Forecasting mortality in Spain: How reliable is expert opinion?

Francisco Villavicencio[† a], Ugofilippo Basellini[b], Marie-Pier Bergeron-Boucher[c], Sara Solanilla Blanco[a], Carlo Giovanni Camarda[d]

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Abstract

Forecasting mortality is a critical component of demographic research and public policy planning, as accurate projections inform healthcare resource allocation, pension systems, and social welfare strategies. In Spain—where population ageing represents a major challenge due remarkable gains in life expectancy and persistently low fertility—official mortality forecasts rely primarily on expert opinion. While experts generally capture broad directional trends, previous research has shown that expert assessments have systematically produced conservative forecasts of life expectancy, underestimating future mortality improvements. Over the past decades, multiple statistical methods have been developed to forecast mortality based on historical data on age-specific death rates. Such methods have the advantage of extrapolating empirical data that often show long-term regularities and are more objective than expert opinion. This study critically examines the reliability of expert judgment in predicting mortality trends in Spain, comparing it to model-based approaches such as Lee-Carter and Bayesian population projections. Preliminary results show that current official mortality forecasts tend to underestimate future trends in life expectancy. Consistent with previous studies, we speculate that expert opinion remains a valuable yet imperfect tool in mortality forecasting, best used as a complement to, rather than a substitute for, statistical modelling.

1 Introduction

Every two years, the Spanish Statistical Office (Instituto Nacional de Estadística, hereinafter INE) publishes population projections for Spain. The most recent release was in

[†] Correspondence: villavicencio@ub.edu.
[a] Department of Economic, Financial and Actuarial Mathematics, University of Barcelona, Barcelona, Spain.
[b] Max Planck Institute for Demographic Research, Rostock, Germany.
[c] Interdisciplinary Centre on Population Dynamics, University of Southern Denmark, Odense, Denmark.
[d] French Institute for Demographic Studies (INED), Aubervilliers, France.

June 2024 and covers a 50-year projection period, extending through 2074. At the regional (Autonomous Community) and province levels, the projection period is 15 years. These population projections are based on the forecast of three main components: fertility, migration, and mortality.

Current forecasts published by INE are primarly based on expert opinion. While experts generally capture broad directional trends, previous research has shown that expert assessments have systematically produced conservative forecasts of life expectancy, underestimating future mortality improvements (Oeppen and Vaupel 2002). This study critically examines the reliability of expert judgment in predicting mortality trends in Spain, comparing it to model-based approaches such as Lee-Carter and Bayesian population projections. Preliminary results show that current official mortality forecasts tend to underestimate future trends in life expectancy. Consistent with previous studies, we speculate that expert opinion remains a valuable yet imperfect tool in mortality forecasting, best used as a complement to, rather than a substitute for, statistical modelling.

2 Official mortality forecasts in Spain

The current methodology used by the Spanish Statistical Office (INE) to produce mortality forecasts can be summarized as follows (for additional details, the reader is referred to INE 2024):

On February 2024, INE carried out a survey among experts asking them to provide an estimate of the sex-specific life expectancy at birth within 50 years. Individual answers are not available and no information is provided regarding the number of experts, selection criteria, or response rate. The median of all the answers, which for simplicity here we denote by e^*, is taken as the maximum asymptotic estimate of life expectancy at birth in 2074.

Using observed life expectancy values since 1991 and the asymptotic e^*, a logistic regression is fitted to estimate the life expectancy at birth for each year t (e_o^t) of the forecasting period (2024–2074),

$$\text{logit}(e_o^t) = \frac{e^* - e_o^t}{e_o^t - e_o^{\min}} = \alpha + \beta \cdot t$$

where α and β are parameters to be estimated and $e_o^{\min}$ is the minimum life expectancy in the observation period (1991–2023). This logistic regression provides an estimate of the life expectancy at birth for each year of the projection period (until 2074). Next, two Coale-Demeny model life tables (Coale et al. 1983) for the corresponding levels of e^* are picked as the estimated sex-specific life tables in 2074. Model East for males and model

West for females.

Using the observed sex-specific life tables from 2023, and the selected Coale-Demeny life tables for 2074, INE carries out a linear interpolation of the age-specific values of two of the columns of the life table (Preston et al. 2001, Chap 3):

- q_x: age-specific probabilities of dying; and
- a_x: age-specific average person-years lived in the interval by those dying in the interval.

Using the sets of interpolated values of q_x and a_x, it is possible to generate an arbitrary large number of life tables whose corresponding life expectancy at birth lie between the life expectancy at birth in 2023 and the asymptotic maximum e^*. Finally, INE assigns to each forecast year t of the period 2024–2073 the life table whose corresponding life expectancy at birth is closer to the estimated e_o^t from the logistic regression.

This approach has several limitations:

1. First and foremost, it relies on expert opinion. It might be possible to make structured use of expert judgments to develop forecasts based on alternative scenarios about future economic, political, and social conditions, and experts might provide useful information about the probability and timing of research advances that increase longevity. However, previous research has shown that expert assessments have systematically produced pessimistic forecasts of life expectancy (Oeppen and Vaupel 2002).
2. On the other hand, the Coale-Demeny model life tables are useful to gain insights on the mortality patterns of populations with limited or inexistent vital registration data, as for instance current sub-Saharan Africa or historical populations. But Spain is among the countries with the highest quality vital registration and mortality data: basing the population projections on model life tables disregards the richness of the available data.
3. In Western societies with very low levels of neonatal, infant, and child mortality, future gains in life expectancy will mainly depend on improvements in mortality at older ages, say, at years 85+ (Wilmoth 1998; Vaupel et al. 2021). The Coale-Demeny model life tables were originally built using data from high mortality settings, and struggle to capture current dynamics and improvements in mortality at older ages among the longevity pioneers, including Spain. Even though INE uses the most recent version of the Coale-Demeny life tables published by the United Nations, these life tables are rather inflexible.
4. The uncertainty of the estimates is not (and cannot be) reported. INE performs a sensitivity analysis by testing different scenarios (high/central/low fertility and

migration), but by using scenarios it is not possible to get a statistical estimate of the uncertainty of the forecasts (Lee 1998).

5. Last but not least, the robustness of the method and the reliability of the results cannot be tested. Typically, statistical methods use training data to calibrate a model and evaluate whether it can accurately predict the desired outcome. The methodology devised by INE does not allow for it in a simple way

3 Preliminary results

The methods and assumptions to forecast mortality vary across national statistical offices. Japan's official forecasts, for instance, are based on a Lee-Carter approach (Lee and Carter 1992) combined with a model that shifts mortality curves to advanced ages to reflect the changes in mortality that gradually slowed down in recent years. Sweden also uses a variant of the Lee-Carter model for their forecasts. The official forecasts for France are a mixture of expert opinions and extrapolation (Blanpain and Buisson 2018), as well as in Italy (Billari et al. 2012, 2014). The most significant difference with respect to Spain, however, is that the expert opinion is incorporated *a posteriori* to validate the results provided by the model, rather than *a priori* as in the case of INE.

Our starting hypothesis is that the methods for population projections devised by INE can be substantially improved to provide more robust and reliable estimates of the future population in Spain. Essentially, we aim at developing methods that do not depend on expert opinion. As a preliminary analysis, the figure below compares the female life expectancy forecast published by INE with the estimates obtained by fitting the Lee-Carter model (Lee and Carter 1992) to age-specific death rates and exposures since 1991. This is the same period used by INE to fit the logistic regression to forecast life expectancy (INE 2024).

Several conclusions can be drawn from this figure:

1. With the Lee-Carter model—or any other extrapolative method—it is straightforward to calculate and report uncertainty intervals, making the estimates sounder and allowing for a proper quantification of forecast uncertainty .
2. The Lee-Carter model produces more optimistic forecasts than INE. This is also interesting because it has been widely reported in the literature that the Lee-Carter model tends to underestimate life expectancy (Booth et al. 2002; Bergeron-Boucher et al. 2017). Although additional analyses are needed, this may imply that current INE forecasts are underestimating future improvements in life expectancy which, among other relevant issues, has a direct impact on the pension system.
3. That said, INE estimates fall inside the Lee-Carter uncertainty intervals.

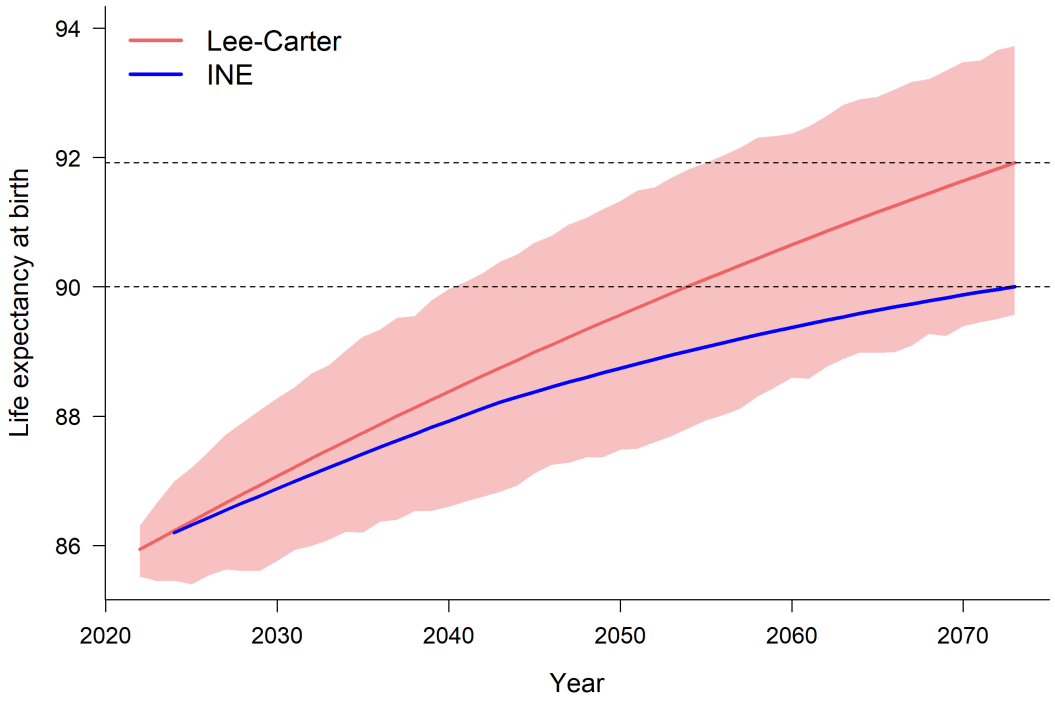

Figure 1: Life expectancy at birth forecasts, Spanish females, 2022–2074, INE vs Lee-Carter

Following steps will focus on recovering previous mortality forecasts published by INE decades ago and evaluate how accurate they were estimating, for instance, observed values of life expectancy in 2015–2019. Next, we will use age-specific death rates from 1980–2000 to test different forecasting models. The model (or models) that better predict the observed mortality for the period 2015–2019 will be identified as the most reliable candidate(s) to forecast. Comparing the results with those published by INE will enable us to evaluate the accuracy and reliability of expert opinion in forecasting mortality in Spain.

As a final remark, extrapolative models are useful when the trends are regular, but when there is mortality shock, they are not as accurate. It would be interesting to see if integrating expert opinion on an extrapolative model like Lee-Carter can better predict the mortality trends since 2021 after the COVID-19 pandemic.

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