number of pre-school-age children, school-age children, or university students<sup>[33]</sup>. Forecasts of the future population structure is also of high importance for long-term planning of health services, such as hospital and nursing home capacities<sup>[1][15]</sup> and the demand for nurses<sup>[15]</sup>. At the political level, the aging of society could shift the power structure, as the voting behavior of older people differs from that of younger people. In the future, senior citizens will represent a larger population group, and politics may therefore increasingly focus on this target group with measures and “election gifts”<sup>[1]</sup>.

## 2.6. Global Trends

Population forecasts offer a valuable basis for planning at the global level as well. The rapid growth of the world population is leading to an increasing demand for food<sup>[34]</sup>. This development leads to new challenges because food production already causes major environmental problems today, which will become more acute in the future. Against this background, the connection between future population development and climate change is a central research topic and area of application of population forecasts<sup>[35]</sup>. Moreover, according to the current study results, the growing world population is causing an increase in the global volume of waste<sup>[36][37]</sup>. Therefore, population projections provide valuable information for economic cost evaluation of possible subvention programs, which aim at reducing garbage and wastefulness.

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