Forecasting the Italian population, 2005-2055: A stochastic approach

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1 Introduction

Italy is the oldest demographic country in the world and one of the twenty nations with high number of immigrants. The ageing process, as a consequence of the lowest-low Italian fertility and continuous improvements in levels of mortality, results in an increasing burden on working age population and the Social Security System.

No one can say precisely how the future demographic development will look like. However, differently from other forecasts performed using a deterministic approach, by means of Monte Carlo simulations we have quantified the probability at which our projection will be reached.

2 Data

The starting population is the Italian population on the 1st of January 2005. The data consisting of population counts by sex and single-year-age groups up to the age 100+ refers to the resident (de jure) population.

Concerning fertility we analyzed the development of the Period Total Fertility Rate from 1950 till 2004, and changes in fertility pattern represented by the Age Specific Fertility Rate by single years of age ($\alpha \leq 15$; $\beta = 50$) for the period from 1950 till 2003. Regarding mortality we looked at the trend of life expectancy at birth and at the Age Specific Mortality Rates for single years of age (0,1,...,110+) from 1872 until 2002 from the Human Mortality Database. Finally, the number of immigrants and emigrants for the years 1994-2000 by age and sex were used to estimate net migration rate.

3 Method

Population forecast are based on the cohort-component method. For each projected interval the method consists of three steps for both male and female populations. The first step is forward projection of the population in each age-group at the beginning of the next time interval in order to estimate the number of people still alive. At the second step the number of male and female births over the time interval, as well as the number of survivors to the beginning of the next interval is computed. Finally, the number of immigrants is added and number of emigrants is subtracted in each age-group during the interval. The method just described provides only the point forecast of the future population. In order to have a stochastic version of it, providing the probability distribution of the future population size, we have to translate the uncertainty of the vital rates forecast into the uncertainty of the future population size.

To carry out the uncertainty analysis, we applied the so-called scaled model for error by Alho and Spencer (1997) to the errors of the baseline forecasts. The method assumes that the error of the actual forecasts is similar to that of baseline forecasts. It is assumed that the value of a vital process during the forecast year t, at age j, can be written as: $R(j,t) = exp\{\hat{r}(j,t) + X(j,t)\}$ where $\hat{r}(j,t)$ is the point forecast and $X(j,t)$ is the error process. The error processes are assumed of the form $X(j,t) = \epsilon(j,1) + ... + \epsilon(j,t)$, where the error increments are $\epsilon(j,t) = S(j,t)(\eta_j + \delta(j,t))$. The $S(j,t>0)$ are known weights that can be adjusted to match any increasing sequence of error variance $Var(X(j,t))$, the terms η_j describes the error in the forecasted trends and $\delta(j,t)$ represent the unpredictable random fluctuation around the trend. The model also assume that for each j, the variables $\delta(j,t)$ are independent over time and that the variables $\delta(j,t)$ are independent from the variables η_j. Furthermore they assumed $\eta_j \sim N(0,k_j)$, $\delta(j,t) \sim N(0,1-k_j)$ where $0 < k_j < 1$ are known. Additionally an autoregressive correlation structure on $\delta(j,t)$ and η_j is assumed .

To perform the forecast and the corresponding uncertainty we first estimated each parameters of the scaled-model for errors and then we used PEP (Program for Error Propagation), a software package developed by Alho (1998). In the program, the cohort-component method is applied 3,000 times, with stochastically varying values for age-specific mortality, age-specific fertility, and net migration, determined by means of Monte Carlo simulations. In this way we determined the probability distribution of the future population size and structure.

4 Assumptions and forecasts

Concerning mortality the present forecast was performed based on the estimates of past mortality levels assuming a persisting reduction of mortality levels at all ages. We applied the well known Lee-Carter model Lee and Carter (1992) to Italian male and female age-specific mortality rates and we modelled the level of mortality k_y with a random walk with drift. The model shows good estimation of the mortality rates at older ages, but worst estimation at younger ages. To select the period to base the forecast on, we proceed with a cross-validation.

Currently, Italy has one of the lowest fertility levels in the world: the average number of children per woman is equal to 1.33 and even lower in some regions. According to the period rates, however, a recent decline in period total fertility rate seems to stagnate and a slight upsurge of fertility level has been observed. Behavioral and structural changes have been suggested to explain this phenomenon. We hypothesized a moderate increase of fertility level in Italy essentially attributable to the recuperation effect of postponed fertility. At the same time a role can also be played by the increasing number of female immigrants. Considering this assumption, a linear increase of the Italian TFR from 1.33 children per woman to 1.5 after the first 25 years of projection (2005-2030) is assumed. However, due to serious barriers to enter labor market after childbearing and family re-conciliation, as well as a lack of political will to reform the family policy system and integrate it with other social policies we do not expect this increase to be strong. Thus during the following years (2031-2055) the TFR value will be kept constant.The mean age at childbearing is assume constant during our forecasts.

Currently, it is well known that the migration component plays a crucial role in determining population structure by age and sex at the national level. Moreover, with the regime of natural decrease of population the importance of the migratory component as a factor of demographic development has markedly increased. Even though a trend toward an increasing level of total net-migration is observed, it is difficult to make expectations about its future. Therefore, in the present study a constant level of net-migration for the years 2001-2055 is assumed.

5 Conclusion

The following assumptions have been made in this study: (1) an increase of life expectancy at birth from 77.09 to 84.0 for men (with a 80% confidence interval 80.4-87.4) and from 82.96 to 90.8 for women (with a 80% confidence interval 87.9-93.9); (2) an increasing TFR from 1.33 to 1.5 (with a 80% confidence interval 2.28-0.99); (3) a constant level of net-migration of 153.000 units, whose cumulate number of net migrants in 2055 equals 13.4% of the jump-off population (with a 80% confidence interval 2.4%-24.4%). The results are presented in terms of the median, the spread around the median is used to provide a realistic indication of forecast uncertainty. Despite the hypothesis of a positive effect of migration, the median size of the Italian population will decline from 58.5 million in 2005 to 54.1 in 2055 (with a 80% confidence interval 43.7-66.4). At first glance the aggregated results clearly indicates how the natural component of the Italian population change represents the driving force. This is a result of two complete different dynamics. The first is the decline of about 8.2 millions of the age classes that take part in the process production-reproduction (15-64), and the second is an increase of about 6.7 million of the population aged more then 65 years.

It is very likely that the population of Italy will decline in the future and that the population aging, consequences of the persisting lowest-low level of fertility and continuous reduction of mortality especially at older ages, is inevitable. Policy makers, in particular those responsible for the Social Security System and the state of the public finance, should be aware of this process and take appropriate measures in advance to be able to face these demographic changes.

References

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