Population Dynamics and Projection Methods

Understanding Population Trends and Processes

Volume 4

Series Editor

J. Stillwell

In western Europe and other developed parts of the world, there are some very significant demographic processes taking place at the individual, household, community and national scales including the ageing of the population, the delay in childbearing, the rise in childlessness, the increase in divorce, the fall in marriage rates, the increase in cohabitation, the increase in mixed marriages, the change in household structures, the rise in step-parenting and the appearance of new streams of migration taking place both within and between countries. The relationships between demographic change, international migration, labour and housing market dynamics, care provision and intergenerational attitudes are complex to understand and yet it is vital to quantify the trends and to understand the processes. Similarly, it is critical to appreciate what the policy consequences are for the trends and processes that have become apparent. This series has its roots in understanding and analysing these trends and processes.

This series will be of interest to a wide range of individuals concerned with demographic and social change, including demographers, population geographers, sociologists, economists, political scientists, epidemiologists and health researchers as well as practitioners and commentators across the social sciences.

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Understanding Population Trends and Processes – Volume 4

Edited by

John Stillwell
University of Leeds, UK

and

Martin Clarke
University of Leeds, UK

Springer

Editors
Prof. John Stillwell
University of Leeds
School of Geography
Woodhouse Lane
LS2 9JT Leeds
UK
j.c.h.stillwell@leeds.ac.uk

Prof. Martin Clarke
University of Leeds
School of Geography
Woodhouse Lane
LS2 9JT Leeds
UK
m.c.clarke@leeds.ac.uk

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Preface

Good understanding of contemporary demographic structure and population dynamics underpins effective planning and decision making for the future. One of the key contributors to the development of a range of population projection methodologies over the past 40 years is Professor Philip Rees at the University of Leeds. This book contains an eclectic range of methodological and substantive contributions by a number of eminent researchers in the fields of population geography and demography that were presented at a symposium in July 2009 to honour Philip Rees' retirement. Different macro and micro approaches for estimating and projecting populations are reviewed, trends in the components of change in the UK (births, deaths and migration) are presented, international comparisons of internal migration are drawn, impacts of population ageing are considered and a new perspective on understanding urban evolution is offered. All these themes are interconnected in one way or another but the key dimension of linkage in this particular volume is that, collectively, they represent a compendium of Phil's research interests and the celebration of a lifetime of commitment to undertaking meticulous analytical research, developing innovative modelling methods and enhancing knowledge in population geography and spatial demography.

Demographers have always been interested in change and have wrestled with the demands of policy makers to inform them about the future of national and sub-national populations and their productive capability or destructive potential. Chapter 1 of the book, by *Philip Rees* himself (Fig. 1), considers the dynamics of global population change by reviewing the projections of world population development over the next 90 years and the regional differences that will become apparent under the assumptions adopted by the major projection agencies. The key factors influencing the ageing of most national populations include low or declining fertility (until relatively recently), rising life expectancy and international migration gains and losses. These demographic processes are creating older and more diverse populations. Within national borders, internal migration is the main driver for redistributing these changing populations. Drawing on recent research on ethnic group projections (Rees, Wohland, Norman, & Boden, 2010), undertaken as part of the 'Understanding Population Trends and Processes (UPTAP)' initiative and funded by the Economic and Social Research Council (ESRC) in the UK, Rees compares

Fig. 1 Phil Rees delivering his lecture at the symposium on 1 July 2009

alternative projections of ethnic fertility in the UK and then presents new estimates of life expectancy by ethnic group in the UK which he contrasts with experience in the USA. The final sections of the chapter provide us with some indications of how the ethnic composition of the UK will change between 2001 and 2051 as minority groups mature and as ageing exerts its influence on the demographic structure of all groups within the population. Whilst the demographic changes identified in this chapter have very significant policy implications, not least for the provision of services, many policy questions need more than demographic explanations; there is a requirement also to understand changes in educational attainment, participation in the labour force, family and household formation (many demands are household generated), changes in retirement dependent on state support and savings and on health/illness outcomes, all of which are underpinned by the availability of population projections.

A variety of strategies are available to model our changing populations. Sometimes population stocks are modelled as a time series (such as when a consultancy project needs swift execution). However, it is better to study and model transitions between states. The classic cohort-component model is still at the heart of the projection of large and small populations, in many forms as single region, bi-regional or multi-region models, whether implemented using macro-populations experiencing average group intensities or using micro-populations of individuals sampling their transitions from a macro-distribution. What is vital in implementing such models is that the input intensities match model intensities in definition. Even the best demographers can get this wrong. Sometimes the input data are inadequate and it becomes necessary to resort to other modelling strategies. To solve the student migration issue (poor data on the migration of students on graduation), recent work has introduced agent based models into microsimulation, for example (Wu, Birkin, & Rees, 2008). In other situations, no direct estimates of inputs to

projection models are available and the needed inputs must be modelled from proxy variables, survey data or administrative sources, as has been done recently for ethnic group mortality, fertility and immigration in the UK (Norman, Rees, Boden, & Wohland, 2010).

To drive our projection models, assumptions must be made and uncertainty must be dealt with. Traditionally high and low variants are used, but will be replaced in the future by stochastic projections. These use time series models or historical analysis or expert opinion to produce error distributions of the main projection drivers for sampling. It is also necessary to think 'out of the box' and develop scenarios that establish 'what might happen if' such as: What if the conventional view of continuous life expectancy improvement was replaced by predictions of higher mortality from the obesity epidemic? What if climate change crises caused a rise in the migration of environmental migrants? What if resource depletion (the end of oil) reduced mobility and migration in Europe? These are scenarios which the European Commission has charged a network of European demographers to explore through a major ESPON project (de Beer et al., 2010).

In the 1970s, Philip Rees pioneered multistate demographic accounts involving tables of flows that are moves/transitions between states. The population covered by an account, the age-time framework, the observation window and the states distinguished define the boundary of an account which provides a framework for the measurement of flows and the estimation of flows when data are incomplete. An account-based model provides a framework for combining flows and stocks in a consistent manner. A major aim in the development of accounts is that the data are valid (i.e. measure what they are supposed to measure), reliable and timely. Chapter 2 by *Frans Willekens* presents the major principles of multistate demographic accounting developed by Philip Rees and extended by his team and others. It incorporates some aspects of multistate modelling in survival analysis. The account that results includes population flows, population stocks and durations of exposure and is a basis for the estimation of transition rates and probabilities for demographic modelling (life tables and projections).

It is well-known that existing models of population projection, including those that have multiregional structures, do not adequately handle the international migration component of population dynamics. In many cases, they are not adapted to the modelling of the populations of several countries as well as regions within those countries simultaneously. The arguments for taking international migration into account in the modelling of population change are twofold. First, population processes are systemic in nature and international migration is an interaction between elements of the population system, that is between national and regional populations of various countries, that should be included since the volume of international migration has been growing in the last 20 years. Second, there is a very practical argument that the forecasting errors arising directly from ignoring international migration are very large; Rees, Kupiszewski, Eyre, Wilson, and Durham (2001) have shown that the magnitude of errors using Eurostat forecasts for the 1980s. Thus, the incorporation of international migration into models of population dynamics is a key issue in terms of reducing forecasting error and one way to

achieve this is to use a matrix of flows between countries, rather than net migration, and to use emigration rates where possible. These developments have led *Marek Kupiszewski* and *Dorota Kupiszewska* to use the *ECPOP* model (Rees, Stillwell, & Convey, 1992; Rees, 1996) as the basis for constructing *MULTIPOLES*, a multiregional multilevel model of population dynamics which takes into account international migration. *MULTIPOLES*, which simultaneously models population change in countries and regions and takes into account international migration between as well as from the 'rest of the world', is explained in Chapter 3 where an application of the model to forecast the elderly population of countries in central and eastern Europe is also presented.

Chapter 4 by *Tom Wilson* describes the model, assumptions and projection outputs from the official New South Wales Government 2008 release population projections. The model, the *New* South Wales *D*emographic *S*imulation *S*ystem (*NEWDSS*), incorporates directional migration modelling and produces projections at three geographical scales: (i) New South Wales and the rest of Australia; (ii) major regions of the State; and (iii) Statistical Local Areas. The system utilises movement accounts-based projection models at the State and regional scales and a transition accounts-based model at the local area scale. One of the innovative feature of *NEWDSS* is the way the local area transition accounts-based model uses migration probabilities based on census data but, to simplify assumption-setting, constrains the projections to net movement assumptions. Projected population accounts at this scale are then presented in the form of movement accounts to ease understanding by non-technical users. The chapter describes the principal aspects of the model, provides an overview of how the projection assumptions were prepared and discusses some of practical issues which arise in preparing local area projections. Key aspects of the demographic future of New South Wales for the period 2006–2036 are presented.

In contrast to the first five chapters of the book which outline alternative approaches to projection and demonstrate projection methods used in different contexts, the next three chapters concentrate on specific components of population change: fertility, mortality and migration. In Chapter 6, *Paul Norman* focuses on the relationship between fertility and infant mortality in the United Kingdom and the hypothesis that reductions in fertility are a direct result of falls in infant mortality. Whilst William Brass found little evidence at regional and county level in England and Wales of changing geographies of fertility and child mortality between 1876 and 1928, with no detectable 'direct influence of child mortality on fertility' (Brass & Kabir, 1979, p. 86), recent studies of the late twentieth and early twenty-first centuries show distinct geographic variations in both fertility (Boyle, 2003; Boyle et al., 2007; Tromans et al., 2008) and infant mortality (Norman et al., 2008). Brass' study framework has been adopted in Chapter 6 for analysis using UK-wide data for local authorities for the period 1981–2006. The results suggest that the relationship between trends in infant mortality and fertility remain unclear and that each of these indicators is influenced by different variables.

Migration is the most uncertain component of population change and the one which requires careful monitoring. The problem is that UK migration statistics, be

they on internal or international migration flows, are unacceptably poor for use in monitoring and policy making. There has been a significant outcry for improvement and the Government has responded by establishing programmes of actions and activities to meet the requirements for better data. In this context, the aim of Chapter 6 by *John Stillwell, Peter Boden* and *Adam Dennett*, is to review the need for migration statistics and the current predicament over reliable data and then to illustrate some examples of migration information systems that have been developed in an academic environment for different type of users so as to support the monitoring of migration trends over time and better analysis of the changing patterns and complexion of migration.

Cross-national comparisons of demographic indices provide valuable insights into the status and trajectory of different societies. However, whilst demographic indicators such as total fertility rate, life expectancy or total immigration rate are relatively easy to calculate from available data for many countries of the world, indicators of internal migration intensity that are comparable between nations prove more difficult to compute. This is the case for a number of reasons, as *Martin Bell* and *Salut Muhidin* establish in Chapter 7, including differences in the way internal migration is defined, in the time intervals over which internal migration is measured and, in particular, in the way in which national territories are divided spatially in different countries. Every country has its own hierarchy of geographical areas and because these areas differ in areal or population size, it is difficult to make accurate comparisons between countries of a phenomenon that involves interaction between and within zones in different tiers of the spatial hierarchy. It is very unlikely that countries have zones that are similar in size and shape, between or within which the volume of migration can be compared directly. It is for these reasons that Bell and Muhidin turn to an indicator introduced by the French demographer, Daniel Courgeau, in order to compare internal migration across 27 countries from Asia, Africa, Latin America and the Caribbean as well as the developed world. Courgeau's k is a synthetic measure which indicates internal migration intensities at a range of spatial scales since it is the slope of the regression line that connects the migration intensities involved. The results are intriguing and provide evidence that migration intensities in countries of the developed world tend to be relatively high whereas Asian countries tend to be at the other end of the mobility spectrum. When Courgeau's k values for different countries are compared over time, increasing intensities are apparent when the lifetime migration data are used and declining trends are evident from the 5-year migration intensities. Thus, the analysis tells us that whilst more people are moving from their place of birth during their lifetime, the trend in intensity of movement in the last three decades based on 5-year data is downwards.

In Chapter 8, *Les Mayhew* addresses some of the major issues around demographic restructuring that are currently confronting policy makers as they try to establish what the implications of an ageing population will be over the next two decades. Whilst increased longevity is a laudable aim, we must be conscious that this implies greater and greater need for health care to maintain healthy life expectancy whilst simultaneously a sharp decline in the old age support ratio implies longer and longer working lives for the healthy population of working age. This chapter

is concerned with explaining these trends and the relationship between ageing, health and work so that the implications of getting the outcomes wrong are better understood as well as the potential economic benefits of getting better outcomes in later life right through focusing on better health and greater participation. The chapter uses three concepts in particular: life expectancy; healthy life expectancy; and working life expectancy. It explains what these concepts are and considers optimistic or pessimistic hypotheses that follow from changes in the quantities of these concepts. An 'active ageing' scenario, for example, which narrows the gap between life expectancy and healthy life expectancy and which increases working life expectancy, is to be welcomed as it will improve living standards and reduce the need for immigration.

The focus of most chapters of the book is on macro-demographic theories, methods and applications with consideration for particular components of population change or specific sets of sub-national populations. However, there is a huge body of work that has evolved over the last 60 or so years that is based on a building micro models of individual (e.g. person or household) behaviour. In Chapter 9, *Mark Birkin* and *Martin Clarke* provide a review of these approaches by tracing the development of microsimulation models from their origins in the late 1950s through to the present time, noting how it was only in the 1970s that geographers (including Phil Rees) embraced the approach and began exploring the application of the models in a spatial setting. They examine issues around population reconstruction within spatial microsimulation, outline some of the issues surrounding household dynamics and consider some of the new developments taking place involving the development of agent-based models and attempts to embed behaviour into these models.

In the final chapter of the book, the focus moves to the evolution of cities as nonlinear dynamical systems. It is known that, in general, for such systems, the step from one period to the next is highly dependent on the initial conditions prevailing at the beginning of the period. The evolution of a city is a sequence of such steps and this kind of evolution is said to be path dependent. It is shown that at any one time, the initial conditions for a city can be characterised by an analogue of DNA. The argument can be applied to a system of cities as well as to a particular city. Urban history, therefore, can be seen as giving an account of the evolution of this DNA in either the intra-urban or the inter-urban case. In this chapter, *Alan Wilson* and *Joel Dearden* re-interpret the urban retail model as a model of a system of cities but also with an emphasis on the impact of the evolution of transport systems. An appropriate model is articulated and illustrated by the growth of Chicago in the nineteenth century which offers a new perspective for historical geography and can also be seen as a novel way of modelling population dynamics.

The symposium in July 2009 to celebrate Phil's retirement was attended by past and present colleagues from far and wide (Fig. 2). It is fitting to draw this short introduction to an end with a short poem entitled 'Working with Phil' that was penned at the time by Nicole van der Gaag from the Netherlands Interdisciplinary Institute, an organisation with which Phil has had close association over many years. This poem expresses many of the sentiments of Phil's friends and collaborators.

Working with Phil

Geography, countries, but most of all regions
All over Europe, from NUTS 1 to NUTS 5
The continuous search for regional data
You could easily drown in, but with Phil you'll survive

To migration and models, with figures and arrows
To examples of flows from part A to part B
To mobility, maps, even poems of Shakespeare
To workshops and papers and dinners and tea

It also reminds me of sea-level stories
To the border between Holland and the UK
To what happens if sea level ceaselessly rises
To the parts of our countries that will fade away

I know Phil as an expert in several topics
The projects he touches they turn into gold
He's always so modest and never pretending
For persons he works with a keystone to hold

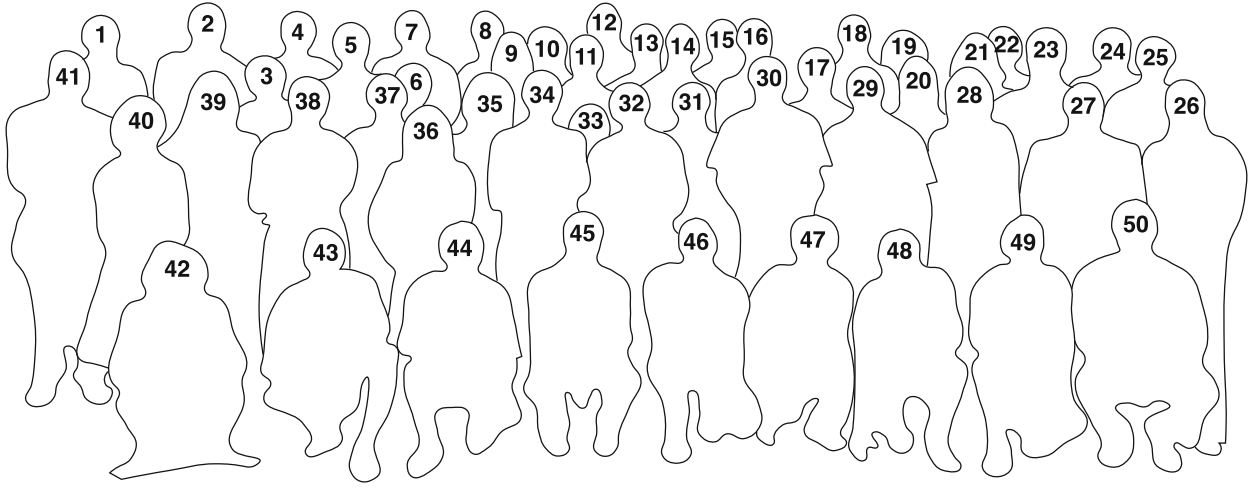
Top of all that he is, he's a very nice person
Kind-hearted and gentle, and always in peace
I'm honoured and grateful for our collaboration
It was ever a pleasure, I felt always at ease.

Nicole van der Gaag, July 2010

Leeds, UK

John Stillwell
Martin Clarke

Fig. 2 Participants attending the symposium on 1 July 2009



1 Myles Gould
2 Mark Birkin
3 Frans Willekens
4 Robin Butlin
5 Les Mayhew
6 Angela Dale
7 Bob Woods
8 Martin Bell
9 Pia Wohland
10 Nicole van der Gaag
11 Cecilia MacIntyre
12 Leo van Wissen
13 Paul Norman
14 Nico Keilman
15 Graham Clarke
16 Maryvonne Plessis-Fraissard
17 Martyn Senior
18 John McCarthy
19 Helen Durham
20 Belinda Wu
21 Linda See
22 Heather Eyre
23 John Jenkins
24 Marek Kupiszewski
25 Dorota Kupiszewska
26 Caroline Hoy
27 James Raymer
28 Lisa Youngman
29 Dan Vickers
30 John Stillwell
31 Darren Smith
32 Phil Rees
33 Peter Goldblatt
34 Sir Alan Wilson
35 Julia Williams
36 Rukchanok Karcharnubarn
37 Adrian McDonald
38 Peter Boden
39 Maja Biernacka
40 Beata Nowok
41 Alex Hirschfield
42 Dimitris Ballas
43 Patrick Sim
44 Paul Williamson
45 Adam Dennett
46 Dieter Kramer
47 Jianhui Jin
48 Oliver Duke-Williams
49 Andy Peloe
50 Tom Wilson

References

Boyle, P. J. (2003). Population geography: Does geography matter in fertility research? *Progress in Human Geography*, *27*(5), 615–626.

Boyle, P. J, Graham, E., & Feng, Z. (2007). *Contextualising demography: The significance of local clusters of fertility in Scotland*. Working Paper 2007-036, Max Planck Institute for Demographic Research, Rostock.

Brass, W., & Kabir, M. (1979) Regional variations in fertility and child mortality during the demographic transition in England and Wales. In J. Hobcraft & P. Rees (Eds.), *Regional demographic development* (pp. 71–88). London: Croom Helm.

de Beer, J., van der Gaag, N., van der Erf, R., Bauer, R., Fassmann, H., Kupiszewska, D., et al. (2010). *DEMIFER, Demographic and migratory flows affecting European regions and cities*, Applied Research Project 2013/1/3, Final Report, The ESPON 2013 Programme. Luxembourg: ESPON and The Netherlands: NIDI.

Norman, P., Gregory, I., Dorling, D., & Baker, A. (2008). Geographical trends in infant mortality: England and Wales, 1970–2006. *Health Statistics Quarterly*, *40*, 18–29.

Norman, P., Rees, P., Boden, P., & Wohland, P. (2010). Ethnic group populations: The components for projection, demographic rates and trends. In J. Stillwell & M. van Ham (Eds.), *Ethnicity and integration understanding population trends and processes, Vol. 3*, (pp. 289–315). Dordrecht: Springer.

Rees, P. (1996). Projecting the national and regional populations of the European Union using migration information. In P. Rees, J. Stillwell, A. Convey, & M. Kupiszewski (Eds.), *Population migration in the European Union* (pp. 331–364). London: Wiley.

Rees, P., Kupiszewski, M., Eyre, H., Wilson, T., & Durham, H. (2001) *The evaluation of regional population projections for the European Union*. Eurostat Working Paper Population and Social Conditions 3/2001/E/n 9. Luxembourg: Office for Official Publications of the European Communities.

Rees, P., Stillwell, J., & Convey, A. (1992). *Intra-community migration and its impact on the demographic structure at the regional level* (Working Paper 92/1). Leeds: School of Geography, University of Leeds.

Rees, P., Wohland, P., Norman, P., & Boden, P. (2010). What happens when international migrants settle? Ethnic population trends and projections for UK local areas. UPTAP Project. Accessed January 22, 2011, from http://www.uptap.net/project36.html

Tromans, N., Natamba, E., Jefferies, J., & Norman, P. (2008). Have national trends in fertility between 1986 and 2006 occurred evenly across England and Wales? *Population Trends*, *133*, 7–19.

Wu, B., Birkin, M., & Rees, P. (2008). A spatial microsimulation model with student agents. *Computers, Environment and Urban Systems, 32*, 440–453.

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Contributors

Martin Bell School of Geography, Planning and Environmental Management, University of Queensland, QLD, Australia, martin.bell@uq.edu.au

Mark Birkin School of Geography, University of Leeds, Leeds LS2 9JT, UK, m.h.birkin@leeds.ac.uk

Peter Boden School of Geography, University of Leeds, Leeds LS2 9JT, UK, p.boden@leeds.ac.uk

Martin Clarke School of Geography, University of Leeds, Leeds LS2 9JT, UK, m.c.clarke@leeds.ac.uk

Joel Dearden Centre for Advanced Spatial Analysis, University College London, London, UK, joel.dearden@ucl.ac.uk

Adam Dennett Centre for Advanced Spatial Analysis, University College London, Chorley Institute, Pearson Building, London WC1E 7HB, UK, a.dennett@ucl.ac.uk

Dorota Kupiszewska Central European Forum for Migration and Population Research, International Organization for Migration, Twarda 51/55, 00-818 Warszawa, Poland, d.kupisz@twarda.pan.pl

Marek Kupiszewski Institute of Geography and Spatial Organization, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland, m.kupisz@twarda.pan.pl

Les Mayhew Cass Business School, Faculty of Actuarial Science and Insurance, City University, London, UK, lesmayhew@googlemail.com

Salut Muhidin Demography Program at Department of Business, Macquarie University, North Ryde–Sydney, NSW 2113, Australia, Salut.Muhidin@mq.edu.au

Paul Norman School of Geography, University of Leeds, Leeds LS2 9JT, UK, p.d.norman@leeds.ac.uk

Phil Rees School of Geography, University of Leeds, Leeds LS2 9JT, UK, p.h.rees@leeds.ac.uk

John Stillwell School of Geography, University of Leeds, Leeds LS2 9JT, UK, j.c.h.stillwell@leeds.ac.uk

Frans Willekens Netherlands Interdisciplinary Demographic Institute, The Hague, The Netherlands, Willekens@nidi.nl

Alan Wilson Centre for Advanced Spatial Analysis, University College London, London, UK, a.g.wilson@ucl.ac.uk

Tom Wilson School of Geography, Planning and Environmental Management, University of Queensland, QLD, Australia, tom.wilson@uq.edu.au