Improving Empirical Foundations for Making Population Forecasts

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Summary: The following describes the plan for a research project by Economist Andreas Koch, DREAM, and Professor Niels Haldrup, University of Aarhus, on improving the econometric methodology for making forecasts of the development of mean lifetimes for the Danish population by refining the so-called Lee-Carter method for estimating mortality rates.

Background and Policy Relevance of the Project

Population projections are essential as the basis for long-term projections of the Danish economy and the challenges awaiting it as a consequence of demographic changes. Consequently, it is extremely important to develop the best instruments available in order to constantly improve the methodology of the institutions making population projections. Among other things, the results of the present project proposal will carry over directly into the prospects of assessing correctly the sustainability of Danish public finances.

The various institutions making long-term projections of the Danish economy such as the Ministry of Finance, the Danish Economic Council, the Danish Welfare Commission, and DREAM all use long-term population projections as one of the corner-stones of their economic projections. Changes in e.g. fertility or mortality may have important implications for the results of economic analyses, cf. e.g. the Danish Welfare Commission (2004). Also, for other major long-term policy issues such as the likely future development in the pension sector or the consequences of migration, population projections play a major role.

DREAM publishes population forecasts on a yearly basis which among other things serves as an input for the DREAM CGE model, cf. Markeprand *et al.* (2003). However, the population forecast also receives a significant amount of attention in its own right and is extensively used by public administrators and various organizations.

DREAM's population projection takes a fairly mechanical statistical approach in order to guarantee a high degree of consistency from one year to the next. This is opposed to more traditional demographic forecasts where the methodology is to use expert opinions to forecast mortality indices. The trade-off between an approach purely based on data and an experts' opinion approach is between a highly formalized method which can be consistently updated when new data is available and a method which takes into account future developments which experts foresee but which have not yet had an effect on data.

The Lee-Carter method

For the Welfare Commission, Niels Haldrup has recently developed a projection of the mortality of the Danish population based on the so-called Lee-Carter method, cf. Lee and Carter (1992) and Haldrup (2004). The method introduced by Lee and Carter has received widespread attention amongst demographers and internationally it is now being used as a standard method for the calculation and projection of age specific mortality rates and mean life expectancy. It introduces cohort effects by separating time-specific and age-specific effects on mortality. The intuition is for instance that if a generation experiences better nutrition, say, then its mortality may be influenced by this over the whole life-cycle of the generation. International comparisons made by e.g. Lee and Miller (2001) indicate that the method is able historically to project mortality probabilities more precisely than other methods.

An additional reason for the success of the Lee-Carter approach is that the (stochastic) time trend in the mortality index can be modeled using time series techniques. In the original paper Lee and Carter used an ARIMA(1,1,0) process, i.e. a random walk, to model the time-specific component, but this need not be the best specification.

The Project Proposal

DREAM intends to use the Lee-Carter method in our future population projections. However, we believe that it is possible to improve the basic method in several respects, which is the motivation for this project proposal. One reason is that whereas the original method was developed for American population data, some adjustments of the method may be relevant when focusing on the development of the Danish population.

Denmark has relatively good historical data on population issues providing excellent opportunities for long-term statistical analysis. Mortality data can be obtained from 1901 until today[1], which makes it possible to apply more advanced econometric techniques than those originally used by Lee and Carter. In particular, we wish to explore the possibilities of refining the method in three ways:

1. Preliminary calculations show evidence of fractional integration (long memory) in the time-dependent index of mortality rates, see e.g. Bailey (1996) for a review of long memory processes. Pursuing this further may allow us to better interpret the dynamics of the underlying processes driving the mortality indices. In particular, the difference in the processes driving male and female mortality rates over time can be investigated. Understanding the processes governing the observed differences are important to explain historical discrepancies between male and female mortality rates and also the specification of appropriate models for the differences is important in making projections into the future of the mortality gap. Also, it is conceivable that new knowledge about the mortality time process will help understanding the possible effects on mortality rates by

[1] In the first half of this period, data are not readily available for every single year and every single age-step, and are aggregated for individuals which are older than 89 years. Despite these flaws, the Danish data are of a very good quality by an international standard.

technological advances in e.g. health care to the extent that such advances can be considered permanent and hence will have a long memory effect.

2. Secondly, it is possible to analyze the data with respect to possible structural changes in Danish mortality over the sample period. Potential structural shifts, besides being interesting in their own right, will give us more knowledge about the robustness and accuracy of mortality forecasts and the effects on life expectancy. Robustness of estimation results with respect to the sample period underlying the estimation is of great importance for the credibility of forecasting exercises. This analysis will further help to set up reliable confidence bands of mortality and life expectancy when forecasted into the future.

3. The original paper by Lee and Carter also suggested increasing the order of the model by allowing multiple factors (rather than just a single factor) in the identification of age-specific and time specific effects in mortality. If the data can accommodate this, it will enable us to increase the fit of estimated mortality models and improve the accuracy of projections.

Altogether, the suggested refinements will
a) improve the model fit of actual age-specific mortality rates and life-expectancy when applied to Danish data
b) help providing reliable confidence bands for these quantities
c) help providing accurate forecasts of mortality rates and life expectancy when projected into the future
d) enable a better understanding and interpretation of the historical evolvement of mortality rates and life expectancy for both men and women and the differences between the sexes.

Resulting Reports

The results are intended to be utilized directly in future Danish population projections and will be used as model documentation. Concerning scientific dissemination of the results, we expect the project to result in at least two papers: One paper (to be published in an internationally refereed forecasting journal like e.g. *Journal of Forecasting* or *International Journal of Forecasting*) focusing on the technical advances of the methodology resulting from our research and which will have a more general and broader interest and applicability in demographic modeling and projection. Another paper is intended for e.g. *Nationaløkonomisk Tidsskrift* which will report the most significant results on the forecasting of sex-specific mortality rates and life-expectancy for the Danish population. A central issue in the latter paper would also be a discussion of the inevitable uncertainty in the projections made. Also sensitivity analyses for macroeconomic results and sustainability will be conducted.

Time Schedule and Budget

We intend the research project to start in January 2005 and take place during the first half of that year. Participation in the project outlined above is expected to require at least 4 months of full-time research for Andreas Koch, for which we are applying for financial support. Additionally, Niels Haldrup contributes with research time for the project, for which we do not apply for support. We have available data which may be used for the project, though it may be advantageous to obtain additional data. Expenditures for this purpose are not part of this application.

We apply for wages for one economist for 4 months (monthly salaries from DJØF, October 2004).

Wage 4 months	=	129.126,- kr.
Overhead (28 %)	=	36.155,- kr.
Total	=	165.281,- kr.

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