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Abstract

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4.1

Projections of ageing migrant populations in France: 2008-2028

Jean L. Rallu *

Ageing of migrant populations is an important issue that has not yet been much addressed quantitatively. The large waves of migrants who arrived from 1960 to 1975 are now reaching retirement ages. It is no longer expected that most migrants will return after retirement. Census estimates show that return migration at ages above 60 years old is small. The needs of ageing migrants raise important issues for health and social services that will have to serve linguistically and culturally diverse populations, often with low resources/pensions due to life histories of unstable employment. But data are lacking for most EU member states.

Migration projections are a component of national population projections. They draw little attention due to large uncertainties, because natives' migration is usually not well documented and foreign-born migration is strongly dependent on economic crisis and policy changes. Projecting migrant populations raises specific challenges. Migrants' children born in-country are not migrants; therefore migrants' age pyramids show narrow bases and their structures are not comparable with those of national populations. In the case of ageing migrants, what we need to know are future trends in the numbers of older migrants. Such projections can be reliable, because most of the migrants who will reach 65 years and over in the next 20 years are already in-country and migration at older ages is much smaller than at adult ages.

The main flow consists of return migration. Out-migration rates can be estimated between successive censuses - or from population data files or surveys. In France, 2006-2008 intercensal emigration rates at ages 55-64 were between 1.1 per cent and 2.0 per cent per year according to origin. Then, rates decline with age. Many returning migrants are lone men who migrated single, did not marry or could not afford to bring their wives. Since migration has been more frequently family migration since the 1970s, these profiles will become less frequent and return migration could decline in the future. Immigration at ages 55-64 is small, with yearly rates between 0.1 per cent and 0.4 per cent for males. Rates are about twice as high for females as for males, because of family reunification and some working couples bringing their mothers to care for children. Survival rates of migrants by origin can be used; however, they are affected by various biases.

We shall present projections of 65 year-old (and oldest-old) migrants in France by origin up to 2028, based on the 2008 population census, using origin-specific survival, emigration and immigration rates. Trends vary greatly according to origin. Migrants from earlier flows are closer to age 65 than those from recent flows. Some origins show very rapid increases over the next 20 years (6-fold for Sub-Saharan Africans, 3-fold for Moroccans and Turks). Migration policies have impacts on the shapes of migrants' age-pyramids and therefore also on future ageing. Increases are lower for origins that were most affected by the closed border policy from 1975. Trends are different for males and females due to unbalanced sex ratios in older cohorts. Thus, receiving countries are expected to show different patterns of ageing migrants according to origin and timing of migration: post-colonial, work migration, family reunification, and policy changes.

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4.2

Introducing duration-dependent emigration in DREAM's population projection model

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The possibilities for foreign nationals to take residence in Denmark are primarily affected by law and by the situation in the country of origin. The difficulties in projecting changes in these factors contribute significantly to the challenge of determining future immigration and future immigrant behaviour. During the last decade an increase has been observed in immigration, especially from Western countries. This is mainly due to legislation easing access to the Danish labour market for citizens from Eastern European countries. Since annual immigration from non-Western countries has been fairly constant during the same period, a change in the composition of origin of residing immigrants has resulted. This is in turn reflected in a shift in the pattern of residence permits, which are recently being granted primarily on the grounds of work or study rather than on the grounds of asylum and family reunification. Work- and study-warranted residence permits are generally associated with a shorter duration of residence than other permits, leading to a change in the composition of the immigrant population with respect to duration of residence.

Considering that demographic behaviour varies considerably with the length of duration, this challenges the baseline assumption of not considering duration of residence when determining future demographic flows. This working paper explains the consequences of allowing forecasted emigration of immigrants, i.e. re-emigration, to depend on duration of residence and investigates whether including this characteristic enhances projection accuracy when facing the aforementioned shifts in immigration structure. Taking the duration dimension into account challenges the density of data, leading to implementation presently being limited to re-emigration. Data mining techniques can potentially be applied to investigate the effects of duration dependency of various other types of demographic behaviour. This is reserved for further studies.

In general the propensity to re-emigrate decreases with duration of residence. Typically emigration probabilities for individuals having immigrated within the last two years lie above the average re-emigration probability, whereas the propensity to re-emigrate lies below average when duration of residence exceeds two years. Using constant emigration probabilities dependent on gender, age, origin, and number of years of duration (up to five) in a group-based population projection model is shown to lead to an increase in the immigrant population. This is due to the fact that the effect of lower than average emigration propensities for those with more than two years of residence dominates because of composition effects. In addition, a change is observed in the age-composition of immigrants, thereby altering the future descendant population.

By performing sequential within-data[1] population projections with a five-year forecast horizon, respectively involving and omitting duration dependant re-emigration, the challenges of including this demographic characteristic are assessed. Finding that a shift in immigration behaviour severely challenges projection accuracy when taking duration into account, it is suggested that duration dependant re-emigration should be used with caution.

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[1] Projections are based on constant emigration probabilities using a three-year average prior to each of the years 1995-2007, respectively involving and omitting duration.

4.3

Model to forecast the re-immigration of Swedish-born by background

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The immigration and emigration in Statistics Sweden's national population projection are presented and analysed by seven different birth groups, of which Swedish-born constitutes one group. For Swedish-born persons, first the emigration is calculated, which then makes it possible to estimate the re-immigration. The numbers of emigrants and re-immigrants are estimated with age- and sex-specific risks.

The propensity to emigrate differs according to background, i.e. according to whether both parents are Swedish-born, both are foreign-born, or one parent is foreign-born and the other is Swedish-born. The emigration rate is the highest for persons with two parents born in a country other than Sweden, followed by those with one Swedish-born and one foreign-born parent. The high immigration to Sweden of foreign-born persons during recent years and the assumption that it will continue implies that the proportion of Swedish-born with foreign background will continue to increase in the future. As this group increases, their emigration rate will be of greater significance when emigration rates for the whole group Swedish-born are estimated.

To estimate the future re-immigration of Swedish-born, the population living abroad is estimated with information on immigration and emigration between 1851 and 2012. For each year, emigrated Swedish-born have been added to the population that lives abroad and re-immigrants been subtracted. The population has been reduced by the same death risks as observed for people living in Sweden. According to these estimates, about 780,000 Swedish-born lived abroad in the early 1900s. Thereafter, the number of Swedish-born living in another country decreased until the 1980s, when the number began to increase. When estimating the future re-immigration, we use a linear regression equation. The model is based on re-immigrant risks applied on the estimated data on how many Swedes are likely to live abroad in combination with data on the emigration of Swedish-born three years earlier.

However, the model does not consider the background of the Swedish-born living abroad, i.e. their parents' country of birth. Little is known about the extent to which people with different background re-immigrate. One example is that in recent years, an increasing number of children born in Sweden to parents from Iraq move from Sweden to Iraq. In the present model this group has the same risk of re-immigrating as persons with two Swedish-born parents. We believe that in reality, however, re-immigration rates differ depending on the parents' country of birth.

The aim of this study is to further develop the model that predicts the return migration of Swedish-born by adding the parents' country of birth to the estimated population living abroad. This makes it possible to calculate re-immigration rates by background, which will help us to construct more accurate projections of migration.

Different registers at Statistics Sweden have been used to follow the migration of the Swedish-born, but the main sources are the Historic Population Register and the Multi-Generation Register. The Historic Population Register contains information about all Swedish registered persons since 1969. Persons can be followed longitudinally with respect to different demographic events. Data on parents' country of birth have been collected from 1969 onwards from the Multi-Generation Register.

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4.4

Dynamic models for migration projections

Violeta Calian*

All model-based forecasts are subject to uncertainties: data and measurement method, model, parameters for any given model, future uncertainty due to effects of unobserved type of events/shocks. In addition, in order to give valid point estimates and prediction intervals for the forecasted values, one cannot rely on classical regression-type models due to the auto-correlated and non-stationary character of the time series involved in migration processes.

We have used dynamic, or auto-regressive distributed lag (ARDL) models as a solution to this problem. This approach does not treat auto-correlation and non-stationarity as nuisance phenomena but includes them in the model. The dependent variable at time "t" is modelled as a function of its own values at different time lags and of the values of several simultaneous or lagged predictor variables.

We have thus obtained short time predictions for the number of immigrants/emigrants of Icelandic and foreign citizenships as functions of several time series predictors: unemployment, change in GDP values, number of graduating students and dummy variables mirroring the EEA resizing in time and the Icelandic economic boom which ended in 2008. The time series we used for fitting the models are about 45 year time steps long and we produced a forecast for the next five years in 2011, 2012 and this year. The results for the first two years when we had applied our models were very good, even as point estimates, although our confidence intervals were rather large.

Our method could be further improved by using vector autoregressive distributed lag models, since all components of our migration process are correlated, but one has to evaluate carefully how realistic this is in terms of time series lengths and dimension of the vector space.

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5.1

Cohort effects and structural changes in mortality trends

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In Portugal, as in other developed countries, substantial mortality gains have occurred at all ages in recent decades. A exploratory study of the patterns of mortality decline in Portugal over the last sixty years shows that, although age-specific death rates have declined at all ages, the rhythm at which specific rates have been improving differs between ages and over periods of time. In particular, an apparently odd pattern of mortality improvement was detected in the male population, suggesting that over time a specific group of male individuals might have experienced a non-declining or even increasing mortality. Also, the presence of structural changes in overall mortality time trend in several European countries (Coelho and Nunes, 2011), among them Portugal, has brought up questions about why such changes have occurred.

In this paper we focus on such questions. Specifically, we explore the presence of cohort effects as a possible reason behind the structural changes. We make use of visualisation techniques and several model specifications, namely the classical log-linear age-period-cohort (APC) model as well as more complex models with age-period and age-cohort interactions. A simulation study allows us to understand the impacts of ignoring important features in mortality modelling.

The paper is divided into two parts. In the first part, using post-1950 male mortality data for Portugal, we explore specific patterns in mortality that are consistent with the presence of cohort effects. We estimate several variants of the APC model. Data from England and Wales, where a cohort effect is well documented (Willets, 1999, 2004), is used as a benchmark. The impacts of using an incorrect specification of the model are also explored. In the second part, using the data and results from Coelho and Nunes (2011) for a set of 14 European countries, Canada, USA, and Japan, we analyse the possibility of an association between the presence of structural changes in the overall trend of mortality decline and the existence of cohort effects in the data.

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5.2

Evaluation of Korean Mortality Forecasting Models

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The purposes of this study are to examine the way to overcome the shortage of historical data on mortality at the older ages, and to find the best model for forecasting Korean mortality. To extend the mortality for age 75 and over, we test two methods of estimating death probabilities for above age 75: the 2-parameter logistic model and the Brass-Logit model. Based on the Mean Absolute Per cent Error (MAPE), the logistic model has better performance than the Brass-Logit model. Four stochastic forecasting models (the Lee-Carter Model, the adjusted Lee-Carter Model, the Lee-Miller Model, and the Coherent Lee-Carter Model) are fitted to the period from 1970-2010 and the forecasts are compared to actual mortality for that period. The results of this evaluation show that the Coherent Lee-Carter Model is consistently more accurate in forecasting Korean mortality than other compared models. The Coherent Lee-Carter model yields a higher life expectancy at birth for both sexes and a larger difference between sexes than other models in which sex differentials diminish rapidly.

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5.3

Coherent forecasting of multiple-decrement life tables: compositional models for French Cause of Death data, 1925-2008.

Jim Oeppen, Carlo G. Camarda*

Problem

Planners in public and private institutions would like coherent forecasts of the components of age-specific mortality, such as causes of death. These can inform decision-makers about potential health interventions, and future costs of treatment and care if mortality can be used as a guide to the prevalence of associated morbidity. Forecasting by cause of death has been difficult to achieve because making a separate forecast for each cause, or group of causes, has proved inadequate. The relative values of the separate forecast components often fail to behave in a way that is coherent with historical experience. In addition, when the individual forecasts are combined the result is often incompatible with an all-groups forecast. It has been shown that cause-specific mortality forecasts are pessimistic when combined and compared with all-cause forecasts (Wilmoth, 1995).

This paper abandons the conventional approach of forecasting separate time-series of log mortality rates for each cause and forecasts the cause-specific density of deaths $d^i_{x;t}$ in a single model of a time-series of multiple-decrement life tables. Demographers have given a little theoretical attention to 'life-saving' models that treat survival improvement as a perturbation of the density of the death distribution by age ($d_{x;t}$), but there have been no previous attempts to define such models for forecasting in a single- or multiple-decrement context.

Data

The data comprise time series of mortality rates by cause of death, age, and sex for France from 1925 to 2008. The causes were classified into major headings to form nine coherent series across the revisions of the ICD. The age groups range over 0, 1-4, 5- 9,. . . ,95-99, 100+.

Methods

This paper exploits the fact that, given an arbitrary unit radix for the birth cohort in all life-tables and the assumption that births equal deaths, cross-sectional densities of deaths by age and cause $d^i_{x;t}$ are compositions', in the sense that they only contain relative rather than absolute information because they have a constant sum, equal to the radix of the life table. A change in $d^i_{x;t}$ for a specific cause i and age x in a multiple-decrement life table is automatically compensated by changes at other ages, or in other causes, to maintain this constant sum property. We believe that recognising this compensation is an important feature of our approach.

We use methods derived from the statistical literature on Compositional Data Analysis to exploit this feature of compensatory changes in $d^i_{x;t}$. The conventional Lee-Carter approach using the singular value decomposition is modified to model $d^i_{x;t}$ and to forecast changes via a random walk with drift. Net changes in the density of deaths by age can be identified for each cause, both within the data and in the forecast. Our model can be thought of as a Lee-Carter style forecast for a multiple decrement life table with internal compensation between causes of death.

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5.4

Changing mortality trends by age and sex are challenges for assumptions on future mortality

Örjan Hemström*

Background

There are a number of different ways to forecast mortality. Extrapolative methods, such as the one suggested by Lee and Carter (LC), has been widely used in recent years. Evaluations of mortality development during the 20th century suggest that the LC-model satisfactorily predicts future gains in life expectancy. Key assumptions of the LC-model are constantly age dependent to the predicted general mortality change. The LC-model is therefore conditioned upon rather smooth mortality changes and relatively homogenous time trends across age groups.

Problems and questions

Trend shifts in recent mortality in relation to age and sex are challenges to the LC-model as well as to other extrapolative models that aim to forecast mortality. An important question is how to interpret and evaluate such shifts for the future. It has previously been shown that in the latter half of the twentieth century, the pace of mortality decline at older ages relative to that at younger ages was faster than was the case in the first half of the twentieth century. Has this development continued further?

Data and method

In this study, the development of Swedish mortality in the period 1975–2011 was analysed by means of various sex-specific LC-models using base periods of varying length. For comparison, simple sex and age-specific trend calculations were performed.

Findings

Results suggest that the LC-model is suitable in forecasting Swedish women's mortality but not as suitable for men's mortality. The predicted mortality change in men differed by length of the base period, in particular at ages 65 years and over. Close inspection of older men's mortality shows that mortality has declined at an increasing rate in older age groups. Such shifts make it difficult to forecast men's mortality on the basis of past trends alone. Findings also suggest that LC-models incorporating all ages between 0 and 100 years tend to underestimate the mortality decline in age groups 50 years and older as compared with simple age-specific trend calculations.

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6.1

Indexation of the pension age to projected remaining life expectancy in The Netherlands

Coen van Duin*

In 2012, a law was passed to increase the state pension age in The Netherlands gradually from 65 in 2012 to 67 years in 2022. To set the pension age after 2022, an indexation procedure is used in which the pension age tracks the increases in remaining period life expectancy at age 65. The state pension age is fixed five years in advance, based on the then most current life expectancy projection of Statistics Netherlands. The age of entitlement for the supplementary collective pensions is fixed 12 years in advance, and hence is based on an earlier edition of the mortality projections.

This paper discusses the indexation procedure and its consequences. This new application of the mortality projections has changed the requirements for the projection model. Transparency and robustness are now more important. Statistics Netherlands introduced a new mortality projection model in 2012, in part to better meet these new requirements. Communicating to the general public about the uncertainty in life expectancy projections has also become more important. Under the new pension system, life expectancy projections also imply projections for the future pension age. People will be planning their financial future based on these projections and therefore should be informed about their considerable uncertainty.

Under the new system, the definitions of potential labour force and 'grey pressure', which are a function of the pension age, become dynamic. Using Statistics Netherlands' 2012 stochastic population projections, we show how this affects the level and uncertainty of the future pension age, the number of pensioners, the potential labour force and the 'grey pressure'. One attractive feature of the new system is that it makes projections of 'grey pressure' and number of pensioners much more certain. The indexation procedure cancels out much of the uncertainty in this projection that is related to the future development of life expectancy. Projections for the potential labour force, however, acquire additional uncertainty.

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6.2

The role of the population projections for a redefinition of the Portuguese higher education institutional network

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Population projections can be used as a tool to provide information on possible scenarios of future population and, hence, to support decision-making processes in diverse socio-economic areas, such as higher education and institutional network planning, in both public and private sectors.

The dimension and the age and sex composition of future populations are influenced by mortality, fertility and migration trends. So, an accurate estimation of those future trends is crucial to evaluate how many inhabitants we will face in the future and hence to prepare ourselves for their future needs. In a country such as Portugal, affected by a severe economic and financial crisis, with a young population characterised by very low levels of education and qualification, it is fundamental to use population projections as a basis for higher education planning.

The main goal of this paper is to evaluate the possible changes in the size of the young population in the coming years as a tool to (re)define and (re)design, geographically, the higher education institutional network in Portugal.

For this purpose, we used the cohort-component method to project the Portuguese population from 2011 to 2036. For the evaluation of the future evolution of mortality we tested the performance, for the Portuguese case, of both the Lee-Carter (LC) method (1992) and the Booth-Maindonald-Smith (BMS) variant (2002), using data from the Human Mortality Database. Regarding the projection of fertility, we used data from the Human Fertility Database and applied the method proposed by Schmertmann (2003 & 2005) to model fertility rates by age. The complexity of migration flows, especially regarding their instability and the difficulties in addressing new forms of population mobility, led to the decision to include only a null migration scenario in this exercise.

Considering the relevance of the projection of the number (and sex composition) of the population aged under 18 years, we centred the discussion on the impact of different estimates of the future mortality rates for the youngest. Alongside the main results, we will focus also on the analysis of the outcomes of LC and BMS models, performing a sensitivity analysis. We use this analysis to give reasons for choosing one of those models, as well as the use of confidence intervals to design alternative scenarios.

Our findings will provide a range of reliable forecasts to support more rational political decision-making, contributing to efficient and effective planning with respect to adjustment of higher education requirements to the future population.

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6.3

On the use of Seasonal Forecasting Methods to model birth and deaths data as an input for monthly population estimates

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The Labour Force Survey (LFS) collects information on a sample population and, every calendar quarter, needs advanced information on estimates of resident population for each NUTS 3 area, with a five-year age-breakdown by sex, to weight sample data. In Portugal, the LFS quarter results are published around forty days after the end of the survey period. This calendar is incompatible with the current production of population estimates, since data on the three components – births, deaths and migration – are not yet available. As such, monthly forecasts of live births, deaths and migration must be used. Empirical time series data for births and deaths by NUTS 3 areas in Portugal show strong evidence of the presence of seasonal patterns, which mean that appropriate forecasting methods must be considered.

In this paper we address the problem of forecasting monthly live births and deaths by NUTS 3 area and sex and the distribution of the total predicted deaths by age. The purpose is to use seasonal forecasting methods in order to capture the seasonal behaviour of the data.

First, for each individual time series, graphical analysis is used to analyse past behaviour of fertility and mortality from 1980-2011. A seasonal pattern is evident in the behaviour of live births and deaths. Substantial changes are observed in the trend of fertility, with the number of life births showing a declining trend after 2000 in the majority of NUTS 3 areas. Mortality patterns are relatively stable, showing a clear seasonal pattern and a reduction of variability in the more recent period.

Second, three alternative methodologies are considered to model and forecast the number of births and deaths by NUTS 3 area and sex: ARIMA models with a seasonal component, Holt-Winters exponential smoothing models, and state-space models. Multiple combinations of each of the three alternative types of models are used to fit births and deaths for each NUTS 3 area, and the best model is chosen using the BIC criterion. To evaluate the forecasting power of each model we use a back-testing procedure using various summary measures of the deviation between the observed values and the forecast point estimates. To assess the robustness of the empirical results to changes in the observation period, we conduct a sensitivity test on the forecasting power of each model, considering a longer observation period and a more recent one. The methodology that provides the best forecasting performance for the majority of the NUTS 3 areas is adopted. Given the forecasted total number of monthly deaths for each NUTS 3 area, we use a cohort component approach to distribute deaths by individual age, considering the most up-to-date death probabilities derived from complete life tables and a calibration procedure to redistribute the residual component.

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7.1

Qualitative and methodological aspects of population projections in Georgia: Georgian Population Prospects, 1950-2050

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The population of Georgia has decreased since its independence from the USSR, from 5.5 million in 1991 to 4.5 million in 2013. Some of the population's decline is due to the decrease of fertility and increased mortality levels, but the main impact is related to emigration. In the period between two population censuses, 1989 and 2002, Georgia lost more than one million persons due to emigration. In the years following independence, an economic crisis, civil war and other armed conflicts led to the displacement of many people. Growing poverty, unemployment, limited access to basic social services, low income and its unequal distribution have had a clear direct impact on population dynamics in Georgia. According to all of the existing projections the population of Georgia continues to decrease. In order to discuss population projections, it is very important to have better estimates of vital statistics and annual population numbers.

In Georgia, data quality has always been an issue, but since the collapse of the Soviet Union in 1991, the quality of population statistics has deteriorated rapidly. This deterioration concerns both reliability of vital statistics and population estimates. In the 1990s, demographic statistics published by national statistics office were far from the real levels. This was due not only to increasing migration flows, along with a conflict in the country that disrupted many statistical data series, but also to the deterioration of the current data collection system for births and deaths. In the 1990s, political instability in the country and socio-economic crisis caused the collapse of the population registration system. Registration of international migrants was especially affected; hence the population numbers which the statistics office published was unrealistic. Several surveys conducted in Georgia shows that the levels of fertility and mortality have been considerably underestimated, by approximately 15 to 20 per cent for the period 2000-2006.

The next very important issue in data quality problems is the discontinuity of statistical data series due to territories being in fact out of control of the government of Georgia. Since 1993-1994 Abkhazia and a large part of South Ossetia, and since 2008 the whole South Ossetia have been out of control of the Georgian government.

In Georgia, besides official statistics, alternative statistics made by local experts are available. In most cases these two sources of population statistics provide very different data.

Given all of the above, first of all it is important to explore the data quality problem in Georgia and where necessary to re-estimate annual population numbers. The next step for our research will be discussing the methodological and specific qualitative aspects of Georgian population prospects. For our research we are going to use several data sources: (1) Official data provided by the National Statistical Office of Georgia; (2) estimated data made by local experts[1] and (3) UN estimates[2].

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7.2

Population Prospects of Georgia

Nika Maglaperidze*

Population projections, in the field of demography, are estimates of future population. In contrast with intercensal estimates and censuses, which usually involve some sort of field data gathering, projections usually involve mathematical models based only on pre-existing data which may be produced by a governmental organization, or by those unaffiliated with a government.

Population projections are calculations which show the future development of a population when certain assumptions are made about the future course of fertility, mortality and migration.

Population projections based on the most recent international standards play a key role in the elaboration of strategies for the development of Georgia.

The present work is a revision of the demographic projections for Georgia published in 2003 (Tsuladze at al. 2003).

The purpose of our paper is to make projections of population quantity and structure by sex and age and other demographic indicators of Georgia until 2050 on the basis of new data, by application of the cohort-component method (Preston et al. 2001), as established by international standards.

All the projections will be based on several sources of information:

A - The data provided by The National Statistics Office of Georgia

B - Data estimated by G. Tsuladze and N.Maglaperidze (Tsuladze at al. 2011)

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7.3

Estimation of the size and vital rates of the Haredi (Ultra-orthodox) population in Israel for the purpose of Long-range population projections

Ari Paltiel*

Background

It was considered desirable that the first long-range population projections for Israel (2009-2059) include component projections for the Haredi (ultra-orthodox) population. It was considered likely that the future characteristics of the population as a whole will be influenced by it considerably, due to its current size, its low labour force participation rates and high fertility rates. This was a departure from previous ICBS projections, which had relied on groups which could be identified directly by characteristics recorded in the National Population Register.

Objective

The paper will present the methods used to estimate the current size of the Haredi population, its age structure, its components of change in recent decades, and its projected components of change. The results of the projection will be presented as well.

Methods

The estimated size of the population, its age structure and its components of change were determined based on self-reports in the annual CBS Social Survey, together with information obtained by linking these surveys to the Population Registry. The results were compared to alternative estimates. Projections were based on a statistical analysis of past fertility and mortality trends, together with a statistical analysis of the degree of success of previous CBS projections. Future scenarios were based on the 95 per cent confidence intervals for each of the components of change. The various scenarios (the medium, high and low projections) were determined according to appropriate combinations from the range of confidence intervals for each of the components.

Results

The Haredi population, which according to the estimates for this projection numbered 0.75 million at the end of 2009, will number 1.05-1.15 million in 2019 (1.10 million in the medium projection), 1.63-2.16 million in 2034 (1.89 million in the medium projection), and in 2059 it will reach 2.73-5.84 million persons (4.15 million in the medium projection), an increase of 264-686 per cent.

Conclusions

In all scenarios, the Haredi population will continue to grow rapidly, both absolutely and relative to other groups in Israel's population.

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7.4

Population and development scenarios for EU neighbour countries in the South and East Mediterranean region

George Groenewold, Joop de Beer*

The European Neighbourhood Policy (ENP) was created to reduce unemployment and income gaps between European Union (EU) countries and their neighbours, notably South and East Mediterranean countries (SEMCs). The ENP applies to sixteen countries, of which ten are SEMCs: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia. Turkey is an SEMC but not an ENP country because it is an EU candidate country. The country is included because it is a key player in the political arena in the region, its culture and economy is intertwined with its ENP neighbours, it is home to the second largest population in the region, and it is the country of origin of the largest non-EU-born immigrant population. Realisation of ENP objectives is influenced by demographic prospects and, surprisingly, these have not been explored in a systematic manner. Demographic prospects of SEMCs differ because they are at different stages of demographic transition regarding timing, speed and level of decline in fertility and mortality, while the importance of international migration to national population growth varies considerably.

While various scenario studies explore the demographic future of EU populations with respect to working-age population growth, economic consequences, and the role of international labour migration in coping with expected labour force shortages, such studies for EU neighbour countries are as yet absent. This paper aims to contribute to filling this gap by exploring (1) what the demographic future of SEMC populations up to 2050 looks like should they come to live in contexts with different economic, political and social conditions, and (2) what the consequences of working-age population prospects are for economic production and migration pressure, with particular reference to the subset of SEMC and EU countries that constitute a large and distinct migration system, which we named the MT4-EU5 migration system. It is estimated that this migration system comprises more than 11 million people.

After a brief presentation and discussion of four cohort component scenario projections of the general population of SEMCs, we focus on analysing working-age population prospects, demographic dividend potential, and future migration pressure in the MT4-EU5 migration system comprising four migrant-sending SEMCs (Algeria, Morocco, Tunisia, Turkey) and five migrant-receiving EU countries (France, Germany, Italy, Netherlands, Spain).

Results show that working-age population prospects and demographic dividend potential in these countries vary considerably, reflecting differences in scenario assumptions and demographic transition stage. Analysis of past population and economic data suggests that some migrant-sending countries, notably Turkey, are unlikely to fully capitalise on future rises of working-age population shares, which may lead to increases in unemployment and migration pressure. EU countries, though, are in an advanced stage of demographic transition, experiencing working-age population decline so that it becomes opportune to explore complementarity of labour forces, including identification of economic and cultural constraints. The plausibility of scenario results are discussed in light of the Arab Spring and related political upheaval in the region.

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8.1

Contribution of fertility model and parameterisation to population projection errors

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The existing literature offers a wide range of fertility models of different types and complexity that may be used in population projections. Yet, systematic studies are not available that would quantify the importance of the model complexity and the correct choice of model parameters for the accuracy of the resulting projections. This work provides such a comparative study of the contributions of model choice and of the accuracy of the three main fertility indicators (the total fertility rate, mean and standard deviation of age at birth, respectively: the TFR, MAB, SDAB) to the accuracy of population predictions.

We apply model fertility schedules to the empirical female populations of the Human Fertility Database (http://www.humanfertility.org) and study the deviations of the imputed numbers of births from the empirical ones. We consider eight model age patterns of fertility rates: two variants of the direct transformation of the empirical schedule; two variants of the Brass model; Schmertmann's Quadratic-Spline model; the Gamma model; the Rectangular model; and the Ryderian pentapartite model.

We find high importance of the accuracy of the TFR and MAB in population projections. We show, in particular, that common simplified approximations to the MAB lead to prediction errors (prediction error of about 1.5 per cent in the annual number of births) that are as high as those arising from assuming an unrealistic rectangular shape of the curve of the age-specific fertility. On the other hand, the role of estimates of the SDAB and of the choice of the fertility model is limited. More attention should be paid in population projection practices to working out (interdependent) scenarios for the TFR and MAB, while relaxing the complexity of all other aspects of fertility projection models. In particular, we suggest a simple relational fertility model that works as efficiently (slightly outperforming) as any of the more sophisticated common fertility models.

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8.2

New family values and increased childbearing in Sweden?

Lotta Persson, Johan Tollebrant*

In many countries the patterns of partnership formation and dissolution have changed substantially, with a general trend towards less stable unions. In Sweden, this development seems to have come to an end. One of our studies, using register data of all children in Sweden living with their biological parents in the period 1999–2011, shows that the percentage of children who experience a separation of their parents has decreased during the 2000s. To better understand the reasons for this development, a logistic regression was performed. Results show that higher levels of parents' education and postponement of family formation are important factors explaining the downturn.

Another of our studies also suggests an end of the trend towards less stable unions. Register data of all children born in Sweden from 1970 shows that half-siblings have become less common during the 2000s. An increasing proportion of children born today have only full siblings. Thus, the impact of stepfamily fertility has declined. With a logistic regression we show that higher levels of education and postponement of family formation are once again two explanatory factors for this development. But these and other socioeconomic and demographic factors do not seem to explain the development fully.

In Sweden, in the 21st century, there has been a rise in fertility. Couples who have stayed together account for the entire rise. Increased gender equality at home may have led to stronger family ties, which in turn could make women and men more inclined to have more children (with the same partner). Another explanation could be a trend towards more family-oriented values in society.

In the 2000s, marriages have increased and childlessness has decreased. To have a second child has become more common and third births have increased, at least among women in their late 30s. That is clear when parity-dependent cohort fertility is studied. How will continuing increases in gender equality and attitudes towards childbearing and family formation affect childbearing in the future?

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8.3

Projecting fertility by regions considering tempo-adjusted TFR: The Austrian Approach

Alexander Hanika*

Stimulated by the paper "Fertility Forecasting in the German–speaking World: Recent Experience and Opportunities for Improvement", Statistics Austria developed an approach to consider tempo effects in fertility projections to be implemented in the latest population projection for Austria at the NUTS 2 level. The aforementioned paper describes the inconsistencies of total fertility rate (TFR), tempo-adjusted fertility (TFR*) and mean age of childbearing (MAC) for the time horizon of fertility projection arising from non-contiguous projections for TFR and MAC based on the national population projections for Austria, Germany and Switzerland.

To project future fertility patterns, Statistics Austria uses the Hadwiger function. This model estimates age-specific fertility rates based on four parameters: TFR, MAC, the mode and the variance of the fertility distribution. Assumptions for all these parameters therefore have to be formulated for the nine Austrian NUTS 2 regions as well as for three fertility variants (high – medium - low). The first step is to project the TFR for the year 2060 according to the mean variant under the assumption that cohort fertility will not fall substantially below the observed cohort fertility of the 1970/71 cohort. The Austrian level of this value is 1.60. The nine regions vary between 1.76 (Vorarlberg) and 1.50 (Vienna). The forecast is done by a logistic regression model of TFR by time (1999-2011) which uses completed cohort fertility of the 1970/71 cohort as an upper asymptote. This produces fertility levels between 1.49 (Vienna) and 1.67 (Upper Austria) with a total value of 1.57 for Austria in 2060. The high and low variant are assumed to vary by ±0.5 children per woman. As spatial differences in MAC have diminished over the last few decades, MAC is assumed to rise up to 33.0 years in 2060 for all Austrian regions.

According to the Bongaarts-Feeney model, the Austrian tempo-adjusted TFR* for the year 2011 currently amounts to 1.70 children per woman (TFR: 1.43; r_t: 0.16).

$$TFR_t^* = \frac{TFR_t}{(1 - r_t)}, \qquad r_t = MAC_t - MAC_{t-1}, \qquad TFR_t = TFR_t^* * (1 - r_t)$$

Because of the assumption that in the long run of population projections, TFR, TFR* and completed cohort fertility will converge to the same value (1.57 for Austria), consistent paths of TFR* and r_t have to be found (*see figure 1 below*). The first step is to calculate a path for the tempo-adjusted TFR* starting with the actual value for the base year (1.70) converging asymptotically to the projected value for 2060 (1.57). The second step is to estimate a path for r_t with $r_t \rightarrow 0$ and $\sum r_t$ = MAC(last year) – MAC(base year). Based on the relationships given above, TFR_t could easily be recalculated.

Together with assumptions on future modes and variances of the different fertility patterns, age-specific fertility rates are estimated using the Hadwiger function for all regions, variants and projection years.

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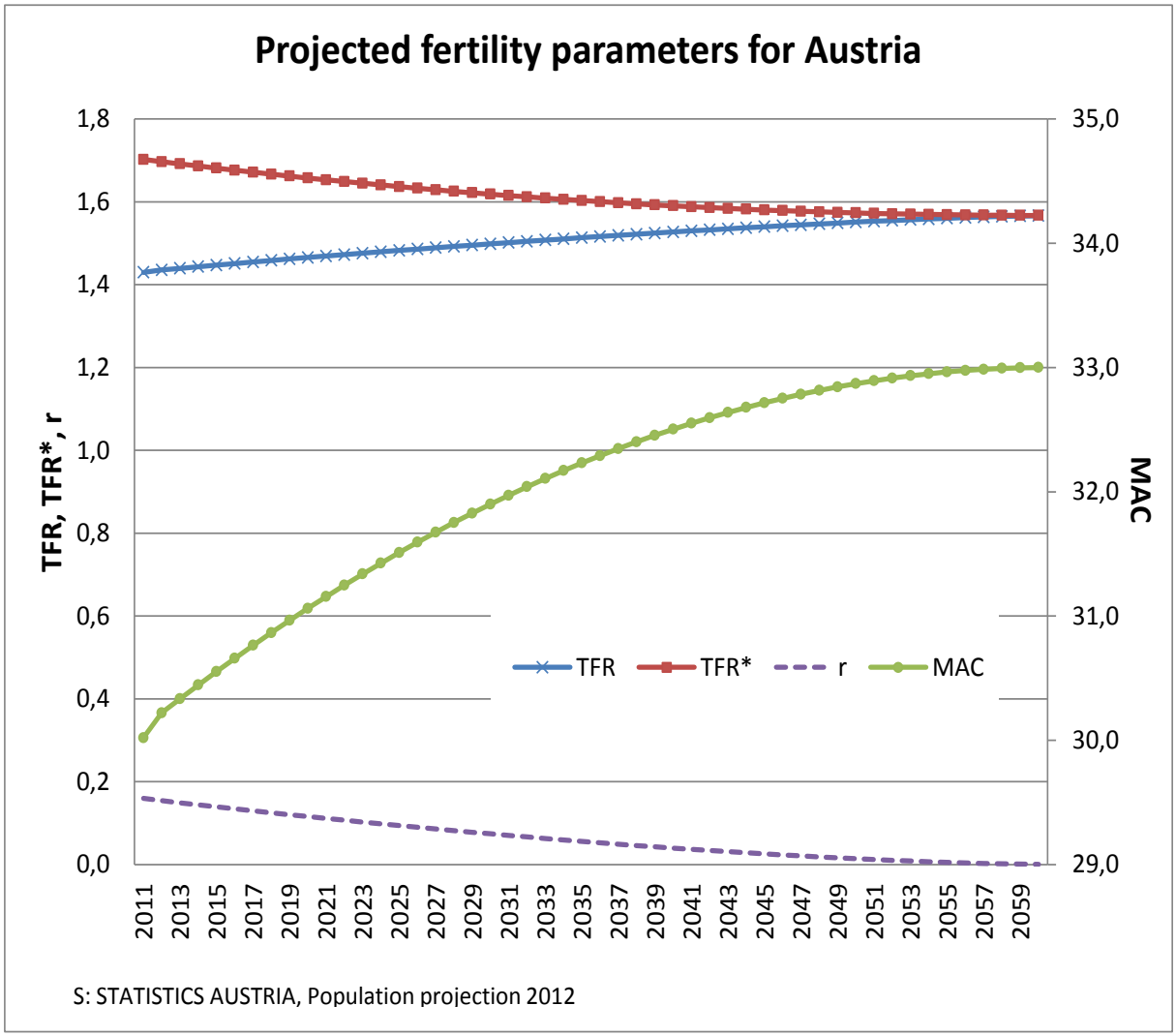

Figure 1: Projected fertility parameters for Austria.

8.4

Effects of childbearing postponement on cohort fertility in Germany

Olga Pötzsch, Bettina Sommer*

Germany has had low fertility for decades. In recent years some slight positive trends have been seen for women who were in their mid-thirties. But it seems that this will not lead to a sustained recovery of cohort fertility (cohort total fertility rate, CFTR). After a small recuperation, cohort fertility is tending towards stagnation at a low level.

We analyse the effects of the increasing age at childbearing on cohort fertility. The amount of childbearing postponement and recuperation is quantified and is used to estimate the final number of births. We also show possibilities and limitations of using analyses of cohort fertility to estimate the future development of births.

Results of birth statistics, including CTFR and cumulated age-specific fertility rates for several ages are used as well as results of the micro census, Germany' large household survey, and a specific smaller survey on births conducted by statistical offices in 2006.

CTFR (for age 49) decreased in Western Germany from 2.2 to 1.6 children per woman in the last 30 years. It can be expected that it will reach a (temporary) minimum for the birth cohort of 1967. We project CFTR for the birth cohorts of 1973 and 1977 using the approach of Tomas Freijka to analyse postponement and recuperation.

The "Recuperation Index" (RI) is applied to estimate the amount of recuperation in CFTR of a cohort. Therefore, one birth cohort is defined as benchmark. For younger cohorts the differences in cumulated age-specific fertility rates from the rates of the benchmark cohort are taken into account. RI has been used to analyse and project cohort fertility by Tomas Sobotka *et al* already.

In Western Germany, RI gives a maximum compensation of approximately 60 per cent of postponed births using the cohort of 1946 as a benchmark. The majority of recovery occurs up to the age of 35. Changes of RI at age 35 are therefore an important indicator for future development of CFTR. For women born at the end of the 1960s a slight increase of CFTR emerges. We estimate that women born between 1973 and 1977 will reach a CTFR of 1.54, whereas for women born in 1967 the CTFR is estimated at 1.47. A further increase for younger women is not seen so far. These women postpone childbearing again and their RI remains the same at age 35, which could even lead to a renewed decrease of CFTR.

For fertility assumptions, information on cohort fertility trends and their underlying patterns is necessary. For this purpose, knowing the average number of children is not sufficient. It is also important to know how this average number is composed. We know that the decrease in CFTR up until the cohort of 1967 was mainly caused by an increase in age at birth of the first child and an increase in childlessness. Today's CFTR of 1.6 results from 80 per cent of the cohort having an average of two children and 20 per cent remaining childless. At birth of the first child, mothers with more than two children were three years younger than mothers of one child. Time lags between first and second and between second and third children are relatively large and stable. If these patterns continue, an increasing share of women bearing their first child between the beginning and the middle of their thirties could lead to fewer mothers with more than two children.

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9.1

Measuring uncertainty in population forecasts: a new approach

David A. Swanson, Jeff Tayman*

Two basic approaches have been used to assess population forecast uncertainty: (1) a range of projections based on alternative scenarios; and (2) statistical prediction intervals. In terms of the latter, there are two complementary approaches: (1) model-based intervals; and (2) empirically-based intervals. We evaluate a model-based approach in this paper, but enhance it by using the information in historical data, a feature found in the empirically-based approach. We describe and test in this paper a regression-based approach for developing 66 per cent forecast intervals for age-group forecasts made using the Hamilton-Perry Method. We use a sample of four states (one from each of the four US Census Regions) with nine *ex post facto* tests, one for each census from 1930 to 2010, which yields 576 observations. The four states and the nine test points provide a wide range of characteristics in regard to population size, growth, and age composition, factors that affect forecast accuracy. The tests reveal that the 66 per cent intervals contain the census age groups in 397 of the 576 observations (68.9 per cent). We discuss the results, and make some observations regarding the limitations of our study. We conclude that the results are encouraging, however, and offer suggestions for further work.

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9.2

Stochastic Population Forecast: an Application to the Rome Metropolitan Area

Salvatore Bertino, Oliviero Casacchia, Massimiliano Crisci*

As stated by various authors (see for instance, Billari, Graziani and Melilli, 2012; Scherbov, Mamolo and Lutz, 2008), stochastic population forecasting has recently received great attention from researchers. The possibility of forecasting future levels of population, fertility, mortality and migration, considering an estimation interval to manage uncertainty, is currently an important topic. At the same time, the stochastic method seems to be a useful and efficient tool to implement multiregional forecasting at the local level.

The stochastic approach presented here is based on micro-simulations of birth-death-emigration-immigration point event processes (Bertino and Sonnino, 2007; Bertino, Sonnino and Lanzieri, 2012). In this sense the model represents a new approach not considered in the usual definition of the currently probabilistic approaches (Billari, Graziani and Melilli, 2012) and permits the production of intrinsically probabilistic output, with different sources of variability.

The paper presents the results of a project financed by the Province of Rome regarding multiple stochastic population forecasting of the Rome Metropolitan Area (RMA), a territory of around 2000 km^2, with 4 million inhabitants including the city of Rome and 120 smaller surrounding centres.

The RMA territory was fractionated into five concentric sub-areas: dividing in two the huge municipality of Rome (core and urban periphery) and aggregating the districts around Rome into three rings (the metropolitan peripheries). For this purpose, mixed regionalisation criteria were used: institutional, functional and geographical. The application of forecasting methodology was preceded by accurate data preparation including the correction of the population structure sourced by the population register of Rome (the *anagrafe*) and the analysis of demographic trends in the RMA during the first decade of the twenty-first century.

The forecast was based on a range of hypotheses, referring to the future demographic dynamics in the period 2009-24, and forming three scenarios: high, medium and low. The output includes many data and demographic indicators for each year between 2009 and 2024, determined by gender, age and sub-area.

The outcome of the stochastic method is compared with deterministic forecasting, based upon the Rogers multiregional method, to verify the efficiency of both the methodologies. This two-step strategy allows for maintenance of “control” on the assumed future demographic scenario, at the same time linking a probability level.

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9.3

Long-term contribution of immigration to population renewal in Canada: a sensitivity analysis using Demosim

Patrice Dion, Éric Caron Malenfant, Chantal Grondin *

In a context of a decline in natural increase, immigration constitutes not only an increasingly important component of growth in Canada, but also a major vector of change for the composition of its population. Immigration *per se*, as it contributes to the renewal of the foreign-born population, has a direct demographic impact. But its contribution to population change is also indirect as immigrants give birth to children after their arrival, who in turn will also have children and so on. What are the possible long-term effects of these processes on the Canadian population? How long would it take, for instance, for the immigrants' share of the population to reach a plateau if immigration, fertility, mortality, mixed unions, etc., were to remain at the recent level? And what proportion of Canada's population 100 years from now would be composed of the descendants of immigrants who have not yet arrived? With Statistics Canada's Demosim micro-simulation model, which projects the immigrant and non-immigrant populations along with other demo-cultural characteristics, it is possible not only to project the share of the immigrant population, but also to flag their children, the children of their children and so on and thus assess how the descendants of immigrants also constitute a factor of change.

The goal of this paper is to analyse the direct and indirect demographic contribution of immigration in Canada according to various projection scenarios over a century, from 2006 to 2106. Firstly, the Demosim model and the assumptions used with regard to immigration, to fertility differentials (immigrants, second generation, third or subsequent generations) as well as to mixed unions, for instance, will briefly be described. The second part of the presentation will be dedicated to the results regarding the projected share of immigrants in Canada and that of the population that would be descendants of immigrants who arrived after 2006. The picture that will emerge will improve our understanding of how, and at what pace, population renewal takes place in a high immigration and low fertility country.

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9.4

From agent-based models to statistical emulators

Jakub Bijak, Jason Hilton, Eric Silverman, Viet Dung Cao *

Contemporary demographic micro-simulations are largely concerned with populations of statistical individuals, whose life courses can be inferred from empirical information (Courgeau 2012). In contrast, agent-based models study simulated individuals, for whom certain behavioural rules are assumed. We wish to bring these two approaches closer together by coupling the rule-based explanations driving the agent-based model with observed data. We also propose a method to analyse the statistical properties of such models, based on the notion of statistical emulators (Kennedy & O'Hagan 2001; Oakley & O'Hagan 2002).

In this paper, we present a Semi-Artificial Model of Population, which aims to bridge demographic micro-simulation and agent-based traditions. We extend the 'Wedding Ring' agent-based model of marriage formation (Billari et al. 2007) to include empirical information on the natural population change for the United Kingdom alongside the behavioural explanations that drive the observed demographic trends. The mortality and fertility rates in this population are drawn from UK population data for 1951–2011 and forecasts until 2250 obtained from Lee-Carter models. We then utilise a Gaussian process emulator – a statistical model of the base model – to analyse the impact of selected parameters on two key simulation outputs: population size and share of agents with partners. A sensitivity analysis is attempted, aiming to assess the relative importance of different inputs.

The resulting multi-state model of population dynamics is argued to have enhanced predictive capacity as compared to the original specification of the Wedding Ring, but there are some trade-offs between the outputs considered. The sensitivity analysis indicates a key role of social pressure in the modelled partnership formation process. We posit that the presented method allows for generation of coherent, multi-level agent-based scenarios aligned with selected aspects of empirical demographic reality. Emulators permit a statistical analysis of the model properties and help select plausible parameter values. Given non-linearities in agent-based models such as the Wedding Ring, and the presence of feedback loops, the uncertainty of the model may be impossible to assess directly with traditional statistical methods. The use of statistical emulators offers a way forward.

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10.1

Estimating the number of households: an unavoidable challenge for the statistical system

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The 2011 Population and Housing Census has provided, once again, a statistical picture of the demography of Spain. According to the census figures, Spain's population has increased by almost 6 million (14.6 per cent) since 2001. In parallel, the number of households has risen by 4 million (27.5 per cent) compared to the 2001 census. As a result, there are 18.1 million households residing in the country as of 1 November 2011, noticeably more than the estimates provided by available sources (i.e. LFS had estimated 174 million households in the 4th quarter of 2011).

Thus, these data describe the demographic boom of Spain at the beginning of the twenty-first century, but the impact in terms of number and type of households is even bigger than that of population size. In particular, these results determine the need to carry out a consequent revision of series for the intercensal years, not only on population but also on number of households and their most basic typology. The need to calibrate and re-calculate the results of surveys accordingly is currently under debate. It would bring the whole statistical system up to date, reaching a higher level of consistency among the different sources.

A methodology for the calculation of household estimates is proposed here, which provides household figures linked to the reference demographic estimates. Beyond that, this method, together with the development of a new Continuous Population Survey, will allow us to build the future architecture to produce 'nowcasts' on the number and type of households in order to feed the statistical system with the reference variables required.

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10.2

A household projection model for Belgium based on individual household membership rates, using the LIPRO typology

Marie Vandresse *

Objective

Up to now, official population projections for Belgium at the NUTS3 level have been produced yearly for the official institutions (among others Eurostat), for use in several short-, medium-, and long-term projection models (such as economic projections, income poverty, long-term healthcare expenditures, energy, transport) and for specific projects or particular demands. Aside from these official population projections, the interest in household projections is growing. Indeed, understanding the population under this dimension is very useful for numerous aspects of social life (expansion of single-parent households - often wives - or of isolated households with old persons who are at higher risk of poverty problems or short of support) and of economic life (impact on consumption, taxation, accommodation, mobility, etc.). In this perspective, a household projection model for Belgium, calibrated on the Belgian population projection at the NUTS3 level, is under development. The objective of this paper is to describe the model and to present the first results.

Methods

The model is based on individual membership rates. For each group of individuals defined by age, sex and residential location (at the NUTS3 level), a specific membership rate is estimated. The membership rates are defined by the twelve LIPRO positions (Imhoff and Keilman, 1991). The LIPRO typology allows the living arrangements of each individual in the population to be taken into account. The membership rates are not presumed to be constant in the projection. They follow either a logarithmic or a logistic trend. The estimation is based on historical data for Belgium at the NUTS3 level. The historical data, including the (LIPPRO) position within the household, are available from 1991. In order to take into account only recent trends, the estimation period is restricted to the period 2000-2011. The estimated membership rates are applied to the last official population projection for Belgium (2013-2060).

The selected method is static in the sense that the transition probabilities from one position within the households to another are not considered. This might be considered as a weakness of the model. Including transition probabilities within a dynamic approach would, however, have been more difficult in terms of data requirement and time resources. Some consistency rules, such as an equal number of married women and of married men, are implemented. All estimations being based by age and sex at the NUTS3 level, local specificities are, in a certain measure, integrated. This point will be discussed in the paper.

The projection of the individuals in a collective household is treated separately from the projection of private households. Given population ageing, assuming a logarithmic or a logistic trend on the rates of individuals in a collective household leads to an explosion of collective households, which might be not sustainable/defendable from a social, political or economic point of view. This element will also be discussed.

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10.3

Household Projections and Welfare

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In our society, households constitute a crucial unit of demand for a variety of goods and services, such as housing, transportation and consumption. They represent an essential statistical unit of analysis when dealing with issues such as migration projections, child care and elderly care needs, per capita greenhouse gas emissions, etc. (Wilson, 2013). In this perspective, both the projected number and the types of household are often required for the purposes of planning and policymaking.

Italy, like many other countries, is experiencing such a pronounced process of ageing that in the next twenty years the number of persons aged 65+ will greatly increase (+34 per cent). According to the available estimates, in 2030 these persons will number nearly 16 million, a significant proportion of whom will be oldest-old (3 million). Moreover, the level of mortality and the enduring gap between female and male survival levels will cause an increase in the number of elderly people living alone and will probably affect the demand for elderly care.

The socio-economic impact of such a scenario can be analysed starting from the results of household projections, with the aim of answering the following question: How many caregivers will be necessary in the future to take care of our elderly parents? For Italy, household projections have recently been produced by a research group (Blangiardo et al, 2012) adopting a propensity method similar to the one used by the Australian Bureau of Statistics (1999) and by Statistics New Zealand (2004).

As is well known, nowadays the majority of caregivers are immigrants. Thus, in order to estimate the supply of caregivers for the next twenty years, we estimate the inflows into Italy and therefore the number of potential caregivers, employing an *ad hoc* model for migrant population (Ministero del Lavoro, 2013).

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11.1

Ageing alone? The future of the Portuguese population in discussion

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Demographic paradigms are constantly changing over time. Together with the increasing lifespan that is breaking limits once thought never attainable, fertility rates are declining across the whole of Europe. These two factors are contributing jointly to a generalised aging in populations for the most industrialised countries. Portugal is no exception, and if in some cases fertility recuperation is starting to be observed, it seems that this recuperation is not close to happening to the Portuguese population. However, even if this fertility recuperation starts soon, the "benefits" will not be identifiable in the short term. Additionally, the fact that Southern Europe is in economic crisis, and that Portugal was the second country from the south, after Greece, to experience economic collapse, resulted in a strong impact on the family context. With such low fertility and deep economic crises, the theme of migration adds a major concern about the country's population future. Migration in Portugal is predicted to increase rapidly in the coming years, possibly returning the country to the same patterns registered in the 1960's when Portugal was a country of massive out-migration.

This reality results in very deep problems to entire populations and poses questions for politicians and demographers such as: Will be the country economically sustainable in the future? Is the total population of Portugal going to decline?, or, How will these changes influence household structures in the future?

In an attempt to answer the questions above, we intend to undertake a cohort component projection for the medium term (the next 20 years), that will allow us to identify the Portuguese population structure in the future and, at the same time, evaluate the possible changes that the country will have to face. Here, we assume that: mortality improvement will not be interrupted, estimating future patterns by applying the Lee-Carter methodology to forecast future mortality and life expectancy; fertility decline and postponement will increase; and finally migration will be characterised by massive out-migration. Another purpose of this study is to break down these projections, using the headship rate method proposed by the United Nations in 1973 and the model improvements proposed by Ediev in 2007 to estimate the future composition of households in Portugal, by age, sex and civil status. In this way, it is also our aim that our results should provide a possible and important basis for policymakers not only to make decisions concerning the population structure itself, which is growing older, but also to predict (and determine how to fulfil) health care demands.

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11.2

Integrating labor market in population projections

Juan A. F. Cordón, Joaquín P. Romero*

This paper focuses on the relationship between macroeconomic assumptions and demographic scenarios, two worlds which have so far remained isolated from each other.

Most economic studies take population as a given exogenous variable, dealing with economic consequences of expected population changes. On the other hand, conventional population projection models are blind to macroeconomic prospects, and they constrain their analyses to the study and extrapolation of past trends in fertility, mortality and migration.

However, life expectancy and people's demographic choices (fertility, migration) are not independent from social and economic circumstances in life. On the contrary, demographic events are but a part of a unique system that is balanced with and adaptive to social and economic circumstances. Keeping demographic analysis within its traditional constraints, isolating demographic events from social and economic variables, leads to biased interpretations of dependency ratios and inter-generational solidarity mechanisms.

Among the social and economic circumstances that influence people's demographic choices, labour market conditions cannot be ignored. To illustrate the interactions between social and economic circumstances and demographic dynamics, in this paper we put forward a model which explicitly links migration flows to economic forecasts in several European countries, taken from the most recent OECD economic prospects.

In our model, migration in each period cancels out the labour market imbalances in the previous period, with labour supply given by population projections and labour demand given by economic assumptions. Fertility and mortality assumptions were kept equal to Eurostat's "EUROPOP 2010 convergence scenario".

The results in the paper show that an integrated model for population projections and labour market provides a different perspective, and therefore different conclusions, regarding sustainability analysis based on dependency ratios and inter-generational solidarity mechanisms.

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11.3

Economic factors and net migration assumptions for EU countries – how to incorporate lessons from the recent economic crisis?

Pawel Strzelecki*

The process of migration is the most variable of all components of population projections. Traditionally the assumptions are usually set on the basis of expert knowledge or different trend extrapolation techniques. In recent projections Eurostat has made an attempt to add a log-term labour market factor to population projections by assuming a positive correlation between migration inflow and decrease of working age population ("replacement migration" rule). However, the recent economic crisis showed that the economic factors such as differences in labour demand and average wages can also be important determinants of migration flows in the short run. Those observations and literature on the economic determinants of migration suggest that the assumptions of population projections and long-term labour market projections need to be consistent. This is particularly important if the population projection is combined with labour market assumptions and used for GDP and public finance projections, as the risks of high unemployment rate and the drop in net migration are usually positively correlated. Thus in countries with very high unemployment it can be questionable to assume simultaneously huge migration inflows. Consequently, a decrease in unemployment rate in comparison to other EU countries should, in the long run, lead to improvement in net migration. The aim of this paper is to propose a new method that allows utilisation of the long-term projections of the labour market prepared by the Working Group on Ageing (AWG) to prepare consistent assumptions about future changes in the net migration. The result is population projection migration assumptions consistent with labour market projections.

The paper is based on the Eurostat data in EU countries and AWG labour market projections. The parameters for the projection models are based on the estimated relationships between migration flows and values of unemployment and wages in each of the countries in relation to the average in the EU. The majority of the results of regression models estimated for EU countries suggest that changes in unemployment rate are correlated with changes in net migration. These observations are also confirmed by more empirical literature (Mayda 2005, SOPEMI 2012, Czaika 2012). The parameters of the models and the AWG assumptions regarding unemployment and wage growth are used to prepare net migration assumptions for population projections for EU countries.

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12.1

Bayesian functional models for population forecasting

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In this paper, we extend the framework developed in Wiśniowski *et al*. (2013) to explore the functional modelling approach to population forecasting, which we embed in a wider context of Bayesian predictions and model uncertainty. The underlying method, originally suggested by Hyndman and Ullah (2007), extends the well-known model of Lee and Carter (1992) to allow for the analysis and forecasting of many different age- and time-specific components for each of the three main processes of population dynamics – fertility, mortality and migration. For each process we perform Bayesian model averaging across the outcomes of several functional models, in order to take into account the model uncertainty and a varying level of data support for different models. Finally, we combine the results in a joint cohort-component framework to obtain a fully Bayesian population forecast.

The method is illustrated by a population forecast for the United Kingdom for 2010–2035, which we compare against the official population projection of the Office for National Statistics. We discuss the importance of various modifications of the basic functional approach, most importantly related to including additional cohort-specific terms for fertility and mortality, as well as to smoothing irregular age patterns of international migration. The proposed method is argued to offer more flexibility than those based on single forecasting models, such as the traditional Lee-Carter approach, whilst allowing for a coherent treatment of various types of uncertainty thanks to the overarching Bayesian statistical framework.

An additional contribution of this paper consists in evaluating an application of the proposed methodology to a situation of relatively good, yet still not perfect data availability. Given the regularities in age profiles of fertility, mortality and migration, disaggregation of the relevant data by age and sex provides important additional information for the forecasts. We argue that, data permitting, the population forecasting should follow bottom-up, from the age-specific rates, which describe the underlying processes more fully, rather than top-down, from summary aggregates such as total fertility rates or life expectancies. For that purpose, the functional approach coupled with a coherent analysis of model uncertainty offer a very natural way of maximising the use of the available information.

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12.2

Towards stochastic forecasts of the Italian population: an experiment with conditional expert elicitations

Francesco Billari, Gianni Corsetti, Rebecca Graziani, Marco Marsili, Eugenio Melilli*

In this work we report on the whole process developed to produce expert-based stochastic forecast of the Italian population for the period 2011-2065.

In recent years several methods of stochastic forecasts have been developed. Three main approaches can be identified (Keilman et al., 2002). The first is based on time series models. The second approach is based on the extrapolation of empirical errors, with observed errors from historical forecasts used in the assessment of uncertainty in forecasts (e.g., Stoto, 1983). Finally, the third approach, referred to as random scenario, defines the probabilistic distribution of each vital rate on the basis of expert opinions.

We follow the latest approach and apply the method proposed by Billari et al. (2012), where the full probability distribution of forecasts is specified on the basis of expert opinions on future developments of the main components of the demographic change.

In particular, we derive the joint forecast distribution of the pair Total Fertility Rate and Immigration, on one side, and of the pair Male and Female Life Expectancies at Birth on the other side. The forecast distribution of Emigration and Mean Age at Birth are derived separately.

The conditional elicitation procedure makes it possible to elicit from experts information on the marginal behavior of a single indicator in terms of expected value and variability, but also on the across time correlation of each indicator and on the correlation between any two indicators at a given year or across time.

We designed a questionnaire according to such elicitation procedure and submitted it online to thirty Italian demographers. In particular, the forecast interval is divided in two subintervals: [2011 2030] and [2030 2065]. Considering the case of two indicators, at the beginning the expert is asked to provide central scenarios of indicators at 2030 and 2065 and a high scenario of one of them. The following questions elicit central and high scenarios of one indicator conditional on the values taken by the same indicator at a previous or by the other indicator at the same or previous time. Two typical questions are:

- if Immigration at 2030 is 100,000, provide a central scenario for the Total Fertility Rate at 2030;
- if Immigration at 2030 is 100,000, provide a central and high scenario for Immigration at 2065;

Any demographic indicator is then prorated in term of age specific values, the distribution of which is obtained resorting to well-known and widely used models.

Collected all the necessary information for running the probabilistic projections, in this paper we show the main results of this experimental project, covering the projected distribution for indicators of the demographic behaviour, for the total population and for age related population indicators.

In specifying the probabilistic distribution of the proposed indicators, we discuss the problems that can arise in the collection of expert opinions and the solutions that can be implemented in order to avoid inconsistencies in the calculation of the parameters.

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12.3

Expert-Based Stochastic Population Forecasting: a Bayesian Approach to the Combination of the Elicitations

Francesco Billari, Rebecca Graziani, Eugenio Melilli*

This paper builds on Billari *et al* (2012) and suggests a method that derives expert-based stochastic population forecasts in such a way as to account for relationships, on one hand, between demographic components, and on the other hand, between experts. Two main issues are addressed. First, we aim to define, for each expert, a joint distribution for the demographic indicators that allows both for across-time correlation for a single indicator and for dependence between indicators at the same time and across time. There is a certain debate among researchers about the advisability and/or necessity of allowing for dependence between different components. We believe that the most sensible approach is to be neutral in some respect, that is to allow for dependence without imposing it. Indeed, the method we suggest can, in principle, manage any type of dependence within any pair of indicators.

The second goal we pursue in this work is to find a suitable way to combine opinions elicited from several experts, to be used as the basis for the forecasts. We suggest addressing this issue by resorting to the so-called Supra-Bayesian approach, introduced by Morris (1974) and then developed by many authors. This approach makes it possible to combine expert opinions on unknown quantities within the formal framework provided by the Bayesian approach to statistics, by assuming that such opinions are data. The analyst is therefore asked to specify on one hand a likelihood function, to be parameterised in terms of the unknown objects, and on the other hand a prior distribution for the parameters. The posterior distribution, obtained by applying Bayes' theorem and updating the analysts' prior opinions on the basis of the evaluations provided by the experts, can then be used as a collective distribution for the unknown quantities of interest.

As for the likelihood, we suggest resorting to a mixture model approach. We assume that experts can be grouped into a given number of clusters, according to the shared information. The number of clusters is fixed by the analyst, but we let expert evaluations determine the cluster memberships. We assume that within each cluster, expert evaluations are generated by the same distribution. This makes it possible to account for the variability of the evaluations of experts exposed to the same information. The centres of the clusters' distributions are then assumed to be independently generated from the same distribution, centred on the unknown vector of future values of the indicators. In this way, on one hand we are able to account for the heterogeneity of the expert evaluations due to their possessing different pieces of information. On the other hand we achieve the goal of allowing for dependence between experts, without explicitly fixing it.

A Markov Chain Monte Carlo algorithm is designed to approximate the posterior distribution, to be used as a forecasting distribution. Moreover, expert opinions are elicited by means of a questionnaire, designed by the authors along with researchers of the Italian National Statistical Office, on the basis of the conditional method described in Billari et al. (2012). Finally, an application to the forecast of the Italian Population from 2010 up to 2065 is proposed.

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13.1

Bayesian Probabilistic Projection of International Migration Rates

Jonathan Azose, Adrian E. Raftery *

Bayesian methods for probabilistic population projections have recently been developed (Raftery *et al* 2012), incorporating methods for probabilistic projection of fertility (Alkema *et al* 2011) and of life expectancy (Raftery *et al* 2013). The methods for fertility were used in the UN World Population Prospects 2010 (WPP), and the life expectancy methods may also be used in the WPP 2012. The UN also uses projections of net international migration for all countries, but these remain deterministic.

We propose a simple methodology for projecting net international migration for all countries in the future. The method produces a large number of samples from a posterior predictive distribution of net international migration for all countries. Each posterior sample balances across the globe in each sex and age group. The method only requires data on past total net international migration for each country, and does not need data on between-country migration flows.

The method is based on a hierarchical Bayesian model for net migration rates, which are assumed to follow an autoregressive model whose parameters themselves have a world distribution. The model is estimated using Markov chain Monte Carlo. The method was validated in an out-of-sample predictive experiment, by holding out up to 15 years of recent data, re-estimating the model and forecasting the held-out data. The resulting probabilistic forecasts were accurate in that they had smaller mean absolute errors than other methods considered. They were also calibrated in that the forecast intervals had coverage close to the nominal coverage.

This method could provide in a fairly simple way the probabilistic forecasts of migration necessary for a Bayesian fully probabilistic WPP, in which all the components of demographic change (fertility, mortality and migration) are projected in a probabilistic way for all countries.

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13.2

Bayesian Probabilistic Population Projections: Do It Yourself

Hana Ševcíková, Adrian E. Raftery, Patrick Gerland*

A Bayesian approach for probabilistic population projections (Raftery *et al* 2012) has recently been used by the United Nations Population Division in the preparation of the latest revision of the World Population Prospects. The methods have been implemented in publicly available Open Source software as a collection of R packages: bayesTFR for probabilistic projection of the total fertility rate for all countries (Ševicíková *et al* 2011), bayesLife for life expectancy, bayesPop for probabilistic population projection by age and sex, and the graphical user interface bayesDem.

We will show how to reproduce such population projections easily, including probabilistic projections of total fertility rate and life expectancy. The packages allow analysts to generate variations of the UN projections, to use their own data, to impute missing data and to apply the methods to sub-national datasets. Using a flexible expression language, probabilistic results can be summarised and visualised in graphs, maps, or population pyramids. The software can be controlled conveniently from a graphical user interface.

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13.3

Bayesian Mortality Forecasts with a Flexible Age Pattern of Change for Several European Countries

Christina Bohk, Roland Rau*

Background

Is life expectancy going to increase as linearly in the future as it has done in highly developed countries in the past? Valid and reliable mortality forecasts are needed to answer such questions, which have great societal relevance. Linear increases in life expectancy in the past were due to mortality reductions at younger ages at first and due to mortality reductions at higher ages thereafter. Medical successes in combatting infectious and, later on, chronic diseases, in particular circulatory diseases, were the primary reason for this altering age pattern of mortality change. Common mortality forecasting approaches often neglect to model such a flexible age pattern of mortality change, and can, therefore, induce substantial projection error. Surveys of mortality forecasts for European countries show that projection errors of three years and more in life expectancy at birth are common [1]. We seek to overcome these problems with a new forecasting approach that incorporates a flexible age pattern of mortality change in order to generate more realistic and more accurate mortality forecasts.

Methods and Findings

Input data for our new mortality forecasting approach are age-specific death rates by single calendar year from the Human Mortality Database. To gain information about the age pattern of mortality change with time, we calculate the rates of mortality improvement for each age-specific death rate. We put this information in a Bayesian model that re-estimates and forecasts mortality change. The advantages of our Bayesian model are (1) that it automatically models coherence of mortality change among adjacent ages and (2) that it captures forecast uncertainty, i.e. it gives information about the likelihood and spread of our outcome [2, 3]. We then take the forecasted rates of mortality improvement to calculate future age-specific death rates and life expectancies. This is our baseline model which we can extend with several optional functions. For instance, if the extrapolation of an unsteady development is implausible, we can optionally complement the mortality trend of the country of interest with that of at least one other reference country (such as a neighbouring country). We implemented our new mortality forecasting approach with the statistical software R [4] using JAGS [5, 6], a program that can be deployed for Bayesian analysis. We conducted in-sample as well as out-of-sample mortality forecasts for several European countries including Great Britain, Spain and Denmark. The in-sample forecasts take the observed death rates from 1970 to 1990 in order to forecast them from 1991 to 2010. A comparison between the forecasted and the observed mortality data between 1991 and 2010 shows that our forecasts are more accurate compared to the forecasts of the canonical model of Lee and Carter [7]. For the Lee-Carter model, the forecast errors show systematic bias, i.e. they increase with the length of the forecast horizon, and they are, for example, about two years higher in the Danish forecast than for our proposed model (see Figures 1 and 2). The out-of-sample forecasts take the death rates from 1970 to 2010 in order to forecast them from 2011 to 2050. They indicate that the linear increase in life expectancy at birth is very likely to continue in the future due to mortality decline at higher ages.

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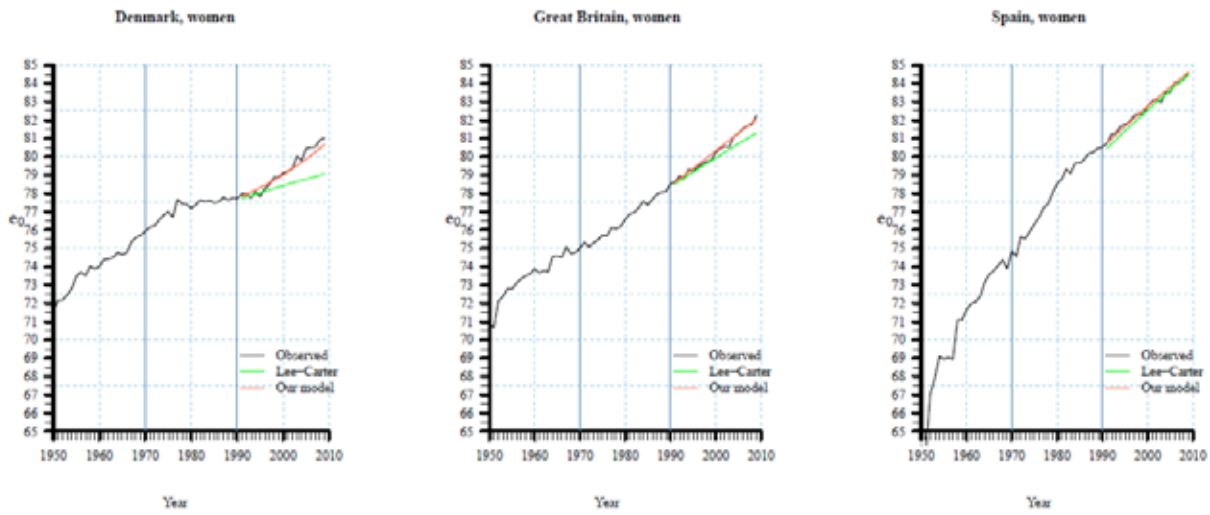

Figure 1: Forecasted life expectancy at birth for women in Denmark (left), Great Britain (centre) and Spain (right) with the Lee-Carter model (green) and with our proposed model (red). For these forecasts, we take the mortality data from 1970 to 1990 in order to forecast them from 1991 to 2009 so that we can compare them with the observed data (black).

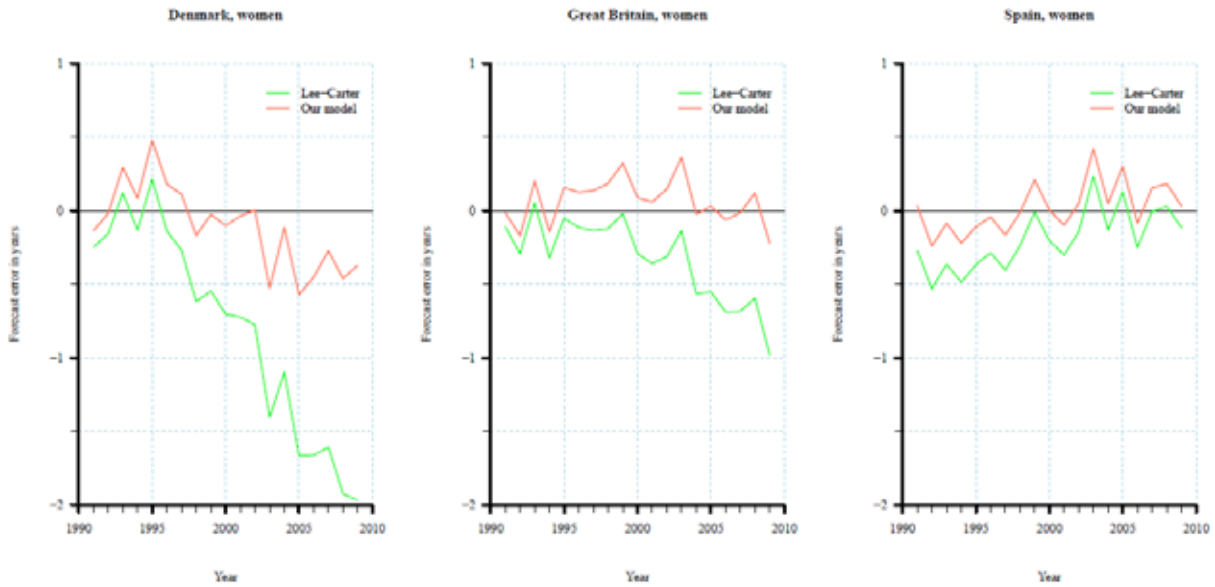

Figure 2: Forecast errors, i.e. differences between forecasted and observed life expectancy at birth for women in Denmark (left), Great Britain (centre) and Spain (right). Clearly, the forecast errors are higher for the Lee-Carter model (green) than for our proposed model (red). This is especially true for Denmark, where women had an unsteady mortality development during the 1980s and early 1990s which makes it more complicated to forecast them properly. We can generate such an accurate mortality forecast for Danish women due to the similarity of the Danish mortality trend with that of Swedish women.

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14.1

Examining the Role of International Migration in Global Population Projections

Guy Abel, Nikola Sander, Samir K.C.*

Advances in projecting international migration have been hindered by a lack of adequate data. Consequently, international projection-making agencies commonly use simplistic assumptions of net migration measures derived as residuals from demographic accounting. However, past net migration estimates can often be volatile and are known to introduce inaccuracies when projecting populations (Rogers, 1990). This paper presents a set of global population projections to 2060, focusing on two alternative assumptions of international migration. Assumptions on rates of other demographic factors, namely fertility and mortality, are held constant.

In the first projection, we set up the future migration in each country to mirror that of the United Nations Population Division (UNPD), where "[p]rojected levels of net migration are generally kept constant over the next decades. After 2050, it is assumed that net migration will gradually decline." (UNPD 2011, p.12, paragraph C.1). In the second projection, we use a first-of-a-kind set of estimated five-year bilateral migration flows by sex developed from Abel (2013). The net migration estimates within these flow tables match those of the UNPD. The bilateral flow table estimates are further disaggregated by age using a standard Rogers-Castro migration schedule, and then summed over rows and columns to obtain immigration and emigration rates by age and sex. These estimates are used as base data in the projection model, where immigration and emigration rates are assumed to remain constant up to 2060.

Our results highlight differences in the future levels of population around the globe and numbers of migrant flows between the net migration projection model and the immigration and emigration projection model.

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14.2

Subnational Population Projections for Turkey, 2013-2023

Sebnem B. Canpolat, Baris Ucar, M. Dogu Karakaya *

In Turkey, subnational population projections were produced officially for the first time in 2013. These projections were made for 81 provinces for the period 2013-2023. The reason for the choice of the projection period was that 2023 is the centenary of the Republic of Turkey.

In these projections, data from administrative sources were widely used. The main difference from previous projections was the use of administrative data as inputs. The cohort component method was used in the projections. The software package chosen was the PADIS-INT population projections programme, produced by the China Population Information and Research Center.

Recently, the quality and coverage of demographic data from administrative sources have improved extensively. Since 2007, information about the population of Turkey has been announced to the public by the Turkish Statistical Institute annually and regularly from the Address-Based Population Registration System (ABPRS). The base population used in the projections was taken from 2012 figures. Data on births are compiled from Central Civil Registration System (MERNIS). Birth data is available in the system for the period since 2001. Data on deaths are also obtained from MERNIS for the period since 2009, but in addition to the information from this system, data collected by death certificates are also used.

Data regarding internal migration was produced from ABPRS. An average of recent migration patterns of provinces were taken as inputs.

The institutional population living in barracks was separated from the rest of the population and the age structure of this population was assumed to be unchanging throughout the projection period.

Turkey consists of 81 provinces, among which there are considerable differences regarding demographic indicators. All provinces were examined in terms of their fertility, mortality and migration patterns, and inputs were prepared for the projections.

The results indicate that the population of Turkey will be about 84 million in 2023. The population of 60 provinces will increase and the population of 21 provinces will decrease in 2023 compared to 2012 ABPRS results. The order of the four most populous provinces will not change. The population of İstanbul will be 16.6 million in 2023, the population of Ankara will increase to 5.9 million, the population of İzmir will be 4.4 million, and the population of Bursa will be 3.1 million.

The proportion of elderly persons in the population of Turkey will increase to 10.2 per cent in 2023.

The population of Turkey will continue ageing. The number of elderly persons, i.e. the population at 65 years of age and over, was 5.7 million in 2012 with a proportion of 7.5 per cent. This population will reach 8.6 million people with a proportion of 10.2 per cent in 2023.

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14.3

An alternative projection model for interprovincial migration in Canada

Patrice Dion*

The multiregional model has numerous advantages for projection of internal migration. However, the use of constant out-migration rates implies the assumption that migration depends only on population changes in the region of origin, and not in the region of destination. It follows that net migration increases in regions that are shrinking and decreases in regions that are growing. This purely mechanical effect does not reflect recognized theoretical principles, and compromises the development of varied, clear migration assumptions, which are crucial given the high volatility of this component over time. These limitations are especially acute in Canada, which is composed of a small number of provinces and territories with huge discrepancies in terms of population sizes size and net migration patterns.

A review of the literature did not reveal a model that would make it possible to project internal migration more consistently and clearly in cohort-component models. In fact, the complexity of migration processes, the limited number of variables that can be included in matrix models, the limited availability of data and the difficulty of projecting economic conditions make it so that predictive models are not attractive. By contrast, the use of transition matrices as in the multiregional model allows for a natural integration with other components within the cohort projection system, facilitates the composition of assumptions and preserves the structural links between regions and in the age structure of migration which, while not explicit, definitely exist.

The goal of this paper is to present a simple and elegant adjustment method to correct the imperfections of the multiregional model “at the source.” It appears to us that the criterion for judging these imperfections should be the net migration rate, in particular because it directly accounts for the impact of migration on each region, and because it is a criterion often used in formulating assumptions. That is why we propose adding a simple out-migration rate correction factor that makes it possible to take into account changes in the population sizes of the regions of destination and to greatly reduce the variability in net migration rates over time. The model thus makes it possible to propose clear and transparent assumptions, while not preventing the incorporation of temporal variations into net migration rates if desired. The greater control over the results thus obtained makes it possible to propose a range of projections that is more varied and therefore paints a more realistic picture of the potential impact of internal migration. The proposed solution fits in easily with the cohort projection model used by the Demography Division of Statistics Canada.

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14.4

A Space-Time Extension of the Lee-Carter Model in a Hierarchical Bayesian Framework: Modelling and Forecasting Provincial Mortality in Italy

Fedele Greco, Francesco Scalone*

Aim

The main purpose of this paper is to define a statistical method to forecast mortality rates by age for provincial areas in Italy by combining the Lee-Carter model and a Bayesian approach.
Standard mortality forecasting performs poorly when applied to very limited areas. When working on single small areas, forecasters have to deal with large variance residuals and imprecise estimates. In these terms, we redefine an extension of the Lee-Carter method as a statistical model accounting for sub-populations at the provincial geographical level.

Model and Data

Lee and Carter (1992) proposed a model for describing the secular change in mortality as a function of a single time index. Following their approach, we propose to add into the original Lee-Carter equation an additional index that takes into account geographical sub-area units. In order to represent age-specific mortality we use the central death rate.
Let $m_x(t,u)$ denote the central death rate for age *x* at time *t* in a geographical unit *u*. We assume the following log-linear form:

$$ln\ m_x(t,u) = \alpha_x + \beta_x k_t + \gamma_x z_u + \epsilon_{x,t,u}$$

As Lee and Carter proposed, the α_x's describe the age-pattern of mortality averaged over time, whereas the β_x's describe the deviations from the averaged pattern when k_t varies. The change in the level of mortality over time is described by the (univariate) mortality index k_t. In addition, we include a further index z_u to take into account mortality levels at the geographical level, on *u* units. The γ_x´s capture the deviations from the averaged pattern when z_u varies. They indicate the sensitivity of the logarithm of the force of mortality at age x to variations in the geographical mortality index z_u. Finally, the quantity $\varepsilon_{x,t,u}$ denotes the error term, with mean 0 and variance δ^2, reflecting particular age-specific historical and geographical influences that are not captured by the model. We will use 110 provincial life tables from 1992 to 2011 provided by ISTAT, taking into account the age-specific mortality rates.

Bayesian approach and forecast

Adopting a Bayesian approach, Markov chain Monte Carlo methods will be used to fit the model and to sample from the posterior predictive distribution. Provincial age-specific mortality rate forecasts will be produced for the period 2012-2022 based on data from 1992-2011. Based on the obtained forecasted mortality rates, a set of projected life tables at the provincial level from 2012 to 2022 will be produced.

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15.1

Projecting Inequality: the Role of Population Change

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The aim of the paper is to examine the role of population change in the evolution of inequality and poverty in Flanders. While most of the literature studies the general role of demographic as compared to economic change, we will disentangle the effects of ageing, the modification in household composition, and the shift in the population's educational attainment on the evolution of income distribution. Using census and register data, we make multi-state population projections (Lipro-projections) by age, sex and household position on the one hand and by age, sex and educational attainment on the other. These projections are employed to reweigh EU-SILC 2008 up to the year 2031. The data are calibrated to obtain household weights - necessary to measure household income – congruent with the population distribution of both projections.

When adapting wages, income from investment and pensions to capture a real yearly 1 per cent economic growth, the results show a clear increase in poverty and inequality in terms of the Gini coefficient. Without real growth, however, demographic change alone leads to a decrease in inequality and poverty. How can this rather unexpected result be explained?

The results of the demographic projections indicate an important increase in educational attainment, that is most pronounced at advanced working ages. Ageing results in a growth of the proportion of pensioners and a net decrease in the adult population of working age. In addition, we observe an increased survival of couples at advanced ages, but also a growth of single person households, mainly women.

The relative distribution represents the rank that the value of a comparison group (population of 2031) has in terms of the reference group's (population of 2008) cumulative distribution function. This relative density can detect the effects of compositional changes in covariates as well as changes in the covariate-outcome relationship. This type of analysis allows analysis of the whole distributional change in detail, moving beyond the comparisons of means and variances. The method combines a graphical presentation of results with statistical summaries, decomposition, and inference.

We expect the following outcomes.

1. A detailed analysis of the forecasted change in income distribution between 2008 and 2031, and the general role of demographic evolution therein. Does demographic change enhance or depress income levels? What income levels are most affected? Does it change the shape of the income distribution? Do the extreme income categories grow or shrink?
2. A graphical and statistical analysis of the net effect of ageing, increased educational attainment and the growth of single person households, on changes in income distribution. Again, we distinguish between location (changes in income level) and shape effects (compositional effect).
3. A detailed comparison of changes within and between the group of pensioners, the working population, and children and young people under the age of 20. For the first two groups, we also take into account educational differences and whether or not people live in a single person households.

This analysis will allow us to understand in detail how demographic change induces changes in income distribution, and hence why we find that it decreases projected inequality and poverty.

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15.2

The Impact of Canadian Immigrant Selection Policy on Future Imbalances in Labour Force Supply by Broad Skill Levels

Alain Bélanger*

With looming labour shortages caused by the expected retirement of Boomers, Canada increased its immigration intake a quarter of a century ago and has since maintained one of the highest immigration rates in the world. Its selection process favours highly educated candidates in a context where education levels of the Canadian-born population are also increasing rapidly. As a consequence, immigrants and Canadian-born entering the labour market are almost substitutes for each other in terms of educational attainment. If the high immigration intake can prevent a declining labour force and avert a global shortage, it can also create imbalances between labour force supply and demand by broad skill levels.

The main objective of this paper is to compare the results of a projection of the labour force supply by education levels with the results of official projections of labour force demand by broad skill levels. The supply side of the equation will be projected using DemoSim, a dynamic, continuous time, event-based microsimulation projection model developed at Statistics Canada. The principal purpose of DemoSim is to project the future ethnocultural diversity of the Canadian population, but it also includes modules on labour force participation and on education.

In Canada, occupations can be grouped into four broad skill levels on the basis of the minimal education needed to perform a job:

1. Level A or professional represents occupations usually requiring university education,
2. Level B or skilled and technical refers to occupations usually requiring college education or apprenticeship training,
3. Level C or intermediate and clerical represents occupations generally requiring completion of secondary school and some job-specific training or completion of courses directly related to the work, and finally
4. Level D or elemental and labourers represents occupations usually requiring on-the-job training.

These broad skill levels are used by Human Resources and Skills Development Canada (HRSDC) to project labour force demand regularly over a 20-year horizon, and their results will serve as the basis for the projected labour force demand (HRSDC 2008).

Results show that over the next 20 years, the total growth in labour force supply matches the projected demand and that for technical jobs (Level B) projected supply will be only slightly lower than demand. For lower skill jobs, however, the projected mismatch may be important and labour shortages are likely to occur. On the other hand, for professional jobs (Level A) growth rate in supply will be twice the demand.

This has important policy implications, especially regarding possible increasing rates of overqualification and declining return to education. According to the OECD (2008), overqualification is already much higher in Canada than in other developed countries. Traditionally, wages of university graduates have risen faster than wages of workers with lower education levels, but this pattern has reversed since 2000 (Morissette *et al*, 2008). As a result, the wage gap between males with bachelor degrees and males with lower levels of education has narrowed.

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15.3

Microsimulation of language characteristics and language choice in multilingual regions with high immigration

Alain Bélanger, Patrick Sabourin*

In Canada, whereas French and English are official languages at the federal level, speakers of each language are highly concentrated in specific regions. With close to 8 million people, the province of Québec is the second largest in Canada and the only one with a French language majority. All other provinces have an English language majority, and only New Brunswick has a substantial French minority.

In the coming decades, Canada, like many other Western countries, will be facing rapid population ageing and declining, perhaps even negative, natural increase. As a response to these demographic challenges, Canada has increased its immigration intakes to levels which are among the highest in the world.

Official language groups are almost equally affected by this decline in natural increase. Both Francophones and Anglophones suffer from similar sub-replacement fertility levels and increasing death counts. On the other hand, the demographic impact of immigration is very different for each language community.

The composition of international immigration is increasingly diversified in its ethnocultural and linguistic characteristics. According to the 2006 census, 66.7 per cent of Canadians declared English as the language most often spoken at home, whereas this proportion reached 71.4 per cent among the native born population and 49.0 per cent among the immigrant population. In Québec, 81 per cent of the population declared French as the language most often spoken at home, 88 per cent among its native born population and 31 per cent among its immigrant population.

New immigrants have to learn either one or both of French (official language in Québec and New Brunswick and at the federal level) and English (official language at the federal level and in all provinces except Québec) to integrate fully into the host society. In this context, their linguistic choices will have an increasing impact on the linguistic composition of the Canadian population. This is an important political issue in a country where language is an important part of national identity. What will be the demographic fate of the French- and English-speaking minorities and majorities in Canada? How does immigration policy influence the demographic characteristics of both language groups?

To answer these questions, a dynamic model was developed using the Modgen microsimulation programming language developed by Statistics Canada. The data used in the model were taken from the confidential microdata file of the 2006 Canadian census (20 per cent sample of the population).

In addition to standard variables such as age, sex and region of residence, the model includes ethnocultural characteristics such as immigration status, place of birth, years since immigration, mother tongue, language used at home and knowledge of official languages. Language characteristics vary dynamically within and across generations through a module assessing language shifts over the life course. The linguistic composition of the future Canadian population will be projected up to 2051 for different scenarios at the national and sub-national levels. Stable populations will also be derived for all scenarios.

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15.4

A method for projecting economically active population. The case of Andalusia

Silvia Bermúdez, Juan Antonio Hernández, Joaquín Planelles*

World population structure has undergone dramatic changes over the last few decades. With the exception of several "demographic outliers", mean lifespan has kept growing during this period. Meanwhile, fertility rates have decreased and/or remained very low. As this process is expected to continue in the future, there is a growing concern about population ageing, dependency and sustainability.

A key factor for evaluating all these issues is plausible development of the economically active population, both in absolute and relative numbers against their non-active counterpart. Future active population depends not only on population structure, but also on individual willingness to work, something that has experienced equally dramatic changes in the past.

In this paper, we put forward a new method for projecting economically active population which we developed to project active population in Andalusia, the most populated of the Spanish regions (8.4 million inhabitants in January 2013). Therefore, in this paper we use Andalusian data –extracted from the Spanish Labour Force Survey– to exemplify the model. Nonetheless, it could be used to project active population in other areas undergoing similar changes in their activity patterns, namely growing retirement age and gender convergence. The model is a cohort parametric model, based on the two following empirical findings. First, women´s willingness to work is more affected by a "cohort-effect", with younger generations of women showing increasingly similar labour market behaviour to that of men. Second, the male age-specific active profile is more stable across both time and space than women's. Major changes for males are found in entry and exit times from the labour market. Finally, considering that labour patterns differ between the genders, we allow for gender differences in our projection methodology.

Our suggested methodology to project male activity rates is similar, but not exactly the same as, other methods developed elsewhere to project economically active population. Thus, the main novelty we introduce is to be found in methodology for females, which explicitly models the convergence process in activity rates towards men's.

The paper is organized as follows. In section 2 we present a general approach to prospective work on the labour market, distinguishing between supply-side and demand-side focuses. Section 3 summarises recent trends in the European labour force. Section 4 develops the suggested methodology to project activity rates for men. Section 5 focuses on methodology for females. In section 6 we briefly present results. Finally, the paper ends with concluding remarks in section 7.

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16.1

The Scientific Base of the New Wittgenstein Centre Global Human Capital Projections: Defining assumptions through an evaluation of expert views on future fertility, mortality and migration

Wolfgang Lutz*

This paper is proposed to be the introductory presentation for a set of papers describing the major new effort conducted by the Wittgenstein Centre for Demography and Global Human Capital (a collaboration between IIASA's World Population Program, the Vienna Institute of Demography and WU – Vienna University of Economics and Business) to produce alternative scenarios to 2100 for all countries in the world by age, sex and level of educational attainment.

This new international projection effort also included a major inquiry among population experts around the world through an online questionnaire in which the experts were asked to assess the validity of a large number of predefined scientific arguments that would have direct relevance for the future course of fertility, mortality and migration in different countries of their choice. All members of international professional population associations were invited to participate and over 450 replies were received, despite the fact that it took between 45 and 60 minutes to go through the material. The answers to this inquiry were then analysed by scientists from the Wittgenstein Centre and provide the basis for a series of Meta-Expert meetings of 8-20 experts each. Five such meetings were held on five different continents, focusing on the future trends of High Fertility, Low Fertility, High Mortality, Low Mortality and Migration. These discussions then resulted in the definition of alternative scenarios for future trends together with a full written documentation of the state of our knowledge on these issues as well as process and reasoning that led to the specific assumptions for each country. These assumptions about overall trends were then translated into education-specific fertility, mortality and migration trends and combined with a number of alternative education scenarios and calculated for 171 countries up to 2100. This whole process, including the scientific reasoning and the projection results are documented in a forthcoming volume published by Oxford University Press entitled "World Population and Human Capital in the 21st Century"[2].

This new effort of expert argument-based projections was triggered by the results of a Eurostat inquiry in 2005 to all national statistical offices, asking about the current practice in defining assumptions and asking for perceived shortcomings of the current processes. This inquiry, which was carried out as part of the EU-funded project MicMac (linking the micro and macro levels in population projections), clearly showed that national statistical agencies are looking for a more systematic, science-based approach to defining the assumptions for national-level projections. Actually, an earlier form of this questionnaire was already used by individual countries such as the United Kingdom. The report[3] documents the results of this inquiry and provides the reasoning for this major effort which has now been carried out at the global level.

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[2] For outline, see http://www.iiasa.ac.at/web/home/research/researchPrograms/WorldPopulation/PublicationsMediaCoverage/POPNETNewsletter/Past/Popnet44.pdf

[3] See http://webarchive.iiasa.ac.at/Admin/PUB/Documents/IR-09-037.pdf

16.2

Developing Expert-Based Assumptions on Future Fertility, Mortality and Migration

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In this paper, we introduce a set of alternative scenarios for the new Wittgenstein Centre population projections by age, sex and level of education, for the period 2010 to 2100. The projections draw on a variety of sources for observed fertility, mortality and migration data in 2010.

For the future fertility of countries with high fertility levels, the assumption-making process consists of a three stage modelling approach. First, a model is fitted to the country fertility level and fertility decline during the past five-year period. Second, the expected path of fertility is estimated, using information gathered in the questionnaire. And third, numerical point estimates, supplied by the meta-experts, are utilised to estimate future fertility decline. For countries with low fertility levels, the methodology is modified, relying on a combination of experts' predictions, gathered in the online survey, and additional adjustments at meetings of meta-experts.

For mortality, an approach consisting essentially of conditional convergence to the frontrunner was chosen. For Japan as the global frontrunner in life expectancy a future trajectory was defined that, after extensive expert input, was chosen to come close to a continued increase of two years of life expectancy per decade. Next, for all regions a regional frontrunner was identified who would in the very long run (toward the end of the century) slowly approach the global frontrunner. Similarly, all the other countries in a region are assumed to slowly converge to the regional frontrunner. But since the assumptions are made in terms of education-specific mortality, the future trend in education presents an additional conditionality. High and low mortality scenarios were also defined as alternatives to this medium scenario.

As for migration, the development of assumptions for country-specific immigration and emigration was primarily based on (a) meta experts suggesting a 'business as usual scenario' to be most appropriate as a medium scenario, and (b) the impact scores for the seven key survey arguments identified by the meta experts. Hence, our medium scenario assumes immigration and emigration rates estimated for the period 2005-09 to remain constant until 2060, after which we assume a convergence to zero net migration to 2100. We make assumptions for rates rather than absolute numbers to take into account changes in the population size and age structure of populations of origin. The expert-based assumptions about fertility, mortality, migration and education (discussed in a separate presentation) are combined to project each country's population.

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16.3

The Impact of Alternative Assumptions about Migration Differentials by Education on Projections of Human Capital

Nikola Sander, Guy J. Abel, Samir K.C. *

The global flow of people is a critical component of global human capital projections, especially the intensities of country-to-country flows and the characteristics of people in terms of age, sex and education. Mostly due to the lack of adequate data, assumptions are commonly constrained to net-migration flows where migrants' education is assumed to be proportional to that of the population in their country of origin. Because of strong selection effects, these assumptions are known to introduce inaccuracies when projecting populations by level of educational attainment.

This paper is part of a bigger project on the development of a new set of Wittgenstein Centre (WiC) population projections, carried out using directional migration probabilities in a multi-regional cohort-component framework. We draw on a unique new set of estimates of global bilateral migration flows for the five-year period 2005-09 developed by Abel (2013), and combine these flow data with the "Database on Immigrants in OECD and non-OECD Countries (DIOC)". Linking our migration flow estimates with the DIOC data allows us to estimate education differentials in country-specific immigration and emigration flows. In this paper, we focus on the impact of alternative assumptions about migration differentials by education on projected populations, 2010 to 2060. Specifically, we draw on the medium scenario of the WiC projections to compare the results of a model that assumes migrants' education to be proportional to the population at the origin, to those of a model with our estimated education differentials. We demonstrate that education-specific migration propensities vary systematically in relation to a country's overall education composition, thus facilitating the development of assumptions about likely future changes in migration propensities.

We illustrate the various influences of alternative assumptions about education differentials on projected populations, whilst constraining other demographic components of population change to their mid-scenarios. Our findings highlight the importance of considering substantial differences in the intensity and spatial pattern of migration by level of education in human capital projections. Differences in projected population education structures are most pronounced for countries with high overall migration volumes and for those with strong differences in the educational composition between immigration and emigration flows.

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17.1

Estimating transition age schedules for long-term projections of global educational attainment

Bilal Barakat*

Formal educational attainment is typically a strong statistical predictor of fertility and mortality behaviour, open questions of causality notwithstanding. Taking these patterns into account in long-term demographic projections also requires projecting the changing educational profile of the population. While short- to medium-term projections of student flows within schools are fairly widespread in educational policy analysis, projections of attainment stocks in the population are rare, especially on a generational time scale. Such projections require us to focus on high-level overarching trends in attainment.

We attempt to partly close this gap by projecting the formal school attainment levels in the population of 171 countries for the period 2010-2060. In the first stage, we focus on the age group 30-34, who are assumed to have essentially completed their formal schooling. The share attaining each of five levels of schooling (some primary, completed primary, completed lower secondary, completed upper secondary, completed post-secondary, with "no education" as a residual category) is modelled as following a sigmoidal pattern. This is parameterised by a probit model, with global, regional, and country-specific time trends and Gaussian noise. The model is fitted to a data set of reconstructed educational attainment data for 171 countries for the period 1970-2010 (an updated version of the data set previously described by Lutz, Goujon & KC (2007)), within a Bayesian framework. All parameters are assigned diffuse Gaussian priors with their own variances. Estimation is performed using Markov Chain Monte Carlo sampling. This relatively straightforward model fits the data surprisingly well. In particular, the inverse probit growth path was given preference over a logistic or polynomial spline model during exploratory analysis.

As a result of the hierarchical model structure, where information is exchanged between all countries, and additionally between countries in a given world region, the projections reflect not only the past experience of the country in question, but shared trends, even without assuming a convergent trend. It is, however, possible to specify a dynamic convergence of the country-specific parameters towards the corresponding regional or global values if appropriate. Indeed, some assumed convergence is necessary to avoid sending stagnating education systems into a projected catastrophic decline. Additional adjustments are made to enforce overall logical constraints, such as non-overtaking.

A particular challenge is to estimate the timing of the transitions between the ages of 15-19 and 30-34, since the cross-sectional baseline data do not lead to an identification of changes in levels versus changes in timing. The age x attainment transition matrices are estimated using a novel combination of bootstrapping cohort estimates and "standard" educational transition schedules.

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17.2

Results of the New Wittgenstein Centre Population Projections by Age, Sex and Level of Education for 171 Countries

Samir K.C., Sergei Scherbov, Erich Striessnig, Wolfgang Lutz*

This paper will present results from alternative scenarios as defined and discussed in other presentations on the new set of projections by the Wittgenstein Centre. Education differentials in fertility, mortality, and migration are based mostly on our own estimations relying on census (IPUMS) and survey data, as well as on the available literature. Compared to earlier versions (K.C. et al. 2010), various methods of dealing with the differentials have been fine-tuned and some additional complexities were introduced (e.g. allowing child mortality to depend on the education of the mother). Finally, the education projections were improved by allowing country as well as regional trends in addition to the global trend to influence future attainment. The presentation of results will be structured into four parts.

First we will focus on the scenario that combines the fertility, mortality, migration and education trends that are considered most likely. For this scenario we will show the long term implications for population size, and in particular the changing educational composition of the population. We will then demonstrate how population and human capital projections will change under different assumptions of future trends in education combined with identical sets of education-specific fertility, mortality and migration trends. This will indicate how different future trends in education influence outcomes even with respect to total population.

The second part will focus on the results with respect to future trends in population ageing. In addition to the conventional indicators of changing age structures (proportions above age 65, median age, old-age dependency ratios etc.) this study will also look at new indicators that take the remaining life expectancy into account, e.g. the proportion of the population with a remaining life expectancy below 15 years. Here the consequences of alternative future education paths on future population ageing will also be studied.

Finally we will present a set of five different scenarios as they have been defined in a new global effort to produce standard reference scenarios in the context of studies dealing with mitigation and adaptation to global climate change. These so-called SSPs (Shared Socioeconomic Pathways) have as their “human core” the new Wittgenstein Centre Projections by age, sex and level of education with SSP2 (the middle of the road scenario) being identical to the most likely scenario discussed above. These SSP scenarios span a wide range of alternative futures up to 2100 for all countries and refer to different possible future trends in human capital based on agreed-upon narratives such as rapid or slow development, increasing inequality etc. These qualitative story lines have been translated into different numerical assumptions that result in widely differing population outcomes.

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17.3

Labour Force Projections for Europe by Age, Sex, and Highest Level of Educational Attainment, 2008 to 2053

Elke Loichinger*

Problems/issues addressed in the paper

Much research has been done on the potential economic consequences of population ageing. One topic that has received a lot of attention is the expected shrinkage of the working-age population. If patterns of economic activity stay at current levels, the labour force is expected to shrink in the great majority of European countries.

However, the absolute and relative size of the labour force is only one aspect when it comes to estimating future total output and economic growth. The fact that a smaller but more productive labour force might be able to alleviate some or all of the expected financial consequences of population ageing is another aspect that is mentioned and quantified more and more often (Fougere, Harvey, Mercenier et al. 2009, Ludwig, Schelkle and Vogel 2008, Lee and Mason 2010).

The majority of existing long-term labour force projections – provided by national statistical offices and international organizations – are based on explicit assumptions about the future development of age- and sex-specific participation rates, which are then applied to age- and sex-specific population projections. This allows estimation of the absolute future size (quantity dimension) of the labour force as well as its composition by age and sex, but does not allow any inference about the skill composition of future workforce (quality dimension).

This paper shows how the inclusion of the highest level of educational attainment – as a proxy for the qualification of the labour force – changes the outcome of labour force projections compared to projections that do not account for educational differences. The outcome is compared in terms of (a) total size of as well as (b) the composition of the labour force. The analysis covers 26 EU countries (all EU27 countries except Malta), and projects labour supply until 2053.

Data and methods used

The labour force projections are performed in three main steps in five-year intervals:

1. Projection of labour force participation for each country by age, sex, and highest level of educational attainment. Estimates of past and present labour force participation rates by age, sex, and highest level of educational attainment are based on the European Labour Force Survey (EU LFS). There are six scenarios of future participation, applying common methods for projecting labour force participation on the macro level which so far have only been applied to projections by age and sex (e.g. Carone 2005, Börsch-Supan and Wilke 2009, Houriet-Segard and Pasteels 2012).
2. Projection of the population of each country by age, sex, and highest level of educational attainment. The population data are the result of population projections by age, sex and highest level of educational attainment that have been done using the specifications for fertility, mortality, migration and education transitions as laid out in KC, Barakat, Goujon *et al*. (2010).
3. Combination of the results of the participation and the population projections, in order to find the future labour force in each country by age, sex and education.

Main result

The general development of the size of the labour force is driven by the specification of the scenario, not by whether the scenario is estimated with or without education differentiation. As far as the educational composition of the labour force is concerned, there will be a significant shift toward higher degrees between 2008 and 2053 in every country.

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