1 Introduction

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It is a widely held perception that future population paths can be projected with a fairly high degree of certainty. For example, as an input to assessments of the future stance of public finances following population ageing, most countries now routinely report old-age dependency ratios and other demographic indicators. However, by concentrating on one (or a few) selected population path(s), this practice fails to recognize that population forecasts are, in fact, highly uncertain.

Uncertainty in demographics has traditionally been accounted for by considering 'high' and 'low' scenarios in addition to a 'medium' assumption. However, it has long been known that this approach has serious shortcomings. For example, the scenarios assume a perfect (positive or negative) correlation not only between the vital processes of fertility, mortality and migration but also across age and time for each vital process. Moreover, the method is intrinsically unable to assign probabilities to its 'high–low' ranges.

While the flaws associated with the traditional approach in themselves warrant an alternative approach, what matters from an economic perspective is the extent to which the application of stochastic forecasting techniques modifies outcomes obtained using traditional techniques. Despite the different methodologies used in the production of stochastic forecasts, it turns out as an empirical regularity that the level of uncertainty in demographic forecasts is much higher than generally believed. We would clearly expect this finding to translate into economic variables, by making the variability in health- and pension-related as well as in broader macroeconomic outcomes much larger than often recognized.

This volume focuses on these and other important unresolved issues concerning uncertain demographics. We have a collection of twelve chapters, with four discussion essays, which focus on the impact of demographic risks on public finances in general and pension systems and health and old-age care expenditures in particular, and it is discussed how policy strategies and specific policies may be designed in order to reduce the threats caused by such uncertainties. The chapters cover a spectrum

of theoretical and empirical approaches, and different types of computational models are used to demonstrate not only the magnitudes of the uncertainties involved but also how these can be addressed through policy initiatives. We have grouped the chapters into four main parts, each with a particular focus: demographic issues; measurement issues; policy issues; and methodological issues. Each part contains original and self-contained contributions on a specific topic, and concludes with a Discussion drawing out key elements from each contribution and identifying common themes.

Demographic issues

The first part of the book, on demographic issues, has two interrelated contributions. In Chapter 2, Nico Keilman, Harri Cruijsen and Juha Alho discuss problems in official population projections prepared by the UN and Eurostat. These forecasts are widely used to provide a demographic foundation for analyses of likely future economic developments. It was recently concluded by the US National Academy of Sciences Panel on Population Projections that the UN forecasts represent, in many respects, the state of the art. Yet, the authors show that the forecasts appear to suffer from systematic biases. Mortality has declined faster than the official forecasters expected, so in forecast revisions the future number of the elderly has been continuously revised upwards. Similarly, net migration has been typically underestimated, which shows up in forecasts as a gradual revision towards higher numbers, especially in the working-age populations. The authors argue that methods that rely more closely on empirical data on past trends and past levels of the demographic processes should be used. These lead to higher numbers of the elderly – and higher numbers of workers – than anticipated in the official forecasts. Both aspects have important implications for research on ageing.

In Chapter 3, Juha Alho, Harri Cruijsen and Nico Keilman take up the problem of uncertainty in demographic forecasting. Even if biases could be reduced in future forecasts by statistical techniques, the application of the same techniques suggests that considerable uncertainty remains. In the past, demographic forecasters have produced alternative (high and low) variants, in addition to the most likely forecast, to provide forecast users with an indication of the uncertainty one might reasonably expect. The authors argue that the alternative variants are inherently defective as descriptors of uncertainty. In essence, this is due to the fact that forecast errors across sex, age, vital processes (of fertility, mortality and migration), and future year have complex correlations that cannot be coherently approximated by deterministic methods. In contrast, a stochastic

formulation allows the representation of such dependency structures in a flexible manner. The authors emphasize the need to provide an empirical foundation for uncertainty estimates, and provide examples from recent work with European data. In particular, it is shown that the volatility of fertility, life expectancy and net migration is much higher than suggested by the official high and low variants. The chapter contains an appendix that systematically compares traditional forecasts and stochastic forecasts.

Measurement issues

The second part of the book is devoted to measurement issues in relation to the consequences of demographic uncertainty. The basic question is: given the estimates of demographic uncertainty, how uncertain are the projections of ageing costs? By combining economic models and stochastic population simulations, the chapters provide estimates for several European countries.

In Chapter 4, Martin Weale assesses the implications of demographic uncertainty for the budgetary position in Belgium, Denmark, Finland, Germany, the Netherlands, Spain and the United Kingdom. More specifically, Weale evaluates the frequency distribution of the increase in taxes needed to deliver fiscal solvency. The projections reported in this chapter, taken at face value, imply a substantial amount of variation in the tax adjustment needed to restore fiscal balance in the countries examined. The considerable amount of variation in the means is not surprising, since it is well known that different countries are affected by demographic change in different ways. However, there is also a lot of variability in the standard deviations, which may have a less intuitive explanation. Weale argues that this, to a large extent, should be attributed to the nature of the simulations, not simply the structure of the model used to carry out the simulations.

In Chapter 5, Jukka Lassila and Tarmo Valkonen summarize quantitative estimates of the uncertainty in long-term pension expenditure projections caused by demographic factors for Belgium, Denmark, Finland, Germany, the Netherlands, Spain and the UK. The estimates are obtained from model-based country studies which use stochastic population simulations as inputs. The results show a great deal of uncertainty in pension projections. There are significant differences between the uncertainty estimates in these countries. One reason is that the critical demographic feature, the ratio of people in old age to those of working age, appears more predictable in some countries than others. The differences also reflect differences in pension systems, especially whether

there are automatic demographically based adjustment mechanisms as in Finland and Germany. The properties of the models that were used also have effects. The chapter also relates the uncertainty estimates of the country studies to the uncertainty considerations in recent administrative projections that rely on sensitivity analysis as a method to describe uncertainties. The range of the resulting, judgemental quantifications of uncertainty turns out to be small, as compared to those obtained in the country studies that rely on empirical estimates of demographic uncertainty.

Chapter 6, by Namkee Ahn, tries to improve upon the existing literature on the projection of future health expenditure by incorporating probabilistic handling of uncertainties in future population. The impact of uncertainties in fertility, mortality and immigration rates on the age profile of health expenditure is detailed. Ahn also compares the effect of different scenarios of price/preference changes to the range of outcomes that reflect only demographic uncertainty. According to the median prediction, public health expenditure will increase by 33 per cent (or 2 to 5 percentage points as a share of GDP) during the period 2004–2050 purely due to changes in population age-structure, under the hypothesis of constant real age-specific health expenditure. Taking into account demographic uncertainty, one can say that chances are four out of five that the increase is between 28 per cent and 39 per cent. However, even a slightly higher growth rate of per-capita health expenditure (due to price or preference change), relative to that of per-capita GDP, results in a much more substantial increase in total expenditure.

Policy issues

Policies with important linkages to demographics are currently being considered in many European countries. For example, longevity adjustment of pension benefits has been introduced in Finland, Latvia and Sweden, and an indexation scheme which takes demographics into account has been introduced in Germany. Other, new instruments for managing economic risks caused by uncertain demographics have become of interest. Such policy measures may have substantial income and risk-bearing consequences for the citizens, but the magnitude of the effects depend on demographic development. Combining current economic simulation models with stochastic population paths allows us to analyse and quantify the effects. The insights obtained may be important, because the most rapid phase in population ageing (arising from the retirement of the baby-boomers) is just around the corner, and the time for making structural changes is quickly running out.

In Chapter 7, Hans Fehr and Christian Habermann compare the effects of two adjustment mechanisms of the German pension system under demographic uncertainty. The first instrument is an increase of the statutory retirement age, which would reduce future benefits and contribution rates. As an alternative, they consider an increase in the weight of the indexation scheme that links future pensions to changes in the dependency ratio. Both reforms redistribute income from the elderly to the young, and to future generations. They have exactly the same consequences for the intertemporal budget constraint of the government. By taking into account the uncertainty of future population projections, the authors illustrate variations in the intergenerational risk-sharing consequences of the two reforms. They show that increasing the weight of the indexation scheme creates a much larger risk for the current elderly than the increase in the retirement age. The conclusion is that the latter is to be preferred, since it avoids a double burden for the elderly.

Jukka Lassila and Tarmo Valkonen, in Chapter 8, study the effects of longevity adjustment in the context of Finland's earnings-related pension system. If longevity increases, new old-age pensions are automatically reduced and pension contribution rates will be lower. Moreover, the higher the contribution rate would have been without the reform, the bigger the reduction. On the receiving side, longevity adjustment increases uncertainty about the level of pensions. Lassila and Valkonen conclude that longevity adjustment significantly weakens the defined-benefit nature of the Finnish pension system, in effect introducing a strong defined-contribution flavour. With longevity adjustment, demographic uncertainty actually makes future benefits more uncertain than future contributions when measured in comparable units. Without longevity adjustment almost all of the uncertainty would be in contributions. The authors note that the relative timing of longevity and fertility risks is important. For the next twenty to thirty years the effects of future fertility changes on pension outcomes are small, and the longevity adjustment decreases the dominant uncertainty effect of demographics. After thirty years, future fertility starts to affect labour supply more, and longevity adjustment alone is inadequate for controlling the effects of demographic risks.

Chapter 9, by Alex Armstrong, Nick Draper, André Nibbelink and Ed Westerhout, focuses on the implications of demographic uncertainty on public debt policies. The idea is that uncertainty causes households to save for precautionary purposes to the government sector. A computational general equilibrium model for the Netherlands (GAMMA) is combined with stochastic population paths to compare alternative fiscal policy rules. The comparison shows that in an uncertain demographic

environment, setting the short-term tax rates higher than the expected long-term tax rates implies a higher level of social welfare than a tax-smoothing strategy. Interestingly, this result is due not only to the risk aversion of households but also to the concavity of the government's revenue function. The effects are non-trivial. In the two-period setting applied, the first-period labour income tax rate that corresponds to optimal policies is about four percentage points higher than the level that corresponds to a tax-smoothing strategy. This tax increase is particularly painful if it comes on top of the tax increase that is needed to finance the implicit debt that is due to the expected ageing of the population. Yet, even if adopted, precautionary savings policies appear to do little to mitigate the expected aggregate utility loss from demographic uncertainty.

Methodological issues

The combined use of economic and demographic tools in a stochastic setting is still in its infancy, and using the current models leaves much to be desired. An obvious question concerns promising directions to extend the economic models. In addition, how should stochastic population simulations be refined to better serve economic analysis? Attempts to answer these questions are made in the contributions to the final part of the book.

In Chapter 10, Vladimir Borgy and Juha Alho extend existing methods tailored for national economies (which the earlier chapters illustrated) to the multi-regional case. Their model builds on a deterministic model of the world economy (INGENUE) that divides the world into ten regions. Because of data problems, demographic analyses comparable to those available for Europe do not exist for the other major regions of the world at the required, age-specific level. However, the authors use existing analyses regarding uncertainty in the total populations of world regions to extend and calibrate what are essentially models of the type discussed in Chapter 3 to the ten regions. In this manner a full stochastic multi-regional model of world population is created. Sample paths from the ten regions are used as inputs in INGENUE. The authors consider the induced uncertainty in such macro-economic variables as GDP growth and world interest rate.

The remaining chapters embark on an entirely different, theoretical path to extending the models of earlier chapters. In Chapter 11, Juha Alho and Niku Määttänen consider a simple life-cycle savings problem in the presence of both idiosyncratic and aggregate uncertainty concerning mortality. In other words, not only is the decision-maker's own survival random, but so is the future trend of mortality of her cohort. A simplified Markovian mortality model is built that allows a full rational-expectations solution to the life-cycle savings plan. This is used as a benchmark to

assess the nature of other types of decision-makers that have either more (as in the case of perfect foresight) or less information concerning future mortality. In particular, the authors show that in the setting they consider, a decision-maker who revises her savings decisions periodically can achieve nearly as high a lifetime utility as that obtained under rational expectations. As the former decision strategy is considerably easier to compute, this finding points to the potential usefulness of considering a similar updating approach in the context of the more complex overlapping-generations models, for which rational-expectations analyses are, at least currently, beyond our computational capacities.

In Chapter 12, Svend E. Hougaard Jensen and Ole Hagen Jørgensen analyse some macro-economic and distributional effects of stochastic fertility and longevity using a three-period model with overlapping generations. A new solution technique is adopted that solves the model in terms of analytical elasticities. The novelty of this contribution is an analysis of longevity adjustment of the retirement age as a policy instrument to generate efficient risk-sharing in an economy faced by demographic shocks. Jensen and Jørgensen find that a rise in the retirement age following an increase in expected longevity may leave both workers and retirees better off. However, this is not the case within an alternative setting where taxes on wage incomes are adjusted to share risks efficiently across generations. So, the retirement age outperforms taxes as a policy instrument. Recognizing a number of limitations in their proposed analytical framework (including an assumption of an inelastic labour supply), the authors suggest extensions for future research.

In Chapter 13, by Justin van de Ven and Martin Weale, the implications for the annuities market of aggregate mortality uncertainty (risk) are explored. Any cohort can insure itself against individual mortality risk, but insurance against aggregate mortality risk can be provided only by means of a transaction between different cohorts. Van de Ven and Weale consequently study the pricing of aggregate mortality risk using an overlapping-generations model. In their model, the old and the young have different attitudes to the mortality risk of the old because the young can adjust their future consumption to the mortality out-turn of the old in a way that the old cannot. Annuity rates are calculated that balance the willingness of the young to purchase the aggregate mortality risk of the old. The authors find that moderate rates of aggregate mortality risk are likely to imply market-clearing annuity rates, which are between 1 per cent and 7 per cent below actuarially fair rates, depending upon the extent of risk aversion.

Part I

Uncertain demographics

2 Changing views of future demographic trends

Nico Keilman, Harri Cruijsen and Juha M. Alho

Introduction

Are population processes easy to predict? The relative inertia of population stocks suggests that this is the case. Indeed, errors in population forecasts five to ten years into the future are often smaller than the errors of economic forecasts over a similar period (Ascher, 1978). However, population flows are much harder to predict (Keilman, 1990), so in the long run, population processes are much more uncertain than generally recognized. Yet, many tasks of social policy, such as planning of schools and health care require information about the likely developments of population variables for twenty or thirty years into the future. Analyses of the sustainability of pension systems require that we take an even longer view, so the US Office of the Actuary routinely prepares forecasts seventy-five years into the future (Andrews and Beekman, 1987), for example.

One way the uncertainty in population variables manifests itself is through changing views, over time, of the demographic future. For instance, a forecast of a particular population made in 2000 may be different from one made ten years earlier. New data for the period 1990–2000, different interpretations of historical developments before 1990, refined techniques of analysis and prediction – all these shape different conditions for the forecast made in 2000, compared to the one made in 1990. As an example, consider Table 2.1. It shows UN forecasts of the 2050 old-age dependency ratio (OADR), i.e. the ratio of the elderly population (aged 65+) to the working age population (aged 20–64). We show forecasts that were made in 1994 (the so-called '1994 Revision'), and compare them with forecasts computed ten years later ('2004 Revision').

We see that the UN changed its view towards greater ageing in four of the five countries. Leaving out Germany, we find that the average increase in the forecasted OADR was 18 per cent over a decade! From the perspective of analysing the sustainability of pension systems, this is of major importance. Below we shall see that the UN has indeed become more optimistic concerning life expectancy. It so happens that life expectancy

Table 2.1. *Predictions of the old-age dependency ratio in 2050: selected countries.*

	1994 Revision	2004 Revision
Austria	0.517	0.599
Finland	0.402	0.504
France	0.471	0.524
Germany	0.585	0.550
Norway	0.385	0.453

predictions for Germany are also higher for the 2004 Revision than for the 1994 Revision. However, its effect on the German OADR is compensated by an increase in expected immigration levels, which primarily affects the population of working age.

It is not surprising that the UN has changed its views concerning population variables in European countries in 2050. After all, we cannot know the future with certainty, and updates are necessary. However, the changes from one forecast round to the next are far from random. Instead, they display rather *characteristic* patterns. Our purpose in this chapter is to document systematic changes that characterize population forecasts prepared by the UN and Eurostat. In the case of fertility and migration, there are also important differences between the two organizations. Moreover, we shall see that the changes are directly relevant for research on ageing, which frequently relies on official forecasts as a guide for what to expect.

Indicators such as the OADR in Table 2.1 summarize a population's age-structure. The age-structure can be deduced once one assumes certain levels for future fertility, mortality and international migration. We will analyse how the assumptions concerning these flows have changed. We consider a group of eighteen European countries. The group consists of the fifteen members of the European Union prior to the joining of the new member states in 2004 (i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom) plus Iceland, Norway and Switzerland. Except for Switzerland, these countries made up the so-called European Economic Area, hence we call the area 'EEA+'.[1] These countries were also included in our own UPE forecasts,[2] with which we will make comparisons throughout.

The data used in this chapter stem partly from the World Population Prospects of 1994, 1996, 1998, 2000, 2002 and 2004, forecasted by the UN and partly from Eurostat forecasts. Cruijsen and Eding (1997), De Jong and Visser (1997), De Jong (1998) and Van Hoorn and De