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AGEING IN ADVANCED INDUSTRIAL STATES

Riding the Age Waves - Volume 3

Edited by

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Riding the Age Waves

Series Preface

Beginning in the last century and continuing into the twenty-first century, the populations of the world's nations have displayed large and long-lived changes in age structure. Many of these began with fertility change in the form of baby booms, busts or declines, and are amplified by declining mortality and by migration within and between nations. These age-structural transitions have powerful effects on human affairs, from driving the demand for public and private goods and services for young and old, to determining the flow of resources across the different ages of the human life cycle. The consequences of age-structural transitions vary in emphasis and detail, but not in significance, across the spectrum of nations in different stages of economic development. Demography will matter in this century not by force of numbers, but by the pressures of waves of age-structural change.

In 1997 a committee of the International Union for the Scientific Study of Populations was charged with exploring age-structural transitions and their policy implications. The committee brought together distinguished scientists to examine the key demographic, social, economic and policy aspects of age-structural change across a spectrum of nations at different stages of development. Readers will find a rich discussion of their work in 'Riding the Age Waves', a series of three books, 'Population, Resources and Development,' 'Allocating Public and Private Resources Across Generations,' and 'Responses to Ageing in Advanced Industrial States.' These volumes deal, roughly speaking, with developing economies, rapidly industrializing economies and highly industrialized economies.

Developing countries face challenges ranging from building human capabilities and creating jobs, to creating industry, infrastructure and institutions; all of these depend critically on the flow of people into key age groups of the life cycle (school, college, job seeking, marriage, parenthood, etc.). Because many developing countries are in relatively early stages of fertility decline, they are in the early stages of baby booms which will inevitably produce echoes – these manifest as age waves that last for two or more generations. These waves in turn create shifting flows of people into the key age groups, greatly complicating the task of managing the many components of development.

In the rapidly industrializing countries, population age structures typically reflect large fertility declines that occurred a generation or so ago, with resulting baby booms that have aged and are moving through the labour force. Fertility declines continue to have significant social and economic effects, e.g., on the growth of individual savings and thus aggregate capital investment, on declining family sizes and the shift from traditional family structures towards nuclear families, and on the thinning out of traditional kinship networks and changes in traditional forms of intergenerational support. Each of these has short- and long-run effects on government policy with respect to education, social services, welfare, old-age support and macroeconomic and fiscal policies.

The highly industrialized countries confront the rapid decline of mortality leading to increases in the length of lives post retirement, the persistence of below-replacement fertility and, in many cases, the long term age distortions of post-World War II baby booms. In these countries, age-structural changes pose challenges in terms of a long-run decline in the labour force, a shifting balance towards high old-age dependency and growing demands for old-age pensions and health care.

Several features distinguish these books from past writing on the subject: first, a joint examination of dimensions of age-structural change that have often been considered in isolation from each other (for example, in developing economies, education, job creation, land use, health); second, the papers here bring together the many policy implications of these dimensions; third, the use of case studies to examine policy consequences and options of particular dimensions of change; fourth, the development of qualitative and formal methods to analyze the long term dynamic nature and consequences of age-structural change.

The committee (Shripad H. Tuljapurkar, Cyrus Chu, Anne H. Gauthier, Naohiro Ogawa, Rafael Rofman, Ian Pool, Hassan Youssif) thanks the many people and agencies who made this work possible. In addition to the IUSSP, we thank the Asian Metacentre at the Singapore National University, the Academia Sinica in Taipei and the Nihon University Population Research Institute in Tokyo. The editors of the individual volumes were Cyrus Chu, Anne H. Gauthier, Naohiro Ogawa, Ian Pool, Vipan Prachuabmoh and Shripad H. Tuljapurkar.

Shripad H. Tuljapurkar
Cyrus Chu
Anne H. Gauthier
Naohiro Ogawa
Ian Pool

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Introduction

By Shripad Tuljapurkar, Naohiro Ogawa, and Anne H. Gauthier

Population growth slowed across the world as a whole in the last decades of the twentieth century, changing substantially our view of the future. The twenty-first century is likely to see the end to world population growth and become the century of population ageing.

Slowing global population growth has been primarily due to the almost universal reduction of fertility over the recent decades. The United Nations now projects that by 2010 more than half of the world population will live in countries with below-replacement fertility. At present, many industrialized countries in Europe and all the industrialized countries in East and Southeast Asia have a total fertility rate (TFR) below 1.5 births per woman. Particularly in Europe, fertility has been below replacement level for the region as a whole for almost three decades, suggesting that this below-replacement fertility phenomenon is neither temporary nor transitory. As a consequence, there has been a growing sentiment among European demographers that below-replacement fertility is a persistent long-term trend. This view regarding Europe's future fertility prospect has been incorporated in the United Nations population projections since 1998.

Accompanying these rapid fertility declines has been a remarkable decline in mortality over the past few decades in both developed and developing regions. Considering both sexes, life expectancy at birth has been steadily approaching 80 years in many of the industrialized nations. Long life is one of the greatest and most ancient desires anywhere, and becoming a centenarian, for example, is considered to epitomize that dream. In many industrialized countries in the West and East Asia, this dream is now increasingly becoming a reality for many. Because further improvements in mortality at older ages are expected, the number of older persons is expected to increase at a phenomenal rate. In the developed region in 2000 there were 232 million people aged 60 and over; it is expected that there will be 343 million by 2025 and 400 million by 2050.

As a result of these demographic transformations, population age distributions are changing markedly in the developed countries, with a relative increase in the number of the elderly and a relative decrease in the number of the young. These age-structural shifts are generating a wide range of disruptions at both societal and familial levels in the developed countries. At the societal level, governments have grown increasingly concerned about adverse effects of population ageing on socio-economic dimensions such as national productivity; labour supply and its quality; savings and capital formation; fiscal imbalances; solvency of pension schemes; and sustainability of medical care programmes. At the familial level, people are getting married and having children much later in their lives and are also having fewer children. Moreover, there have been increases in childbearing outside marriage, in divorce and in the fraction of one-parent families. These family-level demographic developments have been changing the ways in which family members interact with one another, particularly in supporting elderly parents or children.

Over the past few decades, continuing low fertility and improved mortality have motivated economists to undertake a series of quantitative studies on the impact of ageing populations upon various macroeconomic variables. Many of these previous studies have produced numerous scenarios. The studies that heavily draw upon a blind extrapolation of population and economic variables, for instance, tend to indicate an unprecedented economic burden of population ageing. To avert such gloomy scenarios, however, it is imperative for many industrialized nations to implement effective social and economic policies and programmes with a view to alleviating various difficulties caused by their population ageing.

The papers in this volume aim to broaden and strengthen the basis for the formulation of effective economic and social policies by exploring the economic, social and demographic consequences of the transformations in the age structures of the population and family organization. These consequences include changes in economic behaviour, particularly in the labour and financial markets, but also regarding the patterns of saving and consumption and intergenerational transfers of money and care. Moreover, there are consequences for state policies, including taxation, income support, state pensions and other distributive policies. For instance, women's participation in paid employment and human capital accumulation appear to be influenced by age-structural transformations and related developments in family patterns. Women's labour supply over the life cycle, lifetime earnings profiles and pension rights are also likely to be affected.

Dynamics of Demographic Transitions

The process of population ageing is most advanced in industrialized countries. However, differences in historical conditions as well as socioeconomic and demographic processes have produced considerable differences in the age-structural transformations that exist among these industrialized countries; in some cases, these differences might well diminish in the years to come, while in other cases, they might expand. **The first chapter of this volume by Ian Pool, 'Age-structural Transitions in Industrialized Countries'**, analyzes some of these demographic complexities in the dynamic process of population ageing in industrialized countries. It demonstrates, using the United Nations population projection results, that age-structural transitions involve the movement of waves and troughs through the age pyramid and that there are variations in the speed and timing of transition and the intensity of the waves. The analysis finds that in the majority of developed Western countries, the modal age groups will remain below old age or even as low as early middle ages, which is a markedly different picture produced on the basis of the conventional demographic measure such as the proportion 65 and over. At the end-point of an age-structural transition, the conventional demographic index tends to produce a bleak outlook, leading to an over-dramatization of the ageing issues and to 'panic' among policy makers.

As an important policy implication, Pool stresses that the multiple age compositional oscillations to be generated in the process of population ageing would require public and private responses that could lead to reallocations of resources between generations. In addition, as demographic policy responses to population ageing, he discusses the feasibility of promoting international migration and boosting fertility.

It is axiomatic among demographers that declining fertility, not increased life expectancy, is the principal determinant of population ageing. It should be emphasized, however, that the contribution of mortality improvement to the ageing process becomes increasingly important over time, especially when life expectancy at birth exceeds 70 years. In Japan, for example, the mortality effect on population ageing is expected to become dominant over the fertility effect sometime between 2005 and 2010. For this reason, accurate projection of the future mortality trajectory is increasingly important for social security reform in Japan. This observation applies to many other industrialized countries. **The second chapter by Nico Keilman** analyzes the relationship between the level of mortality and the age structure of the populations in industrialized countries by utilizing various theoretical models such as stable population theory, the variable growth rate method and inverse projection and back projection methods. Each of these models has limitations. In view of the fact that population forecasters in industrialized countries in the past decades have produced substantial under-projections of the number of the elderly, the author concludes that stochastic projections are an appropriate means of improving the quality of forecasts for the elderly because they describe uncertainty in a quantitatively useful way. That is, stochastic forecasts force the users to think in terms of uncertainties and anticipate unexpected trends.

At present, there are two major approaches to estimate stochastic models of vital rates. One approach uses historical data to estimate time-series stochastic models of vital rates and then makes forecasts. The other approach is based on randomized scenarios. In its simplest variant, expert opinions are used to make probability distributions for terminal vital rates, and smooth trajectories are followed over time. Population projections based upon these two methods have been widely used by researchers and government planners in a number of developed countries. There are several key differences between these two methods. In general, compared with the random scenario method, the time-series stochastic modelling method has much smaller serial correlations, higher variance of vital rates (particularly fertility), more irregular trajectories and widening probability intervals at a faster rate over forecast time.

An application of the time-series stochastic model to projecting mortality trends is called the Lee-Carter method. **The third chapter by Lawrence R. Carter** applies the Lee-Carter method to the U.S. death rates from 1933 to 1988 with a view to examining the pattern of U.S. mortality by race and sex and to forecasting age-sex-race-specific mortality from 1990 to 2065. Co-integration analysis of the four race and sex estimates of k(t), one of the key components in the Lee-Carter method, established statistical independence, thus justifying the author's approach to generating age-specific mortality rates and life expectancies by race and sex separately. Preliminary results of the dynamics of ratios of the non-white/white mortality rates show a gradual increase over time in the age of crossover for both sexes, disappearing by 2030. More importantly, the analysis finds that the overall curvilinear patterns in life expectancy are of very slow movement towards race divergence by sex and sex convergence or stability by race. In the most recent version of the United Nation's population projections, the mortality differentials by sex are expected to diminish to a certain extent in many European countries. In a developed country like Japan, however, the mortality differential by sex has been continuously increasing over the last several decades and is projected to continue expanding from 6.98 years in 2000 to 8.27 years in 2050, according to the official government population projections. In any case, Carter's findings, particularly pertaining to sexual differentials, are extremely useful not only to demographers, but also to pension planners and actuarial experts in developed countries.

Fiscal Dynamics and Projections

Economic flows across age groups arise because in any viable society dependent members of the population – those who consume more than they produce – are supported by members of the population who produce more than they consume. Societies take different approaches to reallocating resources from surplus to deficit ages, but two methods dominate. One method relies on capital markets. Individuals accumulate capital during their working ages. When they are no longer productive, the elderly can support their consumption by relying on capital income (interest, dividends, rental income, profits, etc.) and by liquidating their assets. The second method relies on transfers from those at surplus ages to those at deficit ages. Some transfers are mediated by the public sector. Important examples are public education, publicly financed healthcare and public pension programmes. Many transfers are private transfers of which familial transfers are most important. The material needs of children are provided mostly by their parents. The fourth, fifth, and sixth chapters address issues related to these two methods for reallocating resources from surplus to deficit ages.

In view of the recent emergence of massive public transfer programmes in industrialized countries, **Ronald Lee, Shripad Tuljapurkar and Ryan Edwards** examine in their paper, **'Uncertain Demographic Futures and Government Budgets**

in the U.S.' the impact of population ageing on the budgetary allocation of the U.S. federal and state/local governments. Because many public transfers are age-related, the population age distribution is a powerful influence on government budgets. The authors construct stochastic projections of the budgets for the federal and state/local governments, disaggregated by programme. This analytical approach is not only unique but also path-breaking. Although strenuous efforts have been made to model demographic factors with stochastic elements incorporated, as discussed in the second chapter, there has been hardly any research on the effect of economic uncertainties involved in the process of government budgetary allocations. The analysis finds several interesting computational results. For instance, one of the principal findings is that the expected tax share will rise from 24% in 1994 to 35.8% by 2070, with the 95% probability bounds ranging from 28% to 50%.

In the **fifth chapter, Qi Li and Shripad Tuljapurkar** analyze the effects of realistic demographic assumptions on the steady states of overlapping generations general equilibrium models. These models are the workhorse for much economic theorizing about ageing, but traditionally have used simplistic assumptions about mortality, in particular that human death rates are independent of age. Li and Tuljapurkar show that mortality patterns can usefully be discussed in terms of the distribution of age at death and that this distribution is approximately normal in modern humans. They then find and discuss the optimal steady states of three models: a simple model with neither education nor retirement, a model with endogenous schooling and no retirement and, finally, a model with endogenous schooling and an exogenous retirement. They show that both the average age at death, and its variance, matter to the equilibrium properties of the models and that age-independent mortality is a poor approximation. They show that the optimal years of schooling decrease as the exogenous age of retirement increases. This analysis is a fundamental first step in the development of realistic demographic-economic models.

In most developed societies, both annuities and life insurance are important sources of income for the elderly. Annuities play an essential role in converting asset accumulation into a regular flow of retirement income guaranteed for life, and classical life insurance protects individuals and their dependents from the risk of early death. In the **sixth chapter, David McCarthy and Olivia S. Mitchell** analyze the extent of adverse selection in life insurance and annuities in international markets. Theory predicts that in the absence of insurance company underwriting, adverse selection will increase the average life expectancy of annuity purchasers, but worsen that of purchasers of other life insurance products relative to the general population. McCarthy and Mitchell examine the difference between mortality tables for this group in the U.S., U.K. and Japan. Surprisingly, the analysis finds that adverse selection reduces mortality for both life insurance and annuities, contrary to what theory would predict. The authors obtain this finding even after controlling for income and wealth effects. This indicates that insurance company screening of potential higher risks in classical life insurance is very effective, possibly even eliminating asymmetric information held by policy holders.

Wealth and Health

As has been recently discussed in the literature, one of the important linkages between age-structural transformations and economic growth is the role of two demographic dividends in the process of economic development. When a country's fertility begins to fall, the first demographic dividend arises because changes in population age structure have led to an increase in the working ages relative to non-working ages. In other words, the first demographic dividend arises because of an increase in the share of the population at ages during which production exceeds consumption. Another important dividend which arises in response to the prospect of population ageing is 'the second demographic dividend'. When life expectancy is increasing, for example, the impetus for accumulating wealth is stimulated, which, in turn, leads to a permanent increase in income. This implies that if capital accumulation dominates the age reallocation systems for supporting the elderly, population ageing may yield a second demographic dividend in the form of higher rates of saving and capital intensification of the economy. Although the first demographic dividend is purely accounting in nature, the second demographic dividend is behavioural and policy-dependent. Therefore, depending upon how the second demographic dividend (savings and wealth) is used, the country's economic growth performance varies to a large extent.

The impact of population ageing upon national savings is the issue addressed in the **seventh chapter by Andrew Mason, Naohiro Ogawa and Takehiro Fukui**. This chapter deals with an analysis of the impact of population ageing and the decline in the family support system upon saving and wealth in Japan. Using an elaboration of the lifecycle saving model and survey data from the National Survey of Family Income and Expenditure (NSFIE), the authors estimate how demographic characteristics of the household, including constructed measures of the number of non-coresident prime-age (20–64) and elderly (65+) family members, influence saving and wealth. This is an important innovation because it allows researchers to assess whether coresident and non-coresident family members are substitutes and whether changes in extended living arrangements will influence saving. There have been many empirical studies showing a substantial decline in the proportion of elderly living in extended households and lower rates of saving in twenty-first century Japan. However, the authors' projections show far more gradual declines than anticipated by many previous studies on savings in Japan, suggesting that alarmist views about the impact of ageing on saving and wealth are unwarranted. In addition, because the drop in the saving rate is sufficiently small, Japan's wealth is projected to continue growing during the first half of this century.

In addition to savings and wealth, work is an important source of income for the elderly even in many developed societies. It is well-documented that the health status of the elderly is one of the principal determinants of their participation in the labour force. The access to modern medical care services differs from country to country. In many European countries, medical care services are delivered under social insurance schemes. In the U.S., medical expenditure is heavily dependent upon market forces, although both Medicare and Medicaid are important sources of medical service for specific segments of the population. Despite these differences in medical care delivery systems, almost all industrialized countries are facing financial difficulties due to rapidly-growing medical costs. There is great concern that these countries will not be able to afford the future health care costs of ageing societies. In the **eighth chapter, Deborah Freund and Timothy M. Smeeding** shed light on this issue. In most analyses of the future health care costs of an ageing society, the steep overall costs of ageing for social retirement and acute and chronic health care costs are discussed. However, Freund and Smeeding point out that the major problem of these analyses is that they do not consider the benefits as well as the costs of health care improvements. Obviously, rising incomes among the old and the perceived benefits of improved medical treatments and technologies will improve both willingness and ability of the elderly to pay for these treatments. For these reasons, the authors recommend that future income security policy and health care policy be integrated rather than treated separately.

Family and Care

In developed countries, public transfers play a leading role in supporting the elderly, although families still provide their elderly dependents with many support services to a considerable extent. Evidently, such familial transfers are much more common in developing countries. One of the most salient factors contributing to this difference between developing and developed countries is the pronounced difference in family structure between them. Traditional extended families are still prevalent in the developing regions. As has been widely documented, levels of family support decline substantially with the level of economic development. Hence, it is highly conceivable that the proportion of the elderly living in the traditional multigenerational households diminishes over time in developed societies.

In the **ninth chapter, Emily Grundy** examines key variables influencing demand for support provided by families and discusses the availability of familial support. The author also investigates the effects of support of various kinds on the well-being of older people and the policy implications of different patterns of support, with reference to inter-country differences. The analysis finds that families currently provide much of the necessary care for the elderly and despite large falls in the proportion of the elderly coresiding with their offspring, level of intergenerational exchange and support are still high. There are, however, uncertainties about the future, and parental divorce, higher levels of education and declining population are likely to increase such uncertainties. More positively though, improvements in the health of older people as a whole may effectively expand the pool of potential helpers and are also likely to contribute to reducing the conflict between work and support currently experienced by some caregivers. This last point is the issue addressed in the **tenth chapter by Naohiro Ogawa, Robert D. Retherford and Yasuhiko Saito**. Using micro-level data gleaned in a national representative sample survey on the health of the elderly, the authors assess the effects of caring for the elderly on the labour force participation of middle-aged women in Japan. There are a few important findings emerging from this chapter. First, a majority of the elderly, even at ages 85–89, are in sufficiently good health and it is not necessary for daughters or daughters-in-law to care for them. Second, the proportion of parents who live with daughters or daughters-in-law who work differs little between healthy parents and unhealthy parents. These findings suggest that elderly parents' health does not have much of an effect on the labour force participation of daughters and daughters-in-law. However, in their econometric analysis, the authors find that if an elderly person becomes 'unable' to perform at least one ADL (activity of daily living) or IADL (instrumental activity of daily living), the probability that a daughter or daughter-in-law works full-time sharply increases and the likelihood that she works part-time sharply decreases. The authors conjecture that the increase in a daughter or daughter-in-law's full-time work that occurs when the elderly parent becomes 'unable' arises because 'unable' frequently results in long-term hospitalization, thus creating the need to work full-time to help defray the costs of such hospitalization, while simultaneously freeing the daughter or daughter-in-law to work full-time.

The eleventh chapter, by Michael Murphy, entitled 'Family and Kinship Networks in the Context of Ageing Societies', analyzes changes in family and kinship networks in Britain, using the SOCSIM demographic micro-simulation program and historical demographic data. Murphy finds that elderly people are themselves likely to have older kin, with the proportions of those aged 60 with a living parent quadrupling between 1950 and 2050. However, the lower fertility and, in particular, the later ages at childbearing of recent cohorts mean that the age by which half of people become grandparents will increase from 55 in 1950 to 70 in 2050. Reductions in fertility mean that the average number of sibs will show some of the most substantial declines: in 1950, older people had about eight ever-born sibs on average, but only about two a century later, although reduced mortality will attenuate the differential in living sibs. While these results are based on a particular country's experience, sensitivity analysis shows that the main conclusions are robust to a variety of assumptions that cover the patterns of a broad range of developed countries.

Time Use and Labour

In recent years, many economists and policymakers in industrialized countries have been proposing a host of economic strategies for responding to population ageing, and the following three have been commonly and repeatedly proposed as policy options: expansion of intergenerational transfers, accumulation of savings for retirement and later retirement. The issues pertaining to the first two of these economic strategies are discussed extensively in the previous chapters of this volume. In the last two chapters the issues relating to the third economic strategy are addressed.

Evidently, not only are people living longer, but they are also healthier. Why is it then so difficult to let them retire later and work longer? In many industrialized countries, taxation, retirement rules and the legal environment discourage work among the elderly. As pointed out by Gruber and Wise (1998a,b), early retirement around the world can be traced directly to policies that discourage work among those in their 50s and 60s. At the same time, the trend toward early retirement is pervasive, pre-dating many of the public pension programmes that support the elderly. Higher incomes have allowed the elderly to opt for more leisure and less work. The development of financial markets has allowed individuals to accumulate savings to support their old age. It is, therefore, unclear to what extent removing barriers to work will result in a later age at retirement. Nonetheless, many countries are raising or eliminating mandatory retirement ages and exploring other ways to encourage greater workforce participation among the elderly, as described in the OECD's recent report (2006). The tempo of adjusting institutional factors of the labour market varies substantially from country to country. In the case of Japan, for instance, male life expectancy at age 20 increased by 8.7 years over the period 1965–2003, but the age of retirement grew only by 4.5 years during the same period. It is worth noting that because Japan's total labour supply has already been diminishing since 1998, the utilization of elderly workers has become increasingly crucial for the twenty-first century Japanese economy.

In the **twelfth chapter, Anne H. Gauthier and Timothy M. Smeeding** examine trends in the patterns of time use of older adults from the 1970s to the 1990s, using data from time use surveys conducted in the U.S., U.K. and the Netherlands. The results that the authors obtained suggest that time spent on paid work has decreased over time for men (but not in the U.S.), especially at older ages. For older men, time that used to be allocated to paid work has been reallocated to housework and leisure activities. For women, an opposite trend is observed with an increase in time devoted to paid work and a decrease in time devoted to housework. Women still devote more time to housework than men, but the gender gap has been reduced in all the three countries. The authors also investigate whether or not older people lead a more active life. The results appear to vary by country, gender and age and are highly sensitive to the definition of 'active' life.

In the **final chapter of this volume, Atsushi Seike** analyzes the impact of Japan's mandatory retirement and the age limitations for hiring upon the utilization of human resources. The author finds that mandatory retirement has a negative effect on the utilization of older employees. In addition, Seike's analysis shows that age limitations in hiring prevent middle-aged and older workers from finding jobs. In order to remove these two barriers to the utilization of aged workers, he asserts that the seniority-based wage and promotion systems should be abolished or drastically revised.

Clearly, the papers in this volume can only cover some aspects of the issues raised at the beginning of this introductory chapter. For instance, despite its growing importance as a policy option for alleviating the difficulties caused by population ageing, the topic of low fertility has not been covered by the papers in this volume. We trust, nevertheless, that this volume lends itself to providing a stimulus to further research on such issues and to generating new projects on population ageing.

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Part I
Dynamics of Transitions

Age-Structural Transitions in Industrialized Countries

Ian Pool

Age-Structural Transitions, Ageing and Policy

This chapter is exploratory and perforce descriptive. Its objective is to ask questions about population age-structural transitions and ageing rather than to provide robust conclusions. It covers what I will call 'the modern age-transition' running from just after World War II, when the effects of the baby-boom were being felt on age pyramids in industrialised countries, until the middle of the present century. To this end it addresses two issues.

Firstly, it attempts to place the population ageing occurring in Western developed countries (WDCs[1]) into its wider context, consisting of the processes of age-structural transition that will lead eventually to ageing. This paper does not address, except in passing, the proximate demographic determinants that have generated and also will propel the trajectories followed by these transitions. Essentially, I am arguing here that population ageing is not a simple, benign, monotonic process, but is confounded by other processes of age-structural mutation, to such a degree in fact that transitions towards ageing are complex and varied.

Secondly, the paper raises some questions of applied importance for policy, not the least of which are implications deriving from the point raised in the last paragraph. The central issue is that age-structural transitions, and the phase of ageing within such transitions, do not constitute evolutionary trajectories, but may involve a high

[1]The WDCs here include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. We have excluded the minor western and southern European jurisdictions, such as Andorra or San Marino. Data used here on the WDCs relate to the sum of the countries, not the average across the countries.

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level of what might be termed structural turbulence. The key policy questions, then, derive from observations about this turbulence and the complexity of the transitions, and relate *inter alia* to issues such as intergenerational competition for resources, as well as to some proposed demographic responses to ageing (migration and fertility).

The present paper grows out of two papers of which I was the author (Pool 2000, 2005), key points of which will be summarised here to provide some rationale for the issues I will discuss in the current presentation.

A literature review, particularly for the second of these earlier papers showed that, outside the question of population ageing, on which there is a large number of studies, relatively little attention has been paid to age-structural transitions. This is somewhat surprising given that the great theorists (e.g. Keyfitz 1968; Coale 1972) saw these issues as of prime importance. Recently, a new generation has looked at some critical theoretical questions (e.g. Preston 1986, 1988; Wachter 1988; Horiuchi 1995), but these initiatives are relatively sparse and spasmodic in occurrence compared to many other population questions addressed by the demographic community. The substantive issues, again excluding ageing, have also not been analysed as frequently as they deserve. Fortunately, however, this is starting to change, and the result is the appearance of some papers on the patterns, correlates and effects of age-structural transitions (including cohort changes) on a diverse range of factors, all of which have policy implications (e.g. Dittgen 2000; Fair and Dominguez 1991; Higgins and Williamson 1997; Lindh and Malmberg 1999; Loriaux 1990; Macunovich 1999). Thus the questions raised in my paper are not as well traversed as might be the case in some other areas in population studies. This is the reason why I see my paper, and its predecessors on this theme, as merely exploratory.

Background to and Rationale for the Present Paper

In my paper (Pool 2000), an age-structural transition framework was formulated. It identified as an important element the fact that most of the world's populations are at an intermediate transitional stage that I termed the 'Phase of Population Waves' (drawing semantically on Keyfitz 1968). This phase follows one of 'simple momentum' (I return below to a definition of this term). Phase I has as its second and last sub-phase one of accelerating momentum resulting from improving survivorship at young ages in periods in which fertility levels remain high (I referred to this metaphorically as 'a tidal wave' rather than a normal wave).

I also argued that the phenomenon of disordered cohort flows' (again a Keyfitz term) would be widely prevalent at Phase II. As a result at Phase II, population age structures will be subject not only to single waves coming from decelerating oscillation coming from decreasing fertility, but to double- or even multiple-oscillations. These come from fluctuations in fertility rates (e.g. low rates in the depression and War; the baby boom; the baby bust; the baby boom echo), and thus in the sizes of birth cohorts, as these are modified by trends in migration and survivorship.

Phase III was seen as that of ‘ageing’. Its sub-phases were defined in terms of ageing and, sequentially, positive growth, stationarity and negative growth.

In the present paper I focus on the notion of population waves raised in the earlier presentation. While there are some common general features of age transition across the WDCs, there are also differences. These revolve around when they will be ‘aged’ and whether or not in the foreseeable future the older age groups will be the modal ones. Moreover, I will show that the WDCs are subject to a wide variety of patterns of oscillation prior to reaching ageing, and that these have varying implications, particularly for policy. Finally, this raises the problem of whether both waves and ageing can occur simultaneously; that is, does ageing ‘complete’ the age-structural transition.

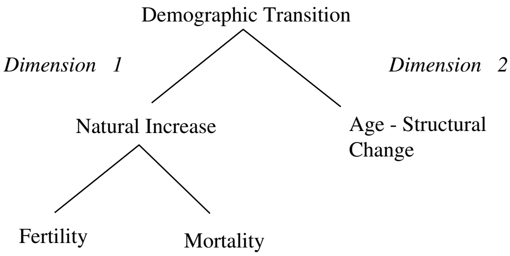
A second paper (Pool 2005), presented to an earlier meeting of the IUSSP Committee on Age Structure and Policy, linked these age-structural transitions to policy. In that paper I also attempted to define ‘momentum’ in a somewhat wider way than had been used by some past demographic studies (e.g. Frejka 1982). The Phuket meeting also discussed this concept in some detail and came to a degree of consensus over its definition. I mention this in passing because it allows me to use the term in the way that I do in the present paper, and also legitimises my defining the concept rather loosely to impute the notion of ‘impetus’. Thus ‘momentum’ as used here draws on three closely related definitions derived from physics ‘The quantity of motion of a moving body, … The effect of inertia in the continuance of motion; impetus gained from movement; *fig* strength of continuity gained from an initial effort’ (New Shorter Oxford English Dictionary 1993).

A number of questions raised by these two papers provide a further context for the present one. In order to provide a setting for what follows, I merely summarise them here, without reporting the detailed evidence presented there.

Firstly, there is a minor issue that should be mentioned in passing: this is a semantic question about the word ageing. At least in English it has two different meanings. Thus, we use the term simultaneously “to signify not only an increase in the size and the proportion of the total population at older ages, but also to describe all the processes of structuring and restructuring of the age pyramid … that lead eventually to ‘ageing’ properly speaking” (Pool 2000). To avoid confusion I will refer to the latter process as age-structural transition.

A second point is also fairly obvious yet has major methodological implications. In the context covered by this paper the demographic community should be more interested in changes in the sizes of cohorts, particularly at birth, than in the rates that determine these shifts. This does require, however, a change of emphasis away from our long-standing focus on measuring trends in population dynamics. Over the last few decades we have paid much more attention to means of estimating and computing refined rates, and far less attention to structures.

Another issue is that I saw ageing as the last phase of an age-structural transition. But, in turn age-structural transition may be construed as a component of a total demographic transition that has two dimensions:



Yet, in much of the demographic literature the structural component of the demographic transition is separated from its dynamic elements. What is interesting is that this element of separation differentiates the classical demographic transition model from other frameworks in the transition family (e.g. Zelinsky's on 'mobility' 1971) – the others have a less singular emphasis on dynamics alone.

The transition literature (certainly that on the demographic, epidemiologic and mobility models) is also replete at present with philosophical arguments about what constitutes the 'end-point' of transition (e.g. see Jones and Douglas (1997)). In the age transition framework drawn on here, a final phase and sub-phase is posited: one of ageing with negative growth. Any further phases would see a turn around in growth coming from either increased fertility or increased immigration, or both. The implications of these strategies will be discussed later in the paper.

Of course, age-structural transitions are not just a consequence of shifts in natural increase and migration, but also can be determinants of both natural increase and mobility transitions. This is of particular importance when the possibility of attaining higher levels of fertility is being cited as a strategy for a return to positive growth and as a counterbalance to ageing. The age composition of the female population obviously then becomes a critical and over-riding factor.

Furthermore, in many policy analyses on ageing in industrialised countries the focus is on age groups 60+ or 65+, or on the ratio between these age groups and the population at working ages. But the fact that ageing is really only an end phase of an age-structural transition is often ignored. This has policy implications which will be identified later in the paper.

Policy typically is built around the notion of ageing as a demand-side factor. The argument is that the elderly need access to services and to social security systems, thereby adding significantly to fiscal burdens, or to pressures felt by families. Supply-side issues that are normally addressed deal primarily with funding social security, and to a lesser degree with the labour-supply for industries servicing retirees, or with family networks.

What are largely ignored are the effects on ageing policy on fiscal or familial demands generated by other dimensions of the age-structural transition. If this question is dealt with the analysis will typically be rather crude, as for example by referring to dependency ratios. Yet it is critical that these other dimensions of the age-structural transition be taken into account as they also have demand-side effects having implications for public policy or for families. Often these effects will take the form of competing demands put on states or families. Equally well, there are also supply-side implications for public policy and for families. Beyond this there are intergenerational effects, including both competition for resources and the capacity to supply resources[2]. I will not discuss familial responses to age-structural transitions, leaving this complex subject to specialist presentations, but I do cover implications for policies relating to age-structural transitions in the context of a longer-term shift to ageing.

The policy areas, the implications for which I am raising here, are of two sorts:

1. Demographic policy responses to age-structural transitions, and especially to its component phase of ageing (e.g. migration; fertility)
2. Non-demographic policy (and familial) responses
   (a) Social security services, housing, etc. for the aged
   (b) Education and employment, etc. (i.e. human capital) policies for the young, especially when there are large waves
   (c) Resolution of issues of intergenerational competition

When WDCs Will Have 'Completed' Their Age-Structural Transitions: Ageing

This section of the paper looks at the start of the 'modern' age-structural transition, defined here as dating from the high birth rate period after World War II, and running to the arrival at a state of ageing per se. A more comprehensive analysis of the 'modern' transition might have gone back to the beginning of the twentieth century and taken the projections out further, but time and data did not permit this to be done here. Other aspects of age-structural transitions will be looked at in later sections of the paper.

It must be stressed that the industrialised countries vary in terms of the speed and timing of their age-structural transitions even as they reach the end phase of ageing. This is assessed here by reference to United Nations projections running out to the year 2050.[3] If we take any of the general, blanket definitions of ageing used in public discourse (I have used as measures 25% aged 60 years and over and 10% aged 75+ years), then it can be argued that there is a great deal of similarity among the developed countries. All WDCs will reach this phase over the next few decades. This is true even for what might be seen as deviant cases such as Iceland, Ireland and New Zealand, to a lesser extent the United States.

Nevertheless and leaving that broad similarity aside, WDCs will become 'aged' at rather different times and with different speeds. Broadly speaking, the countries fall into three categories defined here arbitrarily by the period when they reach the

[2] These are most widely analysed in financial terms in generational accounting exercises. In this paper we are viewing intergenerational competition as a far more complex social, cultural and economic (as well as financial) phenomenon.

[3] All data used here are drawn from the United Nations medium projection series, 1998 Revision.

given percentage of the total at two reference age groups, 60+ years and 75+ years noted above.[4] These categories are: *Early 'agers'*: Germany, Greece, Italy, Japan, Spain and Sweden; *Countries close to the WDC norm*: This is the largest group and consists of Austria, Belgium, Canada, Denmark, Finland, France, Luxembourg, Malta, Netherlands, Norway, Portugal, Switzerland and the United Kingdom; *Late 'agers'*: Australia, Iceland, Ireland, New Zealand and the United States. In graphs used to illustrate my argument later in this paper, data are presented on Greece and Japan from the first group; on France from the second; and on the United States from the third.

The classification just outlined represents one view of 'ageing' as it is spelt out in public debates. Equally well, however, arguments typically advanced in public debates also perceive age transitions and ageing as a sort of 'modal' condition, with the notion of a mode represented most prototypically by the 'baby boomers'. Their ageing is seen as a 'population bomb' awaiting all developed countries sometime in the not too distant future. To attempt to address this issue of public perception, and recognising that the popular views have a real impact on public policy, I have also looked at when various 15 year age groups (0–14, 15–29, 30–44, 45–59, 60–74 and 75+ years) become the modes for their society during the projection period 2000–2050. I use these functional age groups as proxies for key life-cycle stages: childhood, youth, early middle-ages, late middle-ages, early retirement ages and old age.

A caveat should be entered at this point. Not surprisingly, for some populations at a given time (e.g. as I will show below, France in 2040), the differences in the proportions of the total at various age groups, and thus the gaps between modes and some other age groups, are relatively small. This could be seen as a desirable feature for it implies that waves may be rather gentle and the age pyramid relatively rectangular, so that policy changes to meet needs emerging because of shifts in age-structure can also be less radical. There are other WDC populations that have more abrupt shifts, implying greater difficulties in planning.

The perspective derived from the analysis of modes presents a rather different picture from the more conventional analysis of ageing employed earlier and points to variations in the trajectories being followed. In part, of course, these trajectories depend on, and in some cases are confounded by, when a country's baby boom peaked, and on its intensity by comparison with the pattern for the WDCs as a whole (how far this mode was above or below that of the WDCs).

Thus, for all the countries in the early ager category, age group 60–64 years will become the modal group earlier, or at the same time, as the period that is the norm for the WDCs. Among the countries around the norm for the WDCs, there are some

[4] The groupings were based on a scatter gram between when 25% or more of the population in a country were aged 60 years or over and when 10% or more were aged 75 years or more. Group one consists of countries that reach these reference points between 2005 and 2015 in the first case, and between 2010 and 2020 in the second. The second group spans 2015 to 2025 for age group 60+ years, and 2025 to 2030 at 75+. The third group runs from 2025 to 2040 for 60+ years, and from 2035 to 2045 in the case of age group 75+.

expected clusters: the Benelux group for example. For some measures used later in this paper, Austria resembles them, but at other times it is rather different. Finland and Japan are noteworthy for the very large percentage-point difference between their age groups 0–14 in the 1950s and the figure for the WDCs as a whole.

In contrast, no country in the late ager category will see its mode at 60–74 years over the entire period covered by the projections. Within this later ager group Iceland and Ireland stand out as very different from most other WDCs; so too to a lesser degree does New Zealand.

Table 1 refers to the starting point of modern age-transitions, identified here by taking the most recent year since 1950 at which the mode was at 0–14 years. The analysis is further refined by computing the percentage-point difference between any given country and the figure for the WDCs as a whole. Then each country is categorised on this basis. In order to simplify the presentation, only categorical data are presented in this and the next table. It should be noted that the modes of several countries peak across more than one decade. In the table Spain, and to a lesser degree Portugal and Ireland, stand out as populations maintaining peak modes over several periods.

Germany, excluded from the table, is a deviant case with twin and separate peaks. In the empirical analysis on which this paper was based, Germany often turned out to be an unusual case, perhaps a function of the two rather different trajectories followed in the divided Germanys prior to the fall of the wall. This factor may have been

Table 1 Decade since 1950 in which peak numbers were at ages 0–14 years and deviation from WDCs as a whole

P (0–14)	1950s	1960s	1970s
Above WDCs	Finland	Australia	Ireland
	Japan	Canada	Spain
	The Netherlands	Iceland	
	Portugal	Ireland	
	Spain	Malta	
		New Zealand	
		Portugal	
		Spain	
		United States	
Below WDCs	Denmark	Austria	
	Greece	Belgium	
	Italy	France	
	Norway	Luxembourg	
	Sweden	Switzerland	
	Switzerland	UK	

WDC = Western Developed Countries (24 countries)
Germany is excluded as it is a deviant case, peaking in 1950 and again in 1970, but below the WDCs
Ireland and Malta span two periods, while Spain peaks across all three periods

Table 2 Speed of transition from mode at 0–14 years to mode at 60–74 years, in relation to WDC as a whole (spanning 60 years)

Faster than WDC	Equal to WDC	Slower than WDC	Do not ever have mode at 60–74 years
Austria	The Netherlands	Italy	Australia
Belgium	Switzerland	Japan	Canada
Denmark		Luxembourg	France
Finland		Sweden	Iceland
Germany			Ireland
Greece			Malta
Norway			New Zealand
Portugal			United States
Spain			
UK			

Malta's age group 15–29 was again the modal age group in 1990. This would imply a very short transition (20 years to 2030)

compounded by heavy immigrant flows into West Germany, bringing in large populations with rather different reproductive patterns.

In Table 2, the countries are classified in terms of the velocity with which they have moved from a situation when their mode was at 0–14 years to when it is at 60–74 years. Among the early agers are some populations that reach this phase very quickly. Depending on where the starting point is taken from, Malta could be seen as in the middle range, or as a country making an extremely rapid transition. In this case it would join the other Mediterranean countries excepting Italy. Japan and Italy are early agers, yet their transitions, as measured by the shift of the mode to older ages, are relatively slow. In those countries that never see their modal group reach 60–74 years in the projection period, France seems a somewhat aberrant case. Yet, throughout the period between 2000 and 2040 France stands out as a population whose age structure remains relatively evenly distributed and in which, as I will discuss later, wave effects are minimised.

To elaborate on this issue, Fig. 1 graphs the percents at each functional age group at the beginning (1960) and near the end (2040) of the modern age-structural transition for France, and uses Italy as a comparison. While France has a more plateaued distribution, especially in 2040, Italy moves from one that is left-skewed to one that is heavily skewed to the right. In 2040, other WDCs follow broadly one or other of the two patterns:

French: Australia, Belgium, Canada, Denmark, Finland, Iceland, Ireland, Malta, New Zealand, Norway, United Kingdom, United States

Italian: Austria, Germany, Greece, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland

The Benelux countries were most difficult to classify; in Luxembourg's case it proved impossible.

Moreover, as is shown in Table 3, there are also reversals. France along with several of the other countries that never have their modal age group at 60–74 years

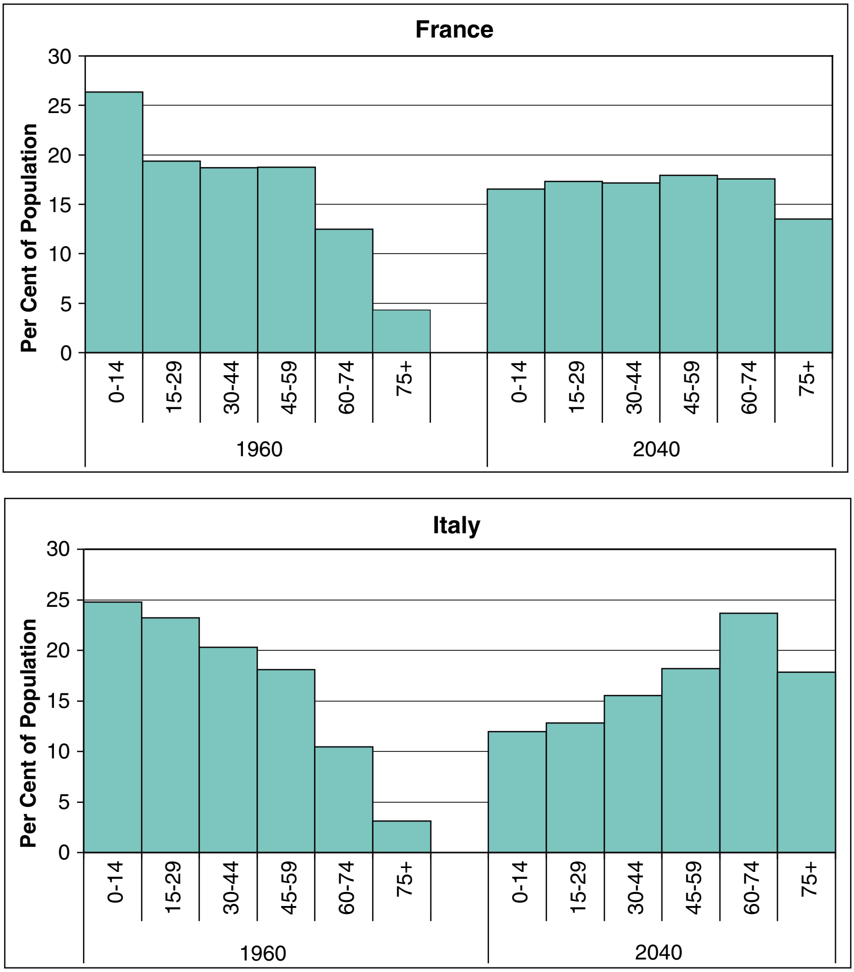


Fig. 1 Percent of the total at each functional age group, France and Italy, 1960 and 2040

actually also reverse their transitions. At first there is an increase at 45–59 years and then at 60–74 in the number of countries with modes at those ages. But from 2040 the number at 60–74 years declines and the number at 45–59 increases. This reverse wave even moves on to 30–44 years. These reversals not only occur for countries that have significant echoes to their baby booms (what I have called a baby-blip in the New Zealand context), and echoes to the echo, such as New Zealand and the United States, but other less evident cases such as Belgium, the Netherlands and Denmark. Echoes or blips come typically from fertility rates that are below those occurring in the baby-boom (50% lower in the case of New Zealand), but that have resulted in birth cohorts rivalling in size those of the baby-boom peaks (Pool 1999).

Table 3 Number of countries (of the 24 in the WDC grouping), each 5 years between 2000 and 2050 with their mode at a given 15-year age group

	0–14	15–29	30–44	45–59	60–74	75+
2000[a]	2	3	17	3	–	–
2005	1	2	18	3	–	–
2010[b]	1	2	7	15	–	–
2015	–	2	5	17	–	–
2020	–	2	3	19	–	–
2025	–	–	6	16	2	–
2030[c]	–	–	6	8	11	–
2035	–	–	4	5	15	–
2040[d]	–	2	1	11	11	–
2045	–	1	2	16	6	–
2050[e]	–	–	7	10	7	1[f]

When a country's distribution is bi-modal it is recorded twice (see subsequent notes)
[a]New Zealand bi-modal: 0–14, 30–44
[b]Austria bi-modal: 30–44, 45–59
[c]Norway bi-modal: 30–44, 60–74
[d]New Zealand bi-modal: 15–29, 30–44
[e]United States bi-modal: 30–44, 45–59
[f]This is Italy

In the other direction, it is Italy that is perhaps the most extreme 'ager'. Alone among all the countries included here, by 2050 it will have shifted its mode from 60–74 to 75+ years.

The perspective presented by the approach taken above is somewhat different from the conventional one. There is almost the need to raise the question whether or not the issue of population ageing has been exaggerated. Certainly at the end of the projection period far more countries will see their modes at 30–59 years than at ages above this.

More importantly this analysis of modes presages the later discussion in this paper. Looking at Table 3 one sees almost a wave and then an ebbing. I turn now to an analysis of these sorts of effects in order to show how turbulent the age transition will be for some countries.

Age-Structural Transitions: Population Waves and Their Troughs

The age-structural transitions producing these distributions in 2040 do not proceed smoothly, but instead each life-cycle stage is subject to population waves and troughs as large cohorts pass through and are succeeded by smaller ones.

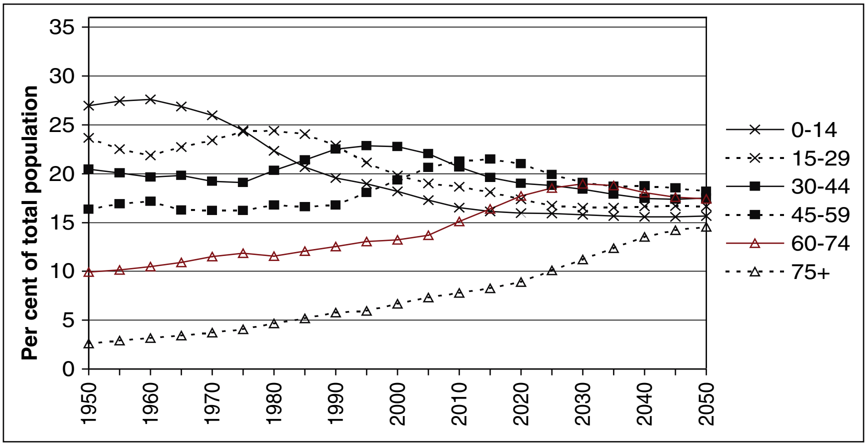


Fig. 2 Functional age distribution, western developed countries combined, 1950–2050

Figure 2 shows this for the WDCs as a whole[5]. In this case the progression, life-cycle stage by life-cycle stage is fairly regular and not too turbulent. The policy implications of this pattern are, however, rather significant. From one decade or so to the next policy makers will have to shift resources from a younger life-cycle stage to the subsequent one. These wave-effects have been most marked prior to 2000, whereas by the end of the period they flatten out.

When one turns to particular countries, as in Fig. 3, it can be seen that there are variations of three sorts. Firstly, in some cases marked wave-like effects continue beyond the early 2000s. While the general tendency is for the waves to diminish in intensity, at 60–74 years several of the countries are hit by marked waves that are followed by troughs. This wave then moves on to 75+ years, a point of significance for policy. The needs of younger elderly are different from the much older, yet jurisdictions may be faced by providing services for peak demands at 60–74 years, only to see demand fall off and needs transferred to the older age group.

Secondly, there are differences between countries around which life-cycle stage is affected. This means that policies will have to be country-specific.

Thirdly, for each country there are also a series of two or more waves, with their intervening troughs, hitting various life-cycle stages. In the last case, Japan, for example, will have experienced multiple-oscillation effects at each of the life-cycle stages 15–29, 30–44 and 45–59 years, and these will continue after 2000. Even age group 0–14 is subject to some minor wave effects at this time.

In Fig. 4, the age-specific changes are expressed as a rate per quinquennium. To standardise the rates so as to show the relative contribution of momentum on any functional age group, the rates take as a base the total population (all ages) at the

[5] Data on the WDCs as a whole reflect to a degree the experience of the largest country, the United States.

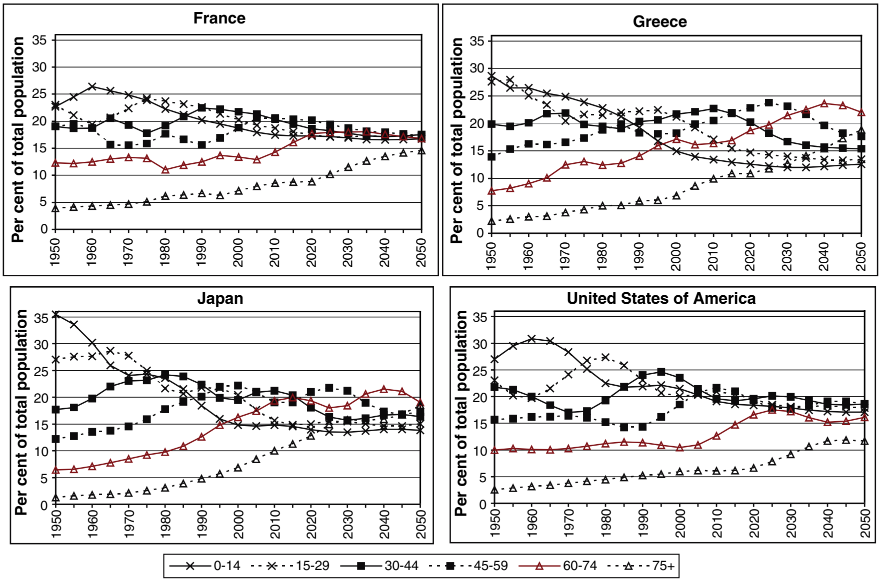


Fig. 3 Selected countries, functional age distribution, 1950–2050

beginning of each 5-year period. Three countries are used as examples. For France, the major trend, following a brief intense period at the start, is a dampening down over the long term, even at older ages. But in the other two cases, Greece and the United States, the early intense waves at younger ages translate, particularly for Greece, into waves and troughs at older ages.

The United States faces another interesting trend, paralleling what I have described already for New Zealand (Pool (1999); cited also in Pool (2000)). Over the next decade or so, waves will occur simultaneously at 15–29 and 45–59 years, but then over the next decade will shift to troughs, only to reappear as waves again after 2030. This illustrates two major points, both of which have policy implications. Firstly, waves belonging to different generations may hit simultaneously, raising the spectre of intergenerational competition for policy and familial resources. Secondly, peak demand for resources can be followed by a drop off in demand as a trough arrives. There is nothing new in this because, for example, the baby-boom had exactly this effect on demands for school and tertiary educational services, but so too has the baby-blip of the period 1988–1997 in New Zealand had a severe impact on school services.

For purely arithmetic reasons, the impact of these wave- and trough-effects can be more easily measured in populations such as New Zealand and the United States, which have positive and significant growth, and in a manner that yields a more dramatic picture than that here. Instead, a different standard (the size of the base year total population) has had to be used because some populations have

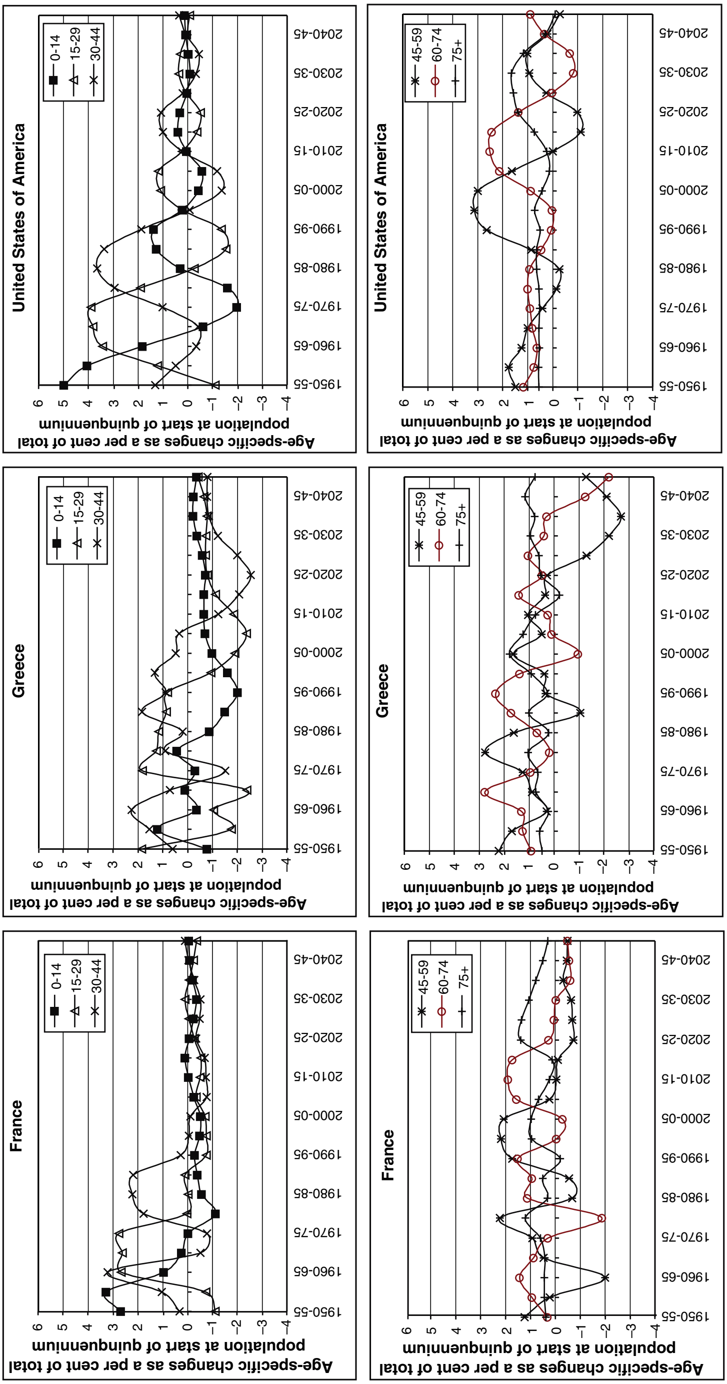


Fig. 4 Selected countries, rate of redistribution by age per quinquennium, 1950–2050

slight or negative growth trends. Using these measures[6] it can be shown that, over the period 2006 to 2016 in New Zealand, 20% of the total growth, due to the combined effects of positive momentum and natural increase, will be produced primarily by momentum (only a little by immigration) at one age group, 20–29 years, alone (Pool 1999).

Age-Structural Transitions: Co-varying Waves, and Co-varying Waves and Troughs

The problem of waves from different cohorts reaching different key life-cycle stages simultaneously has already been noted. But equally well, a trough arriving at one life-cycle stage may be accompanied by a wave at another. Both of these trends require monitoring to avoid the possibility of negative policy decisions being made. In the first case, there is the direct and obvious problem of competition for resources. In the second the problems may be more latent and a result of perceptions. The life-cycle stage facing a trough at any period may be discriminated against in terms of allocation, of resources, simply because it lacks a high demographic profile; equally well troughs could favour it in areas such as labour market demand, as has been true for depression era cohorts.

The occurrence of both co-varying waves, and co-varying waves and troughs, is shown in the graphs in Fig. 5. To represent this, I have taken two age groups with high levels of what Rindfuss, in his PAA Presidential Address (1991) termed 'demographic density'. He used this notion in the context of an analysis of the young adult years (represented here by age group 15–29 years). At these ages, a number of major life-cycle transitions occur more or less simultaneously: biological maturation, the ending of formal education, first entry into the full-time labour force, commencement of cohabitation and/or marriage and the start of family formation. These are also ages at which mobility peaks. We can carry this concept across to 60–74 years which sees a similar occurrence of major life-cycle events. These include retirement, often accompanied by migration; acceleration of biological ageing and increased risk of poor health and death; and more positively today, as the parents of couples starting late with childbearing, a transition to grandparent status.

In Fig. 5, the differences between the country-specific rates used in Fig. 3 and those for the WDCs are graphed for selected countries. Sometimes the percentages of the total population at the two high demographic density age groups peaks simultaneously, as is true for Japan and Greece around 2000.

More interestingly, there are differences between countries in the way their trends fit to those of the WDCs as a whole. After the first few years, France follows the WDCs fairly well. The United States fits less closely, with 15–29 years generally

[6] (P,x,t+n – P,x,t)/ (Sum Px, t+n – Sum Px,t). That is the proportion of the total population change in any time period contributed to by any age group x.

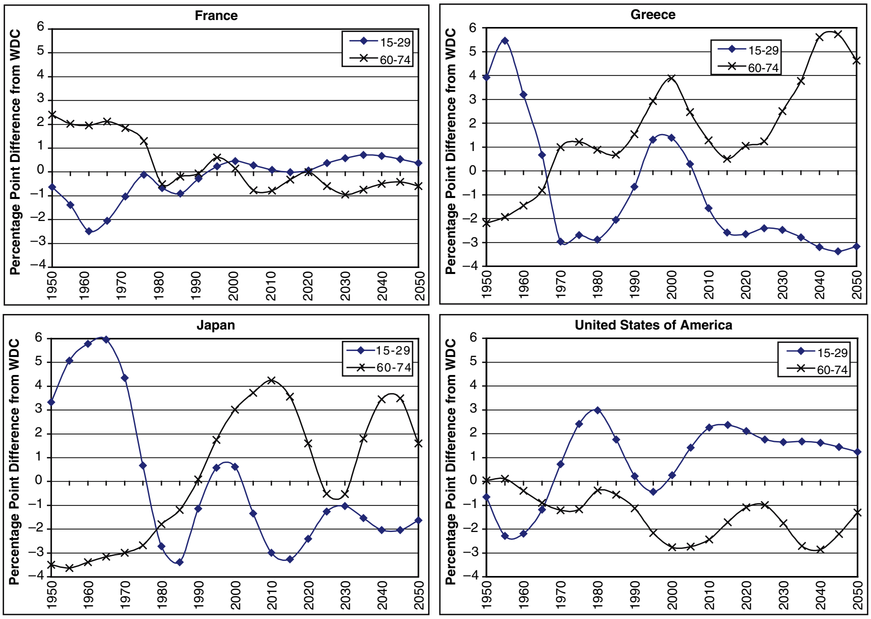


Fig. 5 Percentage point differences for high 'demographic density' ages, between western developed countries and selected countries, 1950–2050

above and 60–74 generally below, trends that could be seen as advantageous. In contrast, not only do Greece and Japan deviate quite markedly from the WDC pattern, but they do so in a way that can be viewed as disadvantageous: above for 60–74 years, below for 15–29.

Towards a Conclusion: Policy Implications of Age-Structural Transitions

This paper has turned to both conventional and non-conventional measures of age-structural transition and of what might be its final phase, ageing. It has also used modes as proxies for public perceptions of pressures coming from age-structural transitions and especially from ageing. The analysis has shown that the transition to ageing is not a simple process. It has shown that in the majority of WDCs the modal age groups will remain or be relocated below old age, even as low as early middle age. This raises two questions: what might constitute the end-point of an age-structural transition, and whether or not the conventional perspectives on ageing may lead to an over-dramatisation of the issue and, thus, to 'panic' among policy makers. More importantly, this may turn the attention of policy makers away from the needs of other age groups in the society.

Age-structural transitions are complex processes involving the movement over time of waves and troughs through the age pyramid. There are variations in the speed and timing of the transition and the intensity of the waves, but even France, that seems to face a relatively benign transition, will be subject to these. Many of the countries will see multiple and co-varying oscillations that may require responses that could lead to intergenerational competition for resources. Beyond this, the population waves may still be hitting younger age groups at a time when structural ageing, as conventionally measured (e.g. the per cent of the Total aged 65+ years) has already been reached.

These trends raise issues beyond simple dependency or generational accounting – who is taxed to pay for whom – but also requires a factoring of investment strategies. In particular there is a need to set priorities, between for example investment on age group 15–29 years, to form the human capital to help the economy grow and thus to be able to sustain ageing, or on the maintenance of services directed to 60–74 year olds.

The age-structural transitions also affect/are affected by policies that propose demographic responses to ageing: increased migration and fertility. Lest my argument here be mistaken as anti-immigrant, let me say that I strongly favour migration because I believe that it enriches the host society. But too often it is seen as a means either of priming the economy, or of providing the human resources necessary to meet rising aged dependency ratios. It must be recognised, however, that immigration is a highly age-specific phenomenon, so that while active immigrants are likely to inflate the sizes of cohorts at young adult ages, the new citizens eventually also age themselves. Moreover, family reunion policies that are a normal concomitant of active migration, typically allow the entry of older dependent relatives. Additionally, smaller more demographically vulnerable WDCs (such as New Zealand) may face highly age-specific emigration, particularly of the more skilled young adults, towards countries with larger more diverse economies. The general result is that migration can have the net effect of accelerating ageing; it could counterbalance it only if inflows were of a constant size and a constant composition onward to perpetuity. This is clearly an impossible precondition.

Furthermore, migration, particularly heavy age-specific inflows distort age structure and can increase the turbulence of transitions. The reality is that when changing cohort sizes produce trough phases, immigration will be advocated to meet gaps ‘not for demographic imperatives, but for economic [needs] and these will fluctuate … These [migratory] movements will only serve to accentuate the chaotic trends in the age-pyramids’ (Dittgen 2000: 24–25; translation present author).

Strategies to increase fertility, or at least to stem its decline, are currently very much to the fore in academic and policy debates, especially in Western Europe. These are very much targeted at the micro-level, at providing incentives or ‘family friendly’ policies that might lead couples to have children. But such targeting must be seen in the macro-level context of the effects of age-structural transitions. If there is a deficit of women at younger reproductive ages, then no incentive can increase dramatically the size of birth cohorts, regardless of the fertility levels of those couples having children. To illustrate this point, Fig. 6 shows the ratio between the

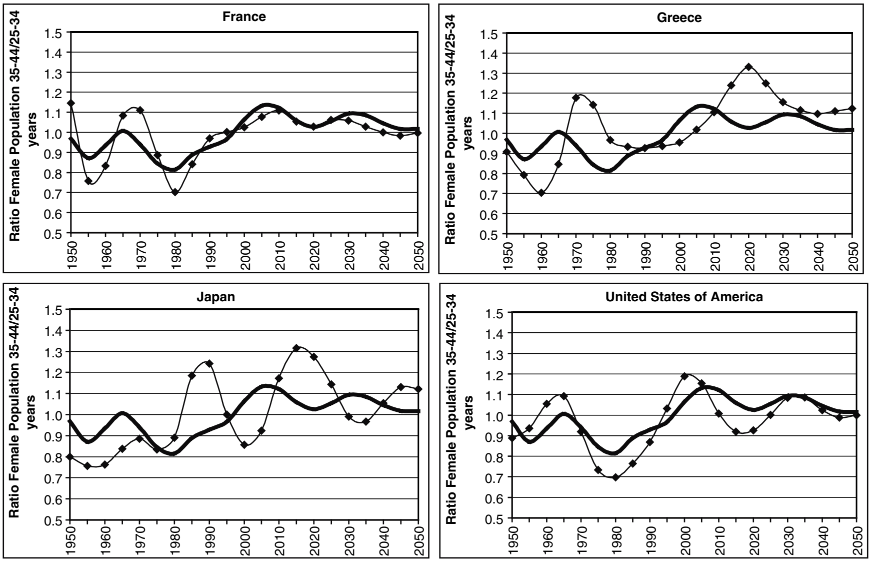


Fig. 6 Age-structural transitions, reproductive potential, ratio of number of women at the late reproductive ages to those at the most highly fecundable ages, selected countries and western developed countries,1950–2050 (*WDC Bold Line*)

number of women at older reproductive ages and women at more fecund ages. Curves in bold relate to the WDCs as a whole so as to provide a comparison. Ratios above one are less favourable to reproduction; below one they suggest a higher potential. For much of the period between now and 2050 the potential is limited, although both Japan and the United States have longer periods, and France a shorter less intense one, when the potential increases. But these will all be less than would have been the case for the United States over the 1990s.

This paper has painted a fairly bleak picture for the WDCs. But these societies, certainly our media and politicians, tend to be introspective, seeing our age-structural transitions and our ageing as a demographic phenomenon having uniquely severe consequences. In part this is because our elderly are a dis-proportionally high per cent of all the elderly of the world.

To remind us that our problems are in fact minor by comparison with those faced by some economies in transition in Fig. 7 I have graphed France at the same scale alongside three different transitional societies. One of these countries has relatively less marked multiple oscillations (Argentina), but at levels far in excess of what is seen in WDCs. The second (China) has extreme multiple oscillations, the outcomes of a series of severe demographic regimes in the recent past. Finally, Mexico has a simple but marked oscillatory pattern, the effect of a rapid decrease in fertility. But it is sobering that all these three societies face far more marked population waves and troughs than does France. In age-structural transitions as for most other socio-economic and demographic trends the world is not an equitable place.

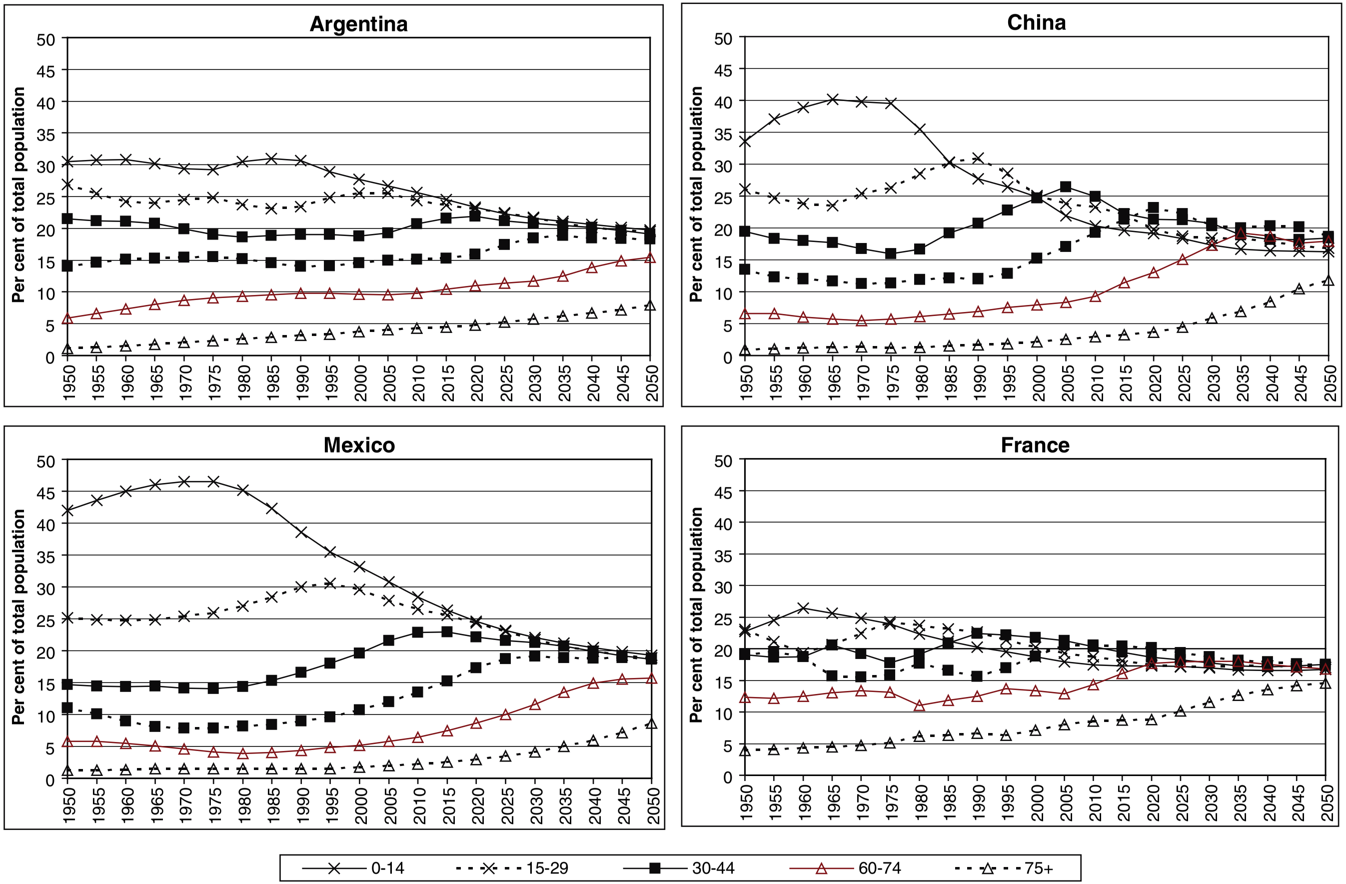


Fig. 7 Selected societies in transition compared with France, functional age distribution, 1950–2050. Note: Scale differs from that used in Fig. 3

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On Age Structures and Mortality

Nico Keilman

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The age structure of any population is shaped by the processes of fertility, mortality and migration, and for a human population it reflects the net effect of those processes during the previous 100 years. When the levels of fertility, mortality and migration have been constant for a long time, the age distribution is also constant. Numbers in each age group may grow or fall over time, depending on the balance between fertility and immigration on the one hand, and mortality and emigration on the other – but their relative share in the total population remains unchanged. When the age distribution varies over time, it signals changing levels of fertility, mortality and migration. The purpose of the present paper is to review the literature that deals with the following question: What lessons can we draw from changes in the age structure of the populations in industrialized countries? Given the interest in the industrialized world for issues connected to the *elderly*, the focus will be on what we can learn about the level of mortality, and changes therein, based on age-structural transitions.

Given the sum of two numbers A and B, we cannot infer A and B from that sum alone. Only by adding extra information can we compute them, for instance when their difference is also given, or their product. Similarly, since the current age structure is the *net result* of historical age-specific fertility, mortality and migration, we are unable to infer the levels of the components of change from the age structure alone. Extra information is needed, for instance:

1. The population is closed to migration.
2. Fertility and mortality rates have been constant for a long time.
3. Growth rates are the same for each age group and they are independent of time.
4. Growth rates are constant in time, but differ between age groups.
5. The age patterns of fertility and mortality are known, but not their levels (e.g. TFR or life expectancy).

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Frequently, the extra "information" is merely an assumption, sometimes a very strong one. For instance, the combined assumption that a closed population (no. 1) has constant growth rate (no. 2) and constant age distribution (no. 3) defines a stable population. This assumption may be realistic in some cases, but more often, it is not. A population in which the growth rates of age groups are independent of time, but differ across age groups is called a variable growth rate population. The assumptions underlying this model are weaker than those for the stable population, and therefore more realistic when one knows that the population is not stable. Yet, the assumption of a stable population is widely used in demography for the following two reasons.

1. Because the assumption is such a strong one, there are also strong mathematical relationships between population size, age structure and fertility and mortality levels in a stable population. These relationships can be used to arrive at powerful conclusions that would be impossible with a weaker assumption.
2. The mathematical relationships mentioned above are good approximations in many cases, in particular when deviations from stability are the result of changing mortality levels, with the changes more or less evenly spread over many age groups.

Information or assumptions of the types 1–5 above may be used in combination as already mentioned in connection with the notion of a stable population. Similarly, we may have more than one observation of the age structure and combine those data with one or more assumptions. Examples of such combinations will be given in the sections that follow. The first section discusses stable population theory and shows how an age structure may be used to infer mortality levels. Most of the theory was developed before 1960 and has been widely applied up to today. The variable growth rate method of the second section emerged in the 1980s and relaxes some of the strong assumptions of a stable population. It is much less used than the methods of stable population theory, not only because it is of more recent date, but also because it allows less powerful conclusions. Two entirely different techniques, that of inverse projection and the closely connected method of back projection were developed in the 1970s and 1980s. They are presented in the third section on "Inverse projection, back projection and generalizations", together with a recent generalization that encompasses both: generalized inverse projection. Next, the section on "Errors in historical projections of age structures" discusses what we can learn about mortality when we compare age structures observed in the recent past with historical *projections* of those age structures. The accuracy of age structure projections for the elderly leads us in a natural way to the question of how we can improve the accuracy of mortality forecasts. In the section on "Improving forecasts for the elderly", causality runs from (future) mortality to (future) age structures.

Important applications of stable population theory and variable growth rate theory involve checking the quality of the available data. When a population is known to be stable, but its data cannot be fit to the stable model, one should suspect incomplete registration. Applications of this kind will not be given in the first and second sections, as the focus is on industrialized countries. In other words, unless explicitly stated, it is assumed that all data used in the empirical examples are of sufficient quality.

Stable Population Theory

Alfred Lotka developed stable population theory in the first half of the previous century[1], although Leonard Euler (in 1760) and Joshua Milne (in 1815) made early contributions. Ansley Coale (1987) gives an overview. A population is said to be stable when:

- It is closed to migration, i.e. when net migration is zero at all ages
- Both its crude birth rate and crude death rate are independent of time
- Its age distribution is independent of time

A large number of mathematical relationships have been derived between indicators for fertility, mortality and the age distribution of a stable population. These expressions, some of which will be given below, have been used to estimate demographic measures from incomplete data and to adjust inaccurate population statistics.

The relationship between the age distribution of a stable population and its levels of fertility and mortality is

$$c(a) = be^{-ra}p(a), \tag{1}$$

where a represents age, r is the growth rate of the stable population, $c(a)$ is the share of the population aged a, b is the birth rate and $p(a)$ is the share of the population that survives from birth until age a ("probability of surviving to age a"). Since age is defined here as a continuous variable, $c(a)da$ is the population's share aged between a and $a + da$, to be more precise. Integration of (1) gives the following expression for the life expectancy at birth e_0:

$$e_0 = \frac{1}{b}\int_0^{\varpi} c(a)e^{ra}\,da. \tag{2}$$

In empirical applications, data for the age structure $c(a)$ alone are obviously not sufficient to determine the characteristics of the stable population. But given an initial estimate of $p(a)$, (1) can be rewritten as

$$\ln\left(\frac{c(a)}{p(a)}\right) = \ln(b) - ra, \tag{3}$$

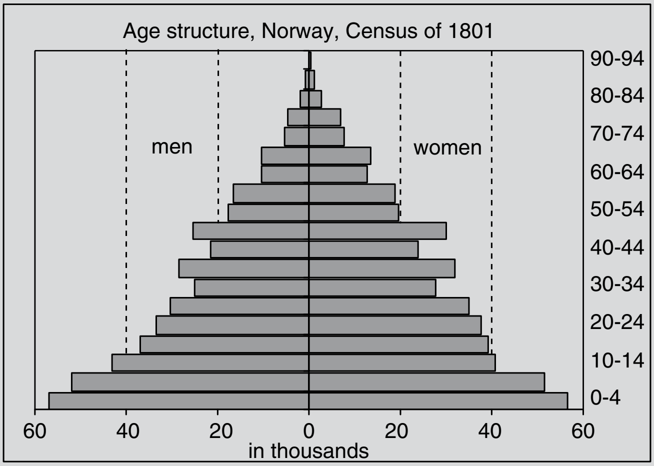
and a regression over a results in estimates for b and r (Keyfitz et al. 1967). However, an approach that avoids regression has become more popular. It is based on tabulated values of the age distribution $c(a)$ of stable populations with varying levels of the growth rate r, the birth rate b, the life expectancy e_0 and the age pattern

[1] Lotka and Sharpe (1911). See also Lotka's *Analytical theory of biological populations*. New York: Plenum Press, 1998 (Plenum Series on Demographic Methods and Population Analysis). This is an English translation of the work that Lotka published in the two-part *Théorie Analytique des Associations Biologiques* in 1934 and 1939, and represents Lotka's contributions to the field of demographic analysis.

of mortality $p(a)$ (see Coale and Demeny 1983). The idea is, first, to select an initial model life table (i.e. an age pattern $p(a)$ and a mortality level e_0) and next to find a stable population for which the age structure closely resembles that of the empirical population[2]. The goodness of fit indicates whether or not one should choose a different life table. When the stable population has been identified in Coale and Demeny's extensive tabulations, the corresponding growth rate r and birth rate b can be read off, as well as numerous other quantities for this particular population. Box 1 contains an empirical example for Norway with data from its population census of 1801.

Box 1 Application of stable population theory to Norway's age distribution in 1801

The Population Census of 1801 in Norway is generally believed to be of high quality (Drake 1969). The age pyramid below suggests that the population might have been nearly stable. Norwegian crude birth and death rates were rather constant at 30–32 and 24–26 per 1,000, respectively, in the period 1735–1801 (Drake 1969, Table 3.6). Age groups between 25 and 45 signal non-stability, although some digit preference probably also contributed to the irregularities. By working with cumulated age groups, this problem will have only minor impact on the findings.



(continued)

[2]In practice one does not work with the age distribution $c(a)$, but with the cumulative distribution $C(a) = \int_0^a c(\alpha)d\alpha.$ This way one avoids problems caused by irregularities in the empirical age structure due to digit preference, age heaping and shifting. Probably this is an important reason why the regression approach is not widely used.

Box 1 (continued)

I compared the cumulated age distributions $C(a)$ for men and women to those of stable populations based on Regional Life Tables Model North of levels 11–15, i.e. life expectancy values of 45–55 for women and 41.8–51.4 for men. For successive values of a, I found the stable growth rate by interpolation between tabulated growth rates. A perfectly stable population should result in the same interpolated growth rate for each a. In empirical applications, interpolated rates vary by age. Variation across levels was lowest for level 12, the standard deviation in the rate over ages 15–70 being 1.1 and 0.7 per thousand for the two sexes. The mean interpolated growth rates were equal to 12.2 and 10.2 per thousand for men and women, respectively. This suggests a life expectancy of around 45 years before 1801.

For men aged 35–39 or 65–69, and women aged 30–34, 40–44, or 70–74, the estimated growth rates were remarkably lower than those for other age groups. Exceptionally low birth rates and high death rates in the 1740s and 1770s explain some of these effects (Drake 1969).

The approach outlined above starts from an assumed level and age pattern of mortality. Thus an important issue is how sensitive the results are for the choice of a particular life table. In other words, how do the characteristics of the stable population change when the mortality pattern changes? There is no general analytical answer to this question, but the effects are probably not large for actual populations. Coale (1972) and Keyfitz (1985) have analysed the case in which the mortality change is the same for all ages. Assume that all age-specific death rates are reduced by an amount k. In that case, it can be shown that the age distribution of the population is not affected, that the growth rate increases by k, that the birth rate is unchanged and that the death rate reduces by k.[3]

Closely related is the concept of a quasi-stable population, defined as a population, in which fertility has been approximately constant, while mortality has steadily declined over the past few decades (Bourgeois-Pichat 1958). Such a population has an age distribution, which differs little from that of the stable population implied by current fertility and mortality schedules.

When a population's age distribution is measured at two successive censuses, two sets of fertility and mortality indicators can be inferred, one for each census. Next, we can combine the birth rate from the first census with the life table from the other. This will tell us to what extent the mean age, or the dependency ratio, or any other indicator derived from the age structure, has changed over the period between

[3] When the reduction of the death rates varies by age, the age distribution of the stable population is changed in such a way that age segments with the strongest mortality reduction get more weight. The typical mortality decline has been strongest below age five. As a result, mortality declines have, throughout human history, tended to make populations younger (Preston et al. 2001, p. 160).

the two censuses as a result of changes in mortality or in fertility (Keyfitz and Flieger 1969). An important assumption is, of course, that the population be stable at both points in time. Such an analysis requires that one calculate a hypothetical age distribution based on a given birth rate and a certain life table. This can be done based on expression (1), provided one knows the intrinsic growth rate *r* of the stable population. The latter is achieved by solving *r* from Lotka's fundamental equation

$$\int_{\alpha}^{\alpha} \phi(x) e^{-rx} dx = 1, \tag{4}$$

where $\phi(x) = m(x)p(x)$ represents the net female fertility rate at age *x*. Coale (1957) describes an iterative algorithm for determining *r*, which converges quickly.

Variable Growth Rate Method

The methods outlined in the previous section assume that the population is stable, quasi-stable, or nearly stable. For industrialized countries nowadays, this is an unreasonable assumption. Following low fertility levels in the 1930s, many of these countries experienced a baby boom in the first two decades after the Second World War and a drop in fertility in the 1970s. At the same time, female life expectancy increased continuously – for men there was a temporary stagnation in the 1960s. Industrialized countries in Eastern Europe showed dramatic declines in fertility around 1990, and life expectancies improved hardly or not at all between 1985 and 1995, in particular for men. Because of these developments, fertility and mortality cannot be assumed to be constant, which means that the assumption of a stable population is too strict. The variable growth rate method relaxes that assumption. Whereas a stable population displays a growth rate that is constant, both with respect to age and time, the variable growth rate method assumes rates that may be dependent on age.

Various authors have contributed to the theory around the variable growth rate method, in a series of papers that were published in the first half of the 1980s (Bennett and Horiuchi 1981; Preston and Coale 1982; Arthur and Vaupel 1984). These papers followed on the work of McKendrick (1926) and Von Foerster (1959), among others. Bennett and Horiuchi started from the McKendrick-Von Foerster partial differential equation, which relates the rate of change in population size with respect to age and time to the force of mortality at that time. Preston et al. (2001) give a useful overview of the theory and various applications. For the purpose of the present paper it suffices to note that Eq. 1 for the age distribution of a stable population, which is closed to migration, is modified to[4]

[4] Expression (5) can be generalized to include migration, by incorporating an age-specific net migration rate. The net migration rate is the difference of the immigration rate and the emigration rate. Note that the immigration rate is not a rate in the demographic (occurrence-exposure) sense, as the population exposed to the risk of immigration to the country is not included in the immigration rate.

$$c(a,t) = b(t)\exp\left[-\int_0^a r(x,t)dx\right]p(a,t), \tag{5}$$

where $p(a,t)$ is now an expression of the proportion that would survive to age a according to the mortality schedule at the moment t for which $c(a,t)$ is the proportion at age a. The growth rate $r(x,t)$ expresses population growth during an infinitesimally short time interval from t to $t+dt$ for the fixed age group x. Note that when the growth rates are independent of age and time ($r(a,t)=r$ for all a and t), the integral in (5) reduces to $r\, a$, cf. expression (1). In order to infer a mortality schedule from an observed age structure, both sides of Eq. 5 are multiplied by total population size at time t and solved for $p(a,t)$. The result is

$$p(a,t) = \frac{N(a,t)}{N(0,t)}\exp\left[\int_0^a r(x,t)dx\right]. \tag{6}$$

Expression (6) tells us that a mortality schedule can be derived from knowledge of the age pyramid $N(a,t)$ and the age-specific growth rates $r(x,t)$. $N(0,t)$ denotes births at time t. For an actual population the rates can be computed based on the age pyramid of two subsequent years. Box 2 illustrates the method for the case of Norway 1850–1995.

Box 2 Mortality schedules computed on the basis of the variable growth rate method, Norway, 1850–1995

Statistics Norway generously provided me with unpublished data on the population of Norway by 1-year age group and sex at 1 January of each calendar year beginning in 1846. First, I used the discrete-time version of expression (6), i.e.

$$\frac{L_a}{l_0} = \frac{N_{a,t}}{B(t)}(1+r_{1,t})(1+r_{2,t})\ldots(1+r_{a,t}).$$

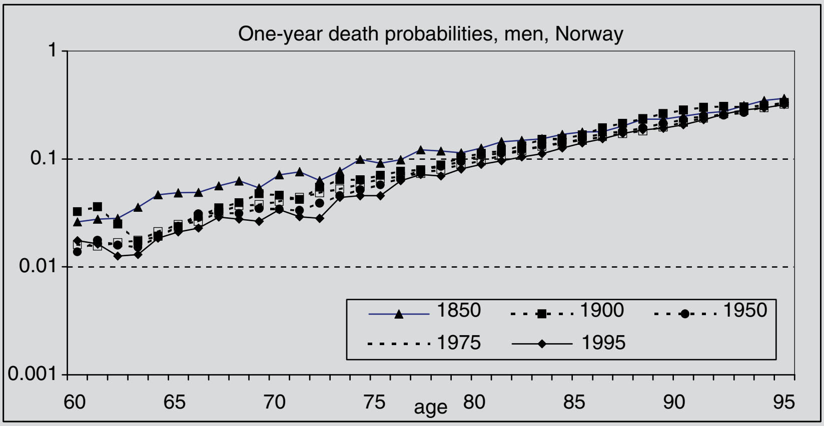
Here $N_{a,t}$ represents the population in age group (a, a + 1) at time t, $r_{a,t}$ is the growth rate for age group (a, a + 1) at time t, L_a represents the life table stationary population in age group (a, a + 1) at time t, and $B(t)$ is the number of births in year t. Assuming that the life table radix l_0 equals 1 (i.e. scaling L_a such that it is expressed per one person), and furthermore assuming that $l_a = ½[L_{a-1} + L_a]$, $a > 0$, I found for the 1-year probability of dying q_a at time t the following expression:

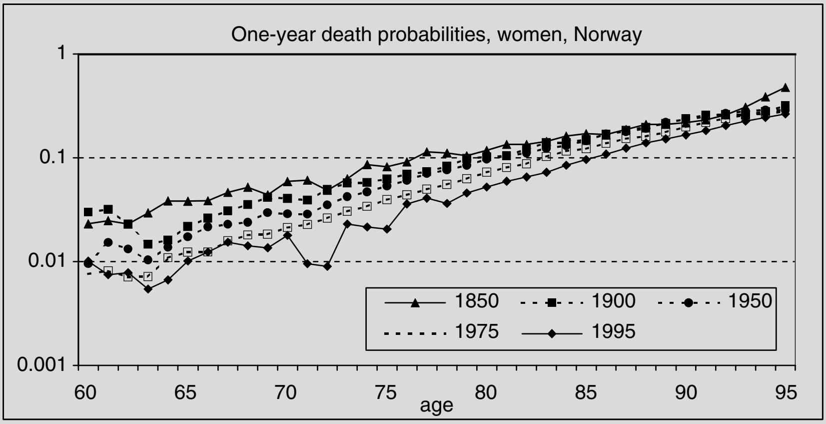
$$q_a = 1 - \frac{l_{a+1}}{l_a} = \frac{N_{a-1,t} - N_{a+1,t}(1+r_{a,t})(1+r_{a+1,t})}{N_{a-1,t} + N_{a,t}(1+r_{a,t})}, a > 0.$$

(continued)

Box 2 (continued)

Next, I computed the growth rates as $r_{a,t} = [N_{a,t+1}/N_{a,t-1}]^{½}-1$, and inserted these in the expression above. The growth rates are the net result of mortality, immigration, and emigration. Migration can be disregarded for ages 60 and over, but not for younger ages. Therefore, I limited myself to the elderly.





The graphs plot 5-year moving averages. They show two distinct features. First, the relative mortality reduction since 1850 was stronger for the youngest than for the oldest old. This led in turn to a rectangularization of the survival curves for both sexes (Mamelund and Borgan 1996, 39–40). Second, the decrease over time was quite uniform for women, although accelerating during the past 50 years. For men the strongest reductions occurred in the second half of the nineteenth century.

Inverse Projection, Back Projection and Generalizations

Several methods have been used by historical demographers to infer time series of vital rates and age structures from a known or assumed age structure, together with time series of annual or quinquennial births and deaths. Ronald Lee introduced in 1974 a technique called 'inverse projection'. Given an age and sex structure at time $t = 0$, and a series of birth and death counts for the period $(0,T)$, the method computes mortality rates, fertility rates and age structures for the years $(0,T)$. It assumes that the age schedules of both fertility and mortality depend on a single parameter and that the population is closed to migration. The method proceeds from one time interval unit (1 or 5 years) to the next. For each interval, it computes a preliminary number of deaths based on the starting population by age and an initial schedule of age-specific death rates. The mortality schedule is scaled up or down on the basis of the observed number of deaths. The death rates thus obtained are used to survive the population to the end of the interval. Finally, birth rates are applied to the mid-period female population of reproductive ages, and these rates are adjusted so as to produce the correct number of births. The assumption of a closed population has been relaxed in later versions of the method (Brunborg 1976, 1992; Lee 1985): when population counts are known from more than one census, migration is determined by comparing intercensal population growth with natural growth. McCaa (1989, 1993) has developed the PC program 'Populate' which includes these and other features. Box 3 gives a summary of Brunborg's application of the inverse projection method to the case of Norway, 1736–1970.

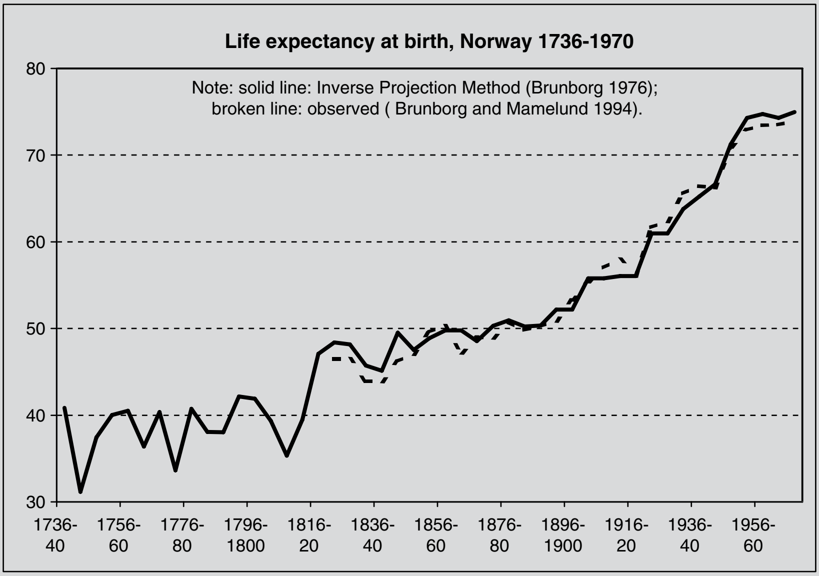
Box 3 Brunborg's application of the IP-method to Norway, 1735–1974

Brunborg (1976) used annual data on births and deaths from Drake (1969) for the years 1735–1769, and official data for the period 1770–1974 (Statistics Norway 1994). Both series suffer probably from underregistration and other errors. Norway's first census was held in 1769, but the recorded age distribution is inaccurate (Drake 1969). Brunborg computed total population in 1735 on the basis of birth and death counts for the period 1735–1769, and total population in 1769. An assumed stable age distribution corresponding to level 8 Model North mortality, with crude birth and death rates equal to 31 and 26 per 1,000 resulted in an estimated age distribution for 1735. The choice of the stable age distribution is not crucial for the results after ca. 1800, see footnote 5. Brunborg selected Model North life tables at levels 7 ($e_0 = 33.5$ for men and women combined) and 24 ($e_0 = 75.9$) as the basis for the range of mortality schedules. The fertility schedule was an average for 1874–1876 and 1889–1892 (the oldest available schedules at that time), with a mean age at childbearing of 33.2 years, and the migration schedule was based on data from 1866–1895. The general pattern for the life expectancy

(continued)

Box 3 (continued)

(and the Net Reproduction Rate) is reproduced well compared to observed values. Brunborg found also that estimated proportionate age distributions in 1801, 1875, and 1966 were very close to observed values: most differences (10-year age groups) were smaller than 0.4% points, and none exceeded 1.2% points. One may conclude that life expectancy was between 35 and 40 years in the eighteenth century, and considerably lower in crisis periods (1741–1745: 31.2; 1771–1775: 33.6).



Brunborg's life expectancy values are 5–10 years lower than those obtained on the basis of stable population theory (Box 1). Several explanations are possible.

1. Brunborg's birth data may suffer from underregistration. McCaa (1989) analyses the sensitivity of Brunborg's life expectancy estimates for underregistration of vital events. From McCaa's Figure 1 I estimate that a continuous underregistration of births by 10% implies life expectancy values that are too low by 3–5 years in the last three decades of the eighteenth century. Although this explanation in itself is plausible, one may object that the most likely source of birth underregistration is infant mortality, which must have resulted in too low counts for deaths as well. McCaa finds that a 10% underregistration of deaths counteracts the effect of too low birth counts by about the same number of years of life expectancy. On the other hand, stillbirths unduly registered as deaths but not as births, may have led to too low life expectancies.

(continued)

Box 3 (continued)

2. The 1769 census (723,000) may have underreported total population size. Drake (1969) assumes that the official figure was too low by about 19,000, or 2.6%. If the error is the same for all ages and the number of deaths is fixed, the one-parameter mortality schedule results in death rates that are too high by 2.6%. This means that the life expectancy is too low by an amount of $0.026.H.e_0$, where H is Keyfitz' concentration index (Keyfitz 1985). By definition, H is lower than 1 – for pre-industrial Norway it is probably around 0.5 (Model North at level 12 gives H-values equal to 0.52 for men and 0.48 for women). With a life expectancy of around 40 years, the undercount in the census of 1769 explains roughly half a year of the life expectancy difference, but certainly not more than 1 year.
3. Brunborg's results are not entirely reliable before 1800, due to the arbitrary choice of the age distribution for 1735 (Model North, level 8). After 1800, the initial age distribution is washed out. Unfortunately, we do not know how sensitive the life expectancy estimates before 1800 are for different choices of the stable age distribution in 1735.
4. The 1801 population was not stable. Fertility and mortality levels between 1735 and 1801 do not indicate any severe deviation from stability (Box 1), but there was probably some emigration (around 270 persons per year, or 0.3 per thousand, according to Drake's estimates). If this is accepted, the stable population estimate for the life expectancy in Box 1 should even be *higher*, but only slightly so.

In spite of the fact that IP rests on weaker assumptions than stable population theory, all in all I assume that Brunborg's life expectancy estimates are too low, for two reasons. First, because the deaths data he used included stillbirths. The effect on life expectancy is stronger than McCaa suggested, because the overregistration of deaths was concentrated in the first few weeks of the life span. McCaa used a one-parameter life table, and thus he assumed implicitly that the overregistration was evenly spread over the entire age span. Second, because the choice of level 8 Model North stable age distribution in 1735 was too pessimistic.

Unlike projection by the traditional cohort-component method (CCM), inverse projection (IP) starts from birth and death counts and infers age-specific vital rates. CCM computes births and deaths on the basis of age-specific vital rates. Both methods proceed forward in time. 'Back projection' (BP) goes backward. The method was developed by Wrigley, Schofield and Oeppen, see Wrigley and Schofield (1982). It starts with a known age structure at time T and births and deaths counts for an *earlier* period $(0,T)$. Next, using a number of assumptions, it calculates age structures for that period, as well as age-specific vital rates and net-migration. Unlike IP, where population totals are specified externally (so that migration can be handled), BP computes population totals within the model. BP has been criticized on two grounds (Lee 1985). First, the model is underidentified: for T periods, the BP-model has T more unknowns than equations. Therefore *ad hoc* assumptions are necessary. Second, the weak ergodicity principle states that any two age structures, however different, that are submitted to the same series of fertility and mortality rates will eventually converge towards the same age structure[5]. This implies that BP selects one path of the demographic variables from among an infinity of reasonably smooth paths, and thus any number of alternative but equally plausible paths may be constructed.

Further work by Jim Oeppen (1993a, b) attempted to respond to Lee's critique, in particular the first point. This resulted in a general method called Generalized Inverse Projection (GIP), which can be related to both IP and BP. Like IP, GIP assumes one-parameter families of age schedules for mortality and migration. The aim of GIP is to estimate a series of mortality and migration parameters that correspond to the period for which birth and death counts are available and, simultaneously, a series of population age structures that are consistent with the data and the parameters. (Fertility schedules are not required for computing age structures – births are given.) First, Oeppen expresses the general equations for population movement, defining the population aged a at time t, $N_{a,t}$, as a function of $N_{a-1,t-1}$ together with the death probability and the emigration rate, both at age a. Births in $(t - 1,t)$ are related to $N_{0,t}$ by means of the appropriate survival probability and migration rate. Next, migrants result from the migration rate and the mid-period population, while deaths are computed based on the death probabilities, the population at the beginning of the period and the number of migrants. Starting from an assumed initial population $N_{a,0}$, subsequent application of these equations results in a system of non-linear equations with the totals of births and deaths for each of the T periods and age groups at time T, as given. For K age groups, there are $T + K$ equations and there are $2T$ parameters to be estimated – a scaling constant for mortality and one for migration in each period. The GIP-method estimates these parameters, given the constraints, by minimizing a penalty function which contains three terms: one for the relative deviations in estimated and observed deaths, one for the deviations in the age structure at time T and a third one with period-to-period fluctuations in the migration scale parameter. Thus, the method obtains an optimal fit of the model to the data on deaths and final age structure, while at the same time the migration parameter changes as little as possible. Additional information, for example, known population sizes or age structures for censuses before time T, can easily be included in the penalty function. If the initial population structure $N_{a,0}$ is given, instead of the final structure $N_{a,T}$, the method solves the IP problem (GIP-IP). If the final structure is given, GIP is reduced to BP (GIP-BP).

[5] This is exactly the reason why the starting age structure of IP is not critical. For example, starting from two very different stable populations (female, North, $e_0 = 47.5$, $r = 0$; and female, North, $e_0 = 27.5$, $r = 0.01$) for the case of England in the period 1540 to 1871, Lee (1985) finds converging IP-results after a few decades already.

Oeppen has tested the BP-version of the method on various data sets, including Brunborg's data for Norway since 1735. Total population was estimated very accurately, even on the basis of the *total* population for *only 1* year (1980), together with quinquennial births and deaths counts. I compared Oeppen's unpublished estimates for the Norwegian population by 5-year age groups for the years 1850, 1870, 1890, …, 1970[6] with official data and found that errors in the proportionate age structure never were larger than 1.2% points. Averages over the age groups for the absolute errors ranged from 0.19% to 0.33% points for these 7 years. Thus for this particular data set, GIP-BP reproduced observed age structures very accurately. The net migration estimates were considerably smoother than the 'observed' values, but this can be improved by giving less weight to the migration smoothness in the penalty function. Similar conclusions hold for data from England 1801–1871. It turns out that Oeppen's GIP-BP estimates are very close to the original ones of Wrigley and Schofield obtained by BP. Other applications that produced excellent fits for the age structure are those for Denmark 1665–1840 and Amsterdam 1681–1920 (see Johansen and Oeppen 2001; Van Leeuwen and Oeppen 1993).

GIP-BP does not resolve the problem connected to weak ergodicity. Oeppen assumed that the initial population is stable and estimated its growth rate from the series of births. Alternatively, it could be estimated from the deaths series, or it could be made endogenous and estimated by the method. Different estimates of the growth rate will produce different initial populations. In one application (England 1540–1871; see Oeppen 1993b Table. 2.1[7]), the initial population estimated by GIP-BP fell linearly by 36% when the growth rate was increased from zero to 10%, with strong implications for the estimates of the first decades after 1540. After about 50 years, the initial differences were washed out. In other words, GIP-BP results are not reliable for roughly the first 50 years, due to the weak ergodicity principle. GIP-BP shares this characteristic with IP, unless the initial age structure is known for IP.

It is surprising that GIP-BP produces reliable empirical results, in spite of the weak ergodicity problem mentioned above. One possible explanation is that the number of feasible solutions is severely restricted by the fact that age-specific mortality depends on only one scaling parameter.

Errors in Historical Projections of Age Structures

Age structure forecasts reflect *expected* changes in fertility, mortality and migration levels. Thus, when old forecast results are compared to actual figures, *errors* in projected age structures reflect *unexpected* developments of the components of change.

The cohort component method (CCM) is the standard method for preparing a population forecast. In the CCM-tradition, forecast errors occur for two reasons: assumptions on fertility, mortality and migration may be wrong, or the forecast may be based on inaccurate data. The latter source of forecast errors is frequently

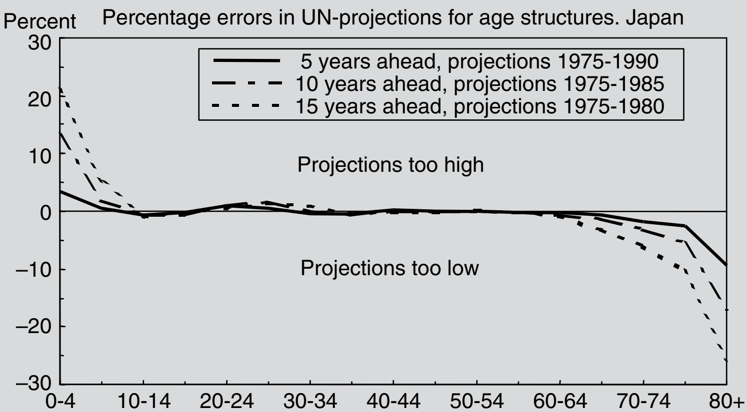
[6] Generously provided by Jim Oeppen (2001) (personal communication).

[7] There is a printing error in Oeppen's Table 2.1: growth rates are too low by a factor ten.

observed for less developed countries, where data quality often is poor (Keilman 2001). In the present paper, the focus is on industrialized countries and, therefore, I shall assume that inaccurate age structure forecasts are only caused by wrong assumptions for the components of change.

Errors in projected age structures for various industrialized countries turn out to have a common pattern. The errors are large and positive for young age groups and more or less equally large but *negative* for the elderly. The overprojections among the young in the 1970s indicated unforeseen sharp declines in birth rates. The elderly were underestimated, because forecasters have been too pessimistic regarding mortality, in particular for women. (There is one exception, however. For middle-aged men in the 1960s, life expectancy forecasts were too *optimistic*, due to unforeseen mortality increases caused by neoplasms, cardiovascular diseases and motor vehicle accidents, see Preston 1974.) This error pattern for age structure projections made by the UN was found for Northern America, Europe, Latin America and Oceania (Keilman 2001), and in projections prepared by statistical agencies in developed countries such as Canada, Denmark, the Netherlands, Norway and the United Kingdom (Keilman 1997). Box 4 illustrates the case of Japan, based on UN projections since 1975. Data from the 1998-round of UN projections were taken as actual.

Box 4 Errors in age structure projections



I calculated mean percentage projection errors by age group, the means taken over successive UN projections, controlling for duration. The figure shows a systematic underprojection of the number of elderly, caused by too pessimistic mortality projections. Japan's life expectancy increased from around 75 years in the mid-1970s to almost 80 years, 20 years later. However, UN life expectancy projections were consistently too low by 1.3–1.9 years in that period (Keilman 2001).

Improving Forecasts for the Elderly

*[**Note:** The discussion in this section reflects the literature as of early 2002. During the past few years, two important developments have taken place, which are relevant for the conclusions below. First, the findings of a series of reports on mortality forecasting in industrialized countries (Palmer 2003–2007, see Social Insurance Studies volumes 1–5, http://forsakringskassan.se/sprak/eng/publications/) suggest that a statistical approach to predicting life expectancy and survival is to be preferred over a causal approach. Second, Alho's approach to stochastic population forecasting (the so-called Program for Error Propagation, or PEP model, see Alho and Spencer 2005) has become the benchmark for preparing and using such forecasts (Tuljapurkar 2008). It has been applied to a large number of individual countries, as well as to a group of 18 European countries (Alho et al. 2006, 2008; Alders et al. 2007). The multi-country setup in this latter project avoided the idiosyncrasies often connected with single-region stochastic and deterministic forecasts].*

The general conclusion that mortality improvements for industrialized countries have been underestimated leads to the question of how mortality projections, and thus forecasts for the elderly population, can be improved. To that end, one first has to understand the reasons why mortality forecasts failed. Broadly speaking, there are two main reasons: assumption drag and inherent uncertainty. First, the extrapolative character of mortality forecasts leads to difficulties each time a trend shift occurs. Empirical studies show that it takes about 10 years before population forecasters acknowledge the new trend (Keilman 1997). Such an 'assumption drag' is clearly visible in life expectancy extrapolations. Second, much of the uncertainty is caused by the fact that experts disagree as to the prospects for further mortality decline. Some assume that there are biological or practical limits to the life expectancy, although these are not necessarily to be reached within the next 50 years (Olshansky et al. 1990; Olshansky and Carnes 1996). Others expect medical breakthroughs in the future, which will lead to rapid mortality decline among the elderly (Vaupel 1997). The empirical evidence is not conclusive either. While human longevity generally improves in industrialized countries, mortality for the oldest old stagnates or even increases slightly in a few countries, such as in Denmark (Denmark Statistik 2000), the USA (Kranczer 1997), the Netherlands and Norway (Nusselder and Mackenbach 2000). At the same time, survival curves show very little or no sign of further rectangularization since the 1950s in some countries (USA, Sweden and Japan; see Wilmoth and Horiuchi 1999), while in other countries the curves continue to become more rectangular, after the rapid developments into that direction until the 1950s (France, England, the Netherlands and Switzerland; see Robine 2001).

How can mortality forecasts be improved, in the sense that they predict the number of elderly more accurately? Several possibilities have been suggested, of which I will mention four.

Mortality Laws

Demographers, statisticians and actuaries have long been occupied with finding a suitable ‘law of mortality’, i.e. a mathematical representation of age-specific mortality – most often (but not exclusively) in terms of the death rates. Once such a law is identified, its parameters are estimated for a sufficiently long period and next they are extrapolated. A large number of mortality laws have been proposed, a process that started with De Moivre in 1725 and that continues until the present day (Hannerz 2001). For a recent review, see Tabeau (2001). Some of the laws are restricted to adult or old age mortality (Coale-Kisker, Himes-Preston-Condran, Gompertz, Perks, Weibull). Tabeau (2001) and Boleslawski and Tabeau (2001) compare 27 of such laws. Relational models, such as Brass’ logit model and the Lee-Carter model, are also considered. Among the laws and models, the Heligman-Pollard curve is widely applied (Rogers and Gard 1991; McNown and Rogers 1989; Hartmann 1987; Kostaki 1992a,b). Compared to other models, the H-P curve has the advantage that it pairs accuracy in prediction with flexibility, in particular when describing mortality changes over time. Hartmann (1987) used Swedish mortality data for the period 1900–1970 and concluded that the H-P curve is a useful model for making population projections, one reason being the fact that it accommodates for changing age patterns of mortality as the level of mortality changes. Another popular model, namely the one proposed by Lee and Carter (Lee and Carter 1992; Carter and Lee 1992) apparently is much less flexible than the H-P model (see Büttner 1999). Moreover, it tends to produce extremely low mortality for young age groups when it is forced to project very high levels of the life expectancy. Adding a lower bound to the death rates may solve that problem (Büttner 1999). However, an important advantage of the Lee-Carter model is that it contains, in effect, only one parameter that has to be extrapolated. A detailed comparative study could shed further light on the issue under which circumstances the Lee-Carter model results in better mortality forecasts than the Heligman-Pollard model, and vice versa. This would extend the single-country comparison of the H-P and the L-C models by Bell (1997). For US white male and female mortality 1940–1991, he finds slightly better performance of the H-P model, although certain bias corrections to the L-C model do better than the original H-P model.

Cause of Death

One could include cause of death (c.o.d.) in the mortality extrapolations. While c.o.d. is useful when analysing historical mortality, it is doubtful that it will help to predict future mortality more accurately. In addition, c.o.d. registration for the elderly is thought to be rather unreliable. Following are two reasons for this, an empirical one and a statistical one. (1) Tabeau et al. (2001a) found very similar life expectancy extrapolations to 2020 with and without c.o.d. in an empirical study for

France, Italy, the Netherlands and Norway, using data for the period 1950–1994. Wilmoth (1995) showed analytically for linear extrapolation models that including c.o.d. will result in lower future life expectancy than ignoring c.o.d. Thus the fact that c.o.d. has been omitted in most official forecasts cannot have been the reason for the underprojection of the life expectancy. Finally, three Dutch c.o.d. mortality forecasts made between 1970 and 1975 were less accurate than six other forecasts based upon traditional mortality extrapolations (i.e. by age and sex only) that were made between 1950 and 1980 (Keilman 1990). (2) Traditional models assume that causes of death are independent. This is an unrealistic assumption: persons who are expected to die from a specific cause obviously have an increased risk of dying from other causes, depending on the illness in question. There is no generally accepted way to take the association between causes of death into account in empirical studies (Chiang 1991).

Endogenizing Mortality

One could include risk factors, life style, health and morbidity status as independent factors in the mortality extrapolations. Marital status, living arrangement, traffic accidents, the introduction of antibiotics and smoking have been used for that purpose (Alderson and Ashwood 1985; Joung 1996; Van Hoorn and De Beer 2001). The simultaneous extrapolation of health, morbidity and mortality has also been suggested (Manton et al. 1992; Murray and Lopez 1997). For a review, see Van den Berg Jeths et al. (2001). The accuracy of such mortality forecasts, as opposed to the rather mechanical ones based on a mortality law, has not been investigated.

Stochastic Mortality Forecasts

A radically different solution is to quantify uncertainty and accept the fact that forecast errors are unavoidable. In the last decade, a number of stochastic forecast models based on the Cohort Component Method (CCM) have been developed (Lee and Tuljapurkar 1994; Lutz and Scherbov 1998; Alho 1998; De Beer and Alders 1999; Keilman et al. 2001). The basic idea is to think of the population in the future not as one number, but as a whole distribution: some numbers are more likely than others. If life expectancies and numbers of elderly are presented in the form of *predictive* distributions of this kind, the user is forced to take forecast uncertainty into account. At the same time, forecasts of this nature are less vulnerable to sudden changes in real mortality trends than traditional deterministic forecasts. Box 5 gives an empirical illustration for the life expectancy of Norwegian women.

Stochastic population forecasting uses the CCM. But instead of one set of parameters for fertility, mortality and migration, as in the traditional deterministic method (or perhaps three, when a high, a medium and a low forecast variant are computed), one specifies the joint statistical distribution of all input parameters.

Because of the large amount of input parameters (35 fertility rates, 200 death rates and 120 parameters for net migration for each forecast year), simplifying assumptions are used. First, one assumes that fertility, mortality and migrations are independent. For industrial countries, this is a reasonable assumption. Second, one focuses on the distribution of a few summary indicators (for instance total fertility rate, life expectancy at birth, level of net-immigration), thereby ignoring the statistical distributions of the detailed parameters (age-specific rates). Three main methods are in use for computing probabilistic forecasts of the key parameters: time-series extrapolation, expert judgement and extrapolation of historical forecast errors. Time-series methods rely on statistical models that are fitted to historical data. These methods, however, result often in excessively wide prediction intervals when used for long-term forecasting. Judgemental methods can be used to correct or constrain such broad prediction intervals. Expert judgement is also used when expected values and corresponding prediction intervals are hard to obtain by formal methods. A group of experts is asked to indicate the probability that the key parameter in some future year falls within a certain pre-specified range. A weakness of this approach is that experts, often being unduly confident, tend to give overoptimistically high probabilities. Finally, empirical errors observed for past forecasts may be extrapolated to predict the expected errors for the current forecast. A problem here is that forecasts prepared in the 1960s or earlier were poorly documented, so that data on historical errors do not stretch back as far as one would like.

In practice, elements of the three methods are used in combination. For instance, time-series often result in unrealistically wide intervals on the long term, which may be reduced judgementally based on expert knowledge. Moreover, the intervals, whether obtained by time-series methods or expert opinion, can be checked against historical error patterns, in particular in the short term.

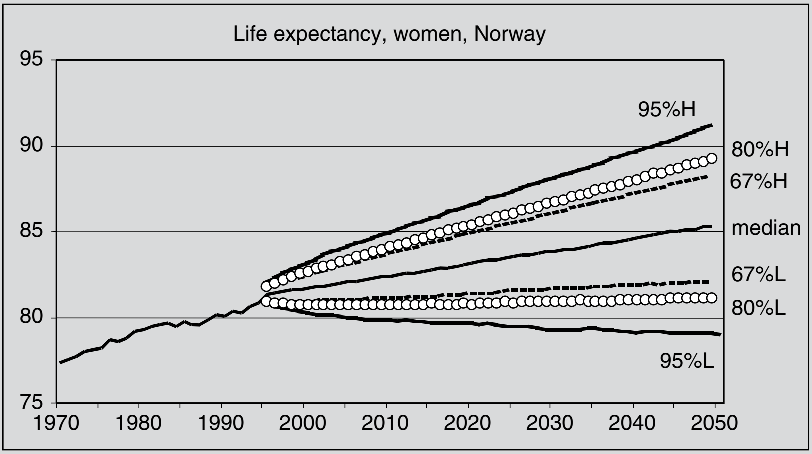
Irrespective of the method used, probabilistic forecasts of the youngest and oldest age groups show the most uncertainty, because fertility and mortality are hard to predict. In addition, prediction intervals are often narrower when variables are aggregated (for example, when 1-year age groups are combined into 5-year age groups, or when the populations for the two sexes combined is analysed), rather than looked at individually, because the errors tend to cancel each other out. These kinds of uncertainty assessments are crucial, and statistical agencies would do a great service to users of forecasts if they would adopt probabilistic methods rather than methods that are more traditional, which do not take uncertainty into account.

Conclusions

This paper shows various ways to infer mortality levels in a population from information about the age structure, and changes therein. The age structure alone cannot be used for such a purpose. Additional data, or assumptions, are necessary. Stable population theory builds on strong assumptions, but has been used successfully for

Box 5 Prediction intervals for future life expectancy and elderly women in Norway

A bivariate ARIMA (2,0,0) model was estimated for the logs of annual life expectancies at birth for men and women in Norway 1950–1995, see Keilman et al. (2001). The model was used to predict future life expectancy after 1995, with targets of 80 and 84.5 years in 2050 for men and women, respectively. The figure below gives the prediction intervals for the female life expectancy. There is an expected 95% probability that the female life expectancy will be between 79 and 91 years of age in 2050. The correlation across the sexes was estimated as 0.65.



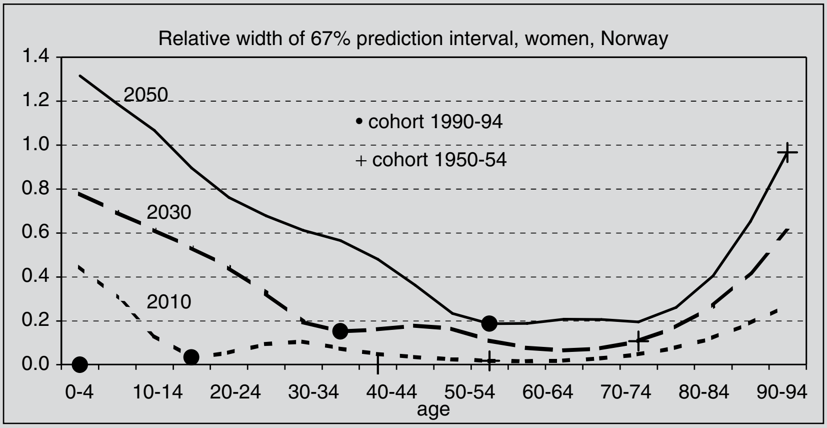
Our results indicate similar uncertainty for the life expectancy at birth as those obtained by De Beer and Alders (1999) for the case of the Netherlands. These authors found a 95% prediction interval of 12 years wide in 2050, both for men and for women. Intervals presented by Tuljapurkar et al. (2000) for the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) are much smaller than ours. The width of their 90% intervals of combined-sex life expectancy at birth in 2050 ranges from a minimum of 2.8 years for Canada to a maximum of 7.5 years for the UK. The intervals are based on a one-parameter Lee-Carter model for age-specific mortality for the two sexes combined, which is fitted to an abridged life table with 5-year age classes up to 80–84. Ages 85 years and higher were lumped into one age class (except for Japan). The age- and sex aggregation, which reduces random fluctuations, may have resulted in these relatively narrow intervals.

The stochastic forecast resulted in prediction intervals for the population by age up to 2050. For the elderly, these intervals were rather narrow, not

(continued)

Box 5 (continued)

because mortality is easy to predict, but simply because there are so few elderly. For purposes of comparison, it is instructive to inspect the width of the relative intervals, i.e. the intervals as a ratio of the median. The graph below illustrates that for the oldest old, uncertainty is almost is large as it is for the youngest age groups. The lines for 2010, 2030, and 2050 indicate relative uncertainty in a *cross-sectional* way. They suggest that uncertainty first decreases from birth to middle ages (up to an age equal to the forecast duration), and that it increases thereafter. These cross-sectional patterns do not reflect uncertainty over the life course correctly. The relative intervals for the birth cohort 1950–1954 illustrate that the age gradient for the elderly is much steeper than what the cross-sectional pattern indicates. The plot for birth cohort 1990–1994 shows that uncertainty increases for the youngest age groups as well.



near-stable historical populations. The method is quite robust against changes in mortality. The variable growth rate method rests on much weaker assumptions, but permits less powerful conclusions. The most detailed information on mortality (and fertility) may be derived in the case where one has series of birth and death counts, in combination with one or more age structures. Inverse projection and back projection have been applied to some historical populations. Finally, some qualitative insight can be derived from evaluating historical age structure projections against observed data. A recurrent finding in this connection is that population forecasters in industrialized countries in the past decades have been too pessimistic regarding mortality improvements. This in turn led to substantial underprojections of the number of elderly. Stochastic projections are an appropriate means of improving the quality of forecasts for the elderly (and other age groups as well), because they quantify forecast uncertainty. They force the users to think in uncertainty terms and anticipate unexpected trends.

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Long-Run Relationships in Differential U.S. Mortality Forecasts by Race and Sex: Tests for Co-integration

Lawrence R. Carter

Introduction

There is considerable interest in demography in comparing mortality by race and by sex to determine the magnitude of the differentials, to understand why they exist and to detect if they are changing over time. The question is if they will converge, and if so, how soon. For race, nowhere is that interest so evident as in the controversy over the well-researched black/white mortality crossover. A persistent decline in the age of crossover signals convergence, while advancing age of crossover indicates mortality divergence. Even so, white and nonwhite life expectancies have been converging generally over time. A similar concern is shown with sex differences since they have displayed a marked increase in the later twentieth century. The confounding of race and sex in mortality analyses invites the desegregation of the U.S. population into four race-sex specific groups, and an investigation of their pairings to understand their possible relationships well into the future. This paper does so by extending the mortality analysis by Lee and Carter (1992) for the total U.S. population and Carter and Lee (1992) for U.S. sex differentials. The basic approach is to examine some life table functions derived from forecasts of mortality for white males, white females, nonwhite males and nonwhite females using the Lee-Carter method (Lee and Carter 1992). We focus on puzzling patterns of life expectancy forecasts that show white and nonwhite life expectancies at birth initially continuing their historic decline, but then reversing themselves and increasing in the latter part of the forecast period.

The strategy for this study is as follows: after (1) the introduction, (2) a background section that explores the mortality transition and the relevance of the mortality crossover to the whole issue; (3) a section describing the nonlinear demographic model we employ and its fit; (4) a section containing estimation and forecast models of the index of mortality and life expectancies at birth for whites and nonwhites by sex; (5) a section investigating possible co-integrated relationships among the

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indexes of mortality; (6) a section discussing the forecasts of life expectancies and their differentials derived from the forecasts; (7) a section examining other life table functions derived from forecasts of the indexes of mortality; (8) a section revisiting the issue of race; and (9) a final section of conclusions.

Background

Historical Mortality Differentials

Different histories among human populations make it difficult to fathom if differences in mortality schedules by race and sex derive from biological selection, environmental exposure, or some combination of the two. Nevertheless, the long term trends in life expectancy in the U.S. have shown marked increases for both races and sexes independently such that the improvements between 1900 and 1990 for white males, white females, nonwhite males and non white females have been 27, 29, 31 and 29 respectively. The gains have not been necessarily monotonic or constant, for they vary by age. Yet the significance of the gains is reflective of the long-term reduction in age-adjusted death rates for each of the populations, for they control for age variation among them. Overall, between 1900 and 1988, the age-adjusted death rate for the general population fell from 17.8 to 5.4, registering a 70% decline. This period represents passage through the epidemiologic transition from the 'age of pestilence and famine' through the 'age of receding pandemics' (most manifest in the influenza epidemic of 1917–1918), to the current 'age of degenerative and man-made diseases (Omran 1971).' The most dramatic phase of the decline occurred between 1900 and 1954 with a stronger decelerated drop for blacks because they were at a much greater initial disadvantage and had substantial room to improve (Zopf 1992). Still, the patterns show male and female similarities among whites as differentiated from male and female similarities for blacks. It is these patterns we wish to examine in greater detail.

Race Differentials and the Crossover

Gross classifications of race in the United States confine the populations to the dichotomy of white and nonwhite. Most investigations of nonwhite/white comparisons in the U.S. are really interested in black/white comparisons, due partly to the centrality of the two races in American history and culture and partly to the numerical dominance of blacks among nonwhite groups (blacks have constituted historically about 12% of the total U.S. population and over 90% of the nonwhite population). We will try to avoid confounding the two in the remaining sections, but here focus on black/white comparisons, realizing that, for the reasons cited, the discussion is almost analogous for nonwhite/white comparisons.

When mortality schedules are paired by sex, male death rates generally exceed female across the age distribution – converging at older ages, but not crossing over. When races are compared, however, black death-rates exceed white rates for both sexes, but only until older ages, where they converge, crossover and then diverge. This pattern also holds true when the schedules are expressed as age-specific risks of death. This pattern of convergence and reversal is what is commonly referred to as the black/white mortality convergence and crossover (Manton and Stallard 1984). A number of studies have shown convergence and crossover patterns to exist in a variety of contexts: (1) crossover for other animal species (Comfort 1979; Economos 1982); (2) crossover for cross-national comparisons of the mortality experience of human populations (Nam, Weatherby and Ockay 1979); (3) crossover for blacks and whites (Rives 1977; NCHS 1975); (4) crossover for blacks and whites by underlying cause of death (Manton 1980, 1982; Manton et al. 1979; Phillips and Burch 1960); (5) convergence for white males and females (Woodbury et al. 1981); crossover between blacks and whites over time (Manton et al. 1979); and (6) crossover between blacks and whites in a closed cohort longitudinal community study (Manton et al. 1979).[1] A precondition for black-white crossovers to exist is that their survival probabilities (from which are derived life expectancies) must not exhibit crossover. Manton and Stallard (1984) have shown this precondition to be satisfied.

Sorting out causes is further confounded by problems of measurement. Techniques exist for minimizing measurement error, so it no longer is as competitive an explanation for the crossover (Manton and Stallard 1984), though there remain dissenting views (Coale and Kisker 1986; Preston et al. 1996, 1998). Additional adjustments for possible age misreporting of deaths at older ages can be made, using a technique conceived by Coale and Guo (1989). Still, the crossover persists. What remain are real substantive analytical concerns.

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[1]Manton and Stallard (1984) express the death process for chronic degenerative diseases as a sequence of age and time dependent transitions from a state of well being to a chronic disease state to a death state. The distributional pattern of deaths for a cohort is best captured in a generation life table. For practical reasons, period life tables are substituted, resulting in the analysis of approximate or synthetic cohorts. Generation tables are a record of the temporal mortality experience of a single cohort at a single point in time. Therefore, period tables cannot mirror exactly the temporality of cohort experience. Still, there are compelling reasons why a period approach may be more profitable for this analysis. Gomez (1990), in his analysis of Norwegian mortality data, considers a model like that used in this study, but enriched by cohort effects, which turn out to be significant and interesting. However, for purposes of forecasting, he finds the period model to be preferable. Wilmoth (1990) and Wilmoth et al. (1989) fit more elaborate models with a cohort basis rather than a period basis. Then each cohort would receive some value of k. There are various reasons why we did not proceed this way: (1) we do not believe it is empirically correct that a cohort's mortality experience is dominantly shaped in its early years (if we have to choose between period and cohort, the period approach comes closer to the truth); (2) lacking genuine and reliable mortality rates by single years of age, implementation of the cohort approach with U.S. data would be at best very rough; (3) age truncation for cohorts at both ends of the data matrix would pose serious difficulties; and (4) the error-covariance structure for the forecasts of rates in any given year would be vastly more complicated with a cohort approach.

Sex Differentials

There is general consensus that, for human populations with rare exception, females historically have had longer life spans than males. There is evidence that, for the majority of species, this pattern holds too (Gavrilov and Gavrilova 1991). For human populations, pairing male and female age curves of mortality or taking their age-specific and age-adjusted death ratios typically expresses this phenomenon. These pairings show that death rates for males show striking excess over death rates for females in all or most age groups. The excesses are most evident for low mortality countries. Why this persistence exists is the subject to some controversy. Much credence is given to the dominance of biology, suggesting that there is a genetic advantage to females having longer life spans than males. Foremost among genetic factors is the view that though females have two X-chromosomes, males have one X-chromosome and one Y-chromosome. The Y-chromosome is seen to be a defective X-chromosome contributing to a male disadvantage in survival. There are reasons to question the generality of this assertion. There are less persuasive biological hypotheses for the sex differential, but they, too, have significant flaws (for a substantial exposition and critique of these hypotheses see Gavrilov and Gavrilova (1991)).

Notably, even though there is a general persistence of male excess mortality over females, there is variation in the levels of such by age and over time. Vallin (1991) found that, in historical trends in mortality in Western countries, excess male mortality was small until around 1900. These variations trigger concern about the constancy or fixity of a biologically deterministic explanation of the differential. There is growing evidence that social and environmental factors play significant roles in sex-differentiated mortality. The higher levels of excess mortality in low mortality countries compared with high mortality countries are concordant with the excesses in socioeconomic advancement between developed and underdeveloped countries. This division suggests that there is greater parity between the sexes in less developed countries compared with more developed countries. The greater excess of mortality for the more developed countries may seem counterintuitive because of the expected greater convergence of male and female mortality with increasing quality of life. Waldron (1995) attributes the differential to the interactions of multiple biological and behavioural factors and these are manifest in age and time variation in the long-term trends in the ratios. Vallin (1995) examined the relationship of sex mortality differentials and socioeconomic status to no avail.

Analytical Concerns

Understanding the substantive bases for mortality differentials beckons the study of the causal relationships, which, due to data limitations, are largely intractable in a time series context. Even cross-sectional analysis provides only speculative answers (see for example Manton and Vaupel (1995)). Where explanatory analysis is not viable, these concerns are addressed typically by comparing black mortality trajectories to those for whites or male trajectories to those for females to determine the patterns of

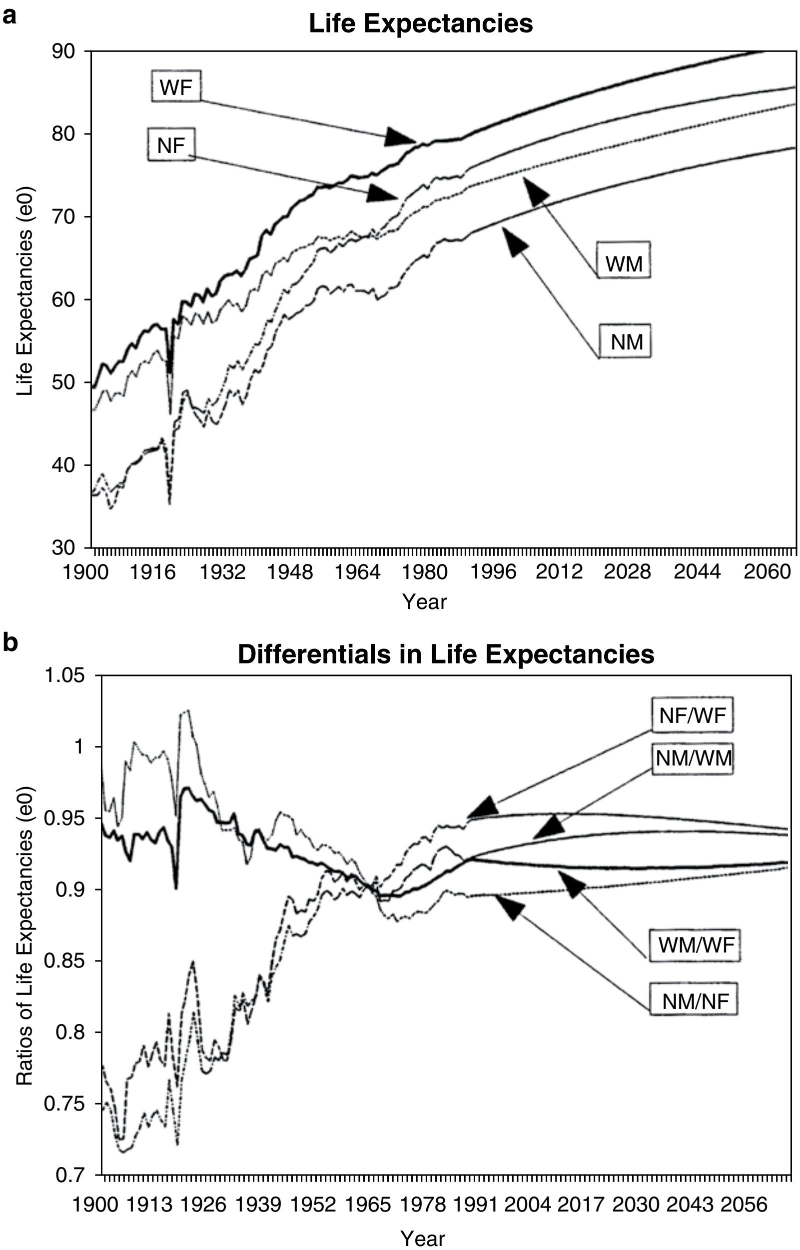

Fig. 1 Life expectancies and their differentials by race and gender, U.S., 1900–2065

convergence and crossover or divergence. The problem is that paired trajectories may be changing at different rates, so the conceptual importance of crossover becomes clouded. There is some evidence that this is true. Figure 1a contains race-sex estimated and forecasted life expectancies at birth, reflecting their differences over time.

Base populations from which the estimates were ultimately derived are not adjusted for undercount. Even so, without loss of generality, the patterns are instructive. Each of the life expectancy distributions has a different trajectory with trends almost linear and invariant over time. The convergence of nonwhite males with white males and non-white females with white females is apparent in the traces of their differentials in Fig. 1b. Concurrently, sex differentials by race show a general pattern of divergence over time within the sample period to a plateau in the 1980s. For both Fig. 1a and b, we defer discussion of the forecast period until later in the paper. Convergence is not complete for either race differential, nor is divergence infinite for the sex differentials, but the tracks are established, at least visually. One is tempted to risk forecasting their timing of closure and separation using time series analysis. However, that would defeat the purpose of demonstrating the utility of generating a single index that can be used to construct all of the life table functions into the future. What these patterns do suggest is that, given present rates of improvement in health statuses of nonwhite and white males and females, race-sex closure in life expectancies at birth is almost assured. The question is largely one of timing. However, since the *differentials* reflect net gains and losses in life expectancy between the paired populations, they cannot signal gains or losses for their respective populations.

These differing trajectories pose a problem for more refined analyses of the crossover. Typically, explanations of the crossover imply cohort phenomena, yet period life table measures are used in their investigation. Reliance on these tables is not problematic so long as the age-specific death and survival probabilities are constant over time. In demographic parlance, the period distributions portray synthetic cohorts that can be used as surrogates for real cohort experiences. But that defeats our interest in understanding if cohort crossover is being extended over time, implying eventual convergence at some older age than presently observed.

The trajectories in Fig. 1a suggest that longevity increases *almost* linearly, but we know that human ageing and mortality are not linear unidimensional processes. Susceptibility is not uniform across diseases. Accordingly, convergence-crossover measures for single causes of death in the absence of competing risks are a more refined description of mortality behaviour than are similar measures for total mortality. Even so, these summary measures for a single age do not expose the dynamic of the rate or probability distribution that results in the crossover. Manton (1982) largely avoids this problem for cause-specific mortality by expressing black/white sex differentials as ratios of black to white net probabilities of death for single years of age for specific causes for 1962, 1969 and 1975.[2] In doing so, he attempts to cap-

[2] Age misreporting induced crossover is not problematic for the empirical analysis in this research. The earliest evidence for crossover in the U.S. population is 1933. Data for prior years are too unreliable to reveal this phenomenon. Subsequent years do show the persistence of the phenomena through 1988, the terminal year of our observed data. Since we are primarily interested in changes in the trending of differential mortality over time and testing for convergence or divergence, misreporting at a constant level should not visibly impact the patterns of *change* over time. Variable levels of misreporting should be detectable in the differential trends.

ture temporal and age variation in the convergence-crossover by showing not only the age of crossover, but also the peak age of variation (considerably younger than the actual age of crossover). Prior to crossover the ratio is greater than one; at crossover is equal to one; and after crossover is less than one. Therefore, the distribution of ratios should give some indication of the timing of events, that is, divergence, convergence and crossover. This technique has the advantage of comparing ratios over single years of age and mapping the progress of the timing of the ages at significant events over time. Later, we employ this technique in assessing the crossover for all causes. Still, we think, problems exist.

As was mentioned earlier, all of the distributions in Fig. 1a have different trajectories, which imply that the underlying probability distributions also have different trajectories. As such, both components of any devised ratios or differences are changing over time. White probabilities are treated as benchmarks for gauging nonwhite progress. The problem is that the white distributions are not stationary benchmarks. 'No relative gain' becomes translated to mean 'no absolute gain,' which may not be true. Thus, the search for a nonwhite/white mortality convergence-crossover is akin to searching for a moving target. Since both probability distributions are changing age wise over time, it may be premature to expect rapid convergence, given their rather distinct social histories. This is not so say that changes in health status parallel changes in socioeconomic status (see Manton and Stallard (1984) on this). They may, in fact, move farther apart on some underlying causes (Jackson 1980). The quest, then, is how to establish a stationary target. The question is 'What to do?'

We propose to resolve the dilemma by tracking the mortality transition of the nonwhite population on that of the white population. Doing so requires that a model be devised that treats the white population as a target that is stationary relative to the nonwhite population (that is, both moving, but not necessarily at the same rate). Thus we expose nonwhite gains and losses in mortality relative to those of whites in a dynamical sense that allows us to conjecture realistically about its future course. The model is presented below.

The Multiplicative Demographic Model

The Nonlinear Model

The procedure in this paper uses time series modelling to forecast single race-sex-specific indexes of mortality, k_t (sometimes designated as k, or k (t)), to which the log of each age-specific rate is linearly related, That is,

$$m_{x,k} = \exp\left(a_x + b_x k_t + e_t\right), \text{ or}$$

$$\ln\left(m_{x,k}\right) = a_x + b_t k_x + e_t.$$

Here $m_{x,k}$ is the central death rate for age x at mortality level k (Fig. 2a), a_x (Fig. 2b) is the general shape across age of the mortality schedule, b_x (Fig. 2c) is proportional

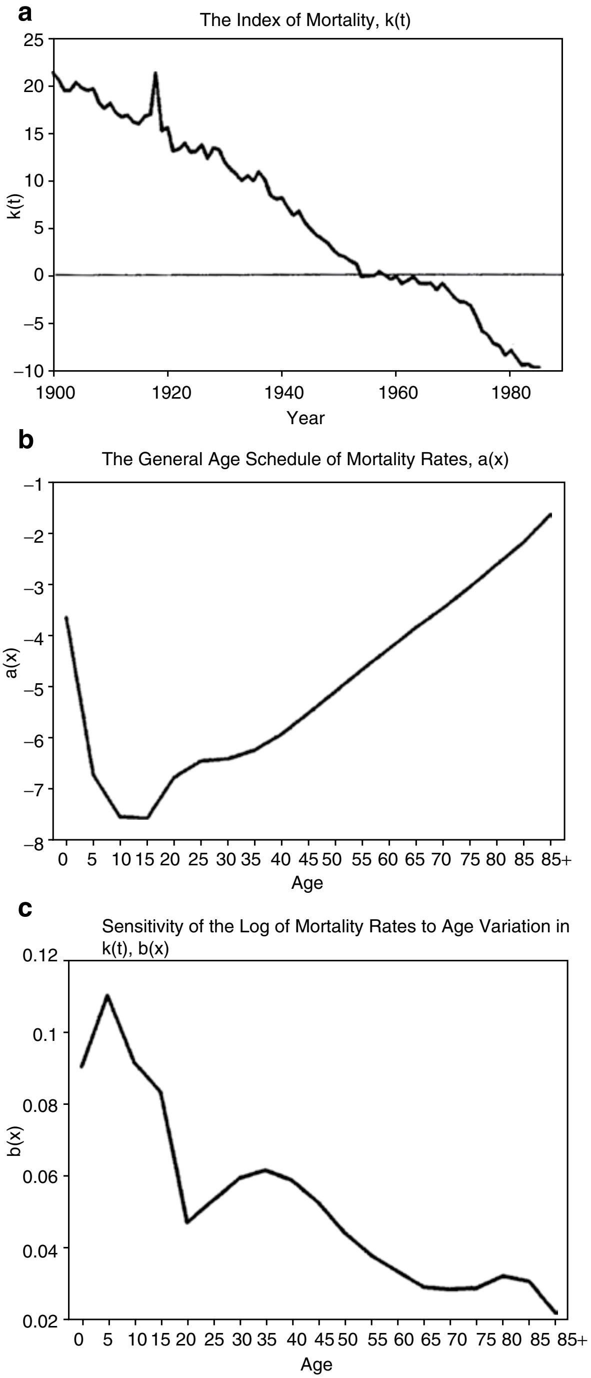

Fig. 2 Components of the basic demographic model for the total U.S. population, 1900–1989

to the annual proportional rate of decline for age group x, so the shape of the b_x profile tells us which rates decline rapidly and which slowly over time.

For any value of k, the fitted model defines a set of central death rates, which can be used to derive a life table. But the procedure can also be used in reverse, to solve for the particular life table in this family which would produce an observed number of deaths, D_t, for a given population age distribution, $N_{x,t}$. For given data of this kind, k_t and D_t are related multiplicatively such that:

$$D_t = \Sigma\,[N_{X,t}\,\exp(a_X + b_X\,K_t)]$$

From all of this, there is no analytical way of deriving k. Consequently, we derive k through an iterative numerical procedure.

Fitting the Model

Data used in the fitting are taken from Grove and Hetzel (1968) and NCHS (various years). These data show that infant and child mortality decline relatively rapidly, while old-age mortality declines slowly, as has been the case historically. Singular Value Decomposition (SVD) (Good 1969; Gruber 1990) is used to estimate a, b and k, as defined above. Once the a_x's and b_x's are estimated, the k_t's are re-estimated by the reverse method so that the resulting death rates, applied to the actual base population, produce the total number of deaths actually observed in the data. Such estimates of k can be made all the way back to 1900, and up to 1990, since all that is needed is a count of total deaths and the age distribution of the population; this is a very attractive feature of the technique. Details of this approach are found in Lee and Carter (1992). These measures, a_x and b_x with k_t are used to generate other life table functions.

Given the dramatic increase in survival beyond age 85 in recent years, some accounting of the distribution in the open-ended age group 85+ is warranted. A review of these changes is provided in Lee and Carter (1992). Since life tables in the U.S. are normally truncated at age 85+, we acquire indirect estimates of the death rates through age interval 105–109 by using the method of Coale and Guo (1989: 614–615). An assessment of the utility of this extension is contained in Lee and Carter (1992).

The Fitted Demographic Model

This model, fitted to race-sex-specific U.S. mortality from 1900 to 1989, explains about 98% of the change over time in the matrix of untransformed age-specific rates, excluding the age group 85+ which is poorly measured and which behaves erratically over this period. The race-sex-specific estimated values of k_t are shown in Fig. 3.[3] These graphs are not exactly comparable as the race-sex-specific k_t's are functions of their respective a_x's and b_x's. However, we do expect comparability in their respective $m_{x,t}$'s and e_0's. Still, as a matter of empirical fact, k estimated in this way fluctuates about a consistent linear trend from 1933 to 1988; its rate of decline in the first half of the period is no more rapid than in the second half. This is in marked contrast to life expectancy at birth, which declines about twice as fast in the first half of the period as the second. We suspect that this feature of k in comparison to e_0 will prove to hold more generally and will be an attractive feature of this approach. The relation of the two trends is mediated by the measure H of the entropy of mortality (see Keyfitz 1977:62–68), and as mortality declines so does H, which halved between 1920 and 1960. This pattern is consistent with that found by Lee and Carter (1992).

So far, then, we have constructed and estimated the equations underlying this simple but robust model for a life table family, indexed on k_t. This approach enormously simplifies the treatment of forecast errors. Thus, time series variations in the logs of the death rates are assumed to be perfectly correlated with one another, since all are linear functions of k. Note that this is not the same as saying that they all change at the same rate, however. Of course, in reality some age groups sometimes show different patterns of change than others. For example, young adult male mortality rates (for races combined) rose strongly in the 1960s, when other mortality rates were falling, and then fell more rapidly than others from the mid-1970s to mid-1980s. Fortunately for this undertaking, those death rates are very low and so their aberrant behaviour will have little effect on our measures of survival to older ages, or life expectancy. Nonetheless, if one has a particular interest in these age groups, some other forecasting method would probably be preferable.

Using the re-estimated k_t's and the estimated a_x's and b_x's, we reconstitute $m_{x,t}$'s for selected ages. The corresponding graphs and tables are not shown here but are available on request. These age groups are replicates of the age groups shown in Lee and Carter (1992) and show consistency in fit with those results. An estimate of goodness of fit between observed and estimated $m_{x,t}$'s is obtained by averaging the explained variances of their regressions. The R^2's for white males, white females, nonwhite males and non-white females are .973, .984, .981 and .969, respectively. Correlations of estimation error across age groups are not calculated. Lee and Carter (1992) find co-linearity among error terms (often substantial) in the study, and we assume them to exist here. These errors can contribute to estimation and forecast error in time series modelling of k_t and, consequently, to estimates and forecasts of e_0. Having no easy solution to this problem, we defer it and proceed with the time series modelling of k_t.

[3] Vector ARMA models of WM, NM, WF, and NF were estimated by sex and to no avail. The stationarity-invertibility principle was nearly violated in parameter estimation, resulting in some values close to 1. These model are deemed too unstable to be considered seriously in the study and, so, are not included.

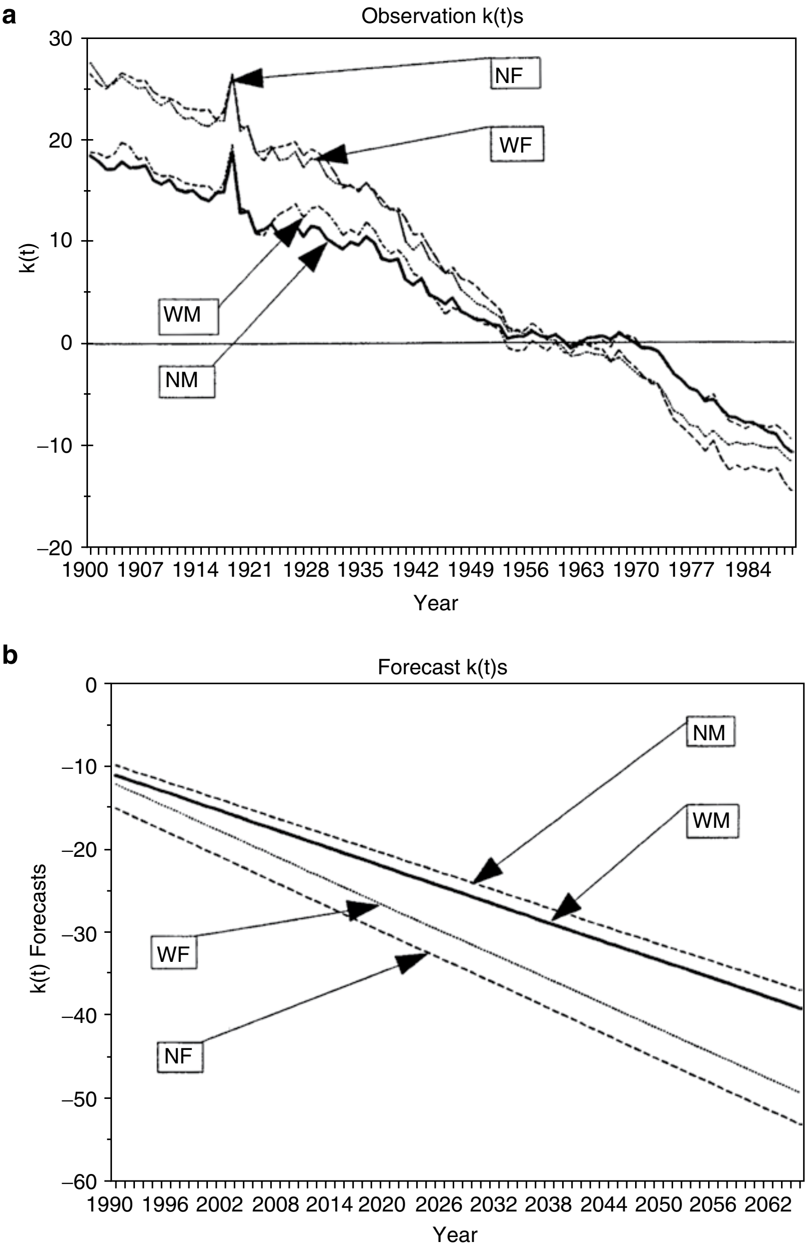

Fig. 3 Observation (1900–1989) and forecast (1900–2065) k(t)s by Race and Gender, U.S.

Time Series Modelling and Forecasting

Modelling Strategies

The modelling and forecasting procedures used in this analysis are techniques credited largely to Box and Jenkins (1976) and elaborated by others. Generally, the Box and Jenkins modelling scheme involves a three-stage iterative process, consisting of tentative identification, estimation and diagnostic checking. Forecasting the designated series according to the model follows successful modelling. Using this process, the identification stage presents a subclass of parsimonious models meriting investigation. Once the model is tentatively identified, estimation is used to make inferences about the parameters conditional on the adequacy of the investigated model. Diagnostic checking is applied to the fitted model to check its agreement with the data. This step reveals model inadequacies, where present, to promote model improvement. After model adequacy is established, minimum mean squared error forecasts of the series are made. The assumption in forecasting is that, for sufficiently long series (50+ data points), estimation errors in the parameters do not seriously affect the forecasts.

Modelling the Mortality Index, k

Next, we model and forecast changes in k and the error variances and covariances of our forecasts. The Box and Jenkins (1976) procedure generates appropriate ARIMA time series models for the mortality indexes, k_t. After experimenting with a variety of models, the best preliminary estimates are as follow (Table 1).

The fits of all the models are extremely good and each describes a random walk with drift. These models are consistent with that for the total population in Lee and Carter (1992). The constant term indicates the average annual change in k_t, and it is this change that drives the forecasts of the long run change in mortality. Within sexes, the constant term is nearly consistent with those estimated in Carter and Lee (1992). Over the 76 year horizon from 1990 to 2065, the expected decline in k_t's of

Table 1 Estimation equations for the index of mortality

White male	$(1 - B)k_t = -.3748 + 4.26flu + e_t$		see = .882
	(.094)	(.887)	R^2 = .988
White female	$(1 - B)k_t = -.4959 + 4.89flu + e_t$		see = .872
	(.093)	(.878)	R^2 = .995
Nonwhite male	$(1 - B)k_t = -.3622 + 3.98flu + e_t$		see = .968
	(.103)	(.973)	R^2 = .988
Nonwhite female	$(1 - B)k_t = -.5082 + 4.16flu + e_t$		see = .885
	(.094)	(.890)	R^2 = .995

Each univariate is a random walk with drift

76 times the constants is, respectively, 29, 39, 28 and 40. The flu variable (representing the influenza pandemic of 1918) is treated as a non-structural anomaly not likely to reoccur with such intensity.

Co-integration

The General Case

There remains the problem of determining if there exist long term relationships among the k, implying that there is some connection between male and female and white and nonwhite life expectancies. It is important to know if the life expectancy series in Fig. 1a, which trend up over time in a non-stationary fashion, do in fact drift together. This drifting together would imply that there is some linear combination that holds among some of the underlying k_ts. This connection does not suggest that the k_ts be causally related, but that they respond similarly to some unknown exogenous forces. This sort of problem is alluded to, but not investigated, for marital fertility in Carter and Lee (1986). An early attempt to model and forecast a joint k common to male and female life expectancies is reported by Carter and Lee (1992). The time series models for joint k, though statistically competitive with those for single sexes, yielded forecasts of life expectancies with a sex difference 2.2 times greater. However, if there is no linear relationship among the k_ts, then they may drift further apart or converge as time goes on. This pattern would be reflected consequently among their corresponding nonlinear e_0s. Co-integration analysis offers an insightful approach that may be more instructive about such long-term demographic behaviour.

In general, two or more time series variables are considered to be co-integrated if they have the same order of integration and the error process from the regression performed on the untransformed variables is stationary. A long-run equilibrium relationship can be said to exist among the variables, while short-run deviations between them are stationary. Engle and Granger (1987) propose a number of tests for co-integration of nonstationarity time series (the initial values for of the k's before differencing for stationary). For a vector of the k_t's (i.e., K_t, with elements k_{twm} for white males, k_{twf} for white females, k_{tnm} for nonwhite males and k_{tnf} for nonwhite females), if there exists a linear combination, $\alpha'K_t$, that is stationary, then the time series in K_t are said to be co-integrated with co-integrating vector α. Among the various multivariate models that we can employ for the races and sexes, we want to determine the α that most closely approximates $\alpha'K_t = 0$, the long-term equilibrium. For $\alpha'K_t \sim 0$, co-integration implies that deviations from equilibrium are stationary with finite variance. The α that provides the best linear combination is the one that pinpoints the best approach to estimating the race-sex-specific k_ts, separately or jointly, and establishing their connectedness. In most instances, α will be suboptimal, such that $z_t = \alpha'K_t \neq 0$. Here, z_t may be called the equilibrium error. Clearly, we hope to minimize z_t. If not, we can adjust for equilibrium error by employing an error correction mechanism (ECM) that can be expressed as:

$$A(B)(1-B)K_t = -\gamma Z_{t-1} + \mu_t$$

where μ is a stationary multivariate disturbance, with A(0) = I, A(1) has all elements finite, $Z_t = \alpha' K_t$ and $\gamma \neq 0$. Since this study is concerned with differentials by race and sex, the following two subsections till present empirical tests for pairings of k_ts. Units root tests of individual series are addressed first, followed by bivariate tests of co-integration.

The Unit Root Test

Until now, we have assumed each of the k_t time series to be I(i), i.e., a nonstationary series integrated of order 1. Stationarity was achieved by first differencing the series. Diagnosis of the residuals was used to verify stationarity.

Here, as a more definitive test of stationarity we use the Augmented Dickey-Fuller (ADF) test for unit roots. The expression for the regression in this test is:

$$\Delta k_t = \mu + \beta t + \gamma * k_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta k_{t-j} + \varepsilon_t,$$

where

$$\phi_j = -\sum_{k=j+1}^{p} \gamma_k$$

and

$$\gamma * = \left(\sum_{i=1}^{p} \gamma \right) - 1.$$

The ADF unit root test is carried out for the joint hypothesis that $\beta = \gamma^* = 0$. Essentially, this is a test for stationarity, meaning there is no drift or stochastic trend in the differences, Δk_t. The test statistic is the t-test with critical values derived by Fuller (1976). Results of these tests are shown in Table 2.

Table 2 Univariate tests for unit roots in the index of mortality

Index	AR(1)	t-ratio
kwm	96	−1.165
kwf	89	−2.912
knm	87	−1.506
knf	92	−1.034

1% critical value = −4.005; and 5% critical value = −3.461
Each index has a unit root, so first differencing can be used to achieve stationarity

In each of these tests, we fail to reject the null hypothesis of a unit root. These tests justify the use of first differences of k_t to achieve stationarity.

Tests for Co-integration

The bivariate fully specified regression model is:

$$k_{ti} = \beta k_{tj} + \varepsilon_t$$

where ij are wm, wf, nm and nf, and $i \neq j$. Here, the disturbances, $\varepsilon_t = k_{ti} - \beta k_{tj}$, are presumed to be a white noise series and, thus, to be stationary. If k_{ti} and k_{tj} are integrated of the same order, say I(1), then there exist a β such that ε_t is integrated of order I(0) and varies randomly around some fixed level with a fixed variance. In such instances, the two time series are said to be co integrated and β is a co integrating vector.

The empirical test for co integration is a two-step process. As a first step, the bivariate regression is performed. The Augmented Dickey-Fuller (ADF) test and the Phillips z-statistics are applied to the residuals, ε_t, to test for co integration. If ε_t is not I(0), then the two series are taken not to be co integrated. Otherwise, the series are assumed to be co integrated and the residuals are subjected to a second step error correction, consisting of a first order auto regression to derive a parsimonious specification of the structure. Results of these tests are shown in Table 3. The t-ratio is the ADF test statistic for no co-integration between the pairs of variables (Phillips and Ouliaris 1990;Said and Dickey 1984). The z_a and z_t statistics are the Phillips (1987) test statistic for no co-integration between designated pairs of variables. None of these test statistics is significant, indicating no co-integrating relationship among the pairs of k_ts. Thus, the univariate models presented in the equations in the section on Modelling Strategies are valid representations of these

Table 3 Bivariate tests for co-integration in the index of mortality

Dep. var.	Indep. var.	AR(1)	t-ratio	z_a-statistic	z_t-statistic
kwm	kwf	.98	−1.109	−5.607	−1.277
kwf	kwm	.98	−1.281	−1.856	–0.599
knm	knf	.92	−2.464	−8.251	−2.154
knf	knm	.92	−2.580	−6.723	−2.350
kwm	knm	.71	−1.640	−24.512	−3.494
knm	kwm	.80	−1.627	−18.523	−3.024
kwf	knf	.80	−1.078	−14.826	−2.801

t-statistic: 1% critical value = –4.504; and 5% critical value = –3.916
z_a-statistic: 1% critical value = –32.454; and 5% critical value = –25.510
z_t-statistic: 1% critical value = –4.504; and 5% critical value = –3.916
The AR(1) models are tests for unit roots in the residuals of the bivariate regressions. Each residual series has a relationship, has a unit root, implying non-stationarity. The conclusion is that none of the pairs is co-integration

independent series of the $k_t s$. The series of k_t are used to reconstitute forecasts of individual race and sex life expectancies.

Forecasts of Life Expectancies and Their Differentials

Based on the results of the preceding paragraph, we focus on forecasts of e_0 derived from k as our optimum extrapolations of life expectancy. These forecasts are presented with their 95% confidence intervals in Fig. 4. Life expectancies in 2065 in descending order are 90.9, 85.6, 82.6 and 77.6 for white females, nonwhite females, white males and non-white males: a continuation of the order prevailing today. The range of uncertainty by 2065 is greatest for males (the highest being 8.4 years for white males contrasting with a low of 4.5 years for nonwhite females).[4] All of these ranges are within the realm of the possible and increase our confidence in the utility of this projection technique. Again, reflecting on the graph in Fig. 1a,

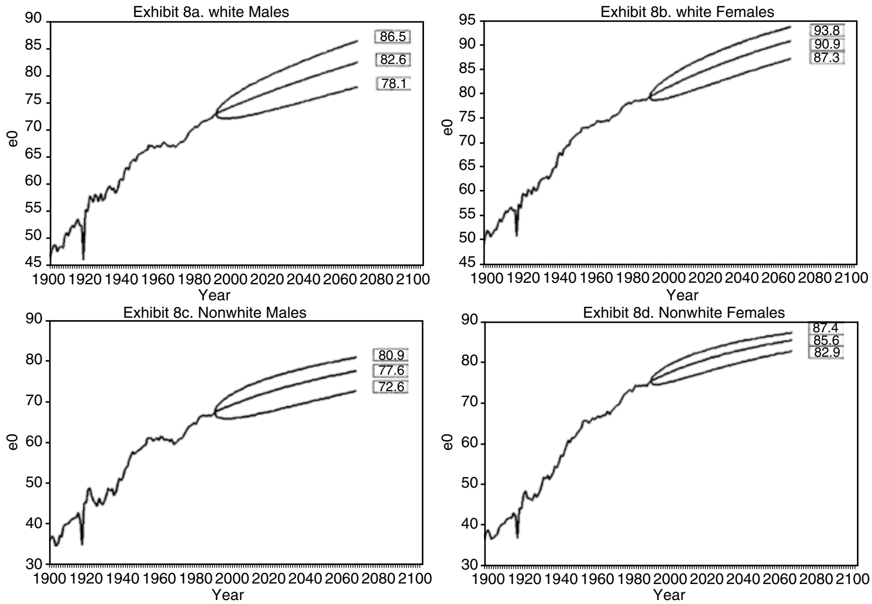

Fig. 4 Estimates and forecasts of e_o by race and sex with 95% confidence bands for the bands for the period 1900–2065

[4]These confidence intervals are not adjusted for uncertainty inherent in the drift term. Taking into account the increase in forecast standard error due to the drift parameter expands the confidence intervals by the year 2065 to 11.67 (versus 8.4), 9.00 (versus 6.5), 11.79 (versus 8.3), and 6.35 (versus 4.5) for white males, white females, nonwhite males and nonwhite females, respectively. Details of this estimation problem for the total population are found in Lee and Carter (1992, see especially Appendix 2) and for sexes in Carter and Lee (1992).

we note the seemingly parallel paths of the sexes by race, and almost imperceptible divergence by sex. These forecast trajectories do not present clear indications of either convergence or divergence.

A more precise assessment of the paired forecast trajectories is presented in Fig. 1b. First, observe the more intriguing patterns for the within sample observations: divergence of the sex differentials until recently where they appear cyclical; and convergence of the race differential to around 1985 where the future is indecipherable. Nevertheless, all of the differentials are at some level greater than zero, so the longer-term future trajectories are intuitively speculative. Still, the differentials of the forecasts present another picture; they all tend to follow the secular trend of the observed differentials. The overall curvilinear patterns in life expectancy differentials are of very slow movement towards race divergence by sex and either sex convergence or stability by race. In no instance is closure expected by 2065. In a later section, these patterns are explored as the process of entropy.

Differentials in Other Life Table Functions Derived from Forecasts of k

Death Rates

As denoted earlier, a_x, b_x and forecasted k_t together can be used to generate other life table functions in addition to e_0. Accordingly, we exploit this technique to forecast $m_{x,t}$ and to produce survival distributions by race and sex to see what they infer about the differentials.

The respective forecasts of k_t and their 95% confidence intervals were shown in Fig. 3. The rank order of these declines of −53.2, −49.4, −39.2 and −37.1 is consistent with the recent historical experience for nonwhite females, white females, nonwhite males and white males, in that order. Again, the significance of these declines for their future age-specific death rates and e_0's are mediated through their respective a_x's and b_x's. The standard errors of the estimates (see's) reflected in the confidence intervals indicate the uncertainty associated with a one-year forecast: as the forecast horizon increases, the standard error grows with the horizon's square root.

Typically, if one wants to determine if parity or reversal in the death rates between races and sexes are probable in the future, one resorts to comparisons of forecasted $m_{x,t}$s across their mortality schedules. With increased longevity in the future as our analysis suggests, the potential for crossover should diminish. The reason for declining incidences of crossover by race is that, with improvements in health and declining death rates for the disadvantaged race (nonwhites in this instance), premature deaths due to genetic frailty would be less prevalent in the earlier years of the life span, but more concentrated in the much older years where intervention is less likely to extend life. What advantage that accrues to nonwhites at these ages now would likely dissipate in the future, changing the prospects of crossover.

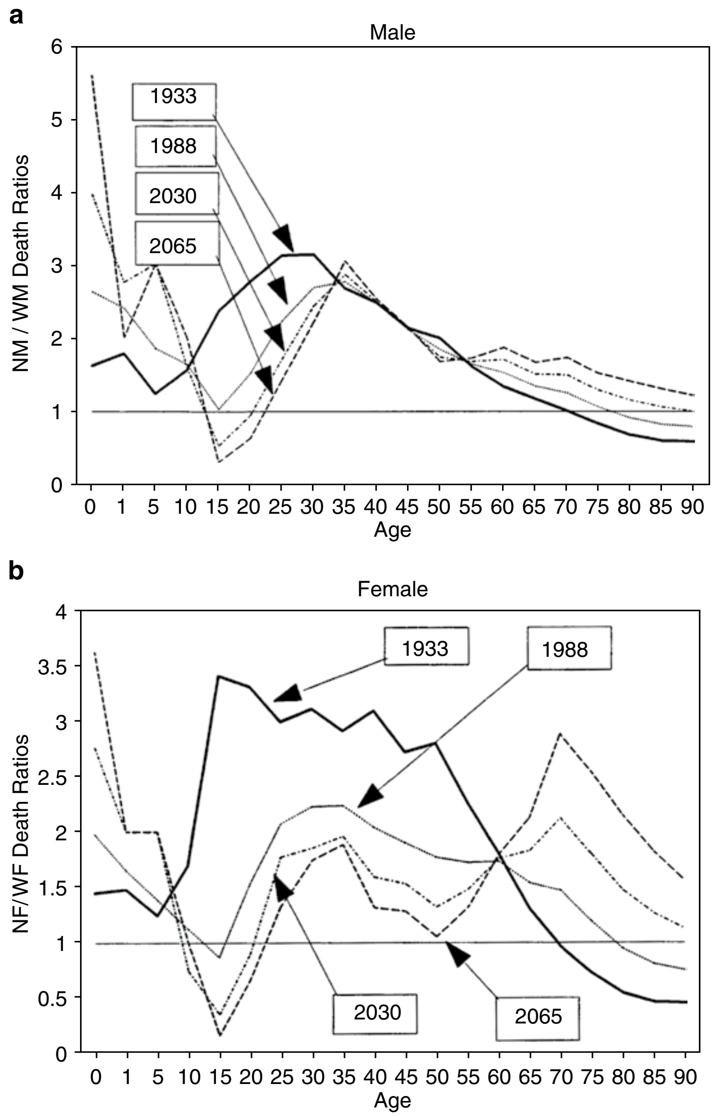

Fig. 5 Nonwhite/white age-specific death ratios by gender, U.S., for selected years

As a parsimonious way of presenting the patterns, we use ratios of nonwhite to white age-sex-specific death rates for the years 1933, 1988, 2030 and 2065, as they represent endpoints of the sample period and the midpoint and endpoint of the forecast period. This is the tack taken by Manton (1982). These ratios are displayed in Fig. 5. Remember, years 1933 and 1988 are from the within sample period, while 2030 and 2065 are from the forecast interval. Only for 2030 and 2065 are the forecasts of very old mortality based on the Coale-Guo model (Coale and Kisker 1986, Coale and Guo 1987), not U.S. data. Even so, the patterns are instructive. For both sexes, there is a declining ratio between ages 5–10 and 15–20, beginning in 1988, and crossover between ages 10–15 and 25–30, peaking at age 15–20. These findings are consistent with the pattern for sex differentials reported in Carter and Lee (1992). We have no ready explanation for these results. For the older ages, for both sexes, there is a steady increase in the age at crossover (age 70–75 for 1933 and 80–85 for 1988) with attenuated depth over time for the within sample estimates. By 2030, crossover for both sexes disappears, with ratios increasing in magnitude over time. The magnitudes are much higher for females than males. Given the increasing magnitude over time of the ratio for older ages below age 85, we doubt that the Coale-Guo extrapolations account for the disappearance of the crossover in the forecast period.

These findings are consistent with the argument we presented in the preceding paragraph. Nevertheless, what is more noticeable is the greater disparity of the ratios in the accidental death period compared to the ages of degenerative deaths. The accidental death period may be more a reflection of social behaviour, signalling the need to explore why nonwhite self-destructive mortality should dramatically decrease over time with respect to white mortality. Obversely, the ratios of degenerative deaths increase over time also. Deaths in old age are, too, a function of the confounding of socioeconomic (Retherford 1975) and, perhaps more so, genetic factors (Omran 1977). Since we are employing strictly extrapolative techniques, we have no way of discerning what matrix of exogenous factors would lead to such outcomes, or, in fact, if the proper mix of exogenous factors would lead to the same outcome. Even so, these results suggest that degenerative causes will continue to increase the disparity in nonwhite and white mortality to sometime in the future, but in directions opposite of the crossover.

Survival Distributions

Another way of presenting the differentials by race is to view race-sex-specific survival distributions. We exhibit the differentials as age-specific survival sex ratios by race for selected years (Fig. 6). The greatest differentials for males and females occur in 1933, diminishing over time up to the late middle ages. Beyond 1933, the comparisons show greater gains for males with respect to females for both races. Both patterns are consistent with the trajectories shown in Fig. 1b. for differences between the extremes of the forecast years (1990 and 2065). Comparisons by sex are shown in Fig. 7. As is apparent in the graphs in both Fig. 7a and b, the crossover diminishes over time and is clearly gone by 2030.

Of all of the race and sex comparisons, it is interesting to see where the greatest gains accrue. The modal differential in age of survival for white males is 80–85 (with 121,307 person-years) and 85–90 (with 177,347 person-years) for

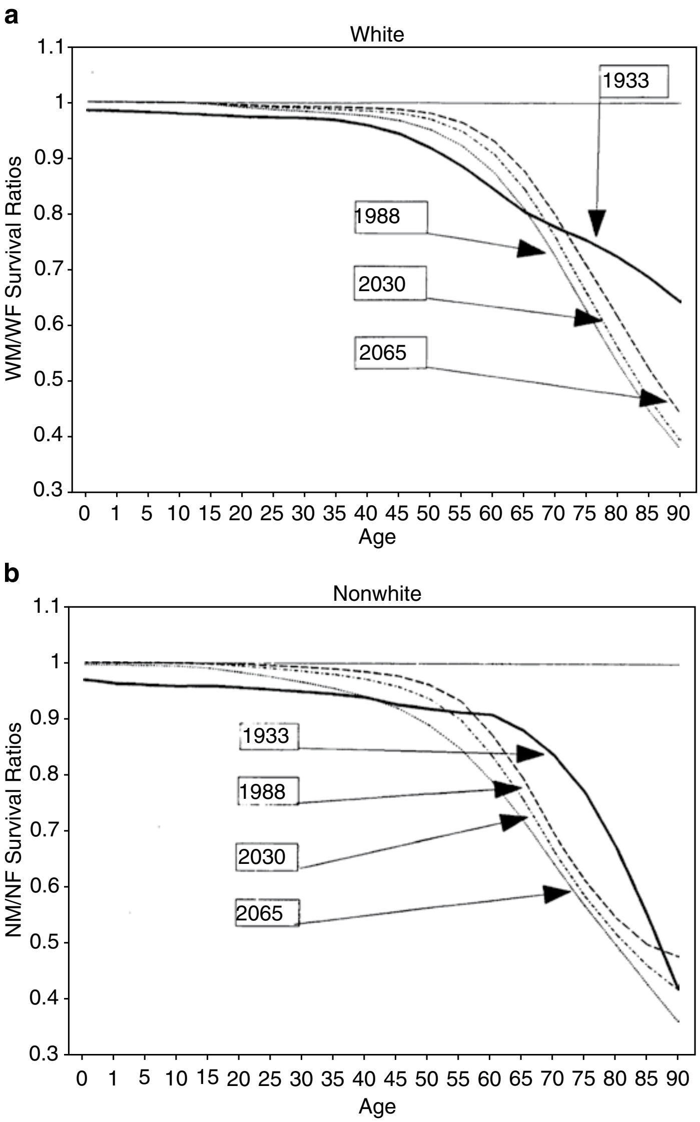

Fig. 6 Male/female age-specific survival ratios by race, U.S., for selected years

white females. The modal ages for nonwhite males and females are 65–70 (with 85,745 person-years) and 75–80 (with 163,122 person-years) respectively. The ratios of the modal frequencies are presented in Table 4. The rank order in averages for modal ratios is white female, nonwhite female, white male and nonwhite male.

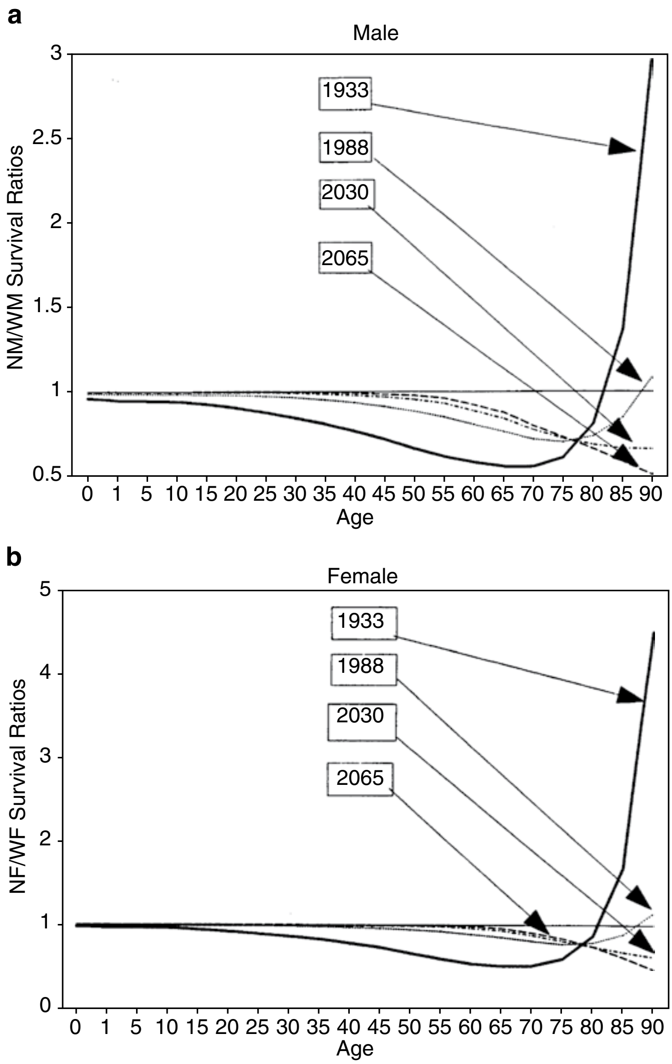

Fig. 7 Nonwhite age-specific survival ratios by gender, U.S., for selected years

Table 4 Ratios of modal differentials in age group survival by race and sex

	White male	White female	Nonwhite male	Nonwhite female
White male	1.00	1.46	0.71	1.34
White female	0.68	1.00	0.48	0.92
Nonwhite male	1.41	2.07	1.00	1.90
Nonwhite Female	0.74	1.09	0.53	1.00
Average	0.96	1.40	0.68	1.29

So far, from the survival distributions, we have gleaned the clear white female advantage in survival over the forecast period. Since we are examining age-structured populations, it is instructive to know how much compositional change to anticipate within the male and female populations. Since we can expect very high survival rates at birth through the inception of agedness (age 65), we concentrate on changes for ages 65–69 and age 85–89 as this latter age group is recently the one experiencing the fastest growth in survivorship. For white males, the percentages surviving to age 65 are 66% in 1990 and 83% in 2065; for white females the figures are 81% and 95%; for nonwhite males, 51% and 73%; and for nonwhite females, 70% and 92%, respectively. These are strikingly high figures in 2065, especially for females. At age 85, the figures for white males are 11% in 1990 and 33% by 2065; for white females, the corresponding figures are 23% and 59%; for nonwhite males, 9% and 19%; and for nonwhite females, 19% and 33%, respectively. All of the percentages indicate rapidly ageing populations, which may promulgate severe policy changes for the social welfare of the elderly in the future.

Life Table Entropy

Finally, we revisit differentials in life expectancies and attempt to draw some closure on the issue of convergence or divergence. The distribution of deaths varies greatly by age in a population in both a period sense and over time. A summary measure of heterogeneity at a given point in time is called entropy (H). In life table notation, this measure is:

$$H = \left\{ \sum_{X=0}^{\omega} e_x d_x \right\} / e_0$$

where, for purposes of this study, $e_x d_x$ can be interpreted as the average number of years an individual could expect to live, given a second chance on life and e_0 life expectancy at birth (Carey 1993). Here, H is used to measure the percentage change in life expectancy produced by a reduction of 1% in the force of mortality at all ages (Vaupel 1986). Measures of H are constructed for each of the populations for each year over the forecast horizon from 1990 to 2065. Both the individual H series and their paired differentials as ratios are presented in Fig. 8.

All of the trajectories in Fig. 8a are downward sloping consistent with diminishing increases in life expectancies at birth for ageing populations. The most advantaged populations in terms of life expectancies (whites and nonwhite females) have lower levels of H over time. While the race-specific trajectories appear to be almost parallel, those for sex seem to be converging. These patterns are more apparent in the graphs of their ratios in Fig. 8b.

The measure we use to describe relative mortality risk over time is

$$\delta = \frac{\left(e_0^{\,a} / e_0^{\,b}\right) - 1}{-H}$$

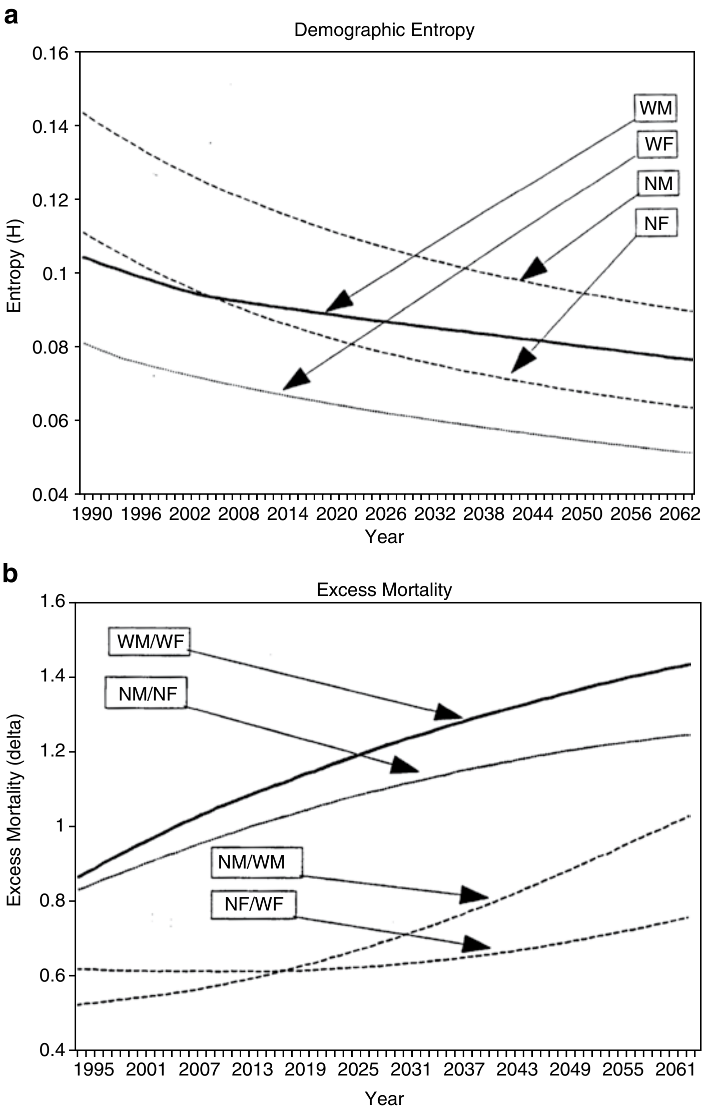

Fig. 8 Demographic entrophy and excess mortality by race and gender U.S., 1990–2065

where δ is a measure of the differential in risk for matched pairs of a and b (i.e., from among wm, wf, nm, nf) distinguished by (e_0^a/e_0^b). Our interpretation of δ here differs somewhat from that given by Keyfitz (1977). We observe the trending of δ as an indication of the temporal spread or gap in mortality between compared populations. In Fig. 8b, the ratios are measurements of disadvantaged (higher H) population to advantaged (lower H). These patterns of ratios contrast with those of differences in e_0 in Fig. 1b. The plots indicate that the pairs, wm/wf and nm/nf will each diverge at a decelerating rate well into the future, while the pairs, nf/wf and nm/wm, will each diverge at an accelerating rate. Since each race and sex trajectory is not co integrated, it is moving at its own pace; no absolute conclusions can be drawn. The moving target analogy holds. Still, it appears that in no instance is parity achieved for either races or sexes and that the increasing ratio by sex within races indicates some movement towards convergence. Obversely, the declining ratio by race within sexes indicates divergence. So, it appears that even with expected improved life expectancies for both races and both sexes over the forecast horizon, the sex differential will narrow, while that for the races will increase.

The Illusory Nature of Race

Just what is a race? As Coros (1997) notes, race is a slippery term. It is slippery because it is a biological term that subsumes a lot of social behaviour to give clear definition to subpopulations that make them readily and simply categorized. Thus, seemingly biological differences are fortified by a confluence of social differences that are seen as immutable, and the consequences of that immutability becomes the basis for the social ordering of societies. Race is so deeply embedded in societies that its biological and social aspects are deeply intertwined in both informal and legal parlance as well. As such race generates misrepresentations and social conflicts that defy resolution. There appear to be three taxonomic classifications of race: the morphological, the genetic and the social construction. We explore them each in turn.

The Morphological Basis for Classifying Races

The construct of race is not new, but its taxonomic basis has changed with the transformation of societies over time. It has been foundational in the structuring of human populations for much of the existence of Homo sapiens since its emergence as a distinct species. In its earliest formulations, race was used to denote geographical populations, language groups, religious groups and nationalities. The intention in these formulations seems to have been to affirm superiority/inferiority and dominance/sub-dominance by the population constructing the hierarchy. These formulations began to proliferate in the fifteenth and sixteenth centuries with the increased exploration of regions of the world largely unknown to Europeans and with the establishment of the practice of imperialism. Then, in the eighteenth century, the biological connotation of race became dominant for the same reason. It was in this period that a scientific basis for describing races was first established. The Swedish physician and naturalist Carolus Linnaeus originated the taxonomic classification system for both flora and fauna of the Earth. In his ninth edition of System Naturae (1756), his fauna classification, he divided humanity into four distinct groups: American or red, European or white, Asiaticus or yellow and Africanus or black. For each of these groups, he linked physical traits with corresponding social behaviour. A contemporary, the German physician Blumenbach, expanded the categories to five, which became one of the most influential and enduring racial classification systems. This classification with modification and contraction or extension by others has persisted until today. Many such taxonomists realized that some artificiality underlay their schemes to classify humankind, yet for most there was an undeniable acceptance of the idea that their categorizations of the groups represented distinct 'subspecies' (Coros 1997). As a consequence, much of the socio-structural differences in human populations have been defined by these 'subspecies' characteristics. These characteristics have been seen as justifications for the hierarchical stratification of modern societies with the consequence that life chances appear as physiologically preordained. Subsequent admixtures of these 'subspecies' have produced a proliferation of human types sufficient enough to call into question the morphologically fixed basis of this distinctiveness. Until recent times, much of the emphasis on taxonomic ordering of races was fortified by an anthropological emphasis on morphology. Now, this approach to classifying human population has lost most of its currency. The interest has now shifted to searching for the genetic distinctions among human populations that justify classifications of 'subspecies.' This approach, too, is fraught with questions.

The Genetic Basis for Classifying Races

This questioning has been enjoined by recent findings of the Genome Project that we all share some 30,000 genes highlighting the statistical invariance of the races. Furthermore, the human body is built and run by fewer than 100,000 kinds of protein molecules that may account for subtle differences among the races that manifest themselves often as rare race-specific genetic diseases. These rare diseases appear to result from genetic mutations that occurred early in the history of the affected populations in specific environments.[5] It is the complex interplay of these

[5]Perhaps a most revealing example of the impact of environment is the historic prevalence of malaria in a geographic belt around the world from the Mediterranean region to a band from West Africa to Madagascar to Asia. In these regions, a high prevalence of malaria correlates with a high frequency of a certain race-specific genetic disease: sickle cell anemia from West Africa to Madagascar and thalassemia in the Mediterranean, Asia Minor, India and some parts of Indonesia. Both diseases result from an abnormal form of the protein haemoglobin resulting from a defective pair of genes. In both instances, inheriting the disease results (under a deficit of oxygen) in mortality, inheriting a healthy pair of genes results in immunity to the disease, inheriting one defective gene results in very mild susceptibility to the disease with an advantage of some immunity to malaria. None of these diseases are exclusive to the specific races so designated as their carriers; these races simply have extremely higher frequencies of genetic susceptibility.

genes, proteins and environment that determine the stability and mutability of human populations (Keller 2000). In all, these biological findings appear insufficient to account for the variability in life chances among the various races.

The Social Construction of Races

Perhaps more importantly, for the United States, race is qualified by its social definition as codified in the U.S. Census of Population. In the past, census takers often imposed much of the racial designation of households, but in recent decades it has been determined by self-selection. The emerging proliferation of admixtures complicates the picture and is probably the most trenchant problem in forecasting race differences in mortality – and in fertility and migration as well. The 2000 Census of Population allows for 63 categories of race exclusive of Hispanics – a language group. Racial mixtures account for 2.4% of the nation's 281 million people, a percent that is sure to rise in subsequent years. The beginning of this study cautiously interchanged black with nonwhite due to the historic dominance of blacks in the nonwhite population. It is not clear how increasing variation in the racial minority population will affect the forecast trajectory. But, since it is increasingly clear that the social construction of race will dominate any biological basis for its classification, the forecasts have extremely important social consequences for their population bases.

Conclusion

This study has demonstrated the use of a rather parsimonious demographic time series forecast model to generate estimates of many life table functions for disaggregates of the U.S. population well into the future. The model produced four indexes of mortality, k, for white and nonwhite males and females. Co-integration analysis was used to establish that there is no long-term relationship between any pair of these indexes. Thus, they and their corresponding derived mortality functions can be viewed as moving independently over time. Time series of the generated functions were used to analyze differentials in mortality for race and sex.

Overall, the results of this study support the view of improving life expectancies well into the future, consistent with the findings of Lee and Carter (1992) and Carter and Lee (1992). In terms of the original concern for mortality convergence or divergence in the future, these findings suggest that the sexes by race will converge, but that the races by sex will diverge. Why this should occur is not all together clear, though the prevailing view is that these patterns are reflections of some complex of biological selection and environmental exposure. The racial divergence in mortality is a seemingly intractable problem, and it appears from these forecasts that it will remain so for the foreseeable future. Bearing in mind that extrapolative forecasts such as these and their derived life table functions do not offer a definitive explanatory understanding of these patterns, they do provide a very reasonable portrayal of the trajectories. However, emerging definitions of race will increasingly complicate them. What these results do suggest is that there is probably no uniform protocol for eliminating the differentials in race and sex mortality. That alone should arouse curiosity about their futures and stimulate further investigation of their causal bases.

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Part II
Fiscal Dynamics and Projections

Uncertain Demographic Futures and Government Budgets in the US

Ronald Lee, Shripad Tuljapurkar, and Ryan D. Edwards

Introduction

Why are we as demographers making long term government budget projections? There are three reasons. *First*, the population size and structure exert powerful effects on many aspects of the budgets, particularly through the numbers of children, workers and elderly. Long term population projections are a key factor in any long term fiscal projection. *Second*, demography is the only ingredient of long term projections about which one can realistically project more than a long term mean. The ageing of the baby boom, continuing mortality decline and continuing low fertility lead to population projections with real long term content, including turning points far in the future. Of course, none of these demographic trends is completely certain (Ahlburg and Vaupel 1990), which leads to the *third* point. Demography has made more progress than other fields in explicitly incorporating uncertainty in long term forecasts. Since long term forecasts involve so much uncertainty that many doubt their utility, explicit treatment of uncertainty is desirable, and demographers are placed at least as well as other specialists to carry this out.

Nonetheless, there is a certain absurdity in focusing on a few demographic and economic uncertainties while treating all else as known with certainty, and then

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presenting probability intervals as if they had real meaning. There is also great uncertainty about future age-standardized health care costs, which will exert a powerful influence on most aspects of these forecasts. Future rates of disability for the elderly and near elderly are another key unknown. The structure of government programmes will probably look quite different in 10 years than it does now. The future progress of education in the US, of technological progress, of the quantity and characteristics of immigrant streams – all are important and uncertain and the list could be extended indefinitely. What, then, is the point of this exercise? Several answers are possible, one of which is ‘Maybe there is none’. Another is ‘We won’t really know the possibilities until we have tried.’ But more positive answers are also possible: These estimates of uncertainty could plausibly be viewed as minima, which are lower bounds for true uncertainty. Furthermore, the role of certain kinds of uncertainty can be largely eliminated by expressing results relative to GDP, rather than absolutely or per capita. The projection of population under girds most long term economic projections and certainly all fiscal ones. Assessing its uncertainty can only help. And uncertainty aside, our mean forecasts are themselves of considerable interest, because they have been done with more attention to the detailed age distribution of benefit programmes than any previous forecasts, so far as we know.

An overarching question which stochastic forecasts such as these might eventually help answer is this: Given the context of uncertainty, should federal policy adopt a ‘wait and see’ approach, since the extent of future problems is not yet clear, or should it prepare for the expected cost increases immediately by building up substantial trust funds in advance, held in the form of real assets? Fluctuating tax rates impose higher deadweight losses on the economy than a constant tax rate set at the average, since there are strong nonlinearities. Smoothing across variations in government expenditures therefore leads to efficiency gains. However, smooth tax rates may or may not be consistent with intergenerational equity.

Why Population Matters

Recent decades have seen the emergence of massive public sector transfer programmes in industrial nations. Because many transfers are age related, the population age distribution is a powerful influence on government budgets and ageing will be very costly. In the next few decades, the US age distribution will be transformed by the ageing of the baby boom generations. This ageing process will have well-anticipated effects on the federal budget, particularly through the OASDI and Medicare programmes, but also through Medicaid, Supplemental Security Income (SSI) and other programmes. The effects of ageing on other aspects of the federal budget, and on state and local budgets, are less well understood and interact with uncertainty about future fertility. Will costs of schooling and other benefits going primarily to children vary so as to offset the public costs of ageing, or will they also rise? And will population ageing alter the balance of federal versus state and local spending?

In addition to these effects of population ageing on costs of public services and transfers, demographic change will also affect the revenue base. Both the size and the age distribution of the working age population will change and these effects may be worth taking into account as well. Growth of the revenue base in relation to the size of the pre-existing government debt will also influence future tax rates.

Explicitly Incorporating the Uncertainty of Forecasts

Demographers have been working for many decades on the problem of producing long term stochastic population projections, including probability intervals for the quantities forecast. In recent years this work has intensified (Sykes 1969; Keyfitz 1981; Stoto 1983; Alho and Spencer 1985; Cohen 1986; Alho 1990; Lee and Carter 1992; Tuljarpurkar 1992; Lee 1993; Lee and Tuljapurkar 1994; McNown and Rogers 1992; Pflaumer 1988; Lutz et al. 1996). An extensive review is provided in Lee (1999). A variety of approaches have been taken, including the use of expert opinion, ex post analysis of projection accuracy, Monte Carlo methods and statistical time series analysis. In this paper, we build on the earlier work by Lee and Tuljapurkar (1994) to generate stochastic projections based on age distributed vital rates that are driven by statistical time series models fit to historical data.

There has also been increased interest in long term budget projections, with work by Auerbach and Kotlikoff (1994) and long term projections of the Congressional Budget Office (1996) and (1997). These budget projections have generally been deterministic, but the Congressional Budget Office also included stochastic projections of Social Security finances based on inclusion of the Lee and Tuljapurkar stochastic population simulations. Homer and Bender(1996) has also generated stochastic projections of the long run finances of Social Security, based on treating the Trustees' high-low intervals for each assumption as implicit probability bounds and then performing Monte Carlo simulation.

Dealing with Economic Uncertainty

In our projections, the only fundamental (as opposed to derived) economic variables that are treated as stochastic are the rate of real (age–sex adjusted) productivity growth and the real rate of interest, and these are treated as independent of the evolution of the population. Many others could, in principle, be modelled and forecast as random variables, including the rate of inflation, labour force participation rates, the rate of increase of health care costs and the rate of unemployment. We have elected to keep the economic side of our analysis relatively simple. We have typically followed the intermediate assumptions of the Trustees in setting long term values for the variables treated as deterministic. It might be desirable to incorporate more general demographic influences on the economy, through savings behaviour, investment, capital per worker, productivity growth, government debt, composition of demand for financial assets and interest rates. Such an expanded endeavour would obviously involve many new assumptions and uncertainties and we do not pursue it in this paper.

The Approach

This paper is the next step in a long term project by Lee and Tuljapurkar, with earlier contributions by Carter. The project started almost 20 years ago with the development of a new method for forecasting mortality, by combining statistical time series methods with a model of the age structure of changes over time in mortality (Lee and Carter 1992). That was followed by a similar approach to forecasting fertility (Lee 1993). These components were then used, together with earlier theoretical work by Tuljapurkar (1990), to develop stochastic forecasts of the population as a whole (Lee and Tuljapurkar 1994). The stochastic population forecasts were then used to produce stochastic projections of the finances of the Social Security system (OASDI) in Tuljapurkar and Lee (2000). The only stochastic component of those projections was demographic. Subsequent work on long term forecasts of Social Security has incorporated stochastic models for productivity growth rates and real interest rates as well (Lee and Tuljapurkar 1998a, b). The present paper incorporates that work on Social Security in a broader treatment of government budgets. It draws on related deterministic budget projections done as part of a project to assess the fiscal impacts of immigration (Lee and Miller 1997). In many respects, we have tried to follow the assumptions and procedures of the long term budget projections published each year by the Congressional Budget Office. Where our approach differs, we generally spell out the rationale and procedures.

It would be absurd to argue that public programmes in the US will remain as they are now, in terms of benefit structures, for the next 75 years. We do not know what programmes will look like decades from now. One might argue that even though the details of programme benefit structures will surely change radically, the overall age distribution of the aggregate of programme benefits may remain fairly similar. Even this weaker assertion would be difficult to defend, however. For example, it is possible that the retirement benefit of the Social Security system will be to some degree replaced by private individual retirement accounts, as in Chile. Then retirement benefit payments to the elderly would vanish from the government budget, dramatically altering the age-shape of federal benefit payments. For the most part, our projections are made conditional on a set of assumptions about the policy environment, often that the current benefit structures persist. Our projections can therefore be viewed as spelling out the long run future implications of different policy regimes, including adaptive policy regimes.

Population Projections

The population projections which underlie the budget projections have been described in detail elsewhere (Lee and Carter 1992; Lee 1993; Lee and Tuljapurkar 1994), so only a short summary will be provided here. The basic strategy is to develop one parameter families of model age schedules for fertility and mortality (to use demographers' terminology). Let m(x,t) be the death rate for age x and time t. Then the descriptive model for mortality is: $[m\ (x,t)] = a(x) + k(t)b(x) + \varepsilon(x,t)$ where a, b and k are estimated coefficients, and ε is the error. a(x) describes the average shape across ages of the death rates, while b(x) describes the rate at which the death rate at age x changes when the overall level of mortality, indexed by k(t), changes. The estimates of k(t) form a time series over the sample period in which mortality is observed, which is modelled and forecasted using statistical time series methods. For the US, a random walk with drift fits the series well. The mean forecast from this method is for sexes-combined life expectancy in 2065 of about 86 years, roughly twice the gain in life expectancy that is forecast by the Social Security Actuaries (Trustees' Report). However, differences in the age distribution of the projected declines tend to offset some of the effects of this more rapid mortality decline in relation to the Trustees' mortality forecasts.

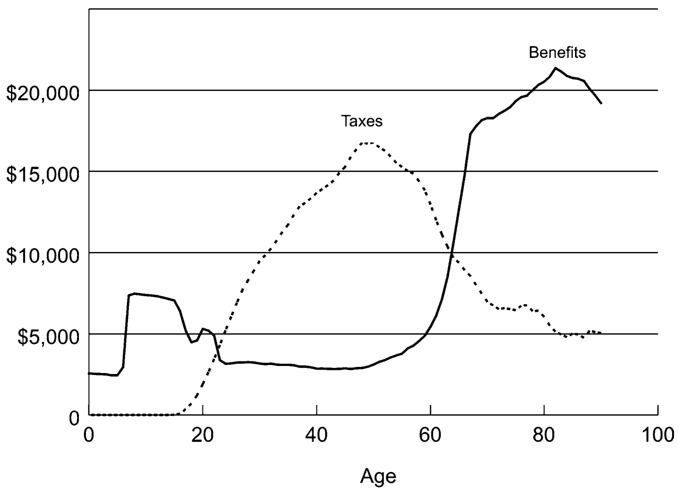
Fertility is modelled, estimated and forecast in a similar way, except that in this case the logarithmic transform is not used and we specify a longer term mean for the stochastic process (see Lee 1993). For the US, we have taken this to be 1.9 for the TFR, consistent with the assumption used by the Actuaries of the Social Security Administration (Board of Trustees 1996). The statistical analysis then provides estimates of the variance and auto covariance of the fertility process. Immigration is set deterministically at the level assumed by the Actuaries, which is 900,000 per year. While it could be modelled in a way similar to the vital rates, the fact that it depends to a considerable extent on policy decisions puts it in a different category.

With stochastic models for fertility and mortality, and a deterministic assumption about immigration, and with initial values for the population size and age-sex distribution, it is possible to construct a projected 'sample path' through stochastic simulation. (An analytic solution for a quadratic approximation to the moments of the distribution of the population variables is also given in Lee and Tuljapurkar (1994), but for present purposes the stochastic simulation is far easier to use.) A set of 750 sample paths (individual stochastic projections) is built up, where 750 was chosen by studying the convergence of the moments calculated from these simulations. This set forms the demographic basis for more comprehensive stochastic simulations, along lines described next.

The Age Structure of Benefits

Some government transfer programmes are targeted to the needy and some are targeted to specific age groups. Of those targeted to the needy, some end up nonetheless being used primarily by certain age groups. In any event, working age people receive a relatively low level of transfers, on average. It is children and the elderly that receive the lion's share. To illustrate this point, Fig. 1 plots the total across all programmes of the cost of benefits received by the average person at different ages in the US. There is a base line for all ages reflecting non-age-specific congestible services provided by the government, such as fire and police protection, roads, libraries and so on. Our main interest, however, is in programmes that have an uneven age incidence, either by design, as with Medicare, or by accident. It can be seen that children aged 5–22 are recipients of major benefits, primarily public education. Levels of receipt are lower for ages 23 through 55 or so and then begin to turn up sharply, with the steepest increase at 62 years, the earliest age at which one can take Social Security retirement benefits. The major benefits received in old age include Social Security, Medicare, Medicaid (particularly for the oldest old in nursing homes) and SSI.

It is these strongly age-structured benefits which make demographic trends centrally important for government budgets. However, governments provide other services which do not depend on age in any obvious way. Some of these are public goods, such as the military. By definition, the cost of providing a constant level of service for a pure public good is invariant to the size of the population. Nonetheless, we follow the Congressional Budget Office in projecting that military expenditures



Note: These data are taken from the 1994 and 1995 March Current Population Survey. Benefits include a per-capita share of congestible goods.

Fig. 1 Cross sectional age profile for benefits and taxes remain a constant fraction of GDP, and therefore grow as it grows. This could be explained as a response to the falling per capita price of providing a given level of service. The cost of servicing the existing level of national debt does not depend on the size of the population, so a larger population can share the burden of paying interest on it.

In addition, there are many government services for which maintaining a constant quality requires increasing expenditure more or less in proportion to the size of the population. We assume that expenditures on such services grow both because of population growth and also because of growth in per capita income. Therefore, they also are assumed to grow with GDP.

Economic Projections

Our raw measure of productivity growth is output per hour of labour. We refine this by adjusting for the age–sex composition of the labour force, weighted by the average wage rate for each characteristic. This adjustment makes relatively little difference. For the interest rate, we have used the time series for the special Treasury Issue for Social Security, which is based on an average of rates for bonds of differing terms. This synthetic rate has averaged 2.3% per year over recent decades, in real terms. Both the productivity growth rate and the interest rate are modelled as processes with long term means constrained to equal the values in the Actuaries' Intermediate Forecast (Board of Trustees 1996). The variances and auto covariances are estimated from the data. We did not find these series to have significant co variances, so they were modelled as independent. In future work, we plan to develop better integrated models of these series, based on the work of Frees et al. (1997). We may also distinguish between rates of return earned by Social Security and rates of return earned by private purchasers of Treasury notes.

Detailed Assumptions and Procedures

Our baseline policy assumption is that the federal budget is adjusted through changes in the level of taxes to maintain a given level of federal debt to GDP. Benefits remain as they are now defined to be (including scheduled changes in the Social Security normal retirement age). State and local aggregate budget also maintains a constant debt to GDP ratio at its current level.

Given this setup, the trajectory of government debt is fully determined. Our interest focuses on the time paths of expenditures for various programmes and various levels of government and on the trajectories of taxes at the federal and state/local levels, for OASDI and for other programmes of interest. There will be a great deal of uncertainty associated with each of these projected trajectories.

These projections involve a large number of detailed assumptions and calculations, which we will briefly describe. Details can be found in Edwards (1998), which is available on request. In general, we have followed many of the procedures used by the Congressional Budget Office (1996) in their long term projections.

Forecasts of GDP

GDP is calculated by applying an estimated age schedule of earnings to the evolving population age distribution. The resulting product represents the demographic contribution to economic growth. A constant of proportionality is chosen to adjust the product so that it matches actual initial GDP. Thereafter, the adjusted demographic product is inflated by the level of productivity given by the stochastic forecast. Recall that productivity growth was measured in an age standardized way. This procedure reinserts the influence of changing age distribution on output by way of the demographic product. This procedure also implies that labour earnings are a constant share of GDP, as are earnings of capital. The procedure implicitly assumes that labour force participation rates remain constant, with declines for older males offset by increases for females.

In our forecasts (not shown here) the expected value of GDP grows from $6.74 trillion at the 1994 baseline to $24 trillion in 2070 (in 1994 dollars), for an average growth rate of 1.67%. Recall that the average productivity growth rate is assumed to be 1% per year; the difference, or 0.67%, reflects growth in the size of the labour force. There is enormous uncertainty about the amount in 2070, with the 95% range bounded by $8 trillion below and $48 trillion above. The upper bound corresponds to an average growth rate of 2.6% per year and the lower bound to 0.2%. Because of this extreme uncertainty, it makes little sense to present results other than in relation to GDP.

Forecasts of Benefits

For most programmes, we begin with the cross sectional age-specific benefit profile estimated from Current Population Survey data and assume that this schedule rises with the productivity growth rate. Total expenditures on such programmes will then be determined by each year's population size, population age distribution and level of productivity. This is true for the following programmes: Earned Income Tax Credit, College Education, K-12 Education, School Lunch, Food Stamps, Energy Assistance, Direct Student Aid, Public Assistance, SSI, Federal Retirement, Military Retirement, Railroad Retirement, Public Housing and Rent Subsidy.

The main exceptions to this rule are as follows.

A. The age profile of costs for all health programmes rises by the productivity growth rate plus an additional amount. This additional amount was projected based on assumptions in past reports of the Medicare Trustees, which the Congressional Budget Office also used. In particular, real per enrolee health costs were calculated from Trustees of HI (1996), which implies that they will rise more rapidly than productivity growth, by an additive amount which is initially 0.0472 per year, but which declines to near zero by 2015. This is a fairly low forecast of excess growth in health costs per elder in comparison to others. Medicaid and SMI benefits are projected subject to the same excess growth rate for the age profile of health costs.

It is important to note that health costs in the last year of life are on average about 15 times as great as the health costs for someone of the same age who is not about to die (Miller 2001; Lubitz et al. 1995). Health costs increase with age largely because the proportion of people in their last year of life itself increases with age, due to rising mortality. Mortality decline may reduce the health care costs at any given age by reducing the probability that anyone at that age is dying. Consequently, health care costs may be temporarily lower in the aggregate when mortality declines more rapidly, because in a transitional stage the costs are pushed to a later calendar year. Miller (2001) takes explicit account of these effects and finds that the pace of mortality decline has virtually no effect on Medicare costs over the next 75 years. Our projections for Medicare and SMI incorporate this effect by imputing costs separately to those in their last year of life, those 1–3 years from death and all others.

It is likely that Medicaid expenditures for long term care depend in a similar way on proximity to death, but the research has not yet been done on this. We examined institutional Medicaid usage rates, controlling for age, and found that they had been slowly declining over the past 25 years. We have assumed that the decline continues, reflecting the documented improvements in measures of functional status (Manton et al. 1997).

A. The age profile of Social Security benefits is determined in a complex manner based on separate work (Lee and Tuljapurkar 1998a, b), and reflects the influence on benefits of the past history of productivity growth and the influence of the planned increase in the normal retirement age.
B. A number of programmes grow as a constant share of GDP. These include all public good expenditures, congestible good expenditures, outlays to manage the Unemployment Compensation Trust Fund and incarceration costs (incarceration costs should probably be projected using an age profile, however). Although constant quality services from a public good have zero marginal population cost, in fact higher quality services are chosen over time as the per person cost of services drops with population growth.

Taxes

With No Budget Adjustment: For the case of no budget adjustment for balancing, federal and state income taxes and sales taxes are projected by applying an age profile to the population age distribution and scaling by productivity growth. Property taxes grow according to an age profile which is raised or lowered to generate revenue equal to the costs of K-12 public education. Corporate income tax, excise taxes and all other taxes grow in proportion to GDP. Payroll taxes for OASDI follow an age profile and productivity growth, but are adjusted to reflect the planned increase in the normal retirement age. We implicitly assume that the real income truncation point for OASDI taxes will be raised with real productivity growth. Medicare costs are assumed to be paid out of general federal tax revenues; we have not tried to model this system separately. In every case, we can allocate tax payments to specific age groups.

With Budget Adjustment: Usually, however, we assume that budgets are adjusted to achieve balance according to some criterion. This is necessary if we are to assume that there is no feedback to the interest rate and the productivity growth rate, and we also believe it is a sensible assumption both from the point of view of both economics and politics. Our balancing assumptions are as follows:

A. The Social Security system is assumed to keep the payroll tax rate at 12.4% so long as the reserve fund has an amount equal to at least 100% of next year's total outflows. Note that this means that taxes will begin to rise as the trust fund is depleted, so as to prevent the fund from falling to zero. Planners are assumed to look ahead 5 years in setting the current payroll tax rate. Note that this means that the 75 year forecast period cannot end with the rapid depletion of the trust fund and a big discrepancy between revenues and expenditures, as it does in the standard Trustees' Report projections.
B. The federal government targets the net debt-to-GDP ratio. Net debt is defined as all federal debt not held by Social Security. When net debt threatens to rise above 0.8 of the level of GDP, taxes are adjusted that year in equal percentages across the board (except for OASDI taxes, which are handled separately) so that the debt exactly becomes 0.8 of GDP. In each subsequent year, taxes are adjusted similarly to keep debt/GDP exactly at 0.8. This rule constrains the federal deficit (exclusive of OASDI net revenues) at a level just sufficient to keep the net debt growing at the same rate as GDP growth. Policy makers are assumed to project the debt to GDP ratio 5 years in the future and set current taxes accordingly.
C. At the state/local level, it appears that trust funds for various insurance and retirement programmes are fully funded (on average), so budgetary pressures from population ageing are light. Because the funding appears to be adequate, we treat these programmes as outside our calculations of benefits and taxes. We assume that states and localities alter their taxes by equal, across-the-board factors in order to maintain a net debt-to-GDP measure of 0.03. Net debt held by states and localities is defined as their gross debts, all bills outstanding, minus their various pools of asset, but not including the various trust funds.

Problems with Current Version

We are aware of certain problems with our analysis. One serious problem arises because we assume that the debt to GDP ratio is fixed at 0.80, once that level is attained. This constraint is observed by adjusting the non-OASDI federal tax rate each period so as to keep the ratio constant. However, the real interest rate is highly variable in our simulations and we have implicitly assumed that the entire debt is refinanced every year. For this reason, very large and volatile adjustments of the tax rate are required each year to offset the interest payments that must be made. Our algorithm produces unrealistically volatile tax rates for several reasons. First, only a portion of the debt is financed each year at prevailing interest rates; the rest is held in bonds of longer maturities. Second, most of the variation in real interest rates arises from the volatility of inflation, not that of nominal interest rates. But we do not incorporate inflation as a separate variable. Third, tax rates are not varied on an annual basis. As a temporary expedient, we have replaced the current real interest rate by a one-sided moving average of current and past rates, with weights equal to average maturity shares of bonds outstanding.

This work borrowed heavily from earlier work on forecasting Social Security finances (Lee and Tuljapurkar 1998a, b), including the time series models for the interest rate and productivity growth rates. We believe we can improve on these time series models by building on the work of Frees et al. (1997). This work also models inflation as a component of an interdependent system.

The fiscal landscape has shifted frequently and often dramatically since 1994, the launching point of our forecasts in this paper. We have not accounted for several notable developments that are sure to bias our point estimates, but will probably leave higher moments relatively unchanged. These include the surpluses that paid down much federal debt in the late 1990s, the increase in federal spending after 9/11, the tax cuts of 2001 and 2003, the introduction of the Medicare prescription drug benefit in 2006, the fiscal stimulus bills of 2008 and 2009 and the ongoing financial sector and mortgage bailouts.

Results with No Budget Adjustment

We would like to begin with the assumption that the current tax and benefit structure remains as it now is, except for changes that are currently planned, such as the increase in the normal retirement age. However, we have not quite been able to do this, because for temporary programming reasons, all the runs in this paper assume that the Social Security system (OASDI) is 'fixed.' By this we mean that a trust fund equal to 2.5 times the level of the following year's expenditures on benefits is achieved and maintained. Payroll taxes are adjusted so as to maintain this ratio. In our runs with 'no federal budget adjustment,' therefore, OASDI is nonetheless adjusted. In these runs, it is only the non-OASDI portion of the federal budget that is not adjusted.

Figure 2 shows the mean and 95% probability intervals for forecasts of the Debt/GDP ratio under the assumption of no adjustment. Starting at 0.6 in 1994, the expected value of this ratio rises steadily to 8.0 in 2070. We do not believe that such a huge increase is possible and, if it were, it would entail large increases in the real interest rate at which funds could be borrowed by the government, whereas we have

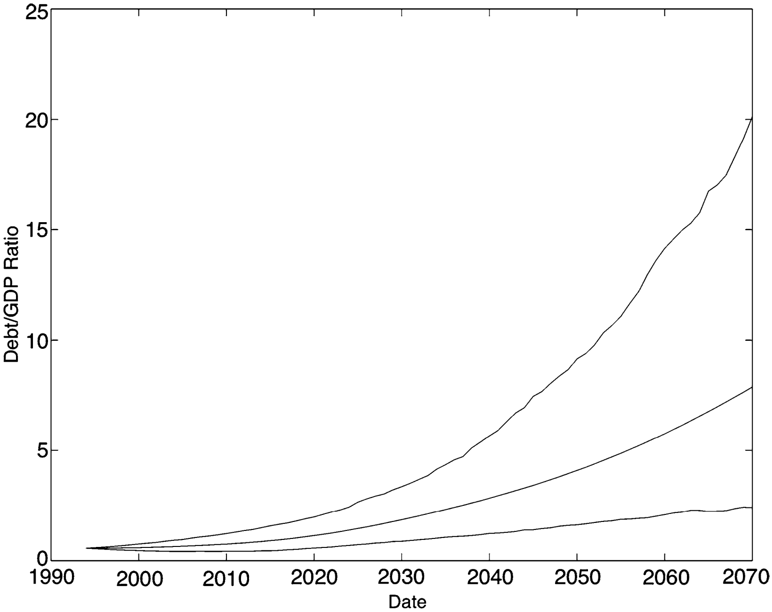


Fig. 2 Forecast of dept to GDP ratio with no budget balancing (mean and 95% probability interval, 1994–2070)

assumed that the real interest rate has a long term mean of 2.3%. This forecast also shows a 2.5% chance that the ratio would climb to at least 20! The point of this conditional forecast is to establish that the condition – no budget adjustment – is simply not realistic. Even under the most optimistic conditions (2.5% probability bound), the ratio would rise to 2.4.

Forecasts of expected federal real interest payments relative to GDP trend upwards from an initial expected value of 1.5% (nominal interest payments are higher) to 16.5% in 2070. Under the budget adjustment regime, however, expected real interest payments rise only to 2.2% of GDP. All these ratios of interest payments to GDP would be about twice as great if expressed in nominal terms and if the rate of price inflation were 2% per year.

Results with Tax Adjustment

We believe it is realistic to assume that the federal budget will be adjusted in such a way that the debt/GDP ratio will be constrained. In the forecasts reported here, we assume that the entire adjustment is made by tax changes, while the structure of benefits is left unaltered. One could also do the forecasts making the opposite assumption, that taxes are unchanged and benefits bear the full cost of adjustment.

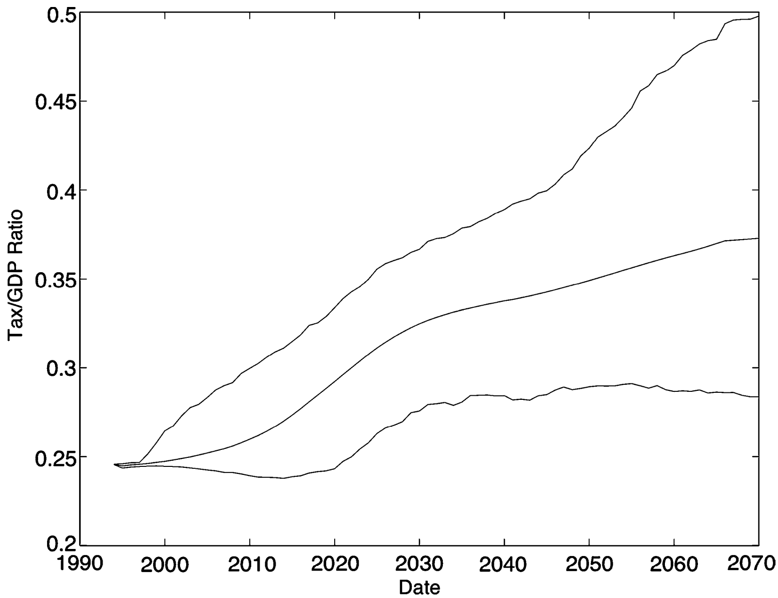


Fig. 3 Forecast of total taxes as proportion of GDP with budget balancing (mean and 95% probability interval, 1994–2070

In our forecasts, following the budget adjustment rules, the debt/GDP ratio of 0.8 is reached by 2002 in 2.5% of the sample paths and at least as late as 2030 by 2.5% of the sample paths.

Figure 3 plots the ratio of total taxes (state, local, OASDI and other federal) to GDP. Total taxes are currently 24% of GDP. The expected tax share will rise at an accelerating rate as the baby boom generation retires, reaching 34% of GDP by 2035 when its retirement is complete. However, the expected share will continue to rise, reaching 38.5% by 2070, an increase of 62% (1.62 = 38.5/24). The lower and upper 95% probability bounds for the total tax share in 2070 are 28% and 50%.

At the state and local level (SL), expenditures are primarily for education and, therefore, fertility is centrally important. There is very little uncertainty about the number of school age children until 5 years into the forecast, when the first projected births would be entering kindergarten. This shows up clearly in the forecasts shown in Fig. 4.

Social Security (OASDI) and Medicare

Figure 5 plots the payroll tax rate for OASDI that is implied by our rule that the system move towards a reserve fund equal to 100% of the next year's expenditures. The initial level is 12.4%, as set by current law. The tax rate on the mean trajectory

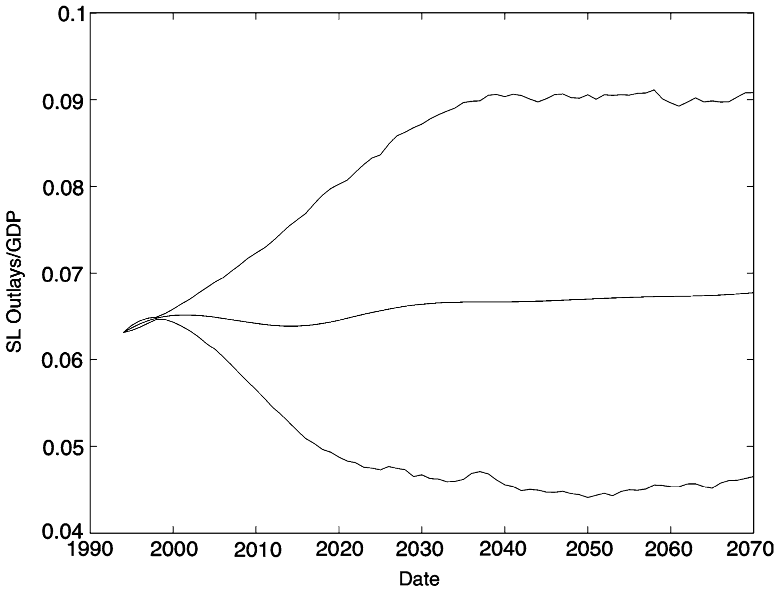


Fig. 4 Forecast of total state and local outlays as proportion of GDP with budget balancing (mean and 95% probability interval, 1994–2070)

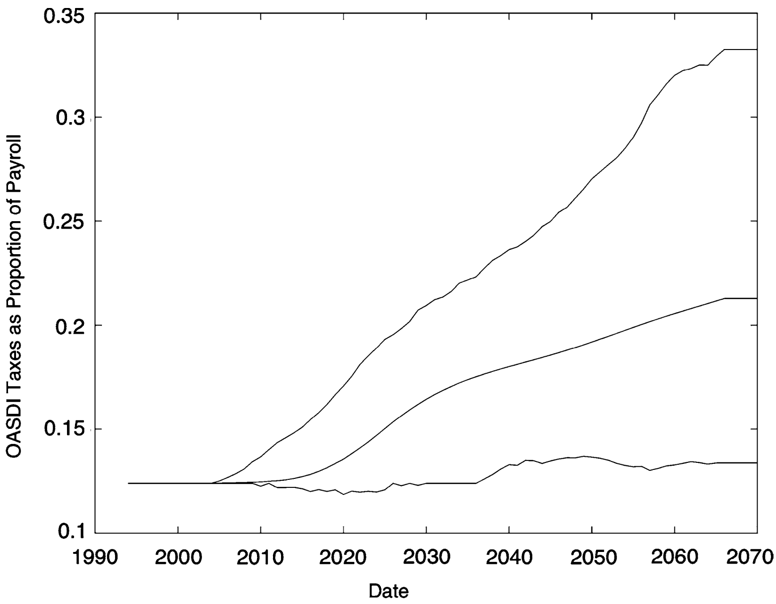


Fig. 5 Forecast of payroll tax rate for OASDI under budget balancing (mean and 95% probability interval, 1994–2070)

rises slowly, reaching a level of 17% by 2035, but continuing to rise to 21% in 2070. This is a substantial increase, but it is quite consistent with the Trustees' projection that under the intermediate assumptions, the cost of the programme in 2070 will be about 19% of payroll. Our figure is slightly higher, probably because we project more rapid mortality decline. But the big difference between the Trustees' calculations and ours is in the question asked. We only raise the payroll tax when necessary and do not seek to accumulate a large reserve fund. The level of reserve fund we maintain is roughly equal to the maximum ratio achieved under the intermediate assumptions. The Trustees, by contrast, ask by how much the payroll tax would have to be raised today to achieve long run balance. They find that a 2.2% increase would do the trick, which would lead to the accumulation of a larger fund, but which would also leave the system losing money rapidly at the end of the period in 2070. Under similar assumptions, our forecast would give results similar to the Trustees and vice versa.

Figure 5 also shows that there is a 2.5% chance that the payroll tax would need to rise by only 1% and a 2.5% chance that it would need to rise to at least 33%. Other experiments, not shown here, also reveal that raising the payroll tax rate by 2% today would leave a 75% chance of trust fund exhaustion before 2070. To achieve an exhaustion probability as low as 5% would require an immediate payroll tax increase between 5% and 6% (Lee and Tuljapurkar 1998a, b). Fortunately, there is no need to pick an increase today that would remain fixed henceforth; policies with an adaptive element are also possible.

Figure 6 shows that the expected level of expenditures on Medicare Part A (Hospital Insurance, or HI) as a share of GDP rises rapidly from about 2% today to

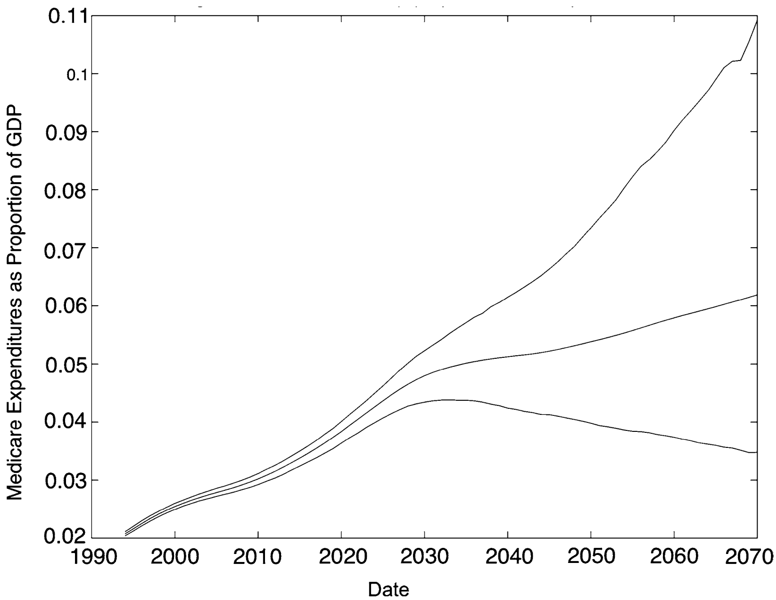


Fig. 6 Forecast of medicare (HI) expenditures as a proportion of GDP

about 5% in 2035, continuing up to 6.4% in 2070 where it is still well below the level of outlays for OASDI at 8.6% of GDP. But taken as a whole, Medicare is likely to exceed OASDI in costs in the long run. Medicare Parts B (Supplementary Medical Insurance, or SMI) and D (the prescription drug benefit, which we do not forecast) are each projected to cost about 2% of GDP by 2070 in the intermediate scenario presented by the Medicare Trustees (Board of Trustees 2008). Although an underestimate, our forecast is more interesting for what it reveals about the uncertainty. Partly because we treat the trajectory of costs per enrolee as deterministic, there is little uncertainty in Part A until projected births begin to enter the labour force in substantial numbers in the 2020s. Thereafter the probability interval opens rapidly, until by 2070 it ranges from 3.9% to 10.5%.

Even after removing OASDI and Medicare, other federal expenditures still rise in expected share from just over 11% of GDP to just under 16%, presumably reflecting increasing costs of other programmes serving the elderly, such as Medicaid and SSI.

Results by Age

We have taken two different approaches to disaggregation by age. Fortunately they yield nearly identical conclusions. In the first approach, we simply categorize government programmes as oriented towards youth, towards the old, or as age-neutral. For each programme, we calculated the average age at which its services would be received in a stationary population. These average ages then provided an objective criterion for classification. On this basis, youth oriented programmes were defined to include food stamps, school lunches, direct student aid, public assistance, K-12 public education, college education and non-institutional Medicaid. Programmes oriented towards the old include OASDI, Medicare (excluding Part D, the new prescription drug benefit, which we do not forecast), SMI, SSI, institutional Medicaid, Federal Retirement, Military Retirement and Railroad Retirement. For age neutral expenditures, we have the Earned Income Tax Credit, energy assistance, rent subsidies and public housing, plus all congestible public services and all public goods (for which we include the per capita cost, even though the marginal cost is zero).

When programmes are grouped in this way and projected (see Fig. 7), we find that for expected values relative to GDP both youth programmes and neutral programmes are virtually flat at 6.5% and 7.5% respectively. Old age programmes, however, rise from 9.5% of GDP currently to 21.4% in 2070. This is a striking demonstration of the importance of population ageing for public budgets.

It is also interesting that the probability fans for the three groups have very different shapes, as seen in Fig. 8. The share of age-neutral expenditures is virtually constant and involves little uncertainty, because the congestible programmes

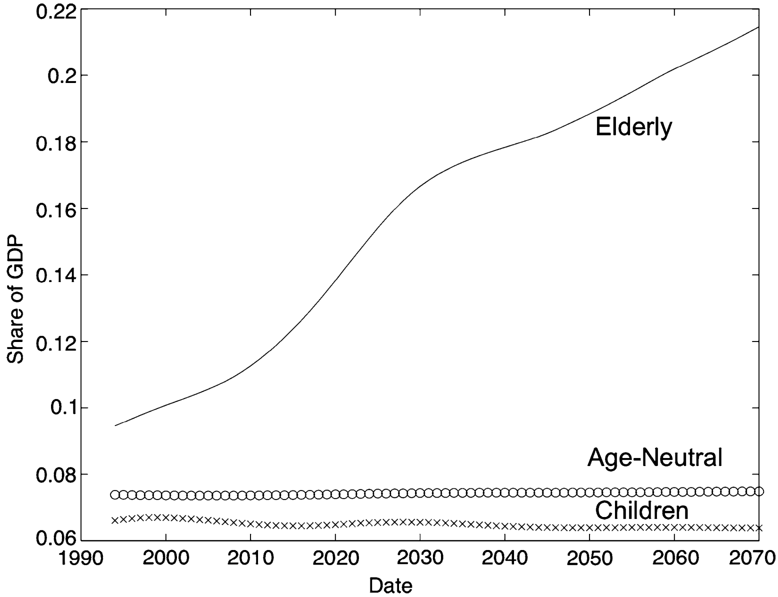


Fig. 7 Mean forecast of expenditures for programs for the elderly, for children, and for age-neutral programs of GDP, 1994–2070

are projected as a constant share of GDP and only the earned income tax credit varies somewhat with age. The share of youth spending is highly certain for the first 5 years, before the first projected births reach school age. After this, the fan opens up rapidly as more births enter childhood, but the edges of the fan become parallel, since mean fertility together with immigration leaves a roughly constant expected number of births. For old age, the fan is initially tight, since only uncertain survival enters in. But once the uncertain number of projected births floods the labour force, uncertainty begins to grow rapidly mainly due to uncertainty about the labour force and GDP. The growth of spending on all government programmes combined, shown in Panel D, is very similar to the growth of taxes shown earlier in Fig. 3.

After 2035 or so, there is a great deal of uncertainty about expenditures for both youth and the elderly. Common sense suggests that some of this uncertainty should cancel in the aggregate, since high fertility and larger labour force would lead to lower expenditures on the elderly relative to GDP. Figure 9 plots the correlation for each year between the share of GDP going to programmes for the elderly and the share going to programmes for children. The correlation is near zero for the first 20 years, when uncertain fertility has not yet had a chance to affect the size of the labour force (the reason for the spike in 1998 is not clear). After this it falls below –0.5 by 2040, consistent with expectations. This suggests that focusing exclusively on trends in the old age dependency ratio, for example, without taking into account

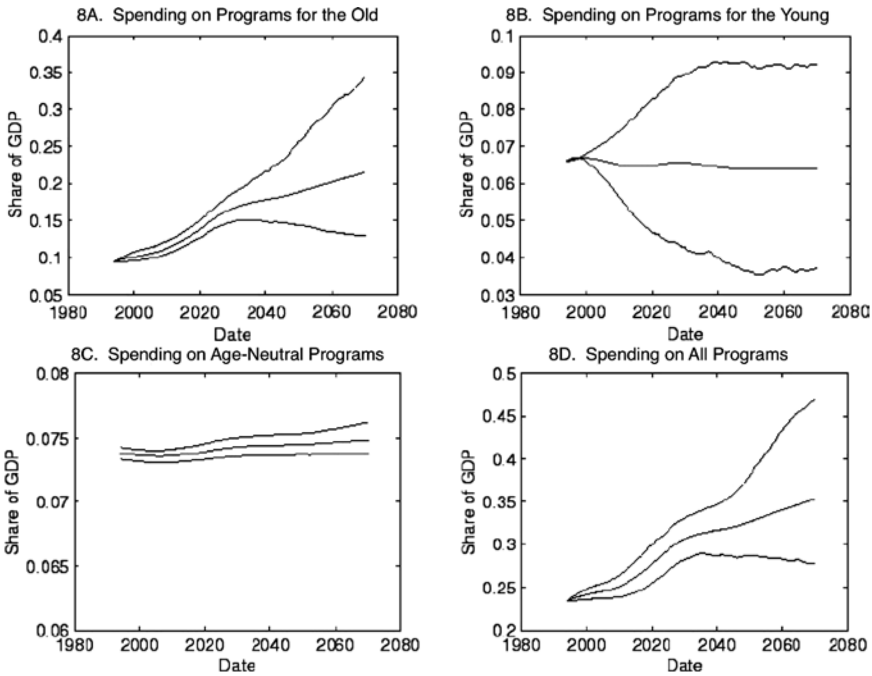


Fig. 8 Forecast of GDP spending for old, young, and age-neutral programs (mean and 95% probability interval, 1994–2070)

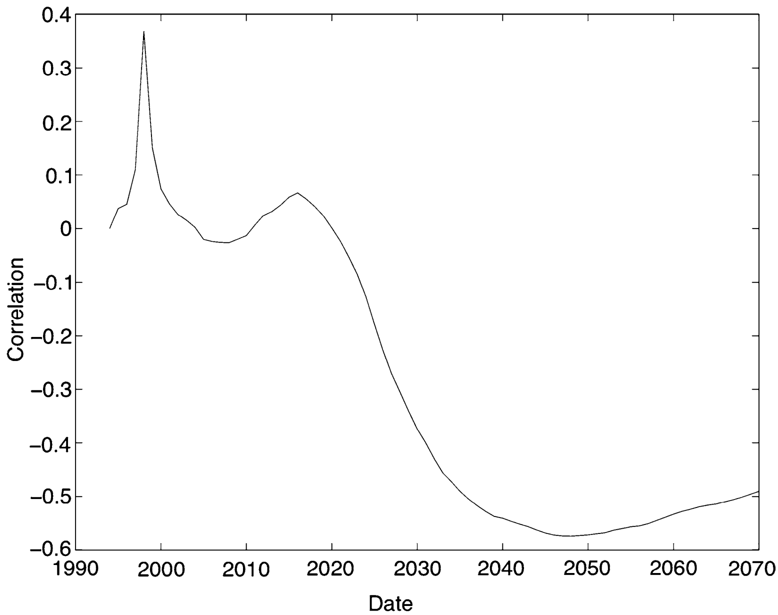


Fig. 9 Correlations between spending on children and spending on the elderly, 1994–2070

the fiscal effects of the fertility trends that give rise to those ratios, could lead to unduly pessimistic conclusions.

We have also segregated expenditures on the elderly more precisely by examining expenditures by all programmes on people who are 60 or over. This method of accounting will disregard the OASDI benefits that go to child survivors, young widows, or young disabled workers, and include only the benefits received by the elderly. Similarly, Medicaid expenditures on the elderly will be counted, as will food stamps, energy assistance, public housing and all other benefits that sometimes go to the elderly. Figure 10 plots the result of this approach. It shows the growth in total expenditures from 8.6% to 21% of GDP, an increase of 144%! It also shows the contribution of each one of many programmes to this overall increase, in a cumulative line graph.

The increase in spending on OASDI for the elderly accounts only for 31% of the total increase in spending on the elderly as a share of GDP. Even excluding the new prescription drug benefit, health costs, which increase by a factor of 3.75, account for 56% of the total increase, or nearly twice as much. That leaves 13% for all the other programmes combined (federal and military retirement programmes and SSI).

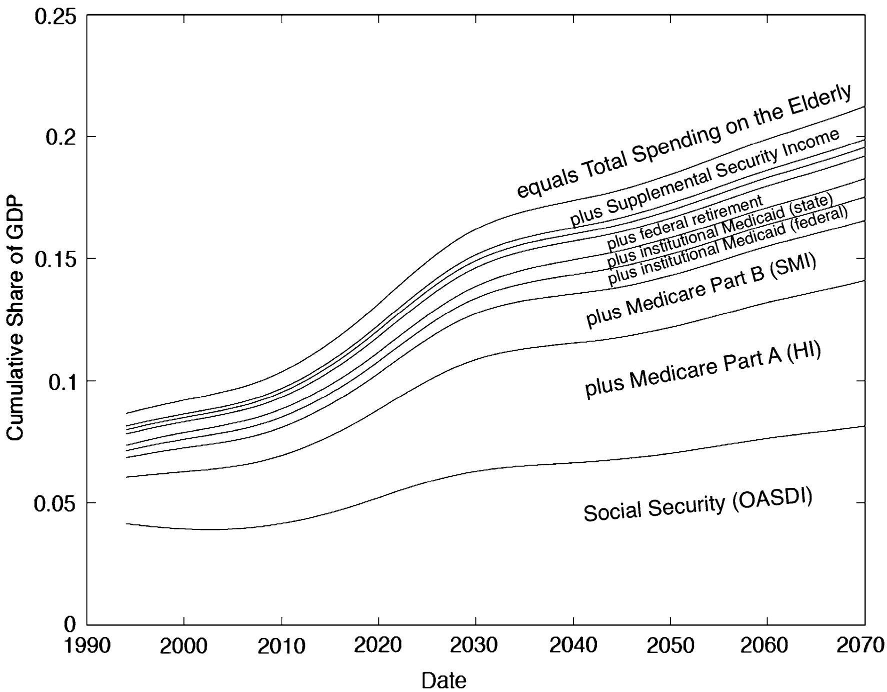


Fig. 10 Mean forecasts of cumulative proportions of GDP spent on the elderly (aged 60+) by program

Conclusions

It is important to keep in mind that all these forecasts are conditional on the current structures of tax and benefit programmes as of the mid-1990s. Since then, government fiscal policy has dramatically altered course several times, and it will doubtless change again in the future. Although our forecasts should not be interpreted unconditionally, we believe they remain highly informative of many of the long-term fiscal challenges posed by population ageing.

Several of our main findings follow. Some apply to the expected forecast trajectories and could be generated by a conventional intermediate scenario projection with suitable disaggregation. It is these specific results that will be most sensitive to changes in the fiscal landscape since the mid-1990s. Other findings derive from the stochastic nature of the forecasts and they are less likely to depend on recent policy adjustments.

- By our measure, current total taxes were 24% of GDP in 1994. The expected tax share will rise at an accelerating rate as the baby boom generation retires, reaching 34% of GDP by 2035 when its retirement is complete. However, the expected share will continue to rise, reaching 38.5% by 2070, an increase of 60%. The lower and upper 95% probability bounds for the total tax share in 2070 are 28% and 50%.
- Fixing Social Security (OASDI) is only a part of fixing the overall federal budget. Population ageing will also have dramatic effects through other programmes such as Medicare, Medicaid, SSI and other retirement programmes, particularly as ageing interacts with rising medical costs per enrolee. Growth in OASDI costs account for at most 31% of the total increase in public expenditure associated with ageing, while the responsibility of rising costs of health care is nearly twice as great.
- The strong influence of population ageing on government budgets is very clear. Expected expenditures on children and on age-neutral services, as a share of GDP, are projected to remain flat, at about 6.5% and 7.5% respectively. Expenditures on the elderly are projected to rise from 9.5% today to 21.4% by 2070, or by 125%. The 95% probability band includes increases to only 13%, or to as much as 35% of GDP, but these forecasts do not include the recent prescription drug expansion of Medicare, which alone is expected to cost 2% by 2070.
- Future expenditures on children and on the elderly (relative to GDP) are moderately negatively correlated in the twenty-first century ($\rho = -0.5$ to -0.6 after 2040), since sustained low fertility both reduces expenditures on children and reduces the size of the labour force relative to the number of elderly. Our forecasts account for this correlation, but others that focus only on the old-age dependency ratio may overlook it and thus overstate fiscal pressures.

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Life, Death and the Economy: Mortality Change in an Overlapping-Generations Model

Qi Li and Shripad Tuljapurkar

Introduction

Mortality rates in the U.S. have been declining for over a century. Demographic ageing in the US, as in many other countries, is due both to this decline of the death rate and to swings in the fertility rate leading to large birth cohorts as in the US baby boom.

Ageing in the industrialized countries has stimulated much work on the economic effects of demographic change. The economic setting for such analyses, beginning with Yaari (1965) and Blanchard (1985), is a general equilibrium model with overlapping generations. Published work on the effects of population ageing in such models has typically sacrificed the details of age-dependent mortality in order to make analytical progress. Indeed, observed mortality patterns are bracketed by two stylized patterns that have been made in the past. The first assumes that all persons die at a fixed age and studies the effect of increases in this age of death, as in Futagami and Nakajima (2001). The second follows Yaari and Blanchard in assuming a fixed age-independent death rate, as in Kalemli-Ozcan et al. (2000). A more realistic two-parameter survival function was used by Boucekkine et al. (2002), but their function has limitations that we will discuss.

We study economic steady states in the overlapping-generations framework with age-dependent mortality and economic feedback. We assume (in parallel with Kalemli-Ozcan et al. 2000) a constant relative risk aversion utility function and an aggregate Cobb-Douglas production function. To study schooling, we choose a wage profile that is only a function of years spent in school. Our focus is on the

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realistic treatment of mortality in modern populations. First, we show that Yaari's formulation neatly incorporates any realistic mortality pattern, if we work in terms of the probability distribution of the age at death (we call it the death age). This approach naturally allows us to think about individual decision-making in response to both increases in the average death age and changes in the uncertainty of the timing of death, i.e., in the variance of the death age. We summarize evidence that mortality decline in the twentieth century has resulted in a tightening of the distribution of the age at death in all industrialized countries, and show that this distribution can be usefully approximated by a normal distribution.

Second, we use a normal distribution for death age to obtain analytical results for the equilibrium in our model. We show that the use of a realistic mortality pattern yields significantly different implications, relative to existing stylized studies, for the effect of ageing on consumption, interest rate, wage and wealth. We present numerical results that show the accuracy of the normal approximation.

Our work is only a step towards a fully demographic analysis because we assume, as have past studies, that birth rates are fixed, and because we assume that the population age structure is stationary (Bommier and Lee 2002).

Modeling Age Patterns of Mortality

Alternative Models of Mortality

At time z define the instantaneous death rate $\mu(s,z)$ at age $z - s$ for members of a cohort (generation) born at time s. Survivorship l(s,z) is the probability that an individual from a cohort born at time$s$ will be alive at time z. Defining T to be the random age at death, the probability density of T is given by the product $\phi(s,z) = \mu(s,z)\, l(s,z)$. If we assume that death rate μ is independent of age, as in many economic analyses, we have exponential survivorship and an exponential density for T. If we assume that everyone dies at the same age T_0, the survivorship function l is a step function, constant at $l = 1$ until age T_0 and falling to $l = 0$ thereafter; the distribution of T is a delta function at T_0.

Past stylized assumptions about mortality contrast sharply with realistic patterns of mortality. We can see the differences clearly by comparing three mortality patterns: age-independent constant death rate, a fixed death age and US projections. We compare these by displaying three functions, death rate μ as a function of age, survivorship l as a function of age and the probability distribution ϕ of death age in Fig. 1. The plots are shown for a life expectancy (i.e., average age at death) of 80 years. Assumptions of a constant death rate or a fixed death age are certainly analytically convenient, but neither captures the essential age-dependence of realistic death rates.

A recent paper by Boucekkine et al. (2002) does a better job of modeling mortality than the two stylized assumptions we have considered. They fit realistic survival

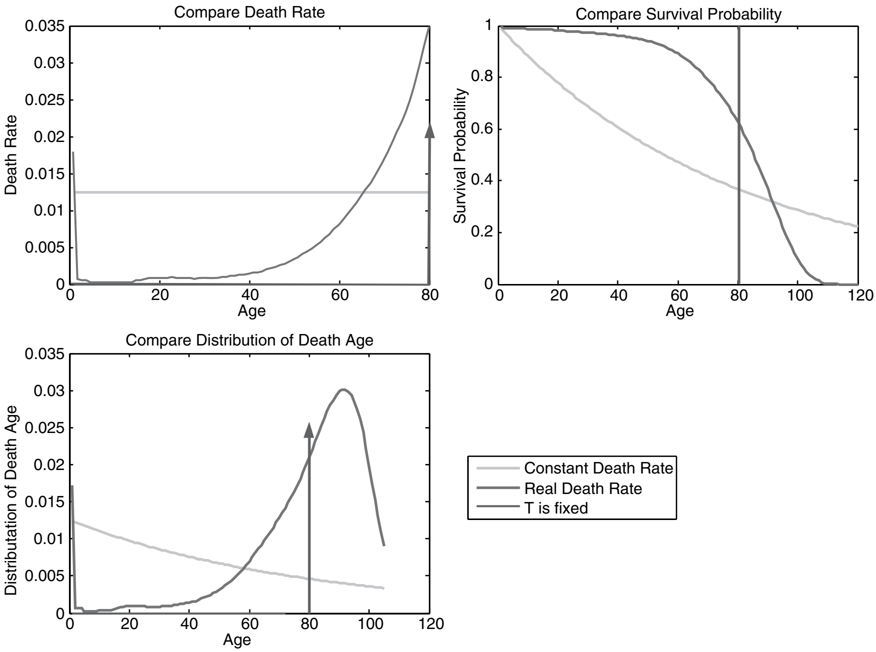

Fig. 1 Comparing three models of mortality: an age-independent death rate, a realistic death rate for modern US populations and a fixed age at death. Note the distribution of age at death in the lower panel

probability using a two parameter, age-dependent survival probability l. Although their model yields shapes of the death rate and survival curve that are approximately right, their model generates a density function $\phi(a)$ of death age which always increases with age. This behavior contradicts the fact that the empirical distribution has a hump shape with a well-defined peak in modern industrial countries such as U.S. and Sweden (Wilmoth and Horiuchi 1999).

Using Mortality Models in OLG Models

In the overlapping-generations framework, a major analytical task is to aggregate individual consumption and saving across cohorts. As Yaari showed, one can use either the functions μ and $l(a)$ together, or simply work with the distribution ϕ of the death age. The stylized assumptions of past studies have, we believe, aimed to yield analytically tractable forms of μ and l. Instead, we work directly with ϕ so we can use richer and more realistic analytical models.

Let $\phi(x)$ be the distribution function of death age T, age-dependent survival curve $l(a)$ is

$$l(a) = \int_a^\infty \phi(t)dt \tag{1}$$

In the analysis of OLG models, we need to aggregate variables such as consumption and saving, using as weights the probabilities of death. A typical aggregate of some function $j(a)$ of age a is defined with respect to survivorship,

$$J = \int_0^\infty j(x)l(x)dx = \int_0^\infty j(x)\int_x^\infty \phi(t)dtdx \tag{2}$$

But a change in the order of integration turns this into

$$J(t) = \int_0^\infty \int_0^t j(x)dx\phi(t)dt = E_T[\int_0^T j(x)dx] \tag{3}$$

This transformation, which Yaari performed in the reverse direction, expresses the aggregate as an expectation over the distribution of death age T. We see immediately that a variety of analytical forms of the distribution ϕ can lead to tractable aggregations. Furthermore, the details of mortality change in industrialized countries in the past 50 years are accurately captured by a relatively simple choice of ϕ, as we now show.

Distribution of Death Age

Demographers have studied extensively the age pattern of mortality. In modern industrialized countries, most deaths occur at ages over 45 years and death rates are falling at all ages, including ages 85+. In terms of the distribution of death age T, the mean age at death has been increasing (Wilmoth et al. 2000) while the variance of the age at death has been decreasing, as shown for several countries by Wilmoth and Horiuchi (1999). To describe cohort mortality for cohorts that are still alive, we use a forecasting model for mortality, the model of Lee and Carter (1992). Distribution curves of death age based on their model shows a linear relationship between life expectancy e_0 and variance of death age v_0 as in Fig. 2. When life expectancy increases, the variance of death age decreases almost linearly, consistent with the study of Wilmoth and Horiuchi (1999). Wilmoth and Horiuchi report that the standard deviation of population death age has decreased from about 29 in 1901–1905 to about 17 in 1990–1995. This trend is not only true in the U.S., but also true in many other countries such as Sweden and Japan. In Sweden and Japan, the standard deviation has decreased to about 14 in 1991–1995. The Lee-Carter model and U.S. historical data together yield the linear relationship

$$v_0 = B_0 + B_1 e_0 \tag{4}$$

where $B_0 = 2582$ and $B_1 = -26.7$. This regression is based on the historical data and our forecast of U.S. population data. The R^2 of this regression is 0.985.

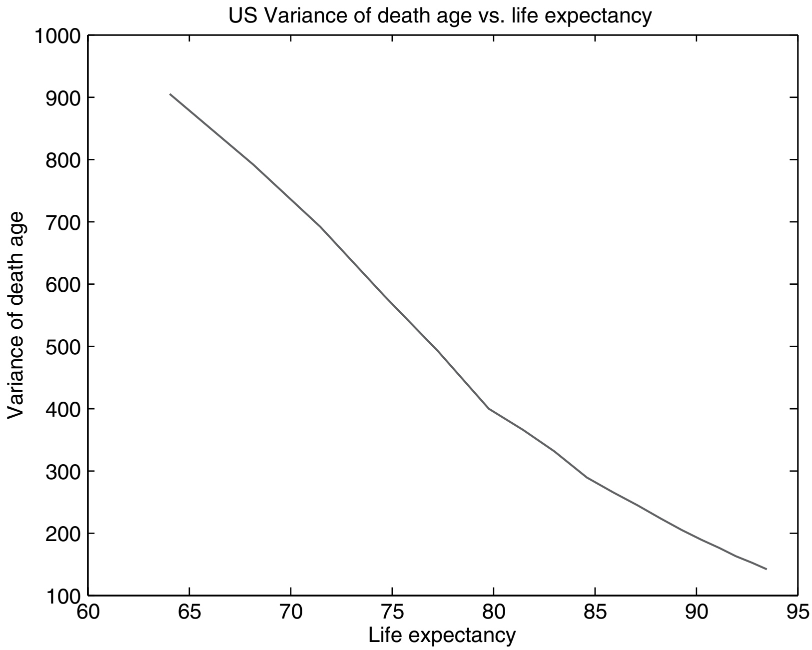

Fig. 2 Historical and projected (using Lee-Carter) changes in life expectancy (*horizontal axis*) and variance in age at death (*vertical axis*) for the United States

The distribution ϕ of the death age T for US cohorts is roughly normal but with a long modest left tail.

It turns out that the left tail can be ignored in the analysis we do here, as we later demonstrate. We thus propose to approximate ϕ simply by a normal distribution,

$$\phi(a) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(a-e_0)^2}{2\sigma^2}}.$$

The corresponding survivorship is

$$l(a) = 1 - [\Phi(\frac{a-e_0}{\sigma}) - \Phi(-\frac{e_0}{\sigma})]$$

and the death rate may be obtained as

$$\mu(a) = \phi(a)/l(a)$$

This approximation is much more realistic than the stylized assumptions of constant death rate or a fixed death age. A major advantage of this approach is that the parameter e_0 captures the length of life whereas the standard deviation σ is a direct measure of the uncertainty in the age at death. These parameters enable us to examine the separate effects of the need to spread consumption over a longer life and the need to adjust savings as a precaution against living for fewer or more years than one might expect. In addition, we can study economic responses to the particular trajectory of increasing e_0 and decreasing σ that is seen in the past data.

The normal approximation does not capture two aspects of historical death rates: the long left tail mentioned above and the high death rates at very early ages between 0 and 1 year. Historically, death rates have fallen faster at the youngest ages, and this is likely to reduce the error we make with a normal assumption. However, our approach allows us to use many alternatives should we wish to capture the details we have left out of the simple normal assumption. For example, a better approximation is the two term distribution function

$$f(T) = \alpha \cdot \lambda e^{-\lambda T} + \beta \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(T-\gamma)^2}{2\sigma^2}}$$

In this model, there are five parameters, α, β, γ, σ and λ. To make $f(T)$ a distribution function, we require $\alpha + \beta = 1$. We can fit this model to the data and, more important, we can also produce analytical solutions for this approximation (we do not discuss them here).

Life Cycles and the Economy

We use a continuous time overlapping generations model based on Yaari (1965) and Blanchard and Fischer (1989). We assume that the population age structure is stationary, with a constant birth rate and a probability distribution ϕ for an individual's age at death. We use a Constant Relative Risk Aversion(CRRA) utility function,

$$u(c(z)) = \frac{c(z)^{1-\gamma}}{1-\gamma} \tag{5}$$

where γ is the relative risk aversion coefficient and $c(z)$ is consumption at time z. We set the subjective discount function for people at age a to be $e^{-\theta.a}$ where θ is a rate of time discount. In this model, the only source of uncertainty is the age at death, and the expected utility to be maximized is

$$\int_t^{\omega} l(z-t) \bullet u(c(z)) \bullet e^{-\theta\cdot(z-t)} \bullet dz \tag{6}$$

We assume the economy is in a steady state and that aggregate output follows the Cobb-Douglas production function,

$$Y = AW^{\alpha}H^{1-\alpha} \tag{7}$$

where W denotes aggregate physical capital stock and H denotes total human capital. A is a positive constant representing productivity level and $0 < \alpha < 1$. The equilibrium interest rate r and the wage level w are determined by the marginal rates of change of output with respect to capital and human capital.

Human capital here depends on the number of years of schooling. We assume that individuals choose an age a_s when they finish schooling and that they then work until a fixed age of retirement a_r. The relative wages of an individual only depend on years of schooling

$$y(a_s) = we^{f(a_s)} \tag{8}$$

when $a_s \leq x \leq a_r$ and zero otherwise. This is the same assumption as in Kalemli-Ozcan et al. (2000). A useful extension would incorporate a hump shaped age profile, for example at age x wages are

$$y(x) = we^{f(a_s)}\,(a_1 e^{-\beta_1 x} + a_2 e^{-\beta_2 x})$$

where $\beta_2 \geq \beta_{\_1} \geq 0$, $a_1 \geq 0 \geq a_2$. This form of human capital is initially an increasing function of age and then a decreasing function of age. It is possible to extend our analytical results to this case. With this assumption, aggregate human capital is just $y(a_s)L$ where L is the total labor force between ages a_s and a_r.

The random death age T has a known distribution, and we use Eq. 3 to define four aggregated functions in terms of which we can write explicit equilibrium conditions for the model.

$$g(z) \equiv E_T[e^{zT}] \tag{9}$$

$$P(z) \equiv E_T[e^{z(T \wedge a_s)}] \tag{10}$$

$$Q(z) \equiv E_T[e^{z(T \wedge a_r)}] \tag{11}$$

$$\lambda(a) \equiv E_T[T \wedge a] \tag{12}$$

Notice when $a_s = 0$, $P(z) = 1$. When $a_r = \infty$, $Q(z) = g(z)$. $\lambda(\infty) = E_{\_T}(T) = e_0$ where e_0 is life expectancy. We have calculated the closed forms of g, P, Q and λ when death age T is normally distributed.

For a fixed level of schooling a_s the standard optimality conditions yield an optimal individual life time consumption path $c(a)$

$$c(a) = c_0 e^{ka}, \tag{13}$$

and the budget constraint yields consumption at birth c_0

$$c_0 = \frac{(k-r)we^{f(a_s)}}{r} \cdot \frac{P(-r) - Q(-r)}{g(k-r) - 1}. \tag{14}$$

Here

$$k \equiv (r - \theta)/\gamma. \tag{15}$$

Thus the initial consumption c_0 is a function of a_s, and the relevant condition leads to an equation for the optimal level of schooling

$$f'(a_s)[P(-r)-Q(-r)]+\frac{dP(-r)}{da_s}=0 \tag{16}$$

Finally, the aggregate consumption is

$$C(t)=\frac{bN(k-r)we^{f(a_s)}}{rk}\cdot\frac{P(-r)-Q(-r)}{g(k-r)-1}\cdot[g(k)-1] \tag{17}$$

We find that the aggregate human capital H and aggregate capital stock W are:

$$W(t)=\frac{bN}{r}we^{f(a_s)}\varphi(r,e_0,\sigma_0)$$

$$H(t)=bNe^{f(a_s)}\,[\lambda(a_r)-\lambda(a_s)]=bNe^{f(a_s)}\xi$$

where

$$\varphi(r,e_0,\sigma_0)=\frac{r-k}{kr}\frac{(Q(-r)-P(-r))(g(k)-1)}{g(k-r)-1}-\lambda(a_r)+\lambda(a_s) \tag{18}$$

and

$$\xi=\lambda(a_r)-\lambda(a_s).$$

These lead to

$$\frac{W}{H}=\frac{w\varphi(r,e_0,\sigma_0)}{r\xi}$$

The first order conditions of production function give

$$\varphi(r,e_0,\sigma_0)=\frac{\alpha\xi(r,e_0,\sigma_0)}{1-\alpha} \tag{19}$$

which reduces to

$$\frac{r-k}{kr}\frac{(Q(-r)-P(-r))(g(k)-1)}{g(k-r)-1}=\frac{\lambda(a_r)-\lambda(a_s)}{1-\alpha} \tag{20}$$

Equations 16 and 20 yield the optimal age of schooling a_s and equilibrium interest rate r, and we can then compute all other variables. Notice that these two equations do not depend on any specific forms of distribution function of death age T.

Comparative Static Results: Simple Case

In comparative static analysis, three cases are studied under the assumption that death age is normally distributed (Table 1).

Table 1 Cases of calibration

Case name	Income	Schooling	Retirement
Basic	Constant	No	No
Schooling	Depend on schooling	Yes	No
Complete	Depend on schooling	Yes	Yes

In the simple case, there is no schooling and retirement. The wage w is assumed constant. We focus on the effects from changes in life expectancy and uncertainty of death age in this case. The joint effects on consumption, wealth and interest rate are compared with those under the assumptions of constant death rate, fixed death age and real distribution of death age. Further analytical details on the analysis are available from the authors on request. We now present results that calibrate our model, assuming the following parameter values (the same as in Kalemli-Ozcan et al. 2000). Our results are robust to alternative choices that vary by 20% from these.

Assumption A: We assume the following values at the equilibrium.

$$\gamma = 1,\ \theta = 0.03,\ \alpha = 0.03,\ \overline{T} = 120$$

where $\overline{T}$ is the maximum death age.

The distribution of death age T is normal. Let r be the steady interest rate, we can solve steady values analytically. We study the separate and joint effects from changes of life expectancy and variance of death age.

Proposition 1. In the simple case, there exists a unique solution for Eq. 20 when T is normally distributed.

The uniqueness of steady state values for other variables follows from the steady value of interest r.

Proposition 2. In the simple case, as total wealth changes, the wage will change in the same direction and the interest rate will change in the opposite direction.

As is known, CRRA utility functions imply that every individual is risk averse and smoothes consumption. In the model, consumption is an increasing function of age, and people borrow risk free assets to reduce consumption differences. As wage increases, there is less need to borrow and this drives down the steady interest rate.

Changes in Life Expectancy

When life expectancy increases but the variance of death age stays fixed, we find that the aggregate wealth W increases. In our model individuals can effectively contract with a life insurance company. Individuals contract to make a payment contingent on their death and in exchange receive a fair rate of payment from the insurance company. This fair rate is the cohort death rate. Since the cohort size is large, the cohort size is deterministic even though the individual death age is uncertain. Although it is not necessary for individual net assets to be a monotone increasing function of age, individual net assets eventually increase when age is large because insurance removes the bequest motive. In our model, as life expectancy increases, birth rates fall to keep total population size fixed and there is a higher percentage of elderly. Since the old have larger assets than the young, the total wealth increases as life expectancy e_0 increases.

We also find that initial consumption c_0 is an increasing function of life expectancy e_0, given that variance of death age v_0 is fixed. As life expectancy increases, wages w increase as we have discussed and lifetime consumption rises because it equals lifetime labor income,

$$c_0 \int_0^{\varphi} e^{-\theta a} l(a) da = w \int_0^{\varphi} e^{-rs} l(s) ds \tag{21}$$

Thus, increasing life expectancy results in an increase in initial consumption c_0. Now $c(a) = c_0\, e^{(r-\theta)a}$, but the decrease in interest r is not big enough to offset the increases in survivorship and initial consumption, so there is an increase in total consumption C.

Changes in Uncertainty of Death Age

When the variance of life expectancy increases with life expectancy fixed, aggregate wealth usually increases so long as life expectancy is much larger than the standard deviation of death age. This condition produces a substantial difference between the wealth of the old and young. As variance increases, there is a higher probability for people to die at old ages and at young ages, but since young people have less wealth the loss at young ages is less than the gain at old ages.

Initial consumption c_0 will increase if variance of death age T increases, given that life expectancy e_0 is fixed. As v_0 increases, wages w increase and interest rate r decreases. To make life time consumption equal to life time labor income, we must have an increase in initial consumption c_0.

Total consumption C is an increasing function of v_0, given that e_0 is fixed. As variance v_0 increases, the gain in consumption at high ages outweighs the loss at young ages.

Joint Effects from Changing Life Expectancy and Uncertainty of Death Age

We now turn to the historically relevant situation where both e_0 and v_0 change. In a model with an age-independent death rate, $v_0 = e_0^2$. As e_0 increases, v_0 increases, and together these lead to a low steady-state interest rate.

In the normal distribution, we assume, consistent with the data, that as e_0 increases, v_0 decreases. The joint effect of these changes is a much higher steady interest rate.

For a model with a fixed death age, we find the highest steady interest rate r since there is no variance. Since the interest rate is an decreasing function of v_0, our result is consistent with our intuition.

The effect of joint change in e_0 and v_0 on consumption is complicated by the effect of changes in the steady-state interest rate.

As Deaton (1992) concludes, there is no simple direction of the effect of interest rates on consumption based on the life-cycle model. There are three effects of the interest rate on individual consumption. The substitution effect and 'human capital' effect act so as to cut current consumption as interest increases. The income effect works in the opposite direction. First assume v_0 is fixed. As e_0 increases, it is clear that total individual labor increases because r will decrease as e_0 increases. Wages also increase as the interest rate decreases. The substitution effect and the 'human capital' effect are large and will increase the consumption level. As v_0 increases when e_0 is fixed, the insurance income for living young individuals increases and so does the total income when they are young. This increases their initial consumption. Again, the interest rate decreases, the total individual labor income increases, wages increase, total individual assets increase. All of this again will lead to a higher initial consumption. However, when e_0 increases and v_0 decreases it is hard to predict the overall effect qualitatively.

Aggregate consumption increases with increasing e_0, but decreases with falling v_0. We find that with mortality rates such as in the US, the effect of increasing life expectancy is larger and leads to increasing total consumption.

Comparisons

We now examine the quantitative differences between four mortality models – the normal distribution, a constant death rate, a fixed age at death and a distribution based on actual US data. We assume constant wages and ignore schooling and retirement in this simple case. We set the relative risk aversion coefficient γ to 1 in our calibration so that we can compare the differences among the models. We find that our results are robust for different values of the relative risk aversion coefficient γ.

Figure 3 plots the equilibrium values of steady interest rate r, total wealth W, individual initial consumption c_0, aggregate consumption C and wage w when life expectancy e_0 changes under the assumption of a constant death rate, fixed death age, normally distributed death age and realistic death rate. In the normal and real distributions we also impose the corresponding decline in variance. Numerical values are summarized in Table 2.

In Fig. 3, the levels of constant death rate, fixed death age and realistic death rate are quite different which is due to the different assumptions on variance of life expectancy. It is clear that normality assumptions fit the realistic curve best. As life expectancy becomes larger, the survival curve becomes more rectangular. Fixed death age is also a good approximation when life expectancy is large.

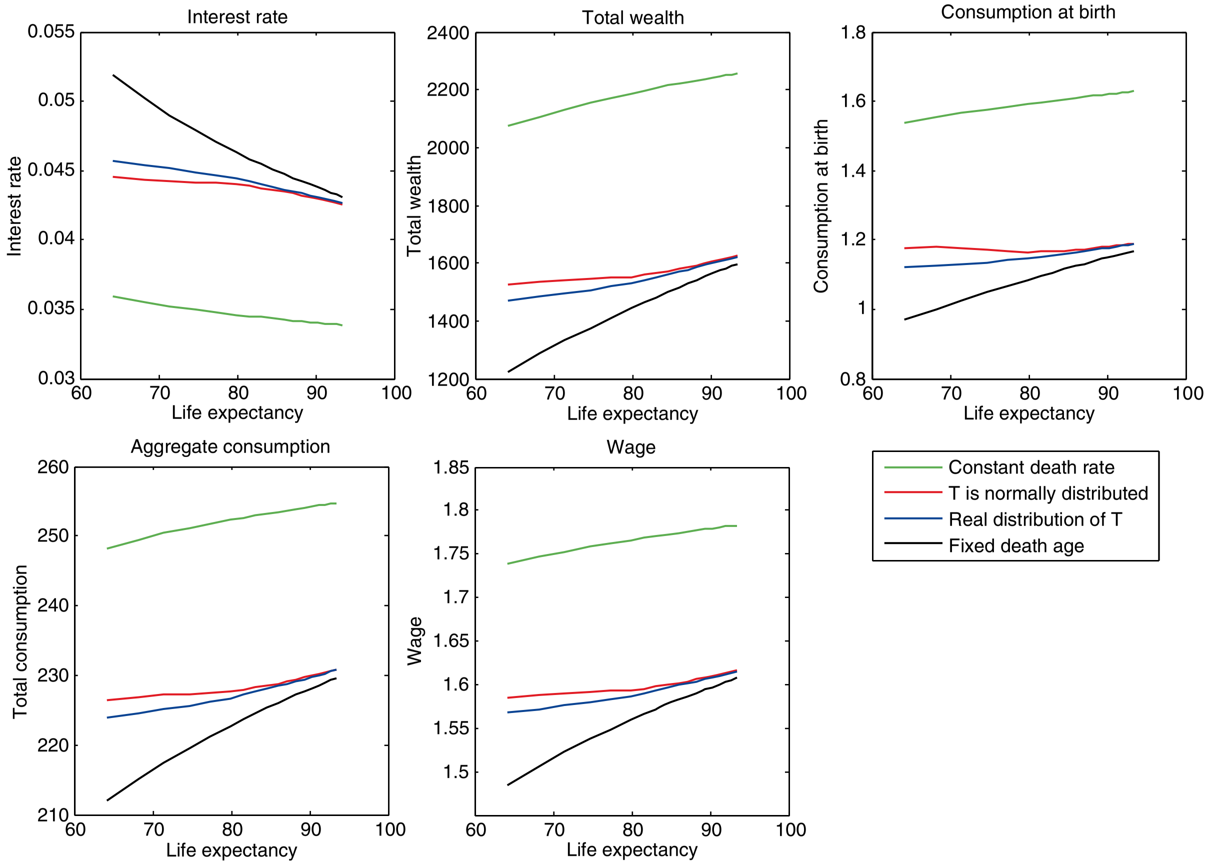

Fig. 3 Equilibria for an overlapping generations model with different mortality assumptions. Note that the realistic rates and the normal approximation are always close and that the assumptions of a fixed age at death and of constant mortality diverge in opposite directions

Table 2 Schooling case, $\gamma = 1$, e_0, = 79.8339

Name	Constant death rate	Normal distribution
H	1278.3	875.2
a_s	22.8203	15.8077
r	0.0396	0.044
w	1.6666	1.3766
W	23039	8339.4
c(0)	7.0312	2.9932
C	3043.6	1721.1

As people become more risk averse, we find a decline in total consumption and total wealth, but higher steady interest rates. As relative risk aversion coefficient γ increases, people become more risk averse and are less likely to borrow and tend to consume less when they are young. The effect of γ on steady values is significant. From $\gamma = 1$ to $\gamma = 2$, the steady interest rate increases about 20%. Under the normality assumption of death age, the steady interest rate is much higher than that of the constant age independent death rate. Therefore, the 'risk free rate puzzle' by Weil (1989) becomes more severe if we include age dependent mortality into our model.

Schooling and Retirement

In this section, we first address the effects of schooling and compare them with previous results, then study the complete case which includes both schooling and retirement.

Schooling

We follow Kalemli-Ozcan et al. (2000) and assume that

$$f(a_s) = \frac{\Theta}{1-\Psi} a_s^{1-\Psi}$$

where $\Psi = 0.58$ and $\theta = 0.32$.

Under this assumption, steady values can be solved by two Eqs. 16 and 20. After steady interest rate and schooling age are found, we can calculate all the other aggregate steady variables. Table 2 compares the equilibrium values under the normal distribution and with an age-independent death rate as in Kalemli-Ozcan et al. (2000).

Since retirement is not considered in this comparison, total labor is given by

$$H(t) = bNE_T[\int_{a_s \wedge T}^{T} e^{f(a_s)} dx]$$

As schooling a_s increases, there are two effects: $e^{f(a_s)}$ increases and the lower bound on the integral, $a_s \wedge T$, also increases. It is generally hard to say which effect is more significant. As we know, a_s is usually small relative to $e_0 - a_s$. In our calibration, the labor profile is fitted with historical data which have the property that total labor H increases as schooling a_s is introduced. In other words, the effect from $e^{f(a_s)}$ dominates.

As in the simple case, total wealth W is also an increasing function of life expectancy. However, the ratio W/H does not monotonically increase with increasing life expectancy. Although the ratio of total wealth and total labor does not change a lot, it first decreases and then increases. Wage w and interest rate r change correspondingly.

We find that the schooling age is an increasing function of life expectancy e_0, as did Boucekkine et al. (2002). This result accords with the intuition that people want more education if they can live longer. However, again, the effect of the variance in our case means that the optimal schooling age in our case is much lower than that of Kalemli-Ozcan et al. (2000).

Another important difference is the interest rate r. A steady interest rate r increases at median life expectancy and finally decreases at high life expectancy. This is totally different from the simple case. The increase in the steady interest rate for median life expectancy is in the period when the variance of death age decreases dramatically. It seems that schooling increases the effect of the variance of death age. Notice that the total consumption still always increases. This is again due to the assumption that people can work until their death.

Retirement

Figure 4 plots a steady interest rate, schooling and other aggregate variables in the complete case, where we fix the retirement age and determine both the optimal interest rate and optimal schooling. As life expectancy becomes larger, the effect of retirement age also becomes more significant. This is consistent with our expectation. As life expectancy becomes larger, more people live longer. Their living will be affected more seriously by the exogenous retirement age.

Observe that schooling is a decreasing function of retirement age, $da_s/da_r < 0$. One simple explanation is that people need more education for higher salaries so that they can pay for a longer retirement life (Bils and Klenow 2000). When individuals maximize their initial consumption, they take the interest rate and the wage as given. For a relatively low a_s and a_r, the optimization problem becomes to maximize

$$e^{f(a_s)} \bullet [e^{-ra_s} - e^{-ra_r}] \approx re^{f(a_s)}[a_r - a_s]$$

The first order condition is

$$0.32 \cdot \frac{a_r - a_s}{a_s^{0.58}} = 1$$

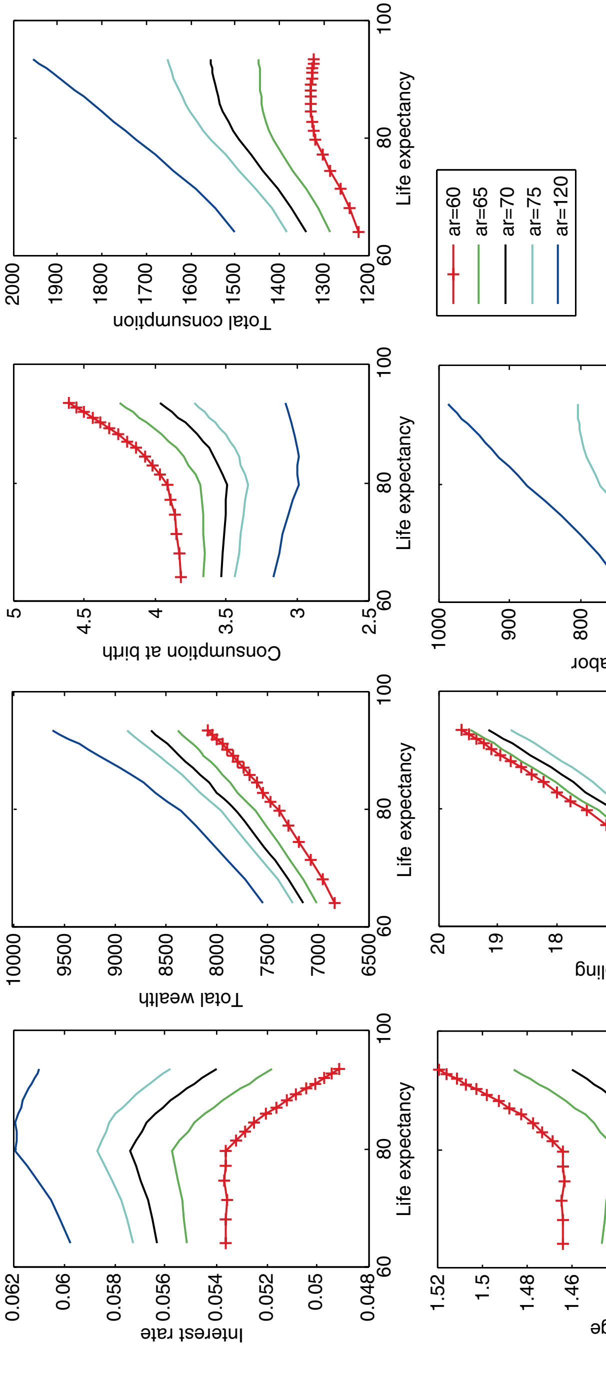

Fig. 4 Equilibria for an overlapping generations model with endogenous schooling and exogenous retirement, showing various retirement ages and different mortality assumptions

Thus as a_r decreases, schooling age a_s must decrease to satisfy this first order condition.

Note the nonlinear changes in r, W, C and H with increasing life expectancy. The interest rate is strikingly affected by retirement age relative to life expectancy and falls as a_r rises for a given e_0.

Conclusion

Our model generalizes the overlapping generations framework to consider the effects of realistic age-patterns of death. Our analytical results apply to general age dependent death rates. We show that we can derive some other popular models such as constant death rate and fixed death age directly from our analytical results. Using U.S. data, we assume that death age is normally distributed. This assumption is not only realistic, but also analytically solvable. In the calibrations we find that this age pattern of death has significant effects. First, the steady interest rate r is always much higher than in a model with a constant death rate. Similar level differences appear in all other macroeconomic variables.

In the case of schooling, our results are very different from those of Kalemli-Ozcan et al. (2000). The steady interest rate r changes nonlinearly, first increasing then decreasing, as e_0 increases. Finally we studied the effect of endogenous schooling and exogenous retirement. Several counter intuitive relations have been found. For example, initial consumption decreases as age of retirement increases. The other one is that the schooling age will decrease as age of retirement increases in general equilibrium.

Among the important questions we have not addressed are endogenous retirement and the effects of a dynamic population structure (Lee and Tuljapurkar 1994, Faruqee 2002).

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International Adverse Selection in Life Insurance and Annuities

David McCarthy and Olivia S. Mitchell

Introduction

Insurance specialists recognize that well-functioning insurance markets – in the form of both life insurance products and annuities – are necessary to ensure effective funded retirement systems and efficient national saving. This is because annuities play an essential role in converting asset accumulations into a regular flow of retirement income guaranteed for life, and classical life insurance protects individuals and their dependants from the risk of early death. But as actuaries know, it takes a great deal of statistical information on mortality patterns by age and sex to develop the necessary survival forecasts needed for valuing annuity and insurance products. And in practice many countries lack a vital statistics collection mechanism, especially for insured lives and annuitants, causing analysts there to rely on mortality data from other countries in order to value insurance products of all types. This paper uses data from three relatively well-developed insurance markets to analyze the differences between the mortality of individuals who have purchased non-annuity insurance products and the general population in these countries. Comparison with previous results permits a comprehensive picture of the effects of adverse selection on mortality and hence on valuation of insurance products in these three markets.

Theory predicts that in the absence of insurance company underwriting, adverse selection will improve the mortality (i.e. increase the average life expectancy) of annuity purchasers, but worsen that of purchasers of other life insurance products relative to the general population. We explore the difference between

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mortality tables for this group in the United States, the United Kingdom and Japan. Many other countries in the Americas, in Europe and in Asia use either the US or UK tables to value annuities and insurance. Somewhat surprisingly, our results indicate that adverse selection reduces mortality for both life insurance and annuities, contrary to what theory would suggest. This indicates that insurance company screening of potential poorer risks in classic life insurance ('underwriting') is very effective, possibly even eliminating any asymmetric information held by policyholders.

In the section on "Raw and Aggregate Mortality", we examine the construction of aggregate mortality data (of the type we use here) from records of individual deaths and survivals. The section on "Adverse Selection in Life Insurance and Annuities" briefly presents the standard theory of adverse selection in insurance and life annuities. The section on "Metrics for Comparing Mortality Tables" describes different metrics for comparing mortality tables. The section on "International Comparisons of Insurance and Population Mortality Tables" presents international comparisons of insurance and population mortality tables and the last section is a conclusion.

Raw and Aggregate Mortality

It is useful to describe the process by which raw mortality data about deaths in a group of people are transformed into aggregate mortality data of the type commonly used by insurance experts. As a rule, raw mortality data consist of records of individual deaths and survivals in a population, while aggregate mortality data are usually presented in the form of a mortality table. Such a table is an estimate of the statistical distribution of the remaining life span that can be expected for members of a given population.[1] A mortality table is generally derived by performing an investigation of deaths occurring in this given population over a specific period of time. Each individual in the population will have one raw data record, which will normally consist of the following information:

1. The date at which the individual entered the investigation
2. Risk characteristics of the individual (usually age and sex, but may include date of inception of the policy, the type of policy and the reason for the purchase of the policy)
3. The date at which the individual left the investigation
4. The reason for which the individual left the investigation (which may include the end of the investigation, the death of the individual or the lapse of the policy)

The investigator counts up the length of time each individual spent in each risk category and then sums these across individuals. The investigator also counts the total number of deaths in each risk category. By dividing the number of observed deaths in each risk category by the total length of time individuals spent in that risk category, the investigator obtains an estimated probability of death for individuals in each risk category.

[1] For additional background see Bowers et al. (1986).

As a rule, the probabilities are smoothed by fitting some sort of hazard rate model or by applying a smoothing algorithm to the raw estimates.[2] In the final step, smoothed estimates of the probability of death at age x (denoted q_x) are used to construct a complete mortality table. For most ages, q_x is extremely small, which implies that a large number of lives must be observed in order to obtain reliable estimates.

In general, mortality patterns differ across segments of the population for many reasons associated with sex, age and adverse selection. The latter can depend on the type of product purchased, the reason the product was purchased and the length of time since the product was purchased. Separate estimates of mortality are generally produced by age, sex, product type (e.g., annuities and life insurance), reason for product purchase (compulsory or voluntary) and the length of time that the individual has owned the policy ('select' or ultimate tables).

Mortality rates also change over time as a result of past and projected future improvements in life expectancies. Over the last several decades, mortality among older people has dropped rapidly in developed countries, and there is reason to believe that this will continue in the future (Executive Committee 1999). Actuaries have handled this problem by estimating so-called *period* mortality tables from past data and then devising separate, forward-looking, *cohort* mortality tables by extrapolating future trends in mortality.[3] Of course, anticipated future declines in mortality built into cohort tables are only estimates based on past trends; it is uncommon to allow for future mortality improvements in life insurance standard tables. This is because it is usually prudent for the insurance company to overstate the mortality of life insurance purchasers (whereas in the case of annuitants, it is conservative to *understate* it). If the recent trend of mortality improvements suddenly reverses, we can expect that in due course insurance companies will adjust life insurance mortality tables for expected worsening mortality.[4]

Adverse Selection in Life Insurance and Annuities

It is not uncommon for insurers to be concerned about adverse selection in the markets for both annuities and life insurance. Adverse selection arises because of information asymmetries between the insurer and the insured. People who purchase

[2] Smoothing is usually necessary to eliminate random statistical fluctuations from the data. The theoretical justification behind smoothing is that, as true underlying mortality is expected to change smoothly as age changes, the raw estimate of mortality at age x provides information not only about the true level of mortality at age x but also at ages close to x.

[3] In the UK, actuaries assume that mortality improvements are constant across product types, and fit an age-dependant model of mortality improvements to a historical database of tables. This model is used to predict future improvements.

[4] This actually happened in the late 1980s when many insurance companies loaded their insurance rates (but not their annuity rates!) for the expected impact of AIDS.

insurance are generally more likely to have 'inside' information about their future mortality, as compared to the insurance companies who sell the products.[5] This implies that there will be a systematic difference between the observed mortality of people who purchase annuities and life insurance products, and those who do not, holding all else constant. In particular, individuals who believe that their mortality is low will find insurance at a given price more expensive than those who believe that their mortality is high, and hence will purchase less (or zero) insurance, *ceteris paribus*. Similarly, individuals who believe that their mortality is low will find annuities of a given price better value than individuals who believe that their mortality is high, and should purchase more, *ceteris paribus.*

If individuals' beliefs about their own mortality are positively correlated with their true underlying mortality, then after controlling for all other relevant variables, a systematic difference between the mortality of those who purchase annuities or insurance and those who do not will emerge. In particular, individuals who purchase life insurance should show higher mortality than those who have not purchased insurance, after controlling for information common to the insurance company and the individual. Similarly, purchasers of annuities should show lighter mortality than a control group. In addition, there will be a systematic relationship between the quantity of insurance or annuities bought and the observed mortality of purchasers, again holding all else constant.[6] The extent of adverse selection is also affected by the reason the individual purchased the insurance product. If the individual is compelled to purchase the product (possibly by law, by virtue of membership in a retirement fund, or because of some other decision such as taking out a mortgage), then the effect of adverse selection will likely be less severe than if the individual purchased the product voluntarily.

Insurance companies collect information about individuals *before* deciding at what price to sell insurance or annuities to them. Since this information is common to both insurer and purchaser, it should ideally be controlled for when testing for adverse selection. Such information usually includes age and sex, but sometimes also includes income, occupation, previous and current health status and the size of the policy applied for. Information that is not easily verifiable (such as current and past health status) is collected by insurance companies during a process called 'underwriting'. During underwriting, applicants for insurance are individually interviewed (often by means of a written questionnaire) and sometimes examined by a medical practitioner. Sub-standard risks are not often rejected for insurance, but are usually offered insurance at a higher price.

In the analysis to follow, only aggregate rather than individual-level data are available. Hence we cannot directly control for these individual risks or their proxies, the price of the insurance or annuity sold. Instead, we omit persons offered insurance

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[5]Cawley and Philipson (1999) present convincing evidence that insurance companies are better at identifying mortality risk than individuals. Their findings are consistent with our conclusion.

[6]In this analysis, the dependence of the price an individual is offered on the extent of adverse selection is ignored. Finkelstein and Puterba (1999) examine this case in the UK annuity market. In extreme cases, this dependence can cause markets to fail. See Akerlof (1970) for more details.

at non-standard prices, implying that information common to both insurer and insured is captured by age, sex, the type of product purchased, the date the product was purchased and the reason the product was purchased. This allows us to ignore the effects of price when comparing individuals who buy the same product, but it does not allow us to ignore price when comparing aggregate mortality data of individuals who purchase different products. In order to do this, we must assume that the price-related selection is the same across product types.[7]

Another factor to be considered when assessing the relative mortality of life insurance versus annuities is the structure of the temporal correlation between peoples' perceptions about mortality and the true underlying probabilities. It is reasonable to suppose that this correlation declines over time: in other words, that people are fairly well informed about mortality next year, but they are less well informed about mortality in 20 years' time. If this hypothesis is correct, we would expect that the impact of adverse selection on observed mortality would decline after the policy is purchased. This implies that both a purchaser's age *and* the length of time since purchase would be important variables correlated with mortality outcomes. For this reason, insurance companies often produce a so-called 'select' mortality table for individuals who own policies at short durations, and an 'ultimate' mortality table covering purchasers with policies at longer durations. The temporary selection effect is more likely to be important in insurance policies (which may have short durations) than in annuities (which often have long durations).

This effect of selection on mortality is summarized in Fig. 1, which shows the stylized mortality rate in a group of individuals as they age. The horizontal axis represents the age of the individuals, increasing from left to right. The vertical axis represents mortality rates of the relevant population. Each of the lines rises from

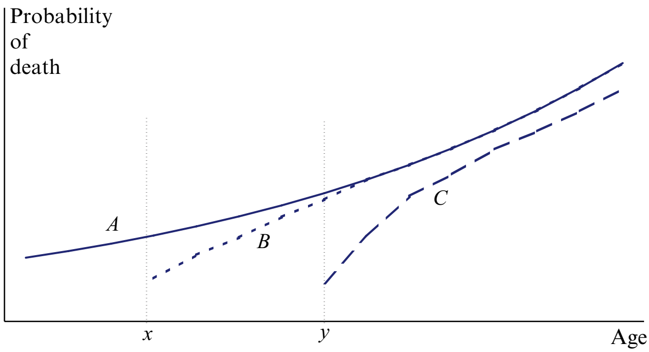

Fig. 1 Effect of selection on mortality (note: Line *A* represents group with no selection. Line *B* represents group undergoing temporary selection at age *x*. Line *C* represents group undergoing permanent and temporary selection at age *y*)

[7]Since different insurance products fulfil different needs, policyholders who purchase different products may need to differ in other ways (such as risk aversion, tax status, search costs) in order for this assumption to hold.

left to right, indicating that mortality, at most ages, increases with age. The top line (*A*) represents the mortality of a group that has not undergone any selection. The lower bottom line (*B*, with thin dashes) represents the mortality of a group that underwent selection at age *x*. As can be seen, the extent of selection declines with time as this group's mortality approaches that of the population as a whole (that has not undergone selection). Eventually there is no difference between the mortality of the group that has undergone selection and the group that has not; thus, the selection can be termed 'temporary' selection. Finally, the line labelled *C* (thick dashes) represents the mortality of individuals who underwent selection at age $y > x$. Again, the effect of the selection declines with time, and the mortality of this group approaches that of the other two groups. However, the mortality of this group never equals that of the other two groups, evincing permanent selection as well as temporary selection. This indicates that a group might reflect permanent selection if the value of the private information it has does not decline with time, if exits from the pool of insured individuals are correlated with mortality or if mortality is partially endogenous (see Philipson and Becker 1999).

Finally, we need to consider the effect of selective exits from the pool of insured individuals. In the first few years that individuals hold insurance policies, lapse rates are usually high. Classical insurance theory predicts that individuals who lapse would tend to have lower mortality than individuals who do not,[8] producing higher observed mortality in the remaining pool of insured individuals. Note that without separate data on the mortality of individuals who lapse, it is not possible to distinguish this effect from other duration-related effects on mortality.

Metrics for Comparing Mortality Tables

Having showed the theoretical way in which selection can have a temporary and a permanent effect on mortality, we next examine two empirical methods for comparing mortality tables. Specifically, following Mitchell and McCarthy (2001), we examine plots of age-at-death distributions and the A/E method.

Plots of Age at Death Distributions

One conventional way to compare mortality tables is to compare the implied distributions of expected age at death. For different mortality tables, this approach requires graphing the percentage of individuals expected to attain age *x* and die

[8]This effect becomes less important the more cash values of policies deviate from economic values. However, in the presence of borrowing constraints, individuals with serious illnesses may surrender policies to pay for medical care, mitigating this effect to some extent.

before reaching age $x + 1$, given they reached some specific age (65 in the case of annuitants, lower in the case of life insurance purchasers). The graphical approach affords an illustration of which mortality curve is higher, or lower, at given ages. However it does not offer any measure for 'how far apart' two mortality tables might be and it cannot be used to compare the severity of mortality tables at two different ages. This is important when comparing the mortality of annuitants (who tend to be over 65) and purchasers of life insurance (who tend to be under 65).

A/E Method

An alternative method to compare mortality tables, the 'A over E' method, is favoured by actuaries and demographers. It expresses the number of deaths expected in a population with a given age structure using one table and then compares these to the expected number of deaths in a population of the same size using a second mortality table. Results are presented as a ratio multiplied by 100: for example, a value of 100 implies that the same number of deaths is expected in a given population, irrespective of which of the two mortality tables is selected. This measure is mathematically equivalent to a ratio of the weighted average probabilities of death for the two mortality tables, using a specific population structure for the weights.

The particular A/E measure one derives depends on the 'baseline' age distribution of the population used to calculate the number of deaths. Therefore it is essential to define the base table clearly, from whence A/E comparisons are then computed as:

$$\frac{\mathrm{A}}{\mathrm{E}} = \frac{\sum_x w_x q_x^*}{\sum_x w_x q_x} \times 100$$

where q_x is the probability that an individual of age x dies according to the table in question and q_x is the probability that an individual of age x dies according to the base table. The weights, w_x, are set so that $w_{65} = 100{,}000$ and $w_x = w_{x-1}\,(1 - q_{x-1})$. The A/E method can be used to compare different mortality tables at different ages.

International Comparisons of Insurance and Population Mortality Tables

In order to implement these mortality measures, we use aggregate mortality data based on smoothed estimates of mortality produced by others rather than on individual mortality records based on 'raw' data. This is primarily because the underlying data are proprietary and access is restricted.

Data Description

In the US case, mortality data are taken from the US Social Security Administration (1999; see Society of Actuaries 1999 updated as per Mitchell et al. 1999). For the life insurance portion of this investigation, life tables use the mortality table database maintained by the Society of Actuaries; we use the 1990–1995 series of tables. We also use a 1991 population table from the Social Security Administration, augmented after age 85 by the slightly more recent tables described in Mitchell et al. (1999). No adjustment is needed to ensure that these tables changed smoothly with age since post-85 mortality has changed little in the last decade.[9]

For the UK case, insurance and annuity mortality tables are produced by the Executive Committee of the Continuous Mortality Investigation of the Faculty and Institute of Actuaries (1999), and population mortality tables by the Government Actuaries Department (1999). The tables used in the life insurance part of this investigation are the 1992 Series of term and whole life insurance tables produced by the Executive Committee (1999). The population table is the interim population table for the United Kingdom for the year 1998, produced by the Government Actuaries Department (2000) augmented after age 100 by an earlier table, obtained privately from the Government Actuaries Department (1999). In the case of the male table, probabilities above the age of 100 were adjusted by a constant ratio to ensure that the values in the table changed smoothly. The effects of the choice of adjustment method are extremely small. In the case of the female table, no adjustment was required.[10] In Japan, the Statistics and Information Department of the Ministry of Health and Welfare (1998) produces population life tables after each quinquennial census, the most recent available being that of 1995. The Institute of Actuaries of Japan (1996) has produced life tables of insured lives in Japan on a regular basis. Their most recent table was published in 1996, along with a table intended to be used to value annuity-style products.

Because the US and the UK data collection mechanisms for mortality experience are relatively consistent, it is widely believed that these two countries produce quite reliable and comparable mortality tables. Accordingly, these tables are widely used in both developed and developing nations as a basis for modelling local mortality. In practice, US mortality tables appear to be commonly used in the Western hemisphere, while UK tables are typically employed in countries that were once British colonies or where British influence was strong.[11] To the best of our knowledge, Japanese mortality tables are not widely used outside the Japanese insurance market.

Several issues arise when using aggregate mortality data in this context. First and most important, the data do not indicate several factors that might affect mortality

[9] The tables used in the annuity portion of this investigation are those used by Mitchell and McCarthy (2001) in their investigation of adverse selection in annuities.

[10] In the annuity section of the investigation, the tables used are identical to those used by Mitchell and McCarthy (2001) in their investigation of adverse selection in annuities.

[11] See James and Vittas (1999). Often actuarial adjustments are applied to these tables, ostensibly to make them more reflective of local conditions. Lacking good mortality data, however, it is difficult to know what actuarial adjustments might be appropriate.

and that could be also correlated with the decision to purchase insurance; obvious examples include wealth and income. As a result, published data do not allow a direct way of distinguishing the effect on mortality of a correlation between insurance purchase behaviour and wealth from permanent effects of adverse selection. We adopt an indirect approach that assumes that these variables affect insurance purchase of all products equally. This implies that any difference between the mortality of, say, annuity purchasers and life insurance purchasers is due only to adverse selection. We also do not have data on the price of insurance offered to any given individual, which reflects the effect on mortality of information known to the insurance company. Adverse selection will affect mortality through information *unknown* to the insurance company. This problem is partially mitigated by the use of standard mortality tables. In other words, the tables are based on those able to purchase insurance at standard rates and who hence face the same price. Finally, there may be systematic errors introduced into the aggregate data by the smoothing process. However, the lack of micro data requires us to make the assumption that mortality tables are unbiased estimates of the true underlying mortality of the population.[12]

Results for Insurance Tables

We turn next to discuss how insured individuals' mortality compares to mortality of the general population in the US and the UK for select and ultimate insurance tables, and in Japan only for the ultimate life insurance table. Figure 2 shows the distribution

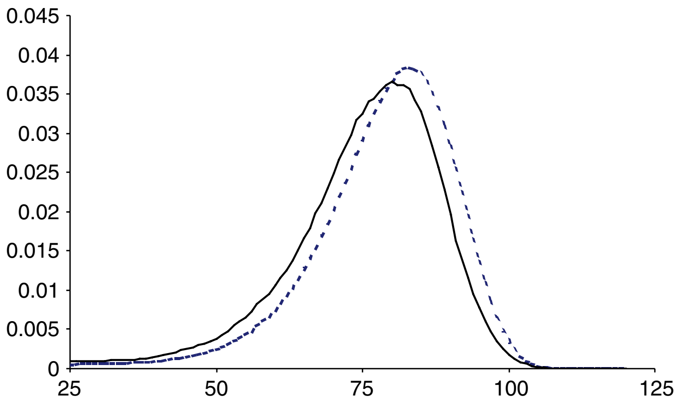

Fig. 2 Distribution of age at death of UK male population and insured lives: conditional on reaching age 25 (notes: *Solid line* indicates UK male population. *Dashed line* indicates male purchasers of UK whole life policies. (Authors' calculations based on data from GAD 1999; GAD 2000; Executive Committee 1999)

[12]This is probably true for the UK and US data; we have no information about possible biases introduced into Japanese mortality tables by the method of construction.

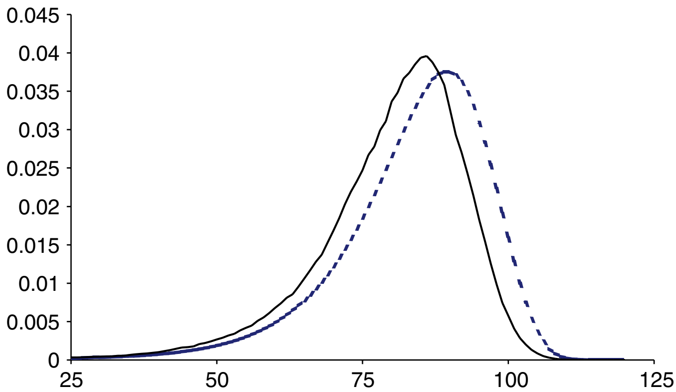

Fig. 3 Distribution of age at death of UK female population and insured lives: conditional on reaching age 25 (notes: *Solid line* shows UK female population. *Dashed line* shows male purchasers of UK whole life policies. (Authors' calculations based on data from GAD 1999; GAD 2000; Executive Committee 1999)

of age at death for UK insured males and the UK male population.[13] On average, the general population dies *earlier* than people who take out whole life insurance. The modal age at death in the general population is lower than the modal age at death of insured males in the UK. This is in spite of the fact that incentives in purchasing life insurance would be expected to encourage people to buy who believe that they are more likely than average to die sooner.

There are two possible explanations for this anomalous result. The first is that insurers can clearly identify high-risk individuals at the time they apply to purchase life insurance. This would undermine the theory of adverse selection in insurance markets. The second is that we have not controlled for other differences between the population that buys life insurance and the general UK population. In particular, there may be an income effect operating, where individuals who are wealthy enough to buy life insurance are also wealthier than average, and thus have lower mortality than average. In Fig. 3 we show the distribution of age at death of the female UK population and female UK purchasers of whole life policies, again conditional on reaching age 25. A similar pattern prevails.

Equivalent graphics for the United States appear in Figs. 4 and 5. While the overall pattern is similar, it appears that the modal age at death of insurance purchasers in the US is equal to that of the general population, while the mean age at death of insurance purchasers is lower. Once again, only the 'ultimate' insurance table is shown, as the 'select' table is very similar to the 'ultimate' table in spite of the longer select period.

[13] There is very little difference between UK Term/Whole Life and Select/Ultimate Tables, partly because of the short select period in the UK. Hence only Whole Life Ultimate tables are shown.

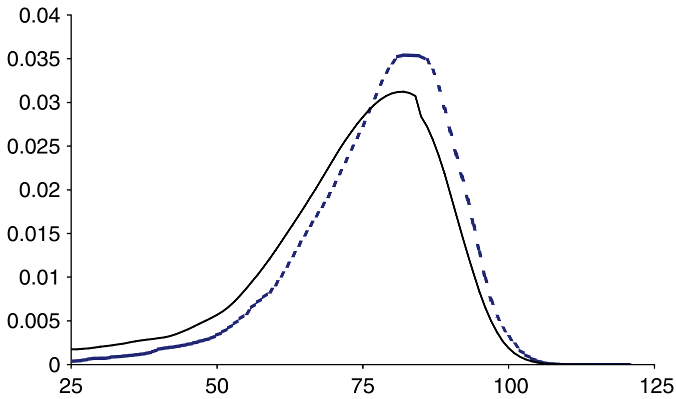

Fig. 4 Distribution of age at death of US male population and insured lives: conditional on reaching age 25 (notes: *Solid line* shows US male population. *Dashed line* shows male purchasers of US life policies. (Authors' calculations based on data from SSA 1999; SOA 1999)

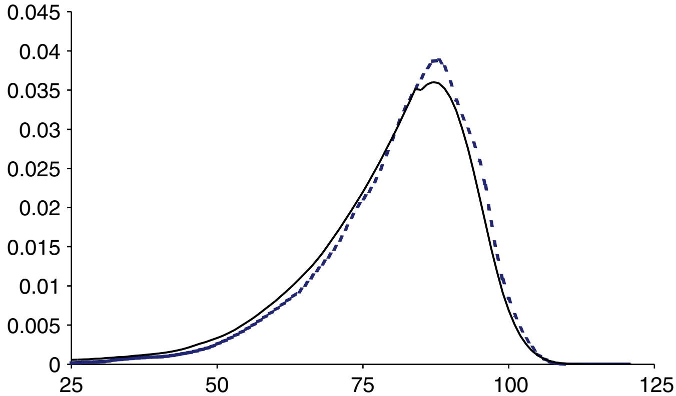

Fig. 5 Distribution of age at death of US female population and insured lives: conditional on reaching age 25 (notes: *Solid line* shows US female population. *Dashed line* shows female purchasers of US life policies. (Authors' calculations based on data from SSA 1999; SOA 1999)

Similar results for Japan appear in Figs. 6 and 7. Here the selection effect appears to be much smaller in Japan than it is in the UK or the US, for men and women. However in Japan, purchasers appear to have *higher* mortality than the general population, although this effect seems to start only at age 60.

Observed patterns in mortality appear in Table 1 based on A/E metrics for a male aged 35 in the US, UK and Japan. Panel A shows results for the UK: Column 3 shows that the A/E metric for the UK male population is 100, since the base table adopted is the UK male population table. Column 2 shows the A/E metric measured for the

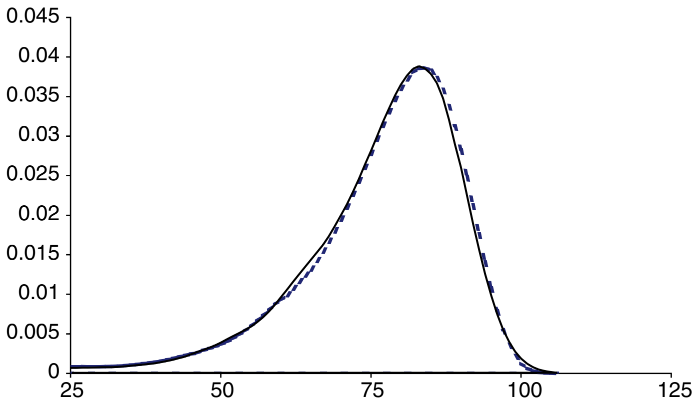

Fig. 6 Distribution of age at death of Japanese male pop and insured lives: conditional on reaching age 25 (notes: *Solid line* shows Japanese male population. *Dashed line* shows male purchasers of Japanese life policies. (Authors' calculations based on data from Statistics and Information Department 1998; Institute of Actuaries of Japan 1996)

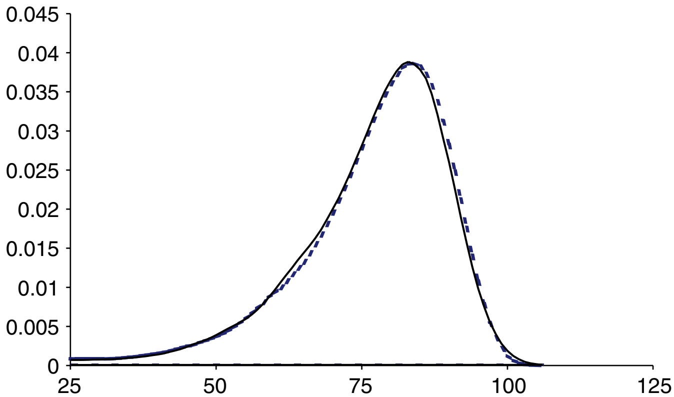

Fig. 7 Distribution of age at death of Japanese female pop and insured lives: conditional on reaching age 25 (notes: *Solid line* shows Japanese female population. *Dashed line* is female purchasers of Japanese life policies. (Authors' calculations based on data from Statistics and Information Department 1998; Institute of Actuaries of Japan 1996)

ultimate UK male insurance table and, hence, it shows the permanent effect on mortality of purchasing insurance. The data range from 56.0 for 10-year policies in the UK, to 77.5 for whole life policies. UK male purchasers of insurance have permanently lower mortality than the population: 58.8% of the population mortality for 5 years, 56.0% for 10 years and 77.5% of population mortality for life. The difference between Columns 1 and 2 shows the temporary effect of selection. For 5-year policies, the select insurance mortality is 54.6 (again with a base of 100 for the UK population), compared with 58.8 for ultimate insurance mortality over that period. This indicates that people who buy insurance have *lower* mortality for the first 5 years of their policies than similar-aged people who have held their policies for a long time. This is in spite of the fact that insurance is a better value for those having higher mortality.

The results suggest that insurance companies in the UK are quite successful at identifying individuals with sub-standard risks. Similar results are repeated for 10-year policies, although the magnitude of the temporary reduction in mortality is lower, as we would expect if the value of information about mortality declines with time. Finally, Panel A, line 3, shows results for whole-life insurance. Here, the temporary effect of selection on mortality all but disappears, as we would expect.

Comparable results for the US appear in Panel B. Column 3 shows the value of mortality for the US population, which is again 100 as we have used US male population mortality as a base for these calculations. The permanent effect of selection is much lower in the US than in the UK, with mortality permanently reduced to something between 68.6% and 80.6% of population mortality depending on the term of the policy. However, the temporary effect of selection is much greater in the US than in the UK. For 5-year policies, the temporary effect of selection reduces the mortality of a 35-year-old male from 73.4% to 21.2% of US male population mortality. For a 10-year policy the effect is reduced, as we would expect, but still extremely large: a reduction from 68.6% of population mortality to 29.0%. Finally, for whole life policies, the effect is very much reduced: the temporary effect of selection lessens mortality from 80.6% of population mortality to 78.6% of population mortality. This is comparable to the UK value of 77.5% reported in column 1, Panel A. In other words, part of the dramatic difference in short-term policies across countries might be due to the much longer select period in the US. In the UK, after a policy is over 5 years old, it is considered to be part of the 'ultimate' group, while in the US, 25 years must pass before this occurs. As a result, it appears that that the UK 'ultimate' mortality is biased downward relative to the US.

Finally, results for Japan appear in Panel C of Table 1. Select mortality rates are not available since the Institute of Actuaries of Japan does not produce select tables. Nonetheless for the available data, the effect of selection on mortality is surprising. Specifically, insured lives in Japan have *higher* mortality than the population. This may indicate that underwriting is less rigid in Japan than in the US and the UK, or that participation in the insurance market is more widespread. It may also be an artefact of the method used to construct the Japanese insurance mortality table.

Table 2 provides comparable results for women across the three countries. Results for UK females are similar to those for UK males, although the effect of selection on mortality for whole life policies is greater for women than for men (possibly indicating a greater income effect). In the US case, the opposite is true, with the insured female mortality closer to population mortality for whole life policies. In the case of policies with shorter terms, the same pattern applies in the US as in the UK, with the effect of selection on mortality being lower for females than for males. Results for Japanese women appear in Panel C of

Table 1 A/E metrics for type of selection, type of policy and country for 35-year old male (Authors' calculations)

	1. Select Insurance	2. Ultimate Insurance	3. Population
A. UK			
5-year	54.6	58.8	100.0
10-year	54.3	56.0	100.0
Whole life	77.5	77.5	100.0
B. US			
5-year	21.2	73.4	100.0
10-year	29.0	68.6	100.0
Whole life	78.6	80.6	100.0
C. Japan			
5-year	na	109.8	100.0
10-year	na	108.4	100.0
Whole life	na	98.4	100.0

Table shows A/E metric for male aged 35, for varying policy terms and mortality tables
See text for the definition of the A/E metric

Table 2 A/E metrics for type of selection, type of policy and country for 35-year-old female (Authors' calculations. See text for details)

	1. Select Insurance	2. Ultimate Insurance	3. Population
A. UK			
5-year	58.7	73.7	100.0
10-year	63.5	69.2	100.0
Whole life	68.5	68.5	100.0
B. US			
5-year	32.8	78.8	100.0
10-year	43.5	73.9	100.0
Whole life	90.9	91.6	100.0
C. Japan			
5-year	na	133.9	100.0
10-year	na	129.0	100.0
Whole life	na	101.3	100.0

Table 2, where, again, insured Japanese females appear to have much higher mortality than the Japanese female population for short policy terms, but only slightly higher mortality for very long policy terms.

In sum, these life insurance mortality tables underscore the important temporary selection effect for purchasers in the US and the UK. Life insurance buyers have lower mortality at very short policy durations than they would have at the same age if their policies had been in force for longer. At least part of this effect may be due to selective withdrawals from the pool of insured individuals. In Japan, the pattern of observed mortality is somewhat different. Insured individuals in Japan seem to have very much higher mortality than the population at shorter policy terms, and mortality roughly equal to the population at longer terms. The reasons underlying this pattern are unknown, but they may be related to weaker underwriting by Japanese insurance companies or a different method of mortality table construction.

Comparing Insurance and Annuity Mortality Tables

In this section we compare adverse selection for life insurance purchasers with that of annuity purchasers in the US, UK and Japan. We control for factors correlated with both mortality and insurance purchasing behaviour, such as income, by assuming that these correlations are independent of the type of insurance purchased. Making the further assumption that price-induced adverse selection effects are also constant across insurance types, we then quantify the effects of adverse selection on mortality by comparing the A/E metrics for the different types of insurance. Annuitants are not underwritten. In addition, compulsory annuitants do not exercise an option, so the extent of adverse selection can be assumed to be minimal. Thus, the reduction in mortality of compulsory annuitants relative to the population can be regarded as a pure income effect. Voluntary annuitants are not underwritten but do exercise an option. Whole life purchasers do exercise an option though this option tends to worsen observed mortality, but they are underwritten.

Table 3 shows values of the A/E metric for voluntary as well as compulsory male and female purchasers of annuities aged 65 in the UK and the US, and voluntary annuity purchasers aged 65 in Japan. For convenience, whole-life insurance A/E metrics have been extracted from Tables 1 and 2 and restated here. In each case, the base table is the population table for that country, as can be seen from column 5.[14] Panel A of Table 3 shows the results for males. As can be seen, whole life insurance tables are between voluntary annuity and compulsory annuity tables in the UK and the US. This suggests that the effect of underwriting on the mortality of whole life policyholders more than compensates for the effect of adverse selection, but that the effect of adverse selection on voluntary annuitant mortality is more than the combined effect of underwriting and adverse selection on whole life insurance mortality.

[14] To control for changes in population mortality over time, the annuity A/E metrics are reported relative to a base population table from the same time that the data for the annuity tables were collected. These population tables differ slightly from the population tables used to calculate the life insurance table metrics due to mortality improvements over the time between the life insurance data were collected and the time the annuity data were collected.

Table 3 A/E metric for life annuity purchasers aged 65 (Authors' calculations. See text for details)

		1. Voluntary Annuities	2. Compulsory Annuities	3. Wholelife Insurance (Select)	4. Wholelife Insurance (Ultimate)	5. Population
A.	Males					
	UK	67.5	82.6	77.5	77.5	100.0
	US	65.3	84.0	78.6	80.6	100.0
	Japan	81.8	na	na	98.4	100.0
B.	Females					
	UK	73.5	84.9	68.5	68.5	100.0
	US	73.6	90.8	90.9	91.6	100.0
	Japan	100.7	na	na	101.3	100.0

Panel B indicates results for females. In the UK, whole life purchasers exhibit lower mortality than either compulsory or voluntary annuitants, whereas in the US, the pattern is reversed. Making the same assumptions as before, females in the UK appear to be underwritten more strictly than males, while the opposite is true in the US. It might also be true that the degree of adverse selection among life insurance purchasers is heavier among females in the US than among males.

Results for Japan again differ strikingly. Among males, insurance purchasers appear to have heavier mortality than voluntary annuitant holders, while among females, mortality is roughly equal. This could be an artefact of the method used to construct the Japanese tables.

Conclusions

Our investigation discerns both temporary and permanent patterns of selection on the mortality of insured individuals in the UK and the US, even after controlling for income and wealth effects. In Japan, there appears to be a permanent selection effect, although our data do not allow us to determine whether temporary selection effects are present in Japan, or their magnitude. The temporary effects are important at short policy durations, while the permanent effects predominate at longer policy durations. Both effects act to improve the mortality of insured lives relative to others, a surprising finding in view of classical theories of adverse selection in insurance markets. This may indicate that underwriters are relatively effective at screening out poor risks. The finding supports the view that insurance companies can better assess mortality risks than individuals themselves.

The analysis might be improved by controlling for income and wealth effects, and by controlling price-induced effects on adverse selection that may differ by product type. In addition, it might be useful to measure the effect of selective withdrawals from the insurance pool that may be correlated with mortality. To control these, however, it would be necessary to obtain micro data that include insurance purchase data and demographic information. Micro-level data would also allow investigators to identify separately the temporary effects of selection on annuity mortality. Such extensions will likely require access to proprietary data.

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Part III
Wealth and Health

Ageing, Family Support Systems, Saving and Wealth: Is Decline on the Horizon for Japan?

Andrew Mason, Naohiro Ogawa, and Takehiro Fukui

Introduction

In many industrialized nations, fertility rates are now below the level of replacement and life expectancy at birth has reached 80 years in a few select countries. As a result, population age distributions are changing markedly, with a relative increase in the numbers of elderly and a relative decrease in the numbers of young.

Demographic developments in Japan are similar in important respects to those occurring among industrialized countries of the West. Japan's demographic transition began more recently and has proceeded more rapidly. The total fertility rate is currently 1.3 births per woman and life expectancy at birth is higher than in any other country. Although a number of Western European populations are older, the percentage of Japan's population 65 or older is increasing rapidly (Ogawa 1996). UN projections anticipate that 36% of Japan's population will be 65 or older by 2050 as compared with 20% of the U.S. population (United Nations 2003).

An overwhelming majority of the Japanese people believe that a variety of social and economic changes will be necessary to accommodate rapid ageing. In business circles, for instance, there has been concern about the implications of a slower-growing and older labour force (Clark and Ogawa 1993, 1996). Government officials are concerned about the future viability of old-age pension schemes and

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the growing burden of medical services for the elderly (Ogawa and Retherford 1997). In addition, although Japan's saving rate is currently relatively high as compared with other industrialized nations, there is widespread concern that population ageing will depress national savings and, along with other ageing consequences, undermine economic growth (Ogawa and Matsukura 1995).

Studies of the impact of ageing on national saving in Japan, reviewed in more detail below, reach widely divergent conclusions. Studies based on the analysis of aggregate saving data often conclude that population ageing will lead to very low or even negative saving rates. In contrast, studies based on the analysis of household survey data typically find that population ageing will have relatively little impact on saving. Efforts to reconcile these approaches have, to this point, been unsuccessful.

This paper addresses the relationship between saving and population ageing using household survey data. The novel feature of this paper is its attention to extended living arrangements and intergenerational transfers. In societies where support for the elderly is achieved primarily through transfers from adult children, the lifecycle incentives for saving are diminished. Population ageing would not lead to a substantial reduction in saving rates if the elderly were not financing their consumption by dis-accumulating personal wealth.

In Japan, however, the situation is very dynamic. Although many elderly live with and rely on their children in Japan, the importance of the extended household and intergenerational transfers has declined markedly in the last few decades. Young adults of today expect to receive old age support from their children to a much lesser extent than was the case in the past. Thus, the importance of life cycle saving may be increasing as elderly retirees become more independent of their children and dependent on personal wealth to meet their material needs. Moreover, strong ageing effects may emerge as the family support system erodes. In a recent simulation analysis, Lee et al. (2003) show that rapid demographic transition combined with a shift from a family-based support system to a lifecycle saving approach generates large swings in aggregate saving – large increases followed by large declines. During the transition wealth grows rapidly relative to income and stabilizes at a much higher level than prior to the transition. In this paper, we present empirical evidence from Japan that is broadly consistent with the simulation analysis in the Lee, Mason and Miller paper. We do not find evidence that saving rates will drop to alarmingly low levels in Japan.

In the next section, we review the literature on ageing and saving in Japan and the standard lifecycle saving model. We show, in theory, how saving and wealth are influenced by the existence of family support for the elderly and we discuss how household saving in nuclear and extended households vary during transition away from a family support system.

In the following section, we use household data from the National Survey of Family Income and Expenditure (NSFIE) conducted in 1994 by the Statistics Bureau of Japan to estimate how demographic characteristics of the household influence saving and wealth. The results are consistent to an extent with the lifecycle model. Saving rates are higher at the working ages and lower when there are more young and elderly in the household. Wealth rises with age, particularly in the later working ages and declines at older ages.

The effect of changing living arrangements on saving are incorporated into the analysis by distinguishing nuclear from extended households. In addition, we use constructed measures of the number of non-coresident family members to assess whether coresident and non-coresident family members are substitutes. It may be that as extended living arrangements decline, inter-family transfers substitute for intra-family transfers either fully or partially maintaining family support for the elderly. Indeed, we do find that increases in the number of non-coresident family members partially offset the decline in coresident family members that results with the shift away from extended households.

The final section of the paper considers the future. Although our focus is on changes in saving and wealth, we also consider living arrangements and the employment status of households. The projections we present anticipate a continued decline in extended living arrangements. By 2050, only 10% of the population 65 and older is projected to be living in extended households as compared with 60% in 2000. We also anticipate a large increase in the proportion of households that are jobless because a larger percentage of the population will be elderly retirees who are not living with employed children. The percentage of jobless households is projected to rise from 15% in 1994 to 37% in 2050.

We find that the demographic changes that are occurring in Japan will lead to lower rates of saving, but our projections are for more gradual declines than anticipated by many other studies of saving in Japan. The household saving rate is projected to drop from 25.6% of disposable income in 2000 to 19.2% of disposable income in 2050. Most of that decline is concentrated in the second quarter of the twenty-first century. The drop in the saving rate is sufficiently small that projected wealth continues to rise during the first half of this century. Total household wealth rises from 9.1 times disposable income in 2000 to 11.4 times disposable income in 2050. Our assessment, then, is that alarmist views about the impact of ageing on saving and wealth are unwarranted.

Recent Studies of Ageing and Saving

Gross national saving rates averaged around 10% to 15% of GNP at the beginning of the twentieth century. An upward trend is apparent starting from the mid-1930s, and very high rates of saving began during the early 1960s. Saving rates have recently declined but are still well above the level that persisted a century ago (Fig. 1).

The trend in aggregate saving rates is broadly consistent with the lifecycle saving model that figures so prominently in most discussions of the connection between population ageing and saving. Reduced fertility, increased life expectancy and accompanying changes in age structure, particularly when they are rapid as they have been in Japan, produce a rapid increase in the demand for lifecycle wealth and the saving rates necessary to produce that wealth. (See Higgins (1994) or Lee et al. (2001)

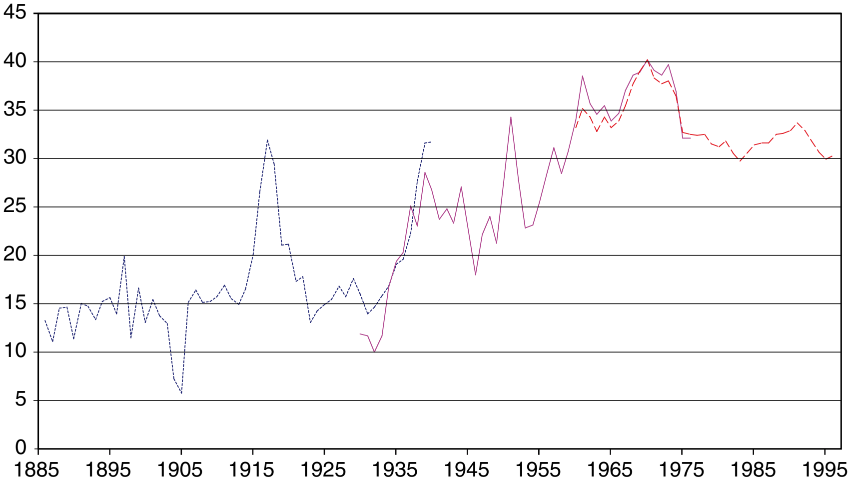

Fig. 1 Gross national saving rate in Japan, 1885–1996
Sources: Japan Statistical Association, 1987; World Bank, 1999

for a more detailed discussion of the implications of demographic transition for lifecycle saving.)

Many studies have investigated directly the issue of whether or not high saving rates are likely to persist in Japan. Most studies take one of two alternative approaches. One approach is based on the analysis of aggregate saving data for Japan, OECD countries, or a larger group of countries of the world. These studies typically conclude that population ageing will lead to a substantial decline in saving rates.

Yashiro and Oishi (1997) provide a recent example of this approach. They estimate saving equations similar to one first employed by Leff (1969). For their baseline simulation, gross national saving as a percent of GNP is regressed on the ratio of the old population to the working age population, the ratio of the young population to the working age population and the rate of growth of per capita GNP. They use annual data for Japan for the period 1958–1992 and estimate the saving relation using ordinary least squares methods. In their simulation, saving rates are depressed by the increased old-age dependency ratio and by the slowdown in the rate of growth of per capita income. They present four simulations with gross saving rates that vary from 5.8% of GNP to 9.1% of GNP by 2020–2025. Given depreciation that averages 15% of GNP, the average for the early 1990s in Japan, net saving as a percentage of net national product would range from −11.2% to −7.4% of net national product. These forecasts imply that Japan would be entering a new period of dis-equilibrium during which wealth would decline substantially relative to income.

The finding that net national saving rates will decline to low or negative levels as economies and populations mature is a robust one so long as the analysis is based on aggregate saving data. A number of such studies are summarized in Table 1.

Table 1 Summary of projections of Japanese saving

Study	Data	2025 Forecast	Forecast percentage change: Medium term	Long term	1995	2000	2005	2010	2015	2020
Gross national saving rate										
Yashiro and Oishi (1997)	Japaneses aggregate data	9.1	–46.6	–61.4	31	23.6	23.6	12.6	12.6	9.1
Williamson and Higgins (2001)	International aggregate data	16.3	–32.9	–45.6	34.6	29.95	25.3	20.1		
Hayashi et al. (1988)	Japanese aggregate data	5.7	–13.9	–62.6		15.1		13		8.1
Net private saving rate										
Horioka (1989)	OECD, Japan aggregate data	–5.1	–86.6	–138.1	17.8	13.4	8	1.8	–5.3	–7
Horioka (1991)	Japanese aggregate data	–10.6	–156.7	–258.2	10.9	6.7	1.9	–3.8	–10.4	–12.2
Masson and Tyron (1990)	G7 and Smaller Industrial Country Block	6.8	–23.8	–53.7	13.4	14.7	12.7	11.2	9.2	7.8
Household saving rate										
Mason et al. (1994)	NFIES	21.7	6.3	13.6	19.1	19.1	18.6	20.3	21.1	21.3
Ogawa et al. (1997)	NFIES	14.5	–5.2	–5.2	15.1	15.3	15	14.5	14.3	14.3

Medium term is for 2000–2010; long-term for 2000–2025. Forecast values interpolated if values for 2000 or 2025 were not available
Mason et al. (1994) is forecast of household saving/disposable income; Ogawa et al. (1997) is forecast of household saving/national income

As can be seen, nearly all conclude that saving rates will drop substantially in the coming decades. There is, however, a wide range in just how substantial the decline is likely to be. Horioka (1991) for example forecasts a drop of the net private saving rate to −10%. A more optimistic assessment is provided by Masson and Tyron (1990) who anticipate a decline to 7%. Several recent studies based on international aggregate data reinforce the conclusion that saving rates will drop substantially. Higgins and Williamson (1997), for example, forecast a decline in Japan's gross national saving to 16.3% of GNP, a value consistent with a net saving rate close to zero, in 2025. Analysis by Kelley and Schmidt (1996) also supports the conclusion that saving rates will drop precipitously as population ageing continues and economic growth slows.

The second method for forecasting saving relies on household survey data rather than aggregate data. Typically, a household saving function is estimated which includes demographic determinants, e.g., the age and sex of the household head and the number of household members in each age group. The simplest version constructs a saving profile that varies with the age of the household head. Projected household income by age of head is combined with the age-saving profile to construct a forecast of the aggregate household saving rate.

Mason et al. (1994) provide a recent example of a saving forecast based on micro data. This forecast of saving employs a saving equation estimated by Ando (1985), Ando et al. (1995) using the 1979 and 1984 NSFIE's. In his model, consumption as a fraction of labour income depends on the age of the household head and the number of household members in specified age-categories. Forecast household saving as a fraction of disposable income is relatively constant between 1995 and 2005 and then rises by 2% points by 2025! Other micro-based studies forecast that saving rates will continue at relatively high levels or decline much more modestly than found by macro based studies. Deaton and Paxson (1997) reach similar conclusions in their analysis of survey data for Taiwan, Thailand, England and the United States.

How can such extraordinarily different forecasts and such different conclusions about the implications of ageing be reconciled? There are a number of possible explanations. The studies use different measures of saving – typically, gross national saving rates by aggregate studies and household saving rates by micro-based studies. However, the differences in forecasts are so great that they cannot be reconciled by differences in measurement.

In some respects, the forecasts based on aggregate data are flawed. Many of the causal factors are endogenous and identification problems have proved to be vexing. The saving-demography models have tended to be very parsimonious increasing the possibility that the strong relationship to demographic factors is spurious. Questions can be raised about the adequacy with which aggregate models have captured the complex dynamics that underlay the saving relationship.

Forecasts based on micro data also face daunting problems. The idea behind the approach is that the behaviour of one age group can be used to predict future behaviour of a younger age group. However, this approach will fail if there are substantial cohort effects or time effects that are not factored into the analysis. Consider the possible cohort effects. Those who are currently young in Japan may follow a different path than those who are currently old because their lifetime experiences are so different. Members of young cohorts marry later, spend more time in school, have fewer siblings and are raising fewer children than members of old cohorts. Members of more recent cohorts can expect to live longer. Their lifetime income will be greater, but they may experience slower earnings growth. They may expect more old-age support from the state, but less support from their children. Each of these factors has a potentially important bearing on saving. Macro-based forecasts may prove to be more reliable than micro-based forecasts if they capture, even inadvertently, some of the cohort effects that are not modelled in micro-based forecasts.

The Lifecycle Saving Model

In the conventional lifecycle saving model, consumption and earning both vary systematically with age. The age profile of consumption is determined by preferences and, in some formulations, physiological needs. The age profile of earning reflects variations in productivity. Saving is a means by which households can achieve their preferred consumption age profile irrespective of the age profile of earning they face. Because humans have an extended period of youth dependency and increasingly significant periods of old-age dependency, there are extended periods during which preferred consumption may differ substantially from earning. If the conventional lifecycle model is correct, rates of saving will vary over the lifecycle of individuals and aggregate saving will vary with the age structure of the population.

That consumption varies systematically with age but is constrained by available resources is represented by:

$$C(a) = f(a)PV[Y^l], \tag{1}$$

where C(a) is consumption at age a, $PV[Y^l]$ is the present value of earnings ($Y^l(a)$) received over the lifetime and *f(a)* is the fraction of lifetime resources consumed at age a. The household's lifetime budget constraint is satisfied if $\sum e^{-ra} f(a) = 1$.

Because households follow the same age earnings profile over their lives by assumption, the fraction of lifetime resources earned at each age, *g(a)*, is fixed.[1] Under these conditions

$$Y(a) = g(a)PV[Y^l]. \tag{2}$$

[1]Several studies take exception to this assumption with important implications for the relationship between saving and economic growth. See Lee et al. (2000), for example.

The fraction of earnings consumed at each age, $c(a) = C(a)/Y^l(a)$, is obtained by dividing Eq. 1 by 2. Taking the natural log of both sides yields:

$$\ln c(a) = \ln f(a) / g(a) \tag{3}$$

Equation 3 gives the age profile of the consumption ratio at any point in time under the simplifying assumptions of the standard lifecycle model.

The aggregate consumption rate, consumption as a fraction of income, is calculated by:

$$c = C / Y = \sum_a c(a) N(a) Y^l(a) / Y, \tag{4}$$

where $N(a)$ is the current population age a and Y is aggregate income. The influence of age structure on the consumption ratio is readily apparent as is its influence on the saving ratio, $s = 1 - c$.[2]

How are consumption and saving rates affected when societies rely on family transfers rather than saving to meet lifecycle needs? To provide a general answer to this question it is helpful to consider a special case. First, we assume that the economy is in long-run equilibrium. The interest rate r is constant; the rate of economic growth g is constant and equal to the rate of growth of technological progress plus population growth, both of which are constant. The age structure of the population is fixed. The aggregate saving rate is constant as is the ratio of wealth (W) to total earnings or total income.

Second, we assume that the population consists of families, each of which has the same demographic composition as the entire population. The individuals in these families can rely on saving to satisfy lifecycle needs as described by the lifecycle model. Or individuals can rely on intra-family transfers to solve their lifecycle problems. Individuals within families would pool their earnings and finance consumption of family members in accordance with preferences as defined by *f(a)*. Under these conditions, there would be no lifecycle saving nor any wealth. Each family would consume all of its earnings and, because it had neither wealth nor interest income, all of its income.

How do the saving and consumption rates of families relying on intra-family transfers compare with those relying on lifecycle saving? To answer this question we make use of some of the properties of a steady-state equilibrium. In a steady state, saving is just sufficient to maintain the ratio of wealth to income, a condition that is satisfied only when $S = gW$.[3] By definition, household income is equal to $Y^l + rW$, and it follows that consumption as a fraction of labour income must equal:

$$C / Y^l = 1 + (r - g) W / Y^l. \tag{5}$$

[2]Although most aggregate saving models assume that saving rates depend on age-structure, it is clear from Eq. 4 that it is the share of income, not the population, of each age group that matters. Consequently, the effect of changes in age structure depend on the age-profile of income, which is influenced in turn by rate of economic growth (see Mason 1987).

[3]See Tobin (1967) for a more extensive elaboration on the steady state lifecycle saving model.

If $g = r$, the golden rule case, consumption will equal earnings. Thus, consumption as a fraction of labour income is equal to 1.0, whether families rely on transfers or saving.[4]

If the rate of return on capital exceeds the rate of economic growth, the more typical case, then consumption will exceed labour earnings by $(r - g)W$ under lifecycle saving. Thus, consumption as a fraction of labour earnings is higher under lifecycle saving. Another way to think about this is that the lifecycle saving family can support higher consumption than the transfer family if the rate of return to savings, r, is greater than the rate of return that can be achieved through transfer systems, g.

Under most circumstances, lifecycle saving families will consume a smaller fraction of *total* income than families that rely on transfers. Consumption as a fraction of total income is given by:

$$C/Y = 1 - gW/Y. \tag{6}$$

If the rate of economic growth is positive, $C/Y < 1$, while for transfer reliant families $C/Y = 1$.

In principle, states can implement transfer programmes identical to the complete transfer system described above, but a multi-generation extended family experiences age-related fluctuations in income and consumption needs that cannot be smoothed entirely through intra-family transfers (Chayanov 1966; Lee et al. 2000). Thus, even in a setting where family support systems are pervasive, the demand for lifecycle saving may still be substantial. Thus, the existence of family support systems will lead to attenuation, not elimination, of the effects of age-structure on aggregate saving (Lee et al. 2003).

As discussed above, the Japanese approach to old-age security is a mixed approach not characterized by either of the two extremes presented above. Some families rely on intergenerational transfers, while other families rely on pensions and personal savings. Nearly all elderly receive partial support from public transfer programmes. Further complicating the picture is that the support system is in transition. Some adults are supporting their parents, have done so, or are expecting to do so in the future, but anticipate receiving much less support or no support at all from their own children.

How will saving in transition households be influenced by the decline in family support systems? This is an issue addressed using simulation techniques by Lee et al. (2003). They show that saving rates will rise in response to a decline in the transfer system. If the transition is relatively smooth and anticipated by those experiencing it, saving rates will rise to levels consistent with lifecycle saving households. If, however, the transition is rapid and unexpected, households may engage in 'super-saving', saving that is higher than life cycle saving, as they reduce their current and planned consumption in response to the decline in expected transfers.

[4] Total consumption will be higher under life cycle saving because of general equilibrium effects, however. Higher equilibrium wealth will lead to a higher capital-labour ratio and greater total earnings. In an economy in which some households are lifecycle savers and some rely on family transfers, both groups of households will benefit in the form of higher earnings from the wealth and capital held by lifecycle savers.

To summarize, the lifecycle model implies that in the steady-state equilibrium, with $r>g$, the ratio of consumption to labour income is lower among households that rely on family support systems, and the ratio of consumption to total income is higher among households that rely on family support systems. During periods of transition, however, the ratio of consumption to total income may be lower among households that rely on family support systems. Thus, whether extended households have lower or higher saving than nuclear households is an empirical issue.

Even if the theoretical implications of the lifecycle model were unambiguous, obtaining reliable tests of these hypotheses would be difficult. Most household surveys, including the National Survey of Family Income and Expenditure (NSFIE), provide only a partial accounting of saving and income because they do not include accumulations in employment based pension funds. In addition, a relatively high percentage of Japanese are own-account workers for whom separating labour income from returns to business assets is very difficult. Adding to the complexities are problems with measuring income specific to the NSFIE. These are discussed below.

Analysis of the Survey Data

The Data

The empirical work is based primarily on the 1994 round of the NSFIE (the 1989 round is used for very limited purposes). The Statistics Bureau of the Japanese Government has been conducting the NSFIE every 5 years since 1959. One of the primary objectives of this survey is to shed light on the structure of the household economy, and regional differences therein, emphasizing three aspects: (i) family income and expenditure, (ii) consumer durables, and (iii) assets and liabilities.

The sample size of the NSFIE is approximately 55,000 private households with two or more members and about 4,700 one-person households, but our analysis does not include one-person households. For each household type, the selection procedure is a stratified random sampling based on geographical location. Because it is difficult to design the stratified random sampling procedure based upon geographical location without creating some variability in sampling ratios over the regions, the NSFIE is subject to regional variability in sampling ratios. For this reason, each observation is weighted so as to obtain a representative sample. Private households with two or more members were surveyed for the period of 3 months from September to November.

The survey data are used to construct measures of disposable income, consumption, wealth and demographic characteristics of the household. In defining each of these variables, there is an inevitable tension between designing a measure that is comparable to national income statistics, consistent with the underlying theoretical model of household behaviour and that is practical given the limitations of any survey as complex as the NSFIE. Thus, the measures used are a compromise between these different considerations.

Household income is measured as disposable household income. Income is net of all taxes and includes wages and salaries, interest income, property income, profits,

Table 2 Distribution of households, 1994 NSFIE

	Worker	Entrepreneurial	Jobless	Combined
Extended	15.6	8.7	2.8	27.1
Nuclear	51.2	13	8.7	72.9
Combined	66.8	21.7	11.5	100

public and private transfers and the flow of imputed rent from owner-occupied dwellings. We exclude transfer expenditures.

Consumption is measured as the NSFIE variable living expenditure plus the imputed value of owner-occupied dwellings. There are some technical issues that arise with respect to measuring consumption and income that we describe in more detail below.

We distinguish three forms of wealth: financial wealth, housing wealth and consumer durables. Financial wealth includes the value of stocks and bonds, savings accounts, cash, the value of life insurance policies and other financial assets less all debt including mortgages against housing and land. Housing wealth is the gross value of real property.

Demographic characteristics of the household are measured by the number of male and female household members in 5-year age groups from 0–4 to 85 and older. We distinguish extended from nuclear households using information about the relationship to head of household members. Extended households as defined here are multi-generation households. Households in which there is a parent of the head, a grandchild of the head, or a child of the head over the age of 30 are counted as extended. The analysis also distinguishes households by their employment status (worker households, independent proprietors and jobless households).

Table 2 provides the 1994 joint distribution of households by type. About two-thirds of all households are worker households, but there are substantial numbers of individual proprietors (21.7%) and jobless households (11.5%). Over 70% of all households are nuclear; nuclear households dominate both worker households and jobless households (about 60%).

Worker households, particularly nuclear worker households, tend to be relatively young as compared with the others. Extended worker households are dominated by prime-age adults with one or more coresident elderly members. Members of independent proprietor households are older, on average, than are the members of worker households. This is true particularly of nuclear independent proprietor households. Jobless households consist mostly of elderly couples.

Adjustments to Income and Consumption

The NSFIE collects detailed income and expenditure data for a 3-month period (September–November). However, the detailed income data are collected only for worker households. Our measure of income is based on *annual income*, a question asked of all households. Annual income refers to income received during the 12-month period ending in November of the survey year. The measure is net of taxes and transfer expenditures.

The analysis is based on disposable income, which excludes transfer expenditures and non-living expenditures, consisting primarily of taxes and which includes the imputed rent of owner-occupied dwelling. A number of adjustments are necessary. First, transfer expenditure is available only for the 3-month period rather than on an annual basis. Thus, we adjust transfer expenditure to account for seasonality in this variable. The adjustment is based on monthly data for the 12-month reference period for annual income collected by the NSFIE. These data are available only for worker households. We assume that worker and non-worker households experience the same seasonality in transfer expenditure.

Second, non-living expenditures, consisting primarily of taxes, are also adjusted for seasonality for worker households. The same method is employed as when adjusting transfer expenditures. Non-living expenditures are not collected for non-worker households. Hence, we reduce annual income by a constant fraction for all non-worker households based on a crude estimate of the tax rate (non-living expenditure/income) paid by these households. Several studies of Japanese taxes indicate that the tax rate paid by worker households exceeds the tax rate paid by non-worker households. Consequently, we assume that the tax rate paid by non-worker households is 80% of the tax rate paid by worker households. The average tax rate paid by worker households was 0.1560 according to the 1994 NSFIE.

Third, consumption expenditure, collected for the 3-month period, is adjusted for seasonality using the NSFIE. Estimates are available for both worker and non-worker households. Japan does not collect monthly data on imputed rents using the NSFIE and, hence, no adjustment for seasonality is possible. There is little reason to expect seasonality in imputed rent in any case.

Incorporating all of these adjustments, disposable income for worker households is:

YD = Annual income/12 − 1.047 × Transfer expenditures – 1.186 × non-living expenditures + imputed rent

Disposable income for non-worker households is:

YD = 0.875 × annual income/12 − 1.047 × transfer expenditures + imputed rent

Consumption is calculated as:

C = a1 × consumption + imputed rents

Where a1 equals 1.058 for worker households and 1.044 for non-worker households.

Non-Coresident Family Members

Two variables are constructed that measure, in crude form, the availability of non-coresident family members. NC2064 is an estimate of the number of non-coresident surviving family members (children or parents) between the ages of 20 and 64. NC65+ is an estimate of the number of surviving non-coresident parents aged 65 and older.

The methods for constructing these measures are described in detail in the appendix to the paper. Essentially we impute values to each of the households in

Table 3 List of variables

Variable name	Description of variable
ln Yd	Natural log of monthly household disposable income (yen)
ln C	Natural log of monthly household consumption (yen)
Total wealth	Sum of financial, housing, and durables (1,000s yen)
Financial	Net financial wealth of household (1,000s yen)
Housing	Gross value of owner-occupied housing (1,000s yen)
Durables	Durables owned by household (1,000s yen)
AGE0004	Number of household members aged 0–4 (persons)
AGE0509	Number of household members aged 5–9 (persons)
AGE1014	Number of household members aged 10–14 (persons)
AGE1519	Number of household members aged 15–19 (persons)
AGE2024	Number of household members aged 20–24 (persons)
AGE2529	Number of household members aged 25–29 (persons)
AGE3034	Number of household members aged 30–34 (persons)
AGE3539	Number of household members aged 35–39 (persons)
AGE4044	Number of household members aged 40–44 (persons)
AGE4549	Number of household members aged 45–49 (persons)
AGE5054	Number of household members aged 50–54 (persons)
AGE5559	Number of household members aged 55–59 (persons)
AGE6064	Number of household members aged 60–64 (persons)
AGE6569	Number of household members aged 65–69 (persons)
AGE7074	Number of household members aged 70–74 (persons)
AGE7579	Number of household members aged 75–79 (persons)
AGE8084	Number of household members aged 80–84 (persons)
AGE85P	Number of household members aged 85+ (persons)
NC2064	Number of non-coresident family members aged 20–64 (persons)
NC65P	Number of non-coresident family members aged 65 and older (persons)
EXFAM	Household is extended (1) or nuclear (0)
WORKHH	Household is a worker household (1) or not (0)
OTHERHH	Household is an entrepreneurial household (1) or not (0)
JOBLESS	Household is jobless (1) or not (0)

the survey based on the age and sex of the household's members and whether or not the household is extended or nuclear. The values are averages that do not reflect many characteristics of the respondent households, e.g., whether or not their parents are still alive, their childbearing pattern and the economic characteristics of their particular parents and children.

We assume that NC65+ equals zero for extended households. This assumption may at first appear to be unreasonable and it no doubt would be for many countries. In Japan, however, relatively few older adults are divorced. Moreover, given the patrilineal nature of Japanese society, the son's parents figure much more prominently than do the daughter's. Essentially, we are assuming that the wife's non-coresident parents have no effect on the household's behaviour.

Variable names and definitions are provided in Table 3. Descriptive statistics are provided in Table 4.

Table 4 Means and standard deviations of key variables, extended and nuclear households, Japan, 1994

	All households		Extended households		Nuclear households	
Variable	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Number of members	3.626		4.650		3.245	
0–4	0.225	0.525	0.205	0.513	0.233	0.529
5–9	0.278	0.586	0.293	0.605	0.273	0.578
10–14	0.293	0.600	0.327	0.632	0.280	0.588
15–19	0.254	0.547	0.281	0.573	0.244	0.537
20–24	0.190	0.471	0.181	0.459	0.194	0.475
25–29	0.188	0.476	0.161	0.437	0.198	0.489
30–34	0.237	0.535	0.278	0.540	0.221	0.533
35–39	0.271	0.559	0.319	0.587	0.253	0.547
40–44	0.300	0.578	0.354	0.609	0.280	0.565
45–49	0.287	0.565	0.319	0.587	0.275	0.556
50–54	0.253	0.535	0.258	0.535	0.251	0.535
55–59	0.209	0.486	0.275	0.542	0.184	0.462
60–64	0.203	0.484	0.339	0.587	0.152	0.428
65–69	0.177	0.457	0.332	0.573	0.119	0.389
70–74	0.109	0.351	0.249	0.489	0.057	0.264
75–79	0.071	0.276	0.202	0.432	0.023	0.164
80–84	0.049	0.225	0.160	0.383	0.007	0.093
85+	0.033	0.184	0.118	0.334	0.001	0.038
NC2064	2.405	1.519	1.807		2.628	
NC65P	0.372	0.350	0.000		0.511	
EXFAM	0.271	0.445	na	na	na	na
WORKHH	0.668	0.471	0.575		0.703	
OTHERHH	0.218	0.413	0.323		0.179	
ln C	12.842	0.462	12.943	0.464	12.804	0.456
ln Yd	13.148	0.511	13.326	0.502	13.082	0.499
Total Wealth	8.930	15.730	7.025		4.346	
Financial	1.650	3.550	1.115	2.431	0.733	1.963
Housing	6.870	14.950	5.644	11.899	3.437	8.023
Durables	0.363	0.244	0.266	0.140	0.176	0.115

Source: NSFIE
Wealth variables are expressed relative to disposable income

The Results

Regression results (estimated coefficients and standard errors) for the natural log of consumption and disposable income are presented in Table 5. The final column is the estimated partial effect on ln C/Yd, calculated as the difference between the ln *C* and the ln *Yd* coefficients. The values in the last column are also approximately equal to the negative of the partial effect on saving of each of the independent variables. The estimates are obtained using ordinary least-squares regression.

Table 5 Parameter estimates, consumption and income, NSFIE, Japan, 1994

	ln C		ln Yd					Age Profiles		
	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Calculated value of ln C/Yd	Means		ln C	ln Yd	C/Yd
INTERCEPT	12.160	0.012	12.027	0.013	0.134					
0–4	0.014	0.004	–0.030	0.005	0.044	0.22517	0–4	12.35069	12.55417	0.815884
5–9	0.029	0.004	0.014	0.004	0.015	0.27845	5–9	12.36527	12.59759	0.79269
10–14	0.042	0.004	0.038	0.004	0.004	0.29268	10–14	12.37905	12.62226	0.784104
15–19	0.112	0.004	0.063	0.004	0.050	0.25373	15–19	12.44909	12.64687	0.820548
20–24	0.078	0.005	0.132	0.005	–0.054	0.19038	20–24	12.41441	12.71559	0.739942
25–29	0.090	0.005	0.179	0.005	–0.089	0.18803	25–29	12.42646	12.76319	0.714099
30–34	0.135	0.006	0.227	0.006	–0.092	0.2365	30–34	12.4718	12.81121	0.712188
35–39	0.161	0.007	0.242	0.007	–0.080	0.27071	35–39	12.49804	12.82558	0.720692
40–44	0.195	0.008	0.249	0.008	–0.053	0.29985	40–44	12.53202	12.83252	0.740446
45–49	0.265	0.008	0.250	0.008	0.014	0.28702	45–49	12.60121	12.83418	0.792175
50–54	0.270	0.008	0.263	0.008	0.007	0.25283	50–54	12.60666	12.84673	0.78657
55–59	0.232	0.008	0.243	0.008	–0.012	0.20877	55–59	12.56818	12.8274	0.771651
60–64	0.195	0.008	0.196	0.008	–0.001	0.20287	60–64	12.53199	12.77988	0.780443
65–69	0.164	0.008	0.194	0.008	–0.031	0.17683	65–69	12.50045	12.77847	0.757279
70–74	0.117	0.010	0.125	0.010	–0.008	0.10908	70–74	12.45377	12.70894	0.774782
75–79	0.086	0.011	0.085	0.011	0.001	0.07113	75–79	12.4223	12.66852	0.781748
80–84	0.082	0.011	0.071	0.012	0.011	0.04896	80–84	12.41866	12.65501	0.789502
85+	0.100	0.012	0.046	0.013	0.054	0.03301	85+	12.43648	12.62989	0.824141
NC2064	0.023	0.004	0.060	0.004	–0.037	2.40516				
NC65P	0.141	0.017	0.310	0.018	–0.170	0.37245				
EXFAM	0.038	0.017	0.234	0.018	–0.196	0.27143				
WORKHH	0.087	0.007	0.264	0.008	–0.177	0.66794				
OTHERHH	0.000	0.007	0.270	0.008	–0.270	0.21766				
Adjusted R-square		0.197		0.277						
Sample Size		53225		53202						

The standard errors are generally quite small. This is not surprising given the large sample size of the NSFIE. The coefficients are all significantly different than zero at conventional significance levels except for *NC65P* in the ln *Yd* regression.

The estimated age profiles of ln *C* and ln *Yd* both have an inverted U shape. The age profiles for both ln *C* and ln *Yd* peak at ages 50–54. Increases in the dependent population lead to a rise in the consumption ratio and a decline in the saving ratio, a conclusion that follows from the positive values in the final column of Table 5 for households members aged 0–19 and 75 and older. The magnitudes of the coefficients are relatively small, however, and changes in age structure may have a relatively modest impact on aggregate saving judging from these values. However, the estimates control for the employment status of the household, and jobless households tend to be concentrated among the elderly.

A puzzling feature of these estimates is that the largest positive impact on saving comes from additional young adults in the household, while the effect of middle-aged adults is very small. This seems contrary to conventional wisdom, but note that these estimates control for the number of children. The saving rate of a household headed by a middle-aged adult and no children is similar to a household headed by a young adult and two children.

The employment status of the household has a relatively modest effect on consumption and a relatively substantial effect on income and saving. Worker households and entrepreneurial households have similar levels of disposable income, but substantially higher disposable income than jobless households (the excluded category). Worker households have somewhat higher consumption than jobless households or entrepreneurial households. Entrepreneurial and worker households have much higher saving rates than jobless households.

Being an extended family has a significant positive impact on disposable income and a much smaller positive impact on consumption. Thus, an increase in the proportion of extended households has a positive impact on saving. Note that we have controlled for family size so that the effect does not reflect the fact that extended households have more members (and more earners) than nuclear households, nor does it reflect differences in employment status that are correlated with living arrangements.

An increase in the number of non-coresident family members also leads to higher income and higher saving. These effects partially offset the impact of being in an extended family, because nuclear households have higher numbers of non-coresident family members. The combined effect of NC2064, NC65P and EXFAM, given the mean values for 1994, is that ln *C/Yd* is reduced by −0.079 by living in an extended household. Saving rates are approximately 8% higher in extended than in nuclear households controlling for the demographic composition and the employment status of the household.

Table 6 presents wealth regressions. Several measures of wealth relative to disposable income are regressed on the same set of regressors used in the consumption and income analysis. The age profile of wealth is consistent to some extent with the lifecycle model. Wealth increases substantially with age with the greatest wealth concentrated among those in their 50s and 60s. The peak wealth/income ratio varies with the form of wealth. Total wealth and housing wealth reach a peak

Table 6 Parameter estimates, NSFIE, Japan, 1994

	Total wealth		Financial wealth		Housing wealth		Consumer durables	
Variable name	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Estimated coefficient	Standard error
INTERCEPT	11.130	0.447	3.930	0.095	6.650	0.434	0.517	0.007
AGE0004	–0.024	0.159	–0.130	0.034	0.098	0.155	0.012	0.003
AGE0509	0.089	0.140	–0.219	0.030	0.306	0.136	0.001	0.002
AGE1014	–0.204	0.137	–0.183	0.029	–0.018	0.133	–0.005	0.002
AGE1519	–0.307	0.148	–0.255	0.031	–0.044	0.144	–0.004	0.002
AGE2024	–1.730	0.183	–0.633	0.039	–1.130	0.177	0.040	0.003
AGE2529	–2.250	0.182	–0.794	0.038	–1.490	0.177	0.051	0.003
AGE3034	–2.350	0.208	–0.875	0.044	–1.500	0.202	0.028	0.003
AGE3539	–2.350	0.251	–0.875	0.053	–1.500	0.244	0.037	0.004
AGE4044	–2.180	0.285	–0.740	0.060	–1.460	0.276	0.033	0.005
AGE4549	–1.700	0.275	–0.536	0.058	–1.210	0.267	0.040	0.004
AGE5054	–1.820	0.288	–0.436	0.061	–1.440	0.280	0.036	0.005
AGE5559	–0.566	0.282	–0.099	0.060	–0.506	0.274	0.026	0.004
AGE6064	1.090	0.275	0.497	0.058	0.559	0.267	0.025	0.004
AGE6569	0.989	0.292	0.445	0.062	0.543	0.284	–0.002	0.005
AGE7074	1.440	0.349	0.369	0.074	1.070	0.339	0.003	0.006
AGE7579	1.600	0.387	0.321	0.082	1.270	0.376	0.001	0.006
AGE8084	1.150	0.403	0.313	0.085	0.828	0.392	0.013	0.006
AGE85P	0.477	0.442	0.332	0.093	0.128	0.429	0.021	0.007
NC2064	1.160	0.144	0.181	0.030	1.010	0.140	–0.036	0.002
NC65P	2.650	0.609	0.243	0.129	2.550	0.591	–0.164	0.010
EXFAM	3.430	0.617	0.311	0.131	3.250	0.599	–0.131	0.010
WORKHH	–5.090	0.263	–1.950	0.056	–3.060	0.255	–0.065	0.004
OTHERHH	–2.090	0.271	–1.950	0.057	–0.174	0.264	–0.020	0.004
Adjusted R-square		0.085		0.194		0.045		0.041
Sample size		53235		53235		53235		53235

among those in the early 70s. Financial wealth reaches a peak in the early 60s. The age profile for consumer durables is quite distinctive with the peak occurring in the late 20s.

Jobless households have the highest wealth-income ratio followed by entrepreneurial households and worker households. The effect of employment status is very substantial. Although part of the explanation is that jobless households have lower income, i.e., a smaller denominator, they have substantially more wealth. A plausible explanation for this pattern is that higher wealth households are more likely to retire (become jobless).

Except for consumer durables, the effects of living in an extended family and the effects of non-coresident family members on wealth are consistent, at least in sign, with their effects on saving rates. Living in an extended family and having more non-coresident family members leads to greater wealth irrespective of whether the family members are elderly or of working age. As discussed above, these variables offset each other because those living in extended families have fewer non-coresident family members. Given the mean values for 1994, the net effect of living in an extended household is to raise wealth by 1.12 times disposable income. Almost all of this gain is in housing wealth. The gain in financial wealth is very small – only 0.04 times disposable income.

Projections

Japan has experienced a rapid decline in the prevalence of extended households in recent years. Whether the trend will continue is too difficult to say, but our look into the future is premised on the assumption that the downward trend will continue and that by 2050 a relatively small percentage will live in multi-generation, extended households. The great majority of elderly will live independently. If these changes do occur, many of the variables in the model estimated above will be affected. The average number of members per household will decline because multi-generation households will be less prevalent. The average number of non-coresident family members will be higher than would otherwise be the case because fewer family members will be living with each other. The proportion of households classified as ‘jobless’ will increase because many more retired elderly will be living independently rather than with their working children. These changes in living arrangements will interact with changes in population age structure to produce changes in the demographic and economic characteristics of Japanese households.

Projections of Population and Living Arrangements

The population projections used here are the medium scenario recently released by the United Nations (2001). Projections of the number of extended and nuclear households, the average number of members in each age group, the number of non-coresident family members and the distribution of households by their employment status are not available. There are several general purpose models available for Japan that can be used to project families or households[5] and household projections (Mason et al. 1996; NIPSSR 1998), but these models do not meet the specific needs of this effort.

The details of the formal model used to project living arrangements are presented in the appendix and in Mason and Lee (2004). Here we provide a general overview and some of the key results obtained by estimating the model using the 1989 and 1994 NSFIE.

The model distinguishes three age groups or generations within the population–older adults, younger adults and children. Those under age 30 are children, those 30 years or older, but younger than 60, are younger adults, and those 60 or older are older adults. Although age 30 is an unusually late age for classifying individuals as adults, the singulate mean age at first marriage is currently nearly 30 for women and just over 30 for men. Thus, for considering living arrangements, using 30 is appropriate and convenient.

The proportion of older adults living in extended households is determined by an age effect and a cohort effect. The age effect captures the influences of infirmity or financial hardship that may increase with age. The cohort effect captures the shift in living arrangements that is occurring over time or, to be more explicit, the shift away from extended families. We assume that the effect of age on the log-odds of living in an extended household is unchanging over time and that the log-odds for a cohort is linear in time (or year of birth).

Analysis of the NSFIE for 1989 and 1994 supports two tentative conclusions.

First, later born cohorts are much less likely to live in extended households than earlier born cohorts. The percentage of those 60–64 living in extended households is estimated to be in excess of 80% for 1969, as compared to the observed values of 52% in 1989 and 45% in 1994. Second, age per se appears to have an important effect on living arrangements only among the older old. Controlling for the cohort effect, the odds that an individual aged 65–69 or 70–74 lives in an extended household are no greater than the odds for an individual aged 60–64. However, the odds for individuals aged 75–79 are 1.3 times as great, for individuals aged 80–84 2.2 times as great and for individuals aged 85+ 3.5 times as great as the odds for individuals aged 60–64.

The proportion of those 65–69 living in extended households is projected to decline to only 20% in 2015 and further thereafter (Fig. 2). Similar declines are projected for other age groups. This dramatic projected decline is an extrapolation based on data for only 2 years and is very tentative in nature. It is no more rapid, however, than expectations regarding the decline in family support for the elderly expressed in attitudinal surveys (Ogawa and Retherford 1997).

The projections of the proportions of younger adults and children living in extended households are tied to the projections for older adults. An extended household as

[5]Examples include SOCSIM (Hammel et al. 1981) and HOMES (Mason et al. 1996).

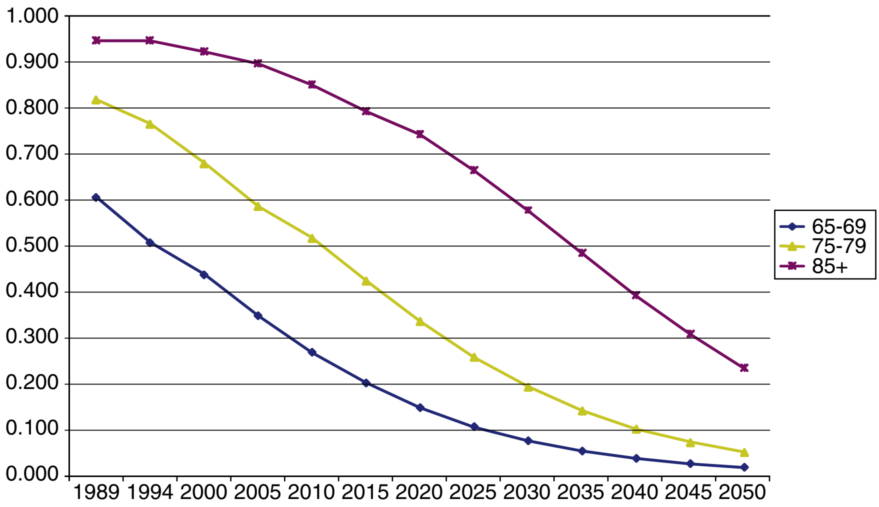

Fig. 2 Proportion living in extended households, 1989–2050

defined here requires at least one adult member from two generations. Consequently, the trend for older adults and younger adults are clearly not independent. The details of the method for modelling this interdependency are relegated to the appendix. The outcome of that effort is that the proportions of younger adults and children living in extended households are projected to decline, as well. The overall change is that the percentage of the population living in extended households is projected to decline from 33% in 1994 to 6% in 2050. The percentage of households that are extended is projected to decline from 25% to 4% during the same period (Fig. 3).

As we shall see, one of the most important implications of the decline in extended households is that it leads to a rise in the proportion of households that are jobless. The reason for this is easy to imagine. The great majority of jobless *individuals* are retired elderly, but in current day Japan most live with their employed children. As independent living becomes the norm, retired elderly will maintain separate households in which no members are working. Hence, the proportion of jobless households will rise. This intuition is born out by the facts as is evident in Fig. 4, which shows the proportion of each age group living in jobless households separately for extended and nuclear households. Fewer than 20% of the elderly living in extended households live in jobless households. Between 50% and 80% of those 65 and older living in nuclear households live in jobless households.

The final methodological issue with respect to our projections is the procedure used to project the number of family members. The methods used are identical to the ones used to construct measures of surviving offspring and parents and are described in the appendix.

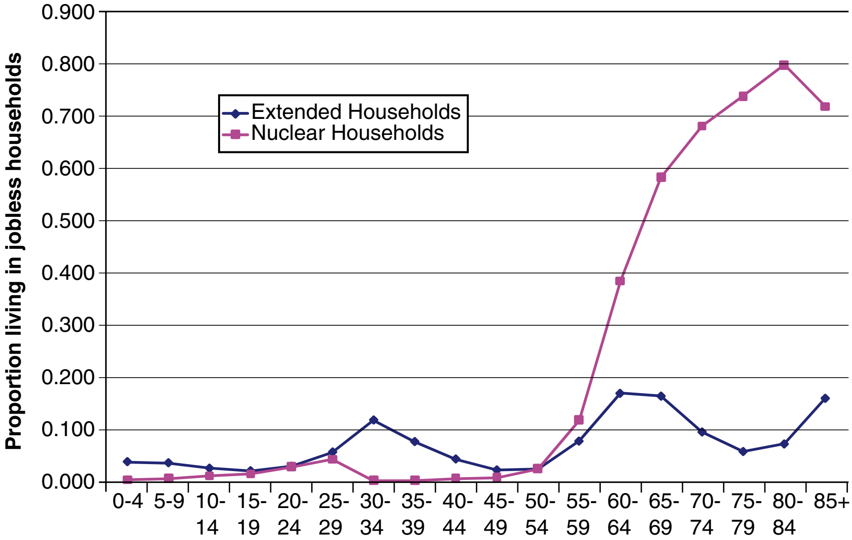

Fig. 3 Jobless households and the elderly

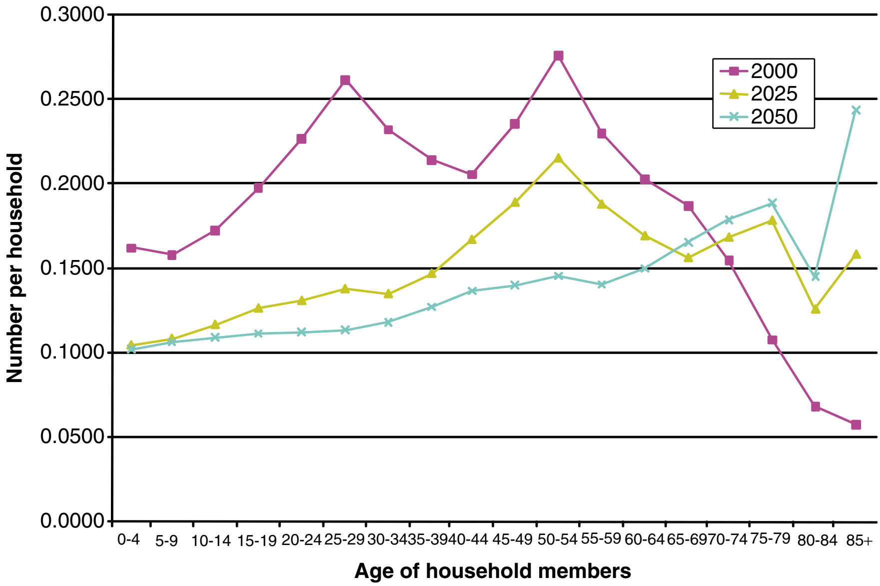

Fig. 4 Average members per households

Projection Results

Rapid ageing in Japan is reflected at the household level in changes in the average numbers of household members at each age. Ageing is so dramatic in Japan that the average numbers of members at all ages below age 70 are projected to decline between 2000 and 2025. Between 2000 and 2025 there are large increases in the numbers aged 75 and older. Between 2025 and 2050, the increase is concentrated among those 85 and older (Fig. 4).

Projected changes in age structure and projected changes in living arrangements combine to produce enormous changes in the demographic characteristics of the family support system. Between 2000 and 2025, the number of non-coresident prime age adults (NC2064) is relatively stable at about two persons per household. By 2050, however, the number has dropped to only one person per household (Table 7). This change reflects the substantial decline in childbearing (or the age structure) and occurs even though a larger percentage of prime age adults are living away from their parents in 2050 than in 2000.

The changes in the number of non-coresident elderly (NC65P) are similar in magnitude to the changes in non-coresident prime age adults. Between 2000 and 2050, the number of elderly living elsewhere more than doubles from 0.40 per household to 0.86 per household. The increase reflects both the increased survival of the elderly and the passing of older cohorts of high fertility Japanese.[6]

Multi-generation extended households are in substantial decline and the projection anticipates that only 4% of households will be extended in 2050 as compared with about 25% in 2000. The employment status of households is also projected to change substantially. In particular, worker households will decline and jobless households will increase, while self-employed households (other) will remain relatively stable. Between 2000 and 2050, the proportion of households that are jobless increases from 15% to 37%. This dramatic change reflects the complementary effects of ageing and the shift towards nuclear households. A much higher percentage of Japan's population will be concentrated at older ages where rates of employment are low and a much lower percentage of those elderly will be living in households with their working adult children.

Table 7 Projected household characteristics

	2000	2025	2050
NC2064	2.029	2.012	1.042
NC65P	0.399	0.666	0.863
EXFAM	0.254	0.129	0.041
WORKHH	0.618	0.514	0.417
OTHERHH	0.232	0.223	0.213
JOBLESSHH	0.150	0.263	0.370

[6]NC65P is measured in such a way as to reflect sharing among siblings. Hence, a value of 1 would correspond to two siblings with two surviving parents.

Table 8 Projected economic variables

	2000	2025	2050
ln C	12.810	12.743	12.686
Ln Yd	13.105	13.006	12.899
Total wealth	9.092	11.237	11.416
Financial wealth	1.830	2.555	2.800
Housing wealth	6.829	8.280	8.204
Durables	0.378	0.338	0.350
C/Yd	0.744	0.769	0.808
S/Yd	0.256	0.231	0.192
Growth rate			
Number of households	0.015	0.001	–0.005
Productivity	0.015	0.015	0.015
Household Income	0.030	0.016	0.010
Equilibrium savings rate based on			
Total wealth	0.275	0.177	0.116
Financial wealth	0.055	0.040	0.028
Housing wealth	0.206	0.130	0.083

If the assumptions that underlie these projections hold, the demographic changes outlined above will lead to a decline in the rate of saving and a rise in wealth relative to income. Total wealth is projected to increase to 11.4 times household disposable income in 2050 from 9.1 times household disposable income in 2000. In percentage terms, the greatest increase is in financial wealth; in absolute terms, in housing wealth. Saving as a percent of disposable income is projected to decline from 25.6% in 2000 to 23.1% in 2025 and 19.2% in 2050 (Table 8).

The bottom rows in Table 8 show the equilibrium saving rates that would sustain the projected wealth-income ratios given the current growth in the number of households and the rate of growth of output per worker, assumed to be 1.5% per annum for the purposes of these calculations.[7] Given this assumption, growth in household disposable income would decline from 3.0% in 2000 to 1.6% in 2025 and 1.0% in 2050.[8]

The equilibrium saving rate in 2000 for total wealth is quite similar to the projected saving rate, 27.5% versus 25.6%. In 2025 and 2050, however, the equilibrium rate has dropped to values substantially below the projected value. Thus, the projected saving and wealth values for 2025 and 2050 are clearly inconsistent with equilibria. Thus, wealth relative to income will continue to rise after 2050 until the current saving rate and the equilibrium saving rate are equal.

[7] Wealth/household income will remain constant only if the saving rate is equal to the rate of growth of household income times the ratio of wealth to household income.

[8] These values do not include the impact of changing demographic characteristics on household disposable income, which have a negligible impact on the calculations.

Exactly how this outcome would be achieved cannot be determined without extending the projections beyond 2050.

What accounts for the decline in saving and the rise in wealth? Although the partial effect of the changes over the projection period in mean values of individual variables can be readily calculated, interpretation requires caution because of the inter-connections among the explanatory variables. Changes in age structure have a direct influence on saving and wealth, but an indirect influence on the number of non-coresident family members, the employment status of households and the prevalence of extended households. Likewise, the decline in the extended family slows the decline in the number of non-coresident family members and contributes to the rise in the number of jobless households. Thus, we cannot readily partition the rise in the wealth ratio or the decline in the saving ratio into additive components that capture the full effects of changes in age structure or living arrangements.

The direct effects are as follows. Between 2000 and 2050, changes in age structure led to a direct increase in the consumption ratio of 4.3%. Changes in employment status, i.e. the rise in the number of jobless workers and the decline in extended living arrangements, led to increases in the consumption ratio by 4.1% and 4.2%, respectively. Changes in the number of non-coresident family members led to a decline in the consumption ratio by 4.2% (Table 9).

Age and employment status also had large positive direct effects on wealth. The changes in age structure between 2000 and 2050 led to an increase in the wealth-income ratio by 1.9. Changes in employment status led to an increase in the wealth-income ratio by 1.1, while the decline in the extended family directly reduced the wealth-income ratio by 0.7. Changes in the number of non-coresident family members had a relatively negligible effect.

The shift away from extended living arrangements is playing a somewhat ambiguous role in the determination of saving and wealth. The direct effect of the decline in the proportion of extended households is to lower saving rates and to reduce wealth. This runs counter to the intuition that those living in nuclear households should save more to satisfy lifecycle needs that are no longer provided through family transfers. As shown above, this intuition may be incorrect during transition periods. Extended households may have unusually high saving rates if young adults living in these households anticipate that they will not be able to rely on support from their own children. If this phenomenon is operating, then the methodology employed here may not successfully capture these dynamic effects.

Table 9 Partial effect of change in independent variable between 2000 and 2050

Variable group	ln c	ln yd	ln c/yd	Wealth	Financial	Housing	Durables
Age	–0.141	–0.183	0.043	1.906	0.673	1.260	–0.028
Age + NC variables	–0.098	–0.098	0.000	1.990	0.607	1.446	–0.069
EXFAM + NC variables	0.035	0.036	–0.001	–0.644	–0.132	–0.504	–0.013
Employment status	–0.018	–0.058	0.041	1.063	0.429	0.618	0.013
Age + employ status	–0.158	–0.242	0.083	2.969	1.102	1.879	–0.015

If we look more broadly at the changes that accompany the decline in the extended family, however, the full effect may be to raise saving rates. The direct effect of a decline in the extended family is entirely offset by changes in the number of non-coresident family members. The rise in the number of jobless households, due in large part to a rise in the number of extended households, has a large positive effect on saving. Under these circumstances, we cannot reach any firm conclusion about the changing role in living arrangements.

These results support the view that demographic change in Japan may lead to a significant decline in aggregate saving over a very extended period, but a decline that is much smaller than suggested by analysis of aggregate data. The decline projected here is not alarming. It is sufficiently small that wealth will continue to rise relative to income throughout the next four decades. This conclusion is supported either by computing the equilibrium wealth-income ratio implied by the projected saving rates or by the direct projection of the wealth-income ratio.

Conclusions

The results from this analysis paint a somewhat optimistic view about one aspect of Japan's future. Even though ageing is more rapid in Japan than in any other country, our analysis suggests that saving rates will decline only modestly over the long term. The decline is sufficiently modest that wealth will continue to rise relative to income if our projections hold. If one believes the standard neo-classical model, the further rise in the capital intensity of the Japanese economy will yield additional economic growth.

Whether high rates of saving are good for the Japanese economy or not is a debatable point. One cannot count on demographics to push domestic consumption to higher levels. Thus, if the Japanese economy needs substantially higher domestic consumption in order to recover and to sustain higher rates of economic growth, then our analysis is bad news. Of course, no one has ever suggested relying on demographics to stimulate consumer demand.

The results do point to the importance of achieving higher rates of return to domestic capital or foreign investment. As Japan ages, an increasingly large percentage of its population will depend, not on earnings, but on returns to capital. The economic status of the elderly will suffer if the rise in wealth depresses returns to capital to even lower levels than those that prevail today.

The importance of personal savings to Japanese elderly will be all the greater if the decline in the family support system continues. Our projections anticipate that only 10% of Japan's elderly will be living with their children by 2050. Of course, many who are living independently may be able to count on their children for support for their instrumental and financial needs. Given the persistence of low fertility and increased life expectancy, however, the potential burden of family support systems on the children of the elderly will be much greater than in the past. Family financial support has a role to play, but perhaps a less important one in the future.

Many questions can be raised about the analysis presented and additional research should provide results in which we can place greater confidence. One of the major shortcomings of this study is its reliance on a single cross-section. This is an especially serious problem when the processes being studied are so dynamic in nature. Making use of repeated cross-sections or panel data to study how saving and wealth are responding to changing demographic conditions should prove very instructive. This is a step we intend to take next.

Acknowledgement The authors wish to thank Rikiya Matsukura and Jonghyuk Kim for their assistance.

Appendix

Surviving Offspring per Woman

Surviving offspring per woman, o'(x,s,a), is an estimate of the average number of offspring by age (x) and sex (s) per woman aged a. The values are calculated using historical data on the distribution of births by age of mother under several simplifying assumptions: (1) that the population is closed to migration; (2) that survival rates of offspring and mothers are independent of the birth age of mothers and the total numbers of births. If we let B(a,t) be the number of births to a woman aged a in year t and s(x,t) be the probability of surviving from birth to age x in year t, the total number of surviving offspring (or population) aged x with a mother aged a in year t is given by:

$$O(x,a,t) = B(a - x,t - x)\ s(x,t) \quad (1)$$

Summing over mother's age a and dividing Eq. 1 by the results yields:

$$O(x,a,t)/O(x,t) = B(a - x,t - x)/B(t - x) \quad (2)$$

If survival is independent of the age of one's mother at time of birth, then the distribution of offspring by age of mother is determined solely by the distribution of births.

The number of surviving offspring in year t is calculated multiplying the birth distribution in Eq. 2 by the population aged x in year t, N(x,t). The number of offspring includes those whose mothers are deceased. The number of offspring with living mothers is given by:

$$O'(x,a,t) = [B(a - x,t - x)/B(t - x)]\ N(x,t)\ s'(a,t) \quad (3)$$

where s′(a,t) is the proportion of women belonging to the cohort aged a in year t who survived to the current age from their childbearing years. This value is approximated here as the proportion who survived from age 50–54.

Offspring per woman is given by:

$$o'(x,a,t) = [B(a - x,t - x)/B(t - x)]\ N(x,t)\ s'(a,t)/W(a,t) \quad (4)$$

where W(a,t) is the number of women aged a in year t.

The birth distribution is taken from vital statistics records for Japan. Single year age distributions are available for 1947 and later; 5-year age distributions are used for earlier years except for a few years during World War II. All values are calculated separately by sex of offspring. We assume that male and female births have the same age of mother distribution. Population data are from the population census. For the projections, the distribution of births by age of mother and the joint age distribution of husbands and wives are assumed to remain constant at the most recently available values. Population and survival data are from the UN Population Division's most recent projections (United Nations 2001 #406).

Surviving Offspring per Man

Given a birth distribution by age of father, surviving offspring per man could be calculated in a fashion that parallels the calculation of surviving offspring per woman. These data are not available for most countries. For Japan a 5-year age distribution is available, but we do not employ this. Rather, we use an estimate of the joint-distribution of husbands and wives while assuming that given the age of mother, the number of births is independent of the age of father. Let H(w,x) be the number of couples with a husband aged x and a wife aged w, then B*(x,t), the number of births in year t to men aged x, is calculated by:

$$B^*(x,t) = \Sigma_w B(w,t)\ H(w,x,t)/H(w,t) \quad (5)$$

where H(w) is the number of childbearing couples consisting of a man of any age and a woman aged w.

The proportion of women aged w married to a man aged x is approximated using the joint age-distribution of households heads and their spouse tabulated from 1% samples of the population census of Japan. The joint age distribution, tabulated for another purpose, is available at 5-year intervals from 1970 to 1995.

Surviving Parents per Offspring

The number of surviving women and men per offspring are calculated separately. Letting o(a,x,t) be the number of surviving offspring aged x per woman a in year t, then the number of surviving women aged x per offspring, p(x,a,t), is given by:

$$p(x,a,t) = [1/o(a,t)]\ [o(a,x,t)/o(x,t)] \quad (6)$$

Note that o(a,x,t) includes offspring who do not have a surviving mother. Surviving parents per offspring is consequently reduced by mortality among parents. Note further that the measure constructed in this fashion also includes women in the numerator who have no surviving offspring including those who never gave birth. There is no attempt to assess the extent to which family links have been severed by mortality or celibacy. Surviving fathers per offspring are calculated in parallel fashion.

Modelling Extended Living Arrangements

Assume that individuals in a one-sex population live for 3 g periods where g is the length of a generation. Individuals give birth at age g, become grandparents at age 2 g and die at age 3 g. There are two types of households: extended households, consisting of at least one member belonging to each generation; or, nuclear households that consist of members of the oldest generation or members of the middle generation and their children.

Further we assume that some unspecified optimizing process leads to a number of adults per household, which we designate by $m^x$for extended households and by m^n for nuclear households.

Proportion Living in Extended Households

Let $x(a,t)$ be the proportion of persons age a living in extended households in year t and let $o(a,t) = x(a,t)/(1 - x(a,t))$ be the corresponding odds ratio. The odds that members of the oldest generation will live in an extended household is determined by a cohort and an age effect:

$$\begin{aligned} o(a,t) &= o(2g,t)\beta(a) \\ \ln o(a,t) &= \ln o(2g,t) + \ln \beta(a) \text{ for } a \geq 2g. \end{aligned} \tag{7}$$

The log-odds of living in an extended household for individuals aged $2g$ is estimated as a linear function of t. The model employed and estimated to project the proportion 60 and older living in extended households is:

$$\ln o(a,t) = \alpha_0 + \alpha_1 t + \ln \beta(a) \text{ for } a \geq 2_, \tag{8}$$

Estimation procedures are described below.

The proportion middle-generation adults living in extended household can be obtained directly given the old-age dependency ratio and the proportion of older-generation adults living in extended households. It is straightforward to show that:

$$x(a,t) = (d(a,t) / d^x(a,t))x(a+g,t) \text{ for a} < 2\text{g}. \tag{9}$$

where the old-age dependency ratio for extended households is defined as:

$$d^x(a) = N^x(a+g) / N^x(a) \text{ for } g \le a < 2g. \tag{10}$$

$N^x(x)$ is the population of age x living in extended households. The support ratio for the general population is defined in similar fashion.

The dependency ratio for extended households is influenced by the social conventions that determine the form of extended households and by differential rates of survival among the members of extended households. In Japan, where the traditional form of the extended family is for parents to live with the eldest son and his spouse, a dependency ratio of approximately one would be expected at younger ages where survival rates are high for both generations. At older ages, however, the dependency ratio will be reduced due to the higher rate of mortality experienced by members of the older generation. The dependency ratio for extended households is given by:

$$\begin{aligned} d^x(a,t) &= \frac{N^x(a+g-5,t-5)}{N^x(a-5,t-5)} \frac{s^x(a+g,t)}{s^x(a,t)} \\ &= d^x(a-5,t-5) \frac{s^x(a+g,t)}{s^x(a,t)} \end{aligned} \tag{11}$$

where $s^x(a,t)$ is the proportion aged a–5 in year t–5 surviving as members of the extended household to age a in year t.[9] The dependency ratio for the general population could be represented in similar fashion, and the ratio of the two dependency ratios is given by:

$$\begin{aligned} \frac{d(g,t)}{d^x(g,t)} &= \frac{d(g,t)}{k} \\ \frac{d(a,t)}{d^x(a,t)} &= \frac{d(a-5,t-5)}{d^x(a-5,t-5)} \frac{s(a+g,t) / s(a,t)}{s^x(a+g,t) / s^x(a,t)} \\ &= \frac{d(a-5,t-5)}{d^x(a-5,t-5)} \delta(a) \quad \text{for } a \ge g. \end{aligned} \tag{12}$$

These two equations can be employed to project the ratio of dependency ratios for the middle generation and, hence, the proportion living in extended households. The dependency ratio for the population at age g is calculated directly using the population projection and the value k is estimated as discussed below. If survival rates are independent of living arrangements, the ratio of survival rates reduces to

[9] Strictly speaking s is not a survival rate as individuals within the population could join extended households. Given the late age at marriage in Japan this might occur with some frequency if older unmarried sons were living with their parents and married.

one. However, here we assume that age-schedule of the ratio of survival rates, δ(a), is constant over time, but not necessarily equal to one.

The number of children ($a < g$) living in extended and nuclear households is projected assuming that the ratio of dependency ratios does not change over time and employing Eq. 9. Note that all children live with their parents so that this simplifying assumption is not violated on its face.

Proportion of Households That Are Extended; Number of Members per Household

Let $\hat{N}(a,t)$ be the projected population aged a and $\hat{x}(a,t)$ be the projected proportion living in extended households. $\hat{N}^x(a,t)$, the projected population living in extended households, and $\hat{N}^n(a,t)$, the projected population living in nuclear households, are given by:

$$\hat{N}^x(a,t) = \hat{x}(a,t)\hat{N}(a,t)$$
$$\hat{N}^n(a,t) = (1-\hat{x}(a,t))\hat{N}(a,t) \quad (13)$$

The projected number of extended households, $\hat{H}^x(t)$, and nuclear households, $\hat{H}^n(t)$, are given by:

$$\hat{H}^x(t) = \sum_{a\geq g} \hat{N}^x(a,t)/m^x$$
$$\hat{H}^n(t) = \sum_{a\geq g} \hat{N}^n(a,t)/m^n \quad (14)$$

The average number of members aged a per extended household is:

$$\hat{n}^x(a,t) = \hat{N}^x(a,t)/\hat{H}^x(t) \quad (15)$$

and the average number of members per nuclear household is calculated in similar fashion.

Proportion of Worker, Other and Jobless Households

Assuming that the average numbers of adults per nuclear household and extended household do not vary by household type, z, then:

$$\hat{h}^x(z,t) = \sum_{a=g}^{3g} h^x(z,a)\hat{N}^x(a,t)/\sum_{a=g}^{3g}\hat{N}^x(a,t)$$
$$\hat{h}^n(z,t) = \sum_{a=g}^{3g} h^n(z,a)\hat{N}^n(a,t)/\sum_{a=g}^{3g}\hat{N}^n(a,t) \quad (16)$$

where the index z distinguishes worker, jobless and other households, and h^x (z,a) is the proportion of persons aged a and living in extended households of type z. $h^n(z,a)$ is defined in similar fashion.

Estimation

Model parameters are estimated using data for 5-year age groups, 85 and older being the upper age group, using the 1989 and 1994 NSFIE for Japan. We assume that the generation length g is 30 years (the singulate mean age at first marriage is currently over 28 years for women and 30 years for men). Thus, individuals who are 60–64 have children 30–34 and grandchildren 0–4 by assumption.

The age effect in Eq. 1 is estimated directly[10] in the following manner:

$$\ln\beta(60)=0$$

$$\ln\beta(a)=\sum_{x=60}^{a}\Delta\ln\beta(x)\quad \text{for a} > 60\text{, where}$$

$$\Delta\ln\beta(x)=\ln o(x+5,t+5)-\ln o(x,t) \tag{17}$$

and a denotes the lower limit of the 5-year age group.

Using the estimated age effects and the observed odds-ratios for t and $t+5$ we construct a time series of values for the log-odds ratio for individuals 60–64.

$$\ln\hat{o}(60,t-x)=\ln o(60+x,t)+\ln\hat{\beta}(x)\quad \text{for } x=(5,20) \tag{18}$$

The estimated values are combined with the observed values for t and $t+5$ and fitted using a logistic, i.e.,

$$\ln\hat{o}(60,t)=\alpha_0+\alpha_1 t. \tag{19}$$

The estimated age effects and the estimated cohort effect, obtained using the logistic, are used to project the proportion living in extended households as in Eq. 8.

The other parameters in the model (the average number of adults per household, the dependency ratios and the relative survival schedule $\delta(a)$) are estimated as the average of the values observed in 1989 and 1994 from the NSFIE.

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[10] A regression approach would be employed were estimates available for more than 2 years.

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The Future Costs of Health Care in Ageing Societies: Is the Glass Half Full or Half Empty?

Deborah Freund and Timothy M. Smeeding

Introduction

This paper considers the multitude of issues involved with estimating the future costs and benefits of health care expenditures for and by the aged (those aged 65 and over) in the rich nations of the world. We argue that there is much hope (and perhaps not so much despair as some of the literature suggests), when one considers future outlays for health care and their relative costs and benefits in an ageing society. In other words, with some distributional exceptions, the glass is more than half full and we should welcome cost effective medical advances which directly and substantially improve the well being of older generations.

We proceed by assessing the recent literature and forecasts of acute health care expenses by and on behalf of, the elderly, both public and private.[1] We include a subset of the Organisation for Economic Cooperation and Development (OECD) nations in our analyses in order to be both concise and offer some depth in terms of institutions, the distribution of costs (as well as their levels) and recent developments in pharmaceuticals and related treatments. We first assess the relatively barren literature on future health care costs in ageing societies. As noted by Henry Aaron (2000), almost all forecasts tend to be wrong once we get to the end of the period being forecast; yet forecasts are useful in that they help us to focus on the key elements and parameters that will determine future outlays.

[1] We do not discuss issues of long-term care, but rather limit this paper to acute care outlays alone. For a discussion of disability at older ages and long-term care services in a cross-national context, see Jacobzone (2000) and Jacobzone et al. (1998).

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Next, and more substantively, we discuss some of the issues involved in forecasting health care expenses for the elderly, including differences in assumptions about the adoption of technology, new prescription drugs and use of both new and established treatments. We discuss the underlying income elasticity of demand for health care and institutional mechanisms which are liable to affect health care spending and financing patterns among the old. Unlike previous authors, we discuss the benefits (in terms of quantity and quality of life) as well as the costs of increased health care services among older persons. We conclude with a frank discussion of the likely future costs and benefits of health care in rich ageing societies, including suggestions for health care policy research and policy considerations for financing these expenditures.

What We Know About the Future Costs of Health Care in Rich Ageing Societies

'Demography is not Destiny' (National Academy on an Ageing Society – NAAS 1999), to quote a recent report. But because future demography can be forecast with much greater accuracy than can future incomes, productivity, or health care costs, almost everyone who addresses this issue begins with future demography (OECD 1998, 2000; Mayhew 2000a). When one looks, it is clear that our populations will become older very rapidly in the early twenty-first century, with the proportionately largest increases in population over the next several decades coming at the oldest ages, i.e., 85 and above (OECD 1998, 2000). This phenomenon of population ageing will occur at different speeds in different nations. For instance, it has already begun to have effects in Sweden and Japan (Mayhew 2000b), with other nations 10–20 years behind these two.

Most of the increase in aged populations is being fuelled by ever-larger members of elders, not by added lifespan at older ages (OECD 2000; Spillman and Lubitz 2000; Cutler and Meara 2001). This is not to say that increasing longevity at older ages will not occur; in fact it has occurred with increasing regularity over the past 25 years (Cutler and Meara 2001). There is debate over whether one can continue to add about 1 year per decade to life expectancy at older ages over the coming decades (e.g., OECD 1998). However, the debate on finite vs. infinite life spans is only a part of the picture. What matters is the growth in total number of extra years of life among those who will reach a given age (e.g., 65, 75, or 85), and the quality of those lives, not the actual number of persons who will survive to much older ages. That is, the number of persons who will live to 85 or 90 years of age is far more important to future health care costs than is the question of whether the oldest person in society will reach ages 125, 130 or above. Whatever the nuance studied, there will be a disproportionate growth in very old populations in the near future in almost all OECD countries (OECD 1998). In fact, some argue that these increases will occur in almost every country, developed and underdeveloped. (Center for Strategic and International Studies 2001).

Basic Spending Patterns

The reasons for concern for the growing number of the aged as it relates to health care outlays are captured in Tables 1 and 2 and Fig. 1. In the three rich nations with recent estimates for total health care spending (Canada, United States, United Kingdom), we find that older persons use between 4.5 and 7.5 times the level of health care spending that younger persons aged 45–64 (Table 1) use.[2] In Table 2, where the ratios are for the over-65 to the under-65, per capita spending for those aged 65 and over is roughly four times above that for the non-elderly, but with substantial variance, from 4.7 or 4.8 in Canada and Japan, to 2.7 and 3.0 in

Table 1 Ratio of per capita health care spending by age (United Kingdom: Mayhew (2000a); Canada: Robson (2001, Figure 1); USA: Cutler and Meara (1999))

Age	Canada	United Kingdom	United States
45–64	100	100	100
64–78	227	180	200
75–84	410	350	265
85+	750	600	450

Table 2 Health spending for the elderly in eight countries, 1993–1995 (OECD Health Data 2001 (Paris: Organisation for Economic Cooperation and Development 2001); and authors' calculations; Anderson and Hussey 2000)

Country	Percent of total health spending on the elderly	Ratio of health spending for persons age 65 and older to persons under age 65	Estimated percent of GDP spent on health care for the elderly	Elderly health spending per capita, 1997[a]	Income elasticity of demand of health care, 1970–1998[b]
Australia (1994)	35	4.0	3.0	5,348	1.20
Canada (1994)	40	4.7	3.6	6,764	1.21
France (1993)	35	3.0	3.4	4,717	1.14
Germany (1994)	34	2.7	3.5	4,993	1.19
Japan (1995)	47	4.8	3.4	5,258	1.18
New Zealand (1994)	34	3.9	2.5	3,870	1.17
United Kingdom (1993)	43	3.9	2.8	3,612	1.20
United States (1995)	38	3.8	5.0	12,090	1.40

[a]United States dollars per elderly person
[b]Authors' calculations of sample income elasticity of health care expenses per capita compared to GDP per capita

[2] These figures can be made more stark by comparing elder expenses to even younger age groups (e.g., see Fig. 1), but our objective is not to startle but to soberly assess. Similar ratios are found in Japan by Mayhew (2000a).

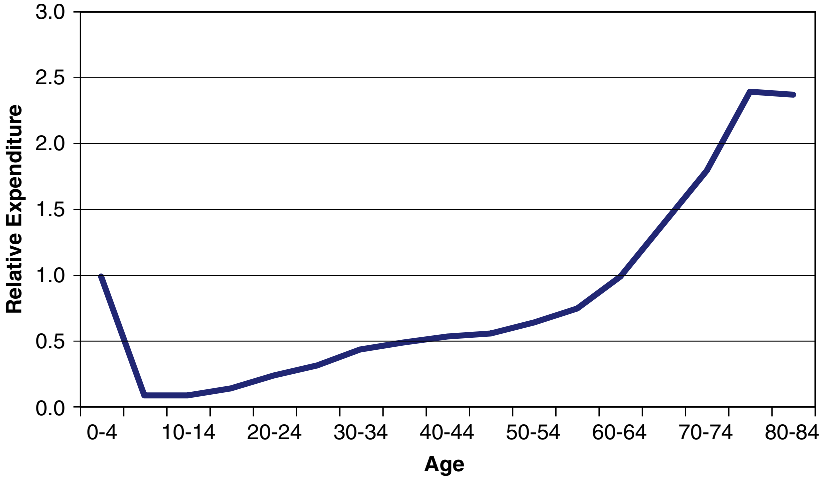

Fig. 1 Relative health care expenditure by age group (age 0–4 = 1.0) in 1995 for more developed countries (*Note*: More developed countries include the OECD nations plus Central and Eastern Europe (CEE), Mayhew 2000a)

Germany and France. Figure 1 suggests that a similar pattern persists for all of the 'more developed countries' (OECD plus Central and Eastern Europe), in the mid-1990s. Thus, we are dealing with a nearly universal phenomenon. Older persons consume larger quantities of health care than do younger persons at any given point in time in all rich nations.

In the high health care consumption nation of the United States, the ratio was 'only' 4.5 to 1 around 1990, but the overall level of spending in 1995 was more than $12,000 per person aged 65 and over (Table 2), almost twice as much as was spent in Canada, the next highest nation. A large part of this spending is because the United States is a richer nation, as 5.0% of the gross national product (GDP) is currently spent on health care for and by the aged in the United States, compared to 4.6% in Canada (Table 2). In Canada and the United Kingdom, where much larger fractions of spending are funded by the public sector, the ratios of older to younger spending are much higher, with the very old being 7.5 and 6.0 times as expensive as the base groups (Table 1), despite the fact that the United Kingdom spends only 2.8% of GDP on elder health care (Table 2). Hence, both overall income levels and institutions for health care provision seem to have an effect on relative and absolute levels of health care spending on the aged.

More controversial is the differential trend in health care spending by age among the elderly. Figure 2 contains two charts on the trends in the age distribution of medical spending, one for the United States (Panel A) and the other for the United Kingdom (Panel B). These are the only two sets of trend data available to us at this time. They clearly demonstrate very different patterns. The panels are not fully comparable because the United States includes all spending (public and private), while the United Kingdom panel includes only outlays by the National Health

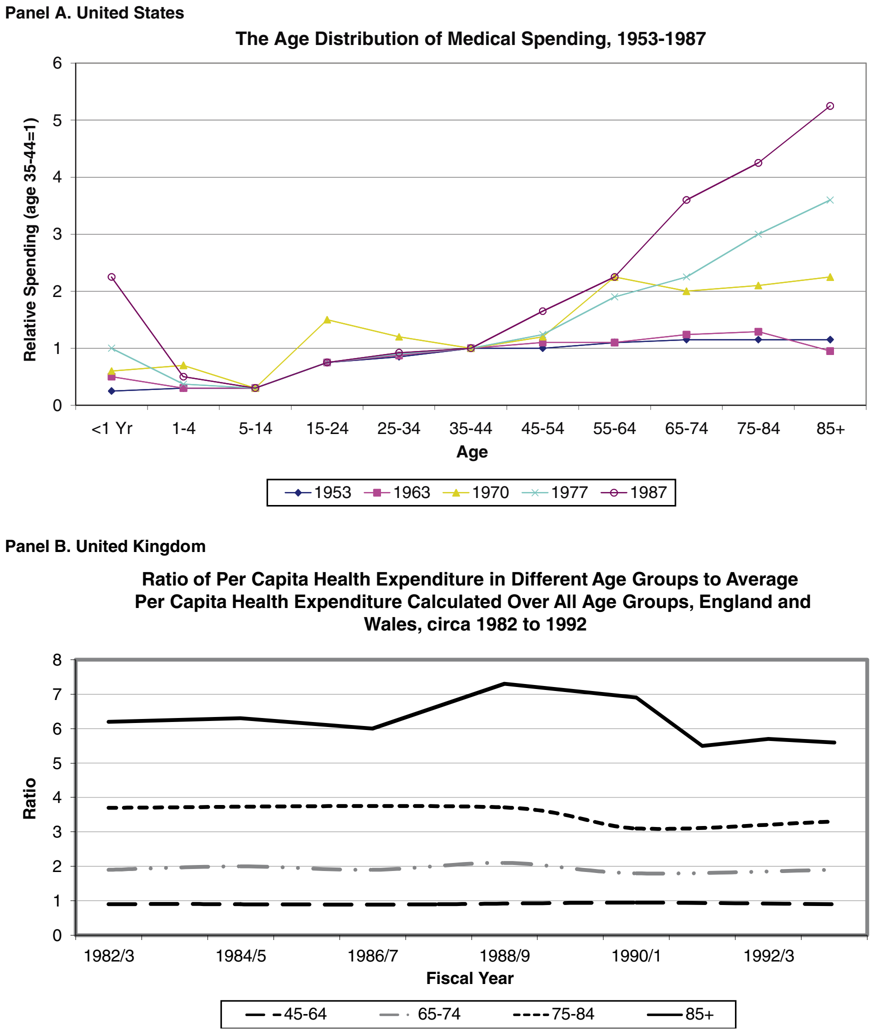

Fig. 2 The trend in health care spending by age. (**a**) Panel A. United States. The age distribution of medical spending, 1953–1987. (Note: 1953 age groups include: 0–5, 6–15, 16–24, 25–34, 35–54, 55–64, and 65+. Relative spending for 5–24 year olds was constructed assuming a uniform age distribution. Dashed lines in 1953 connect all age groups which were combined when calculating relative spending (Cutler and Meara 1999, Figure 1). (**b**) Panel B. United Kingdom. Ratio of per capita health expenditure in different age groups to average per capita health expenditure calculated over all age groups, England and Wales, circa 1982 to 1992 (UK Department of Health, personal correspondence as cited in Mayhew 2000a, Fig. 2, p. 7)

Service (NHS), which is roughly 90% of all health care spending in the United Kingdom. Patterns over time in the United Kingdom from 1982 to 1992 are fairly stable and are very different from the 1963 to 1987 (or even the 1977–1987) patterns in the United States.

In the United States, health care usage amongst the elderly increases rapidly at older ages – much more rapidly than costs among other age groups – up to a point (around age 85) and then flattens. In part, this is a reflection of the elders' increased ability to pay for health care; in part, it reflects inefficiencies in the Medicare programme which pays the largest share of health care costs amongst the aged; and in part, as we argue below, it is due to the increasing effectiveness of technological medicine in increasing the quality and quantity of life amongst the elderly. In the United Kingdom, technological diffusion is lower; incomes of the aged have grown by less; and while health care spending differences across age groups are still very large, they have not grown and, indeed, may have fallen over the past decade.

Clearly, the trends in these ratios reflect the different institutions of health care provision in these two nations, as well as differential availability and usage of care, and differences in medical practice (e.g., see Aaron and Schwartz 1984).[3] It seems clear from these graphs that explaining these differential trends is important to understanding the future pattern of health care spending among the elderly. It is also clear that in both countries we spend substantially more on healthcare for the aged than for the non-aged.

Combining Demography and Expenditures: The Burgeoning Literature on Forecasting Future Patterns of Health Care Costs

Most forecasters of future health care costs among the elderly make use of three basic pieces of information to make their forecast: (a) the age-specific spending summarized above; (b) the forecast future number of persons at each age; and (c) some assumption about the growth of 'real' health care spending (or the 'underlying rate of growth of expense'), both public and private, relative to GDP growth. Some mixing and matching of these three elements produces the 'future cost of elder health care' in each nation. Mayhew (2000a,b) and Robson (2001) provide the two most recent studies in this genre, though others have preceded them (e.g., Fuchs 1998; OECD 1998). A brief review of these studies begins this section.

Mayhew (2000a) builds a simple model of demographic and technological change in both more and less developed countries, where he assumes an underlying growth rate of health expenditures of 3%, the same as the growth rate of GDP. This growth assumes constant technological change, which subsumes major changes in medical treatments, service delivery and the like. In other words, the differential growth of healthcare costs versus other costs is simply assumed to be the same, with the underlying growth rate in health care expenses assumed to be exogenously determined. In contrast, Cutler (1995), Cutler and Sheiner (1998) and Blumenthal (2001) find a distinctly different and growing role of technology and new treatments in health care costs in the United States with 'technological

[3] More comparable charts for added countries should be a high research priority in OECD nations.

change' (new diagnostic and therapeutic approaches and increased usage) explaining over one-half of real per capita growth in health care costs over the past decade. Moreover, when forecasters assume that technology adoption grows at the same rate in the future as in the past, future public health insurance costs for the United States elderly increase by more than twice as much by 2030 as when they are assumed to grow only with GDP. Fuchs (1998) has a similar finding.

In fact, the assumed rate of increase of health care expenses due to technological change is a key variable in projecting the future health care costs of any given population and especially for the elderly (Blumenthal 2001; Cutler 1995; Cutler and Sheiner 1998; Walker 2001; Mohr and Mueller 2001). Because these changes in availability and usage of new pharmaceutical drugs, medical interventions and new procedures have especially benefited older persons, these forces have helped to create the changing patterns of medical expenses for the elderly found in Panel A of Fig. 2 in the United States. Why similar forces were not in play in the UK is not known.

According to Mayhew (2000a), OECD health care costs have grown at 5.7% per year from 1960 to 1995, with about 1.3% due to changing demography (mainly population ageing) and the rest (4.4%) due to technological change and general economic growth (of 3.4% per year). Thus, the underlying rate of growth in health care costs over and above GDP has been about 1% per year (or 4.4% minus 3.4%) across the OECD nations. Because this model includes forecasts for the former Soviet Union and Central and Eastern Europe (CEE) countries where growth is slower, Mayhew assumes a 3% underlying growth rate for medical expenditures and the same rate of growth for GDP in the future for the OECD nations. His model predicts that population ageing will add an additional 0.8% per year (and other demographic change adding another 0.3%) from 1995 to 2020. Clearly, the assumed 'underlying rate of growth' of health care ('the technology effect') is the key factor here. Of the total predicted rise in costs, 4.1% per year, 3.0% comes from the underlying growth (of GDP and health care) and 0.8% from population ageing. If real health care spending were assumed to continue to grow 1% faster than GDP, as it did in the 1960 to 1995 period, the final health care costs would be much higher than predicted, growing at 5.1% per year.

The study by Robson (2001) for Canada is typical of single country studies (e.g., see Cutler and Meara 1999; Spillman and Lubitz 2000 for the United States). The model again is built on population ageing and age-specific health care expenses linked to some underlying increase in health care expenses and GDP growth. This model also assumes that per capita health care costs in the future will increase only with general economic growth, and not at the historical 0.8% per year faster rate of growth compared to GDP per capita in Canada alone over the past several decades. Again, if the historical rate of health care cost growth persists, Canadian spending will be much higher in 2020 than is forecast by Robson.

In fact, in a recent testimony to the United States Congress, David Walker (2001), Director of the United States General Accounting Office, argued that virtually all United States forecasts (e.g., Congressional Budget Office) for future health care costs in the Medicare programme had converged on a forecast increase in spending of 1% per year above the rate of growth of GDP. If we were to add this assumption to the Mayhew model, overall health care costs per capita, as a share of GDP, would be substantially larger than the 12.8% he forecasts for 2020 in the more developed countries. Similar simulations by Fuchs (1998) indicate that Medicare would increase from 4.5% to 5.2% of GDP by 2020 and that total personal health care spending for (and by) the elderly alone would be close to 10% of United States GDP by 2020, more than twice the 5% observed by the OECD for 1995 in Table 2. In fact, 1% real growth may be a low estimate. A recent study for United States overall health care outlays projects that the residual (technology related) growth rate of overall health care expenses will be 1.5% to 2.0% a year over and above other factors driving overall health care costs over the next 5 years (Mohr and Mueller 2001). The effects of population ageing would presumably add to this effort.

Another interesting variable in the Mayhew model is the mix of public vs. private finance. He assumes a 40% share for private finance.[4] Because privately financed expenses have historically been growing more slowly than public expenses in most countries, the assumed share reduces the rate of growth in overall expenses based on historical data. But such a relationship may not endure.[5] The mix of public and private shares may therefore be important determinants of future health care expenses and expenditures. Clearly these shares are also linked to institutional arrangements in each nation and to the distribution of income and wealth, which determine private and public ability to pay for health care.

For instance, in most OECD nations, social spending demands for cash social retirement are already high and are assumed to grow much higher by almost all forecasters (e.g., Smeeding and Smith 1998; Gruber and Wise 2001; OECD 1998). Thus, public cash social retirement expenditures for the elderly will increase as a percent of GDP due to population ageing. To these expenses we must add the cost of the aged to health care budgets as discussed above. In the United States, for example, the forecast is that health care cost outlays for the elderly will exceed cash income costs for social retirement before 2020 (England 2002; Shoven et al. 1994). Thus, the double public burden of population ageing through higher health care costs and higher cash income support costs are forecast. Add to this the growing demand for public tertiary (higher) education spending in most OECD countries, and one finds alarmingly strong pressures on future social expenditure budgets (OECD 1998, 2000). If public expenditure or health care is therefore constrained by these pressures what about private expenses? This too is a key question for forecasters.

In summary, using assumptions that constrain the underlying rate of growth of technology to match that of GDP, demographic change drives the health care cost results in most models and we end up with virtually all of the growth in health care costs for the elderly in OECD countries over the next 20 years being driven by population ageing. There is also strong evidence that the two highest cost nations, Canada and the United States, and the OECD nations in general, have experienced health care cost increases that are about 1% higher than the growth rate of GDP per se.

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[4] Victor Fuchs (1998) reports slightly higher figures for the United States where personal spending is roughly 50% of total acute care spending by the elderly.

[5] Interestingly, Musgrove (1996) finds that while private medical expense is negatively related to GDP per capita, the decline in the private share from 1960 to 1980 has been stopped since 1980. Additional comparative studies on the private spending are also needed.

The results are sensitive to the 'technological' growth assumptions and, perhaps, also to the mix of payers (public vs. private) in each nation. Moreover, if GDP growth slips below forecasts, there is no mechanism that will guarantee that health care costs will slow as well, since population ageing, and not economic growth, is the force behind the rise in health care costs in most nations. Hence, Mayhew (2000b) forecasts that if GDP growth slows by 1% in Japan while health care costs in Japan continue at their current rate, overall Japanese health care expenses will rise from 9.4% to 12.1% of GDP in 2020. Already, Japanese efforts are underway to shift part of these increased costs to the elderly themselves (Yomiuri Shimbun 2001).

Added Features and Concerns

The studies mentioned above and others we have reviewed also point to three additional factors which have been considered in making these forecasts and that should enter into subsequent discussions.

First, Spillman and Lubitz (2000) find that increased longevity per se, has a much smaller effect on increased acute care spending than on long-term or chronic care spending. In fact, the costs of death for acute care increase only marginally with advanced age. Hence, the 'volume' of the aged will have a much larger effect on expenses for acute care than will living to increased ages among the already old. Cutler and Sheiner (1998) have similar findings.

Second, the cost of death appears to be a minor part of total health care costs and, in fact, may be decreasing at older ages as persons assume greater control of the surroundings and choice of treatments as they die (Spillman and Lubitz 2000; Cutler and Sheiner 1998). Thus, the 'rising costs of dying' are not a prime force in higher elder health care costs, in the United States at least.

Finally, our paper excludes reference to changes in disability and their effect on both acute and long-term (or chronic-care) expenses. The general consensus in the literature is that age-specific disability rates appear to be declining in many countries, but increased numbers of very old will likely offset this effect and increase both acute and long-term care costs in most nations (e.g., Cutler 2001a, b; Wolf 2001). Trends toward deinstitutionalization of long-term care, increasing demands for home care and the roles of public funding, private funding and 'family' (in kind) provision of long-term care services all have relatively unknown effects in this context (Jacobzone 2000; Jacobzone et al. 1998; Mayhew 2000a; Crimmins 2001; Waidmann and Manton 1998).[6] In fact, Cutler (2001a) argues that improved medical treatments are one of the reasons for decreasing rates of disability amongst the old in the United States.

[6] The United States evidence, as summarized by Spillman and Lubitz (2000:1415) is as follows: 'If longevity increases because of reduced morbidity and mortality from diseases that are expensive to treat, then Medicare costs may be reduced. If longevity increases as the result of expensive treatments, Medicare costs may rise. The costs of both acute and long-term care increase with the level of disability. If increased longevity is accompanied by declines in rates of disability, as suggested by recent studies, then the effect of increased longevity on health care expenditures may be moderated.' Crimmins (2001) expresses similar sentiments.

Summary

At this point, the estimates we have for future expenditures on health care are rather mechanistic and speculative. What is known is that future costs of health care will increase in ageing societies with population ageing being a key driving force. In part, this is because the forecasters assume that health care costs will rise only as fast as GDP. They do not generally consider that technological change will continue to push up health care expenses as societies adapt new treatments and methods, especially those which are consumed by the elderly. In part, the historical trend may continue because the elderly have greater demand for health care in general and are increasingly able to register these demands. It may also continue because the elderly are more informed consumers of health care than are forecasters, as they perceive the benefits of higher health care expenses (not just their costs) better than do forecasters or government policymakers. In fact, what has so far remained absent from these discussions are the benefits of health care to the elderly, the possible links between acute care and disability status and the question of who should therefore pay for the increasing costs of health care for the aged. We now turn to these issues.

Future Health Care Costs: Other Considerations

This section has three themes: the effects of rising incomes on health care demand among the elderly; the benefits of health care advances in general and amongst the elderly in particular; and finally, the discussion of who will pay for health care in the future. The consideration of these factors provides a better and more rounded context where we might determine how policy ought to react to the rising costs of health care in ageing societies.

Income Elasticity of Demand for Health Care

It is now a well-known fact that, on average, the median disposable incomes of the old (those aged 65 and over) are at a par with, or higher than, those of the younger populations in most OECD countries (e.g., Smeeding and Smith 1998; Smeeding and Sullivan 1998; OECD 2000, 2001). Moreover, the median incomes of the elderly have been rising faster than those of the younger populations in recent decades in at least five OECD countries for which we have comparable data on these incomes (Smeeding and Sullivan 1998). And the relatively recent run up in stock prices (even with a downturn in the stock market in 2001) and rising home prices may have further increased elder wealth, on average, as well (Smeeding and Smith 1998). To be old and poor is now more a function of the distribution of income among the old than the level of elder income relative to the incomes of younger generations (Smeeding and Smith 1998).

As can be seen in the final column of Table 2, there has been a large positive overall income elasticity of demand for health care in OECD countries in general over the past 30 years. That is, for every $1.00 increase in personal income, there is a 114–140% increase in health care outlays among the overall population at large. For most countries, the elasticity is remarkably similar, in the 1.14–1.21 range, with the United States an outlier at 1.40. Thus, the amount of incomes that nations are willing to spend on health care, and the amounts individuals are willing to spend as well, are very income elastic. This fact should not be ignored by forecasters.

To understand how this trend affects the elderly, we would need information on the trend in elder out-of-pocket health expenses (or on outlays for the elderly) in many nations. Recently we have developed estimates of out-of-pocket spending as a percent of income in four countries circa mid-1990s (Table 3). These are out-of-pocket expenses for acute care, drugs and premiums for public insurance and supplemental private insurance. In other words, they cover all expenses for acute care over and above expenses paid by public payers (Medicare and Medicaid in the United States; NHS in the United Kingdom and their equivalents in Canada and France). These are, to our knowledge, the only such comparative data available on this topic.

Table 3 Out of pocket medical expenses for households with such expenses as a percentage of net disposable income in four nations in the mid-1990s (Author calculations from Smeeding and Quinn 1997)

	United States 1997	Canada 1994	United Kingdom 1995	France 1994
All households	**8.84**	**2.86**	**1.85**	**5.60**
Single female	15.33	3.88	2.50	7.13
Single male	9.30	3.38	1.87	2.84
Married couple	10.99	3.27	1.68	6.44
All households head <65	**7.24**	**2.69**	**1.86**	**5.17**
Single female	7.94	3.91	2.90	5.42
Single male	6.78	3.29	1.86	2.34
Married couple	6.98	2.84	1.50	5.34
All households head 65–74	**16.25**	**3.81**	**1.54**	**7.45**
Single female	20.08	3.66	1.63	7.72
Single male	16.25	3.59	1.78	4.37
Married couple	16.75	4.07	1.68	7.83
All households head 75+	**21.31**	**4.14**	**2.22**	**8.44**
Single female	24.62	4.00	2.71	9.75
Single male	20.48	4.16	2.04	4.74
Married couple	21.38	4.45	2.57	8.49

They show several patterns of note:

- Medical care expenses vary enormously across both countries and age groups.
- Out-of-pocket medical expenses increase by age (except in the United Kingdom)[7] and are a larger share of income for single female-headed households (due to their lower incomes) than for couples.
- Outlays were highest in the United States, followed by France, Canada and then the United Kingdom.

Clearly the elderly have both willingness and ability to pay for health care over and above public expenditures on such care. And, we argue below, this willingness to pay will increase in the future.

The only solid information we have in the trend in out-of-pocket expenses comes from the United States, however, where a particular set of institutions affect health care demand.[8] Earlier (Fig. 2, Panel 1), we indicated a large overall rise in per-capita health care expenses by age group within the United States from 1963 to 1987. In large part, this was fuelled by out-of-pocket expenses rising faster than incomes, in addition to the increase in Medicare expense. Figure 3 presents trend estimates in out-of-pocket expenses for the elderly as a percentage of income in the United States for the 1965–2000 period, and predicted outlays for the 2005–2025 period (Moon 2000; Maxwell et al. 2000).

These data show that the introduction of Medicare in 1965 drastically reduced out-of-pocket health care expenses for the United States elderly, but only to about 11% of income in 1970. Since 1970, these expenses have grown to almost 22% of rising elderly incomes by 2000. Moreover, under current projections, they will rise to almost 30% of income by 2020. It should be noted that Medicare pays roughly one-half of the acute care costs of health care for the aged (see footnote 7). And so, even with hospital and doctor insurance covered by public programmes, future out-of-pocket outlays will grow in the United States as elderly incomes grow.

The news from the United States is that where health services are plentiful, and even when only partially insured, people will purchase them. The institutional arrangements in America are likely to be different from those found in other nations. More products are available and patients therefore have more choices. Despite the relative lack of insurance for prescription drugs, the elderly spend freely on these medical treatments. In fact, the elderly, which are about 13% of

[7] United Kingdom expenditure figures refer to the 2-week period during which expenses were observed and may therefore be biased downward.

[8] Medicare, the primary insurance vehicle for the aged, covers hospital and physician care, but not prescription drugs or other treatments. Outlays for Medicare cover only about one-half of all elder acute care costs and are supplemented in three ways: for the poor elderly, via Medicaid which covers some drugs and almost all out-of-pocket Medicare-related expenses; many well-to-do elderly have (former) employer provided retiree insurance which covers Medicare and other costs; and finally, most middle income elderly buy expensive supplemental 'medigap' coverage which pays some fraction of Medicare-related costs and other costs (see Smeeding and Sullivan 1998; Holden and Smeeding 1990).

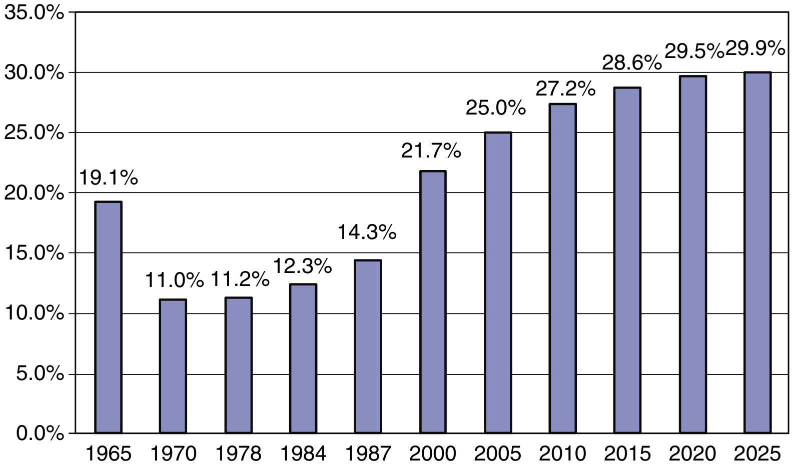

Fig. 3 Acute health care spending by elderly as share of income; actual and projected amounts (Authors' calculations from National Health Expenditure and Current Population Survey as in Moon 2000, Fig. 1 and Maxwell et al. 2000, Fig. 12). Spending includes out of pocket costs for all health insurance premiums, copayments, deductibles, and all expenses on uncovered services

the United States population, accounted for 42% of all prescription drug sales in the United States in 1999 (Harris 2001). In other countries, which offer a lesser range of choices and with higher public subsidies, one might expect a lower level and lower rate of growth of out-of-pocket expenses. However, even if levels of spending differ, the trend toward greater spending is liable to be higher among nations where elderly incomes are growing. This growth may be particularly large if public health care budgets are constrained, if treatments are available and if elders see value in such expenditures over and above public outlays.

Benefits of New Health Care Treatments and New Pharmaceuticals

Research on the benefits of technological advances in medical care, medical research and medical advances more generally is still in its infancy. Yet recent work by Cutler and McClellan (2001), Cutler (1995), Lichtenberg (2001a,b, 2002) and Topel and Murphy (2001) suggest that the net benefits of public health expenditures for research, new treatments and increasing access to high quality health care has produced gains in longevity in the United States that are very cost-effective. The cost of added medical care per life year gained is roughly $11,000, far below the average value of an added life year of $100,000 (Cutler and McClellan 2001) to $150,000, according to Lichtenberg (2002). Studies of return on new pharmaceuticals, cataract treatments and other treatments support these estimates for the general population.

While these added years may not be as high a quality of life as many would desire (Crimmins 2001), the cost effectiveness of treatments in the United States is indeed high. Similar estimates for the elderly compared to other groups are not yet available, but there is increasing evidence that the quantity (life expectancy at older ages) and quality of life at older ages is increasing and that newer and more advanced medical treatments for the elderly are an important part of the reason for these increases (Cutler and Meara 2001; Deaton and Paxson 2001).

Recent changes in the use and availability of pharmaceuticals among the elderly present a case study in health care change, cost and benefit among the elderly. Pharmaceuticals, particularly those that represent 'break through drugs,' those that are used to treat chronic disease or change the focus of care, represent a growing sector of the health care economy in all of the seven countries studied by Freund et al. (2000). Whether financed through public or private payment, purchase of pharmaceuticals by governments and individuals represents one of the fastest growing components of health expenditure, a trend that will likely be exacerbated when the genomics revolution is fully in force early in this century. Previous estimates of ageing and health care costs do not carefully consider the role of pharmaceuticals as an agent of technological change or how their resulting benefits may change the profile of future outlays. Similarly, how publicly or privately financed insurance plans may deal with the additional expenditure burden created by the use of new drugs is never carefully modelled in estimates of future health care costs.

It is only recently that the rate of growth and level of health care outlays for pharmaceuticals have become an international concern. Adequate data on which to predict future pharmaceutical expenditures are scarce and there have been few empirical papers on the topic as a result. At the present time, the best data and papers, to our knowledge, on pharmaceutical benefits at the patient level of aggregation come from the United States. Survey data on pharmaceutical use by patients or on FDA-type approvals over time do not exist in Europe, for example. Cross-national studies that use data from the OECD almost exclusively are restricted to 'countries,' not persons in countries, as the unit of analysis.

In a series of recent studies, Lichtenberg (2001a, b, 2002) attempts to estimate empirically the impacts of drugs on mortality, morbidity, overall health expenditures, as well as on hospital use and other types of medical care utilization. In particular, he focuses on the question whether newer and more innovative drugs have greater benefits than those approved years ago. Corroborating his earlier studies using aggregate United States data (Lichtenberg 2001a), analyses of survey data by Lichtenberg (2001a, b, 2002) reinforce the finding that a great deal of the increase in life expectancy is due to new drugs, and that life expectancy has increased secularly with pharmaceutical innovation.

Lichtenberg's survey data are taken from a household survey, the 1996 MEPS (Medical Expenditure Panel Survey), a nationally representative sample of all non-institutionalized Americans. Household respondents total over 22,000 and the level of detail is impressive, including the person's medical condition, medical events and interventions. The prescribed medicine file of events contains over 171,000 observations including the type of drug used and the amount and source of payment for each drug event used by each person. Lichtenberg merges information collected from the Food and Drug Administration (FDA) indicating the year in which the active ingredient comprising the drug was first approved. The year of approval indicates the 'age' of the drug and is used to model whether ageing drugs have less prominent positive impacts than newer ones. Overall, he finds that the 'replacement of older by newer drugs results in a reduction in mortality, morbidity and total medical expenditures' (Lichtenberg 2001a, b). Overall, of course, new drugs are more expensive than older drugs prescribed for the same medical condition. In the MEPS, a 15-year-old drug replaced by one roughly 5 years old increases the costs of a prescription drug by about $18 on average. However, this is more than offset by a lesser frequency of dying, fewer work loss days and less hospital utilization, summing to a reduction in total health care expenditure of $71. Lichtenberg (2001b) reports that the cost of new drugs for the elderly are three times as large as are the costs for the non-elderly, but the average level of other health care expenses saved by the elderly who use these new treatments are much higher as well. Therefore, the effects for the elderly, a savings of about $4 in other costs for each $1 spent on new drug treatments, are roughly of the same proportion as for the non-elderly. These costs reflect only savings in health care expenses and take no account of the effect on lifespan or quality of life amongst the elderly from new drugs.[9] Thus, they are a lower bound estimate of the total benefits of such drugs and should be taken as illustrative at this point. Were these estimates to hold true for other nations, it seems evident that some 'up front' expense for health care might produce benefits of increased quality and quantity of life and, perhaps, even lower overall health care costs per life year amongst the old as well as the young.[10]

As newer drugs are discovered, particularly those using the technique of genomics, the increase in drug expenditures is likely to grow faster, but so will the benefits for both the young and the old. Whether and how much the rise in total health care costs might be slowed by the advent of new drugs, especially those beneficial to the elderly is an open question. And how applicable Lichtenberg's results are to the greater European and world context also is unknown. A clue that the benefits of drugs are likely similar, is found in Frech and Miller (1999). Frech and Miller conducted an extensive cross-national analysis of pharmaceutical consumption patterns and prices. Using 1996 OECD data, and making appropriate adjustments for purchasing power parity, they estimate the impact of pharmaceutical consumption on life expectancy and infant mortality and find positive impacts at age 60 in 21 countries. However, they are unable to estimate whether the effects of higher

[9] A large part of the value of additional healthy life years can take the form of added productive work. For the already retired and for the very old, these gains are zero yet we should also attribute some benefit, and therefore some willingness to pay for the added length and quality of life for the aged. Thus the reduction in other healthcare costs associated with newer treatments and newer drugs for the aged are a lower bound of the total benefits of these new treatments.

[10] Because many new prescription drugs cost less in other nations compared to the United States, their benefits may be even larger. See also Frech and Miller (1999).

prices and drug consumption (which vary quite a bit across countries), are offset by the benefits when converted into dollars or some other common numeraire.

There should also be a word of caution amongst all of this good news. While substitution of newer drugs and newer treatments for older ones seems cost-effective, the expansion of treatments to larger populations of users may not always be cost effective. Cutler and McClellan (2001) point to several studies of more extensive treatment for breast cancer, which do not seem to have led to cost effective use. Therefore, with all new treatments and new drugs, policies that eliminate waste and which limit the adoption of treatments to those populations where they are cost effective are needed.

An analysis by Freund et al. (2000) of seven countries (United States, Canada, United Kingdom, Australia, Japan, New Zealand and Germany) indicates that financing variables and methods for assessing the cost effectiveness of new drugs will affect future outlays, though in ways that are hard to estimate empirically across countries. Freund and her co-authors study the ways in which the private insurance system in the United States and the public systems in the other six nations use differing benefits structures and cost control mechanisms to arrest the growth in pharmaceutical expenditure. Though for differing reasons, all the countries now use some combination of formularies, negative lists (indicating which drugs are not reimbursable), co-payments and cost-benefits analysis. Future studies of ageing and health care costs that hope to improve forecasts must begin to track all these variables in each national context and to estimate the benefits and costs of drugs and other treatments in a systematic way.

By far, the most important lesson to be learned here is that governments and policy analysts consider only the costs of new treatments and new drugs and ignore the benefits. For instance, the current debate in the United States centers on the costs of adding a Medicare drug benefit for all, or only some lower income seniors. As the range and number of new and expensive drugs increase in the United States, these 'up front' costs will increase even further. Whatever the costs, and assuming at least some tangible benefit, higher income elderly and their physicians will find a way to afford them. Lower income elders, without Medicare subsidies, will have a harder time affording these drugs. Thus, in every society facing these costs, decisions about what is to be made available to whom and at what cost will be on the public agenda for many years to come.

The Distribution of Costs

There is also a downside to the United States experiences with elder health care and with new drug treatments. While the elderly on average spend high fractions of income on health care as seen in Fig. 3 and in Table 2, these costs vary greatly amongst elder population subgroups. In the United States, where 80% of the elderly own their own houses, where durables purchased are infrequent and food costs are low, spending 20–25% of the median (or higher) of the elder household's income on health care is not considered out of line, given the likely benefits which elders are receiving for this care. On the other hand, because insurance is only partial and because public insurance programmes for low income elderly are more parsimonious then are those for workers and for retirees with additional subsidized coverage, there is also a great variance in expense and access to treatment across income groups and health groups.

Figure 4 suggests that out-of-pocket expenses will be particularly large among United States citizens who are older, more disabled and who have less public support. In particular, the burden is high among low-income older women. What is interesting in this chart are two things. First of all, the variance across age, gender and health groups (reflecting, in part, differential health status and access to additional health insurance in the United States) is large. Second, the fact that these burdens are so high among those least well off is a matter of public concern. In fact, recent studies show that delays in care, restricted access to medications and lower quality of care among the elderly, are liable to reduce quality of life, increase disability and lead to additional hospitalization and institutionalization (Soumerai et al. 1991, 1994; Soumerai and Ross-Degnan 1999). Thus, public policies, which limit coverage and quality of care, can have adverse effects on those not able to afford the full menu of health care treatments available to most United States elders. Still, we note that even where insurance and income are low; the elderly are willing to spend a great deal of their incomes (and for many to also draw down their assets) for health care (see also McGarry and Schoeni 2001).

This suggests that the public and private spheres need to work interactively first to put a floor beneath basic health insurance coverage, and second to decide which

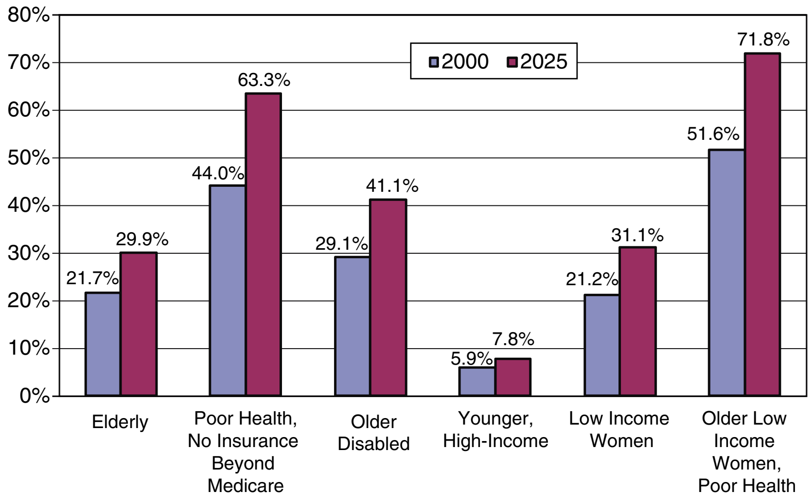

Fig. 4 Projected out-of-pocket spending as a share of income among U.S. cohorts, 2000 and 2025 (The Urban Institute's 1999 Medicare Projections Model; Iams and Butrica 1999)

health care goods and services will be provided or subsidized by the public sector and which will have to be privately purchased. If policy is guided by making cost-effective treatments available to all who would benefit from them, and not only to those who can afford them, policy will be well served. The debate on Medicare prescription drug coverage in the United States today is largely about these decisions.

Summary and Conclusions

Most analyses of the future health care costs of an ageing society are entitled something like 'The Fiscal Challenge of an Ageing Industrial World' (England 2002). They point to the steep overall costs of ageing for social retirement, acute and chronic health care costs. They speak of rationing, large intergenerational fiscal inequities and the like. They conclude something like the following:

> In sum, it is important to recognize the expanding financial risks for governments that medical technology poses for ageing populations. Demographic miscalculations have already taken a significant toll on welfare state finances. Continued increases in longevity, combined with intractably low birth rates, raise the danger that government old age benefit systems could collapse unless appropriate reforms are adopted in the near-term. (England 2002: 3)

The major problem we find with these discussions is that they do not consider the benefits as well as the costs of health care improvements. And were they to examine the benefits more specifically, researchers and nations may rethink the way that health care treatments for the elderly are financed and provided. Clearly, rising incomes among the old, and the perceived (and of times now substantiated) benefits of improved medical treatments and technologies, will improve both elder willingness and ability to pay for these treatments. More studies of the type undertaken by Lichtenberg (2001a, b, 2002), Cutler and McClellan (2001) in the United States can help identify future net benefits and costs, not only for prescription drugs, but also for hip replacement, cardiac treatment, oncology and other types of treatments.

As long as public health organizations can certify the likely benefits of these treatments, they should be made available to elder consumers. And as long as national health care agencies continue to push for cost-effective use of new technologies and drugs, the major issue in future health care costs among the aged will be 'who should pay?' not 'should these be available?'

We believe that future income security policy and health care policy should be integrated rather than treated separately. These policies should set limits on what is expected from public vs. private expense, due to competing budgetary needs and due to the rising ability of the elderly to pay for their own care. Society should protect the at-risk elders from both low incomes and high medical expense for equity sake, but then let non-poor elders spend their own money on additional treatments, drugs and other medical services which directly improve their quality and quantity of life. After all, what better expenditure can these increasingly rich generations make?

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Part IV
Family and Care

Family Support for Older People: Determinants and Consequences

Emily Grundy

Introduction

Substantial increases in the representation of very old people in most industrialised countries together with changes in patterns of family related behaviour and in living arrangements have raised concerns among many policy makers that the availability of family support for older people in need of assistance may diminish while the numbers needing such assistance increases. Two possible adverse consequences of this process are anticipated, firstly, increased demand for formally provided services, with implications for public expenditure, and secondly, negative effects on the quality of life of some disabled elderly people.

Pessimism about the future support of older people with disabilities in ageing populations is not universal. Firstly, some analysts suggest that the proportions needing personal assistance may decrease as a result of improvements in the prevention, postponement and management of disabling conditions and substitution of personally delivered assistance with new technologies (Hoenig et al. 2003). Secondly, some argue that concerns about reductions in the commitment of younger to older generations are over alarmist and that declines in the availability of relatives such as children, nieces and nephews and siblings (due to lower fertility) may be at least partially offset by increases in the supply of stepkin and longer co-survival of spouses. Additionally it has been pointed out that in many European countries the cohorts now entering old age include lower proportions that are childless than preceding generations, although this trend will reverse once those born from the 1950s onwards enter later life (Grundy 1995; Murphy and Grundy 2003; Murphy et al. 2006). Thirdly, in terms of implications for the quality of life of older people, several commentators suggest that formally provided services may be preferable to family provided ones in some circumstances and that a shift in the family/state

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balance of care provision may be positive from the point of view of older people themselves (Daatland 1990). A countervailing influence, certainly in terms of costs of providing health services, may be rising expectations and standards in more recently born cohorts and increasing pressure to reduce explicit or implicit age related rationing of expensive interventions.

In this chapter, variables which influence demand for support, whether family, state or market provided, are first briefly considered. Evidence on the availability of family support is considered next. As kin availability is considered in detail in the chapter on “Family and Kinship Networks in the Context of Ageing Societies”, in this section of this chapter the emphasis is on socio-economic and cultural influences on the provision of family support. In the final section of the chapter we examine the effects of variations in support of various kinds on the well being of older people and the policy implications of different patterns of support, with reference to international variations.

Demographic and Health Trends Influencing Needs for Support

The historical shift to an older structure which many Northern and Western European countries experienced in the first half of the twentieth century was a result of the transition from relatively high to low fertility set in motion in many countries towards the end of the nineteenth or in the first half of the twentieth century. More recently, the effects of these early changes have been amplified by a further shift in some Southern and Eastern European countries, and South East Asian countries such as and Japan towards very low fertility and by falling mortality in older age groups, where most deaths are concentrated. Several industrialised countries now have fertility rates below 1.5 and life expectancies at birth close to 80. Recent improvements in mortality have been marked (except in Eastern Europe). Male life expectancy at age 65 in England and Wales, Japan, the United States and France, for example, increased by as much or more between 1970 and 1995 than in the whole period from 1900 to 1970 (Grundy 2001). Both the pace and now the extent of population ageing within the industrialised world is greatest in those countries which have experienced age structure changes most recently, raising particular problems in terms of social and policy adjustments. As shown in Table 1, by 2020 a quarter of the population in several European countries and in Japan will be aged 65 and over and 3% or more aged 85 and over. In many countries the proportion and number aged 85 and over is growing particularly rapidly and this age group will be as, or more, relatively numerous in 2020 as those aged 75 and over were in the 1950s or 1960s. By 2050 United Nations projections indicate that there will be 19 countries, including France, Germany, Italy, Japan, Spain and the UK, in which at least 10% of the population is aged 80 or more. By then, Europeans aged 60 or more will constitute one in three of the population and outnumber children aged under 15 by 2.6:1 (United Nations 1999, 2001).The assumption of policy makers is that these demographic changes will call for greater expenditure on support systems of various kinds

Table 1 Percentages aged 65 and over and 85 and over and indicators of fertility and mortality, selected industrialised countries 2000 and 2020 (United Nations, World Population Prospects, the 1998 revision, Volumes 1 and 2; medium variant projections)

	2000				2020			
	1995–2000		%		2015–2020		%	
	TFR	e_0	65+	85+	TFR	e_0	65+	85+
Austria	1.4	77	14.7	1.5	1.6	79	19.1	2.1
France	1.7	78	15.9	2.0	2.0	80	20.1	3.0
Germany	1.3	77	16.4	1.9	1.5	79	21.6	2.7
Greece	1.3	78	17.9	1.5	1.4	80	22.7	3.3
Hungary	1.4	71	14.7	0.5	1.4	74	19.4	1.8
Italy	1.2	78	18.2	1.9	1.4	80	24.1	3.5
Japan	1.4	80	17.1	1.7	1.7	82	26.2	3.8
The Netherlands	1.5	78	13.8	1.5	1.7	80	20.6	2.3
Sweden	1.6	79	17.4	2.3	1.8	81	23.1	3.0
U.K.	1.7	77	16.0	2.0	1.9	79	19.8	2.6
Ukraine	1.4	69	14.1	1.1	1.5	74	17.5	1.6
USA	2.0	77	12.5	1.5	1.9	79	16.6	1.9

(OECD 1999). This will require greater economic transfers to older people from younger adults, who will also be called upon to provide more family care.

Certainly in contemporary developed societies rates of morbidity, disability and needs for assistance among older people, particularly very old people – the most rapidly growing segment of many populations – are high. The 2003 Health Survey of England, for example, showed that some 70% of those aged 65 and over reported longstanding illness and of these about half had two or more longstanding conditions. Rates of disability in older age groups are lower than the overall prevalence of chronic disease, but are even more strongly age related reflecting high risks of co-morbidity at older ages and often the poorer environment (for example, poorer housing) of older people. Measures of disability based on indicators such as Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) scores and explicit detailed disability schedules provide more information about the consequences of morbidity in terms of support needed. Figure 1, derived from USA data collected in 1994–6, shows that inability to undertake, or difficulty in undertaking, one or more ADLs is strongly associated with age (as too are IADL limitations). In this survey, the ADLs considered were bathing or showering; dressing; eating; getting in or out of bed or chair; walking; getting outside and getting to and using the toilet. A third of women aged 85 and over had difficulty performing at least one of these activities and a third were unable to perform one or more at all. Moreover this survey excluded those in institutions (nearly a quarter of the US 85+ population) among whom ADL limitations would be far more prevalent. The 2001 British General Household Survey (which also excludes those in institutions) similarly found that among those aged 85 and over the proportion with assistance needs was high; 18% of men and 23% of women in this age group needed help with dressing and 24% needed help with bathing (Office for National Statistics 2003). Reported rates of disability and needs for assistance in countries such as Spain

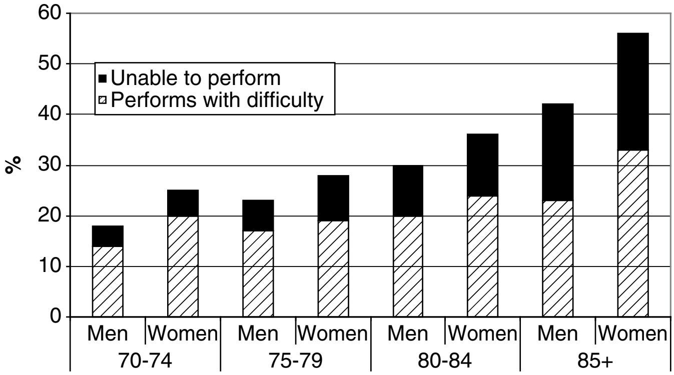

Fig. 1 Proportion of people aged 70 and over who have difficulty performing or are unable to perform one or more activity of daily living by gender and age group, USA 1995 (National Health Interview Survey data in Kramarow et al. 1999)

which have low proportions of older people in institutions (and so a greater proportion of the disabled elderly population eligible for participation in community surveys) tend to be even higher (Beland and Zunzungi 1999).

From a policy perspective, the major concerns arising from the projected increase in the numbers of people among whom rates of poor health and disability are relatively high relate to costs of health care and long-term care. In OECD countries health care expenditure is typically three to five times as high for those aged 65 and over as for those aged under 65 and more detailed information available for some countries shows a continuing rising gradient in costs with increasing age (Anderson and Hussey 2000). However, there is considerable variation in the proportion of GDP devoted to health care spending for older people, and the variation bears little obvious relationship to the proportion of older people in the population concerned. Expenditure relative to GDP is much higher in the USA than in European countries, for example, even though the USA has a younger population. Moreover analyses by health economists have identified the growing costs of new technological innovations in medicine as a far greater influence than population ageing on past growth in health care expenditures (Appelby and Harrison 2006). It has also been argued that health care costs, particularly acute health care costs, are associated with proximity to death rather than age per se implying that models of future demand should be based on estimates of numbers of decedents, rather than age-structural change. In older stationary or declining populations it is of course not just the proportion of old people but also the ratio of deaths to population (crude death rate) that is high; however there is some suggestion that acute care costs (but not social care costs) associated with death are higher among the young old than the very old (McGrail et al. 2000). However, this may partly reflect implicit or explicit rationing of expensive interventions (Bowling et al. 2001), age related variations in the type of health problems associated with the pre-death period may also be important (Guralnik et al. 1991).

Policy and practice may therefore influence the relative health care costs associated with a growing elderly population and increases in health care expenditures cannot be wholly, or even predominantly, explained by population ageing. There may also be scope for offsetting the impact of ageing on health care through improvements in the efficiency and orientation of health care systems. In a detailed examination of the underlying reasons for rising numbers of emergency admissions among elderly people in Scotland, Kendrick and Conway (2006) concluded that increasing numbers of older people and social change leading to constraints on availability of informal care in fact played a minor role in accounting for the increase, which is a major source of pressure on the Scottish health service. The main contributory factor they identified was an inappropriate emphasis on crisis management rather than co-ordinated preventive care.

Although it may be inappropriate to attribute all rising health care costs to population ageing, costs of long-term care (including social care in institutional and community settings) clearly are strongly related to trends in the prevalence of disability (themselves highly associated with age) and the availability of family support. A recent British study found that over a third of elderly people living in private (non institutional) households who had ADL limitations were wholly or partly dependent on formal services for help, even though levels of family-provided assistance were high (MRC CFAS 2001).Variations between countries in provision and expenditure on long-term care are also considerable, as illustrated in Table 2. In general Northern European countries spend more on long-term care than Southern ones and also have a higher proportion of people resident in institutions of various kinds, although, as discussed in the concluding section of this chapter, many countries have recently reformed their services. It is also often difficult to quantify public expenditures on long-term care, which typically may be provided in a variety of different forms, let alone to include costs to 'informal' carers – family and friends – who provide the majority of help needed by disabled older people.

Projections based on current usage patterns and projected demographic change suggest that in Britain, for example, the number of elderly people with two or more ADL limitations will increase by 63% between 1996 and 2031, and the number with limitations and living alone will increase by 45%. As a result a 48% increase in the number of hours of home care needed is projected (Wittenberg et al. 2001).

Table 2 Public and private spending long-term care (as % of GDP): selected developed countries, 2000 (OECD data in Gibson et al. 2003)

Country	Total long-term care expenditure	Public long-term care expenditure	Private long-term care expenditure
	% GDP	% GDP	% of total
Australia	0.80	0.62	0.18
Canada	1.29	1.03	0.26
Denmark	2.12	n/a	n/a
Germany	1.23	n/a	n/a
Japan	0.69	0.62	0.07
United States	1.29	0.74	0.54

Illustrative projections such as these are valuable, but there are considerable uncertainties about both trends in health status and needs for assistance, considered below, and the supply of family support, considered in the second part of this chapter.

Trends in Health and Disability Status

Controversy surrounds the issue of trends in indicators of the health status of populations, including disability. To a large extent this debate, and its lack of certain resolution, arises from measurement problems and the difficulties involved in making comparisons between health indicators derived in different ways (Robine et al. 1992; Bronnen-Hansen 2005). However, there is also an underlying theoretical debate about the implications of declining mortality rates for the health status of the population. Criticisms of the unquestioning use of life expectancy as a measure of population health arise from the concerns expressed by some that reductions in mortality in populations which have experienced the epidemiological transition may be due partly to the prolongation of the process of dying rather than to an extension of healthy life (Gruenberg 1977; Rogers et al. 1990). Conversely, optimists have argued that lifestyle improvements and medical advances in the postponement and management of disability will result in a shortening of pre-death disability (Fries 1980).

In terms of empirical evidence there is some support for both positive and negative interpretations. Trend data show an increase in some indicators of poor health in several populations, especially during the 1960s and 1970s. In the United States, for example, calculations based on National Health Interview Survey data indicate that male life expectancy in good health increased by only 0.3 years between 1962 and 1976, while life expectancy with an activity restriction increased by 1.5 years (Colvez and Blanchet 1981). Results from Britain are similar (Dunnell 1995).

Analyses of more recent trends, however, suggest reductions in disability, especially severe disability, in the United States, Japan, Spain and a number of other European countries (Freedman et al. 2002; Crimmins 2004; Aijanseppa et al. 2005; Schoeni et al. 2006; Zunzunequi et al. 2006). However, as measures of trends depend on the indicators of disability used and various methodological factors, such as whether the institutional population is included in the analysis, there is still debate about the extent of this change (Wolf et al. 2005). Moreover, as disability is an outcome of the interaction between health limitations and the environment, some improvement may be due to changes in the latter, including greater use of assistive technology, rather than in health (Freedman et al. 2006). Evidence from a number of European countries also suggest declines in more serious disability, but possibly some increases in milder disability and morbidity (Perenboom et al. 2004). Overall this is the picture that emerges most clearly from the literature: that is, a scenario of declines in serious disability, but increases in reported limiting long-standing illness, reported prevalence of some conditions and mild disability (Crimmins and Saito 2000). Less positively, results from some Scandinavian countries (which have high quality data) show either no improvement or even an increase in disability rates (Winblad et al. 2001; Parker et al. 2005).

Recent improvements, if sustained, would suggest a decrease in age-specific rates of demand for certain types of support. However, given the large projected increases in the number of very elderly people, the overall demand for support may still increase. Estimates by the OECD which incorporate falling rates of disability nevertheless show increases in the number of 'dependent' elderly people (with ADL limitations) to the order of 6% in Sweden, 11% in the UK (both of which already have large populations of older old), 25% in France and 44% in Japan (Jacobzone et al. 2000).

It is important to remember that elderly people (Arber and Ginn 1990; Young et al. 2006) are not just recipients of care; they also *provide* a large proportion of care for other elderly people (including spouses). Improvements in the health status of this section of the population may mean that fewer elderly people are precluded from providing care to a spouse, or parent, because of health limitations of their own and so effectively enlarge the pool of potential supporters.

Family Support

Just as population ageing is perceived as a threat to the stability of formal transfer and support schemes, so too is it regarded as potentially disruptive of intergenerational exchanges within the family. Other social, economic and cultural changes also present challenges to family support systems. These include longer youth dependency occasioned by labour market changes and wider educational opportunities, greater labour market involvement of women and increases in the complexity of partnership and parenting histories (European Commission 1995). Theorists have associated these latter changes with a shift from familial to individualistic aspirations and behaviours (Goldscheider and Waite 1991). If so, we might expect to see a decline over time in frequent contact and exchanges of help between relatives and, perhaps, a consequent increase in the demand for non-kin support for frail older people.

Demographic influences on the availability of family support are clearly of major potential importance. As documented elsewhere in this volume (see chapter by Murphy), the demographic determinants of a population's size, age and sex structure also determine the size and structure of kin networks. Trends in nuptiality, divorce, remarriage, age differences between spouses, ages at childbearing and the parity distribution of cohorts, as well as overall levels of fertility and mortality, influence the composition of these networks and the proportions with or without specified kin at different ages. In many European countries (and also North America), cohorts born in the inter-war and immediate post-World War II period had much lower rates of celibacy and childlessness than either preceding or succeeding generations (Prioux 1993; Daatland 1996; Murphy and Grundy 2003). This means that short-term prospects for the support of elderly people are in many instances favourable (as spouses and children are the main providers of support) (Grundy 1995; Murphy et al. 2006). However, longer term prospects are much less so, particularly as those born from the mid-1950s on have experienced high rates of divorce and include relatively high proportions of childless and never-married people.

As many of the parameters determining kin networks have varied between developed countries (and over time), there have been and continue to be quite large differences in the availability of particular kin. In Ireland in the 1980s nearly a quarter of the elderly population was never-married, compared with only 5% in Bulgaria, while the proportion of elderly women who are widows is much higher in Eastern than Western Europe, reflecting differences in mortality levels and differentials, as well as variations in the proportion ineligible for widowhood because of permanent celibacy or prior divorce (Grundy 1996).

Differing trends over several generations may amplify country variations as illustrated in Fig. 2, which shows the proportion of women aged 50 and over by age group and number of generations in the family (of direct descent, e.g. grandparent-child-grandchild) for Sweden and Greece. These data, from the 2004 Survey of Health and Retirement in Europe (SHARE), indicate that half of Swedish women aged 80 and over were members of four generation families compared with 30% in Greece (which has recently had much lower rates of fertility). Socio-economic differentials in fertility and mortality patterns mean that there are also differences in the kin resources of social strata within populations. In analyses of two similar nationally representative data sets on adults in late mid life, the Health and

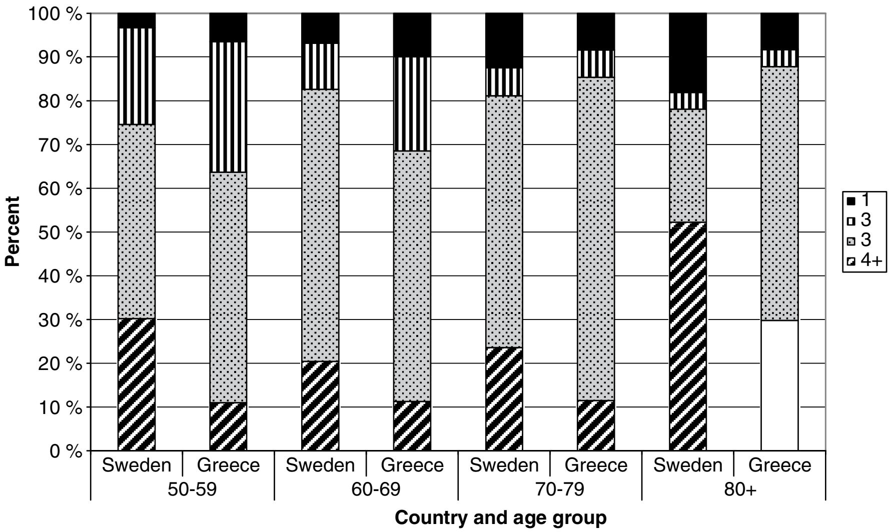

Fig. 2 Women aged 50 and over by number of generations in the family and age group, Sweden and Greece, 2004 (Survey of Health and Retirement in Europe (SHARE); see Borsch-Supan and Jurges 2005)

Retirement Survey from the USA and the British Office for National Statistics (ONS) Retirement and Retirement Plans Survey, Henretta et al. (2001) found that a much higher proportion of 55–63 year old women in the USA had a surviving parent (38%) than their British counterparts (28%), reflecting differences between the two countries in late life mortality and past distributions of ages at parenthood. This, combined with the higher fertility of the US women, meant that the proportion with both an adult child alive and at least one surviving parent was markedly higher in the USA (35%) than in Britain (19%). In both countries, women of higher socio-economic status were significantly more likely to have a parent still alive, although those in lower socio-economic groups had more children. Similarly, a British survey of kin and kin contacts found that 45% of 45–69 year olds from white-collar groups had a living parent compared with only 23% of blue-collar respondents (Grundy et al. 1999). One consequence of these types of variations is that the effects of policies which benefit old rather than young people, or vice versa, may have varying effects on different social groups.

Living Arrangements

Availability of kin clearly operates as a constraint on possible inter and intra generational exchanges, and changes in the availability of kin have often been cited as an important influence on, for example, the changing living arrangements of elderly people (Kobrin 1976; Weinick 1995). However, variations over time and between countries are so great that it is clear that this factor alone cannot be the only, or indeed the most important, influence on living arrangements. Other influences identified as important in the literature include changes in the economic ability of elderly people to maintain separate households, changes in age and gender roles, including changes in women's work patterns; associated changes in attitudes, including the growing value attached to privacy and a shift towards individualistic, rather than familial orientations; and possible improvements in older people's health status (Michael et al. 1980; Burch and Matthews 1987; Grundy 1992; Pampel 1992; Doty et al. 1998). These conclusions are supported by studies showing variations in the living arrangements of older people by level of economic resources; by health and changes in health; and by number and demographic characteristics of children, as well as considerable variation between countries, regions and ethnic groups (Crimmins and Ingegneri 1990; Spitze et al. 1992; Clarke and Neidert 1992; Pampel 1992; Wolf 1990, 1995; Tomassini et al. 2004a). What is perhaps the most striking, however, and for some commentators the most alarming feature of changes in the living arrangements of elderly people and the extent of intergenerational coresidence, is just how great these changes have been.

Declines in the proportion of older people living in inter-generational households in the twentieth century have been described as 'a quiet demographic revolution' (Elman and Uhlenberg 1995). Results from an assortment of surveys show that in the 1950s and early 1960s between a third and a half of elderly people in several Nordic countries, England and Wales and the USA lived in households including at least one of their children. By the 1990s, the proportions of elderly people living with children in these countries lay in the region of 5–15% (Sundström et al. 1989; Grundy 1992; Sundström 1994). Since then there have been further declines. These changes have involved the oldest old, as well as younger elderly people. Figure 3 illustrates this for England and Wales, using data from an approximate 1% sample of the population, the Office for National Statistics Longitudinal Study (here used as a cross-sectional source), to show for 1971, 1981, 1991 and 2001 the proportion of men and women aged 85 and over who lived with relatives and friends (with or without a spouse) – most of whom lived with a child – and the proportions who lived in institutional care. Between 1971 and 2001 the proportion in the former category fell from over 40% to less than 15% and the ratio of those living with relatives to those living in institutions fell from 2.7 to 1.1 among men and from 2.0 to 0.65 among women. More detailed analyses of transitions between household types 1971–1981 and 1981–1991 showed that in the 1981–1991 decade transitions from independent households to institutions were significantly higher and transitions to live with relatives significantly lower (after control for age, marital status and socio-economic status) than in the earlier period suggesting some substitution of institutional care for family care (Grundy and Glaser 1997). However, policy changes appeared to be an important driver of this as during the 1980s available financial

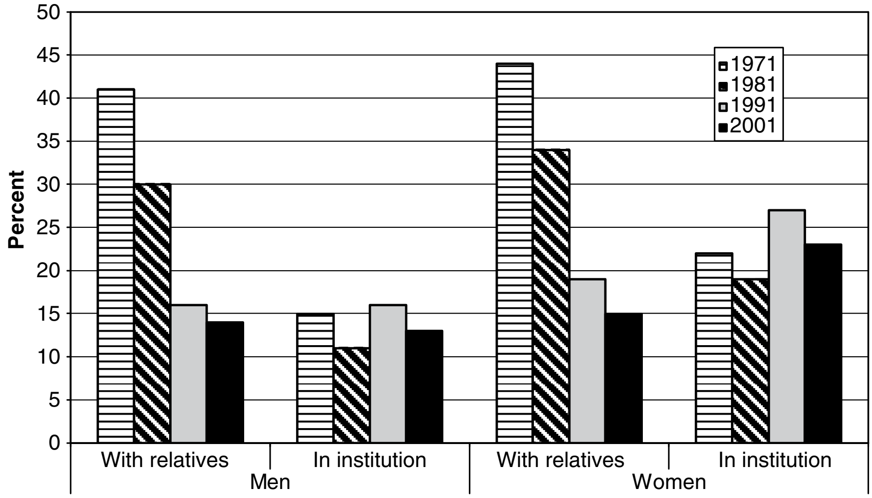

Fig. 3 Proportions of men and women aged 85 and over living with relatives or friends or in institutional care, England and Wales, 1971, 1981, 1991 and 2001 (Analysis of data from the ONS longitudinal study. Definitions: With relatives or friends: People living with a child [with or without a spouse]; other relative or non relative. Institutional care: People permanently resident in a nursing or residential home; hospital or other form of long-term residential establishment)

support for those in nursing and residential care was increased (Laing 1996). This policy has since been reversed and the proportion in institutional care has subsequently fallen again (although not to 1981 levels). This again illustrates the importance of policy and supply side factors in influencing outcomes of demographic change.

Trends in other industrialised countries show similar substantial declines even though the extent of coresidence continues to vary and is higher in Southern Europe and in Japan than in other industrialised countries (Pampel 1992; Ogawa and Retherford 1997; Reher 1998; Tomassini et al. 2004a). In Spain, for example, the proportion of older people living with their children fell by more than half between 1970 and the mid-1990s (from 58% to 23%), but was still high in comparison with Sweden where only 2% of elderly people were living with children in the mid-1990s (Royal Commission 1999; Sundström and Tortosa 1999).

As coresidence with relatives has declined, the proportions in other types of households, particularly solitary households and, more recently, households composed of a married couple alone have increased. In Northern and Western European countries, as well as in North America, very high proportions of elderly women in particular, including very old women, now live alone (Tomassini et al. 2004a).

Other Family Links

Coresidence is only one and, perhaps, a decreasingly important indicator of family resources. Data on support exchanges and contacts between non-coresidents have been much sparser than data on household composition, but results from several studies suggest that intergenerational support and contact is high, although less is known about trends over time (Sundström 1994; Silverstein and Bengtson 1997; Attias-Donfut et al. 2005). In a British survey of kin and kin contacts, Grundy et al. (1999) found that about half of all adults with a non-coresident adult child saw them at least weekly, and adult children reported similar levels of contact with elderly parents. However, 60% of people aged 70 and over who lived alone had no close relative living within half an hour's travel time of their home. We were able to use data from this survey in combination with data from two other surveys conducted in 1986 and 1995 to examine trends over time in contacts between adult children aged 22–54 and their parents. Results showed no indication of a trend towards reduced contact, or towards reduced proximity (an important influence on contact) (Grundy and Shelton 2001).

Frequent family contact, as well as coresidence, is more usual in Southern than in Northern Europe (Reher 1998; Murphy 2004; Tomassini et al. 2004b). Recent data from the SHARE surveys for ten European countries illustrate this in Fig. 4 which shows the proportion of parents aged 80 and over in daily contact with at least one child. In the Southern European countries included (Greece, Spain and Italy) this percentage ranged from 70–80% compared with fewer than 40% in the Netherlands, Sweden and Denmark.

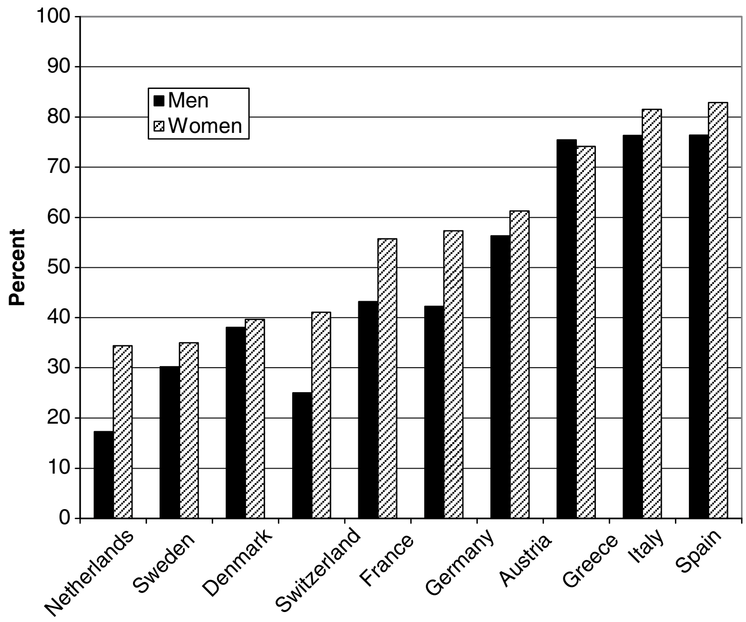

Fig. 4 Proportion (%) of parents aged 80 and over with daily contact with at least one child (Survey of Health and Retirement in Europe 2004; see Borsh-Supan and Jurges 2005))

There are also considerable differences between developed countries (as well as substantial differences between developed and less developed countries) in the amount of help elderly people report receiving from their children. Table 3, derived from a Commonwealth Fund Survey carried out in 1991, shows that a high proportion of elderly parents in the industrialised countries considered reported receiving help of various kinds from their children, particularly practical help (only in Japan did a substantial proportion report receiving help with money). Higher proportions of German and particularly Japanese parents received help compared with parents in the USA. Canada and the UK occupied intermediate positions. In a more detailed comparative study of a Japanese and a US locality, Hashimoto (1999) found that those in the Japanese area – Westside Odawara – had much weaker ties with friends and neighbours, than their counterparts in West Haven USA. Thus 70% of elderly West Haveners received help of various kinds from neighbours compared with only a third of the elderly in Westside Odawara. Hashimoto argues that peer group support is much stronger in the USA than in Japan where filial ties are emphasised more strongly. However, results from a study of Tokyo; a Japanese provincial city; and Sydney, Australia reported by Kendig et al. (1999) are slightly at variance with this. Kendig and colleagues found that in both the Japanese and Australian settings spouses were the main source of support followed by adult children and then other relatives and friends and neighbours. In the Japanese settings support from all these sources was higher than in Australia and neighbours and friends provided much

Table 3 Parents aged 65+ ever receiving help from children, 1991 (1991 Commonwealth Fund survey analysed by Kunemund and Rein (1999))

Type of help	Canada	FRG	Japan	UK	USA
Help when ill	73	87	90	78	69
Domestic	48	60	73	59	36
Transport	48	72	73	66	39
Money	19	24	53	30	20
Any	78	90	91	82	74
N	799	827	852	761	782

more support than in Sydney. It is possible that support from friends and neighbours is higher in the USA than in Japan and higher in Japan than in Australia, but this seems unlikely. However, both Hashimoto's study and that of Kendig et al. were based on studies of particular localities which may differ from other parts of the country. In order to find out whether in societies with lower rates of familial exchange there is a compensating increase in inputs from neighbours and friends or, conversely, whether societies which emphasise family bonds also have stronger neighbourhood and friendship networks would require more research on samples that were both detailed and nationally representative.

Partnership Status and History and Contact Between Adult Children and Parents

Although these findings, and results from other studies, show high levels of interaction between adults of different generations, concerns have been raised that these may be jeopardised by the increasing complexity of family relationships and increased family disruption (Goldscheider 1994). Studies from the United States and European countries show that divorced parents, particularly divorced fathers, have less contact with their adult children than parents of other marital statuses (Barrett and Lynch 1999; Lye et al. 1995; Tomassini et al. 2004b). One study, however, has shown that adult daughters' proximity to mothers is positively associated with the mother being divorced (Rogerson et al. 1997). Two factors may underlie these associations. On the one hand, unmarried parents may be perceived to have greater needs for support and social exchange with their adult children (and more time to initiate and maintain exchanges). On the other, adult children may have weaker or less positive bonds with parents, perhaps particularly fathers, if there is a history of marital conflict between parents and/or absence/repartnering of a parent. The effects of an adult child's partnership characteristics on their relationship with their parents are also likely to be variable. Divorce may precipitate a return to the parental home and divorced children have higher rates of coresidence with their parents than married children (Ward et al. 1996; Grundy 2000). However, although divorced children's heightened support needs may in these cases lead to closer ties with parents, in other cases parental disapproval of marital disruption and other 'non standard' family patterns, such as cohabitation could weaken ties, especially where the parents' and child's history and values diverge. It is possible therefore that both parental divorce and divorce of the child may influence contacts and exchanges and, as in all aspects of intergenerational exchanges, it is possible to examine variations in contact or provision of help from either the parental or the child's perspective.

In the 1999 British survey of kin and kin contacts, we collected data on the provision and receipt of various types of help (such as help with shopping, cooking, cleaning, childcare, transport, decorating and gardening, paperwork and money), as well as on marital status of respondents and their parents (or children). Table 4 shows the results from logistic regression analyses of variations in the proportion of adult children who provided assistance to their mothers/fathers, most of whom were elderly, by marital status of both generations and other relevant co-variates. Provision of help to mothers was positively associated with the respondent having a child under 16, with older age of mother and very strongly with receipt of help from mother and with proximity. When proximity was not controlled for, education was also significant with those in the lowest educational group being twice as likely as those in the highest to provide regular help. Help provided to fathers was more strongly associated with father's partnership history. Odds of providing help to a father were 40% or more lower where the father's partnership history (but not the respondent's) was disrupted and also lower where both had disrupted partnership histories.

The strong effect of reciprocity (receipt of help from the parent) is important to note and is consistent with other studies which have emphasised the two-way nature of support exchanges involving older people. Kunemund and Rein (1999), for example, analysed data from the Commonwealth Fund 1991 Survey and found that receipt of help from a child was associated with being female, with older age, with number of children, with coresidence with a child and, in Canada and the United States only, with poor health. In all countries, it was also associated with providing help with babysitting. Similar results have been reported from more detailed country- specific studies (Grundy 2005).

Care Giving and Care Receipt

Regular contact and reciprocal exchanges of help with domestic tasks would seem to be a normal feature of intergenerational family life even in populations in which coresidence is low, although there may be certain sub-groups, such as those without children and divorced men with poor relationships with their children for whom access to such support is more limited. However, a proportion of older people need more than an emotionally supportive relationship and help with gardening or a lift to the shops; conversely, some middle aged and elderly daughters and sons provide personal care, including sometimes intensive personal care, to a parent. Numerous surveys from a range of countries demonstrate that much of the care needed by

Table 4 Results from logistic regression analyses of provision of regular help to mother/father by adults aged 22–54 who had a living mother/father Britain 1999 (Author's analysis of 1999 Omnibus Survey module on kin and kin contact)

	Help to mother				Help to father			
	Odds ratio	P value	Confidence interval		Odds ratio	P value	Confidence interval	
Parent of child < 16	1.60	0.000	1.23	2.09	1.78	0.000	1.35	2.36
Household has at least one car	0.64	0.010	0.45	0.90	0.67	0.042	0.45	0.99
Mother's/Father's age	1.03	0.000	1.02	1.05	1.03	0.000	1.02	1.04
Receives help from mother/father	5.01	0.000	3.80	6.61	3.62	0.000	2.70	4.85
Low education	1.30	0.108	0.94	1.80	1.47	0.028	1.04	2.07
Medium education	1.25	0.203	0.88	1.78	1.14	0.478	0.79	1.64
Mother/Father divorced, remarried or cohabiting ('non standard' partnership history)	1.04	0.823	0.73	1.48	0.57	0.004	0.38	0.83
Respondent divorced, cohabiting, remarried or lone parent ('non standard' partnership history)	0.75	0.103	0.53	1.06	0.79	0.204	0.55	1.13
Both 'non standard' partnership history	0.91	0.678	0.57	1.45	0.57	0.038	0.34	0.97
Lives within half an hour of mother/father	3.78	0.000	2.89	4.96	1.59	0.000	1.37	1.84
Number of observations	***1495***				1187			
Log likelihood	−808.01				−701.43			
Pseudo R2	***0.183***				0.148			

Reference categories: No dependent child under 16; no car; high education; does not receive help from mother/father; neither mother/father nor respondent non standard marital history; lives beyond half an hour's travel time of mother/father elderly people with disabilities is provided by close relatives, particularly spouses and daughters (Royal Commission 1999; Choi 1994; Doty et al. 1998). Elderly people with heavier support needs usually have a primary carer and studies in a range of countries have shown that this carer is in the majority of cases a family member, often coresident. In no country has it been found that formal carers constitute the majority of primary carers, only in Denmark (which has the most extensive home care services) this proportion reaches 44% (Royal Commission 1999). However, results from a model based on linked data on the characteristics of both elderly people and their children in the USA suggest that this balance may shift somewhat for very disabled older people (those with 5 or 6 ADL limitations) (Soldo and Freedman 1994).

Many 'child' carers of elderly people are themselves elderly and this is likely to become even usual if mortality continues to fall. Analysis of the British Retirement Survey showed that 7% of all women aged 55–69 were providing care to a parent. The proportion appears fairly low, but this largely reflects the fact that most of these women no longer had a parent alive. Calculations based on those actually 'at risk' of caring for a parent – those with a living parent – showed that 9% of married and 18% of unmarried women were providing coresident care for a parent, with a further 33% and 31% respectively providing extra-resident care. Given that some women would have had parents who did not need care, these figures suggest a large proportion of those called upon to provide parent care were doing so.

Although intergenerational support mechanisms appear strong now, will they remain so in the future? The fact that greater levels of contact and exchange are associated with lower educational status and, negatively, with parental marital disruption suggests that changes in the characteristics of populations in the future may be associated with some reduction in intergenerational exchange. The obvious question is does this matter? Does the fact that, for example, more old people live alone than in the past have implications for either their wellbeing or for their use of services? A related issue is whether policies for supporting older people tend to 'crowd out' family support or, conversely, enable families to continue providing support. These issues are considered in the final sections of this chapter.

Living Arrangements, Family Support, Health and Use of Formal Services

A large share of research on this topic has focused on the implications of the choice of living arrangements for the provision of care (Cafferata 1987; Chappell 1991). Risks of entering an institution, for example, are much higher among the never- than the ever-married (Carrière and Pelletier 1995; Grundy and Glaser 1997). As shown in Table 5, those who need help and live alone are more likely to receive this help from formal services than are those with a coresident. Results from Sweden show a similar picture and, additionally, variations by whether or not people have a child (data unavailable in the British survey referred to here).

Table 5 Usual source of help for elderly people unable to undertake tasks without help, Britain 2001 (2001 General Household Survey; ONS 2003)

	Bathing/showering	Domestic tasks	Practical activities
Lives alone	%	%	%
Relative	47	63	49
Health or social services	45	29	32
Other/no-one	8	7	12
Lives with other(s)			
Spouse/other coresident	86	73	56
Other relative/friend/neighbour	5	15	21
Health or social services or paid help	8	11	18
Other/no-one	1	2	5
Health or social services	22	12	3

Sundström et al. (2006) found that among older people who needed help with one or more ADLs, 80% of those who lived with someone else and had at least one child received help only from family members (and not from social services), compared with 42% of those who lived alone and had at least one child and 24% of those who lived alone and were childless.

A dilemma for policy makers and service providers is whether prioritising help for older people who live alone and lack family help (which these variations suggest is the case) disadvantages family carers to such an extent that they become unable or unwilling to continue. In a number of countries there have been recent efforts to target resources on the most disabled. In England and Wales, for example, the proportion of older people receiving home care has dropped since the introduction of new legislation in the early 1990s, but those receiving care have received more hours. A similar development has occurred in Sweden (Sundström and Tortosa 1999). Such policies may also involve families having to provide more help.

A second issue of importance is possible consequences for the well being of those in older age groups. The literature on associations between marital status and health and on links between social ties and health suggests a number of mechanisms whereby living with others might have beneficial effects on health. These include the provision of services such as meals, of nursing care when ill and of support and companionship. While living with a spouse would seem to confer various health related benefits, it does not necessarily follow that living with someone other than a spouse (the only likely 'choice' for an elderly widow) confers similar advantages over living alone. There is some rather fragmentary evidence that living alone may be associated with various health-related disadvantages. Murphy (1997) for example, reported that in Britain rates of long-standing illness were higher among those living alone than those in other types of household, but only in middle aged groups. Welin et al. (1985), in a large prospective study of middle aged and elderly Norwegian men found an inverse relationship between household size and mortality, that is, those with the most coresidents had the lowest risks of death. Mor et al. (1989) using data from the United States Longitudinal Study of Ageing, found that after controlling quite carefully for initial health status, elderly people living alone had a higher risk than others of functional decline. Sarwari et al. (1998) in a prospective study of elderly white women in Baltimore, USA, found that among women with severe impairment at baseline those who lived alone experienced significantly greater deterioration in functional status than those living with others, particularly those living with non-spouse others. However, among the women without severe impairment at baseline, the reverse was the case – those living alone experienced the least deterioration.

A more recent Swedish study also found an increased risk of developing dementia among those living alone; those with no close social ties or who had unsatisfactory relationships with close relatives also had higher risks (Fratiglioni et al. 2000).

The studies referred to above show associations between living alone, or with fewer people, and various indicators of poor health, particularly poor mental health, although in only a few of them is this relationship apparent in elderly age groups. More numerous are studies of elderly people which show those living alone, at least in older old age groups, to be healthier than their counterparts living with adults (other than a spouse), or in some cases, even than married adults (Magaziner et al. 1988; Crimmins and Ingegneri 1990; Stinner et al. 1990; Spitze et al. 1992; Glaser et al. 1997; Hebert et al. 1999). This presumably reflects not the harmful effects of living with a relative (although for older people who attach a strong value to independence perhaps such an arrangement might be psychologically harmful), but rather the effect of selection – those with serious health problems are no longer able to live separately.

Policy Implications and Interactions

As discussed in the first section of this chapter, there are quite wide variations between developed countries in expenditure and provision of health and long-term care for older people. Many aspects of contemporary patterns of care provision have their roots in policies formulated in a different era, sometimes for a different purpose. The still high rate of institutional care and specialist housing for elderly people in the Netherlands, for example, is partly a legacy of serious post-war housing shortages and attempts to reduce these by housing elderly people in small specialist dwellings or communal establishments, thus freeing larger dwellings for families. Similarly, in the UK 'Part III' accommodation established for elderly people in the 1948 National Assistance Act was designed to provide 'hotel' type facilities for elderly people who lacked domestic support (for example childless widowers), rather than provide personal or nursing care, and in the 1950s and 1960s poor housing was a major precipitant factor in admissions (Townsend 1962). Many developed countries, including Finland, Sweden, Norway, the UK, the Netherlands, Germany, Austria, Australia, New Zealand and Japan either reformed their long-term care systems in the late 1980s or 1990s, or are in the process of doing so. Austria, for example, introduced a unified system of long-term care allowances in

1993; Germany introduced a new branch of social insurance to pay for long-term care in 1994 and both the UK and Sweden introduced reforms in the early 1990s which handed responsibility for long term care to local authorities (although in the UK much is privately provided) and aimed to target home support services on the most frail. Even more recently, Japan has radically overhauled the system of support for older people and their families.

Despite variations in level, type and financing of long-term care, some common threads and a tendency towards some convergence in levels of provision have been identified (Royal Commission 1999). Thus 'generous' providers such as the Nordic countries and the Netherlands have been trying to reduce levels of provision, particularly of institutional care, while countries such as Greece and Spain have recognised a need to expand services. The UK Royal Commission on long-term care noted that there was a now a consensus internationally that long-stay wards in general hospitals were not the most appropriate, or efficient, settings for long-term care. Secondly, in most countries provision of nursing home beds had expanded as an alternative to hospital based care while provision in old-people's homes had been curtailed. The latter which provided 'social care were seen as no longer necessary partly because of improvements in housing, advances in home based technologies (both specialist and general) and efforts at providing more intensive care to people at home. Similarly, home care functions have been changing. Thus, in the UK traditional 'home helps' who at one time spent much of their time on domestic tasks which are no longer needed or are much less demanding (such as lighting fires, cleaning grates and washing clothes), have now evolved into home carers who spend a greater proportion of their time on providing personal care. A third important lesson is that deterioration in function in older people usually does not follow a gradual course but is precipitated by an acute episode of illness or injury or some similar event. As a result, admissions to institutions are often from hospital, rather than from home. In some cases better rehabilitative services might enable older people to recover sufficient function to return home and it has been shown that assessment by specialist geriatric teams coupled with post discharge home intervention is associated with shorter hospitals stays, fewer readmissions and fewer nursing home placements (Nikolaus et al. 1999). There is considerable scope for extending such methods of management, especially in countries with poorly developed geriatric services, and for providing more enabling interventions, such as physiotherapy and podiatry, rather than prosthetic interventions, such as home delivered meals (in this example, improving function might enable some disabled older people to do their own cooking) (O'Neill et al. 2004). As already noted, better co-ordination and a greater emphasis on preventive services have also been advocated as a way of reducing emergency admissions (Kendrick and Conway 2006).

From a policy point of view a further crucial question is whether providing more formal support services 'crowds out' family care or, conversely, whether the provision of supports to family carers enables more to care for longer.

Kunemund and Rein (1999) investigated this question in their analysis of data from the Commonwealth Fund survey. They pointed out that Germany had a strong level of family support and a relatively generous provision of formal assistance (as does Austria), while in the USA both were relatively weak and concluded that there was no evidence from their analysis of 'crowding out'. Penning and Keating (2000), in a review of the relevant literature, also concluded that formal and informal caregivers worked in partnership without formal care displacing family help. Liu et al.'s (2000) analysis of data from the US Long Term Care Surveys found that use of formal services increased between 1982 and 1994, which they attributed to changes in available funding, but this was not associated with displacement of informal services, rather it was combined use of both formal and informal care that expanded. Similarly, the introduction of free personal care in Scotland (but not in the rest of the UK) has led to families changing the type of support they provide, rather than withdrawing help (Bell and Bowes 2006). It does seem that in societies which provide more generous home care, such as Denmark or Norway, older people prefer formal to informal support for personal care needs and this preference seems to have strengthened (Daatland 1990). However, Daatland and Lowenstein (2005) in their analysis of variations in intergenerational help in a number of European countries and in Israel, concluded that easier access to welfare services had not 'crowded out' family care, but may have contributed to changing how families relate and enabled elderly people to maintain more independent relationships with their families (Daatland and Lowenstein 2005). It is important too to note that there may be disadvantages to relying on families to provide personal care (rather than help with IADLs which perhaps should be viewed rather as a normal part of intergenerational exchange). Firstly, it may have negative consequences for the health and well-being of family caregivers, particularly women with other conflicting aspirations and commitments (Evandrou 1996). Secondly, it may have negative psychological consequences for those older people who attach a high value to autonomy and 'not being a burden' (Lee 1985).

Conclusion: Looking to the Future

The large increase in the number of very old people in many developed societies will almost inevitably lead to greater requirements for assistance of various kinds, even if age-specific rates of disability fall to some extent. Currently, families provide much of this care and despite large falls in coresidence, levels of intergenerational exchange and support are high. It is important to note that reciprocity is a key feature of such relationships and support flows are often from older to younger people, at least until quite advanced ages (Cox and Rank 1992; Grundy 2005). There are a number of uncertainties about the future. Firstly, characteristics which are associated with reduced levels of contact and support, such as parental divorce and higher levels of education, are increasing in many populations. Secondly, in the longer term future the proportion of childless elderly people will increase again and for demographic and possibly also social reasons they will be less able to call on the traditional supports of past generations of single and childless older people – siblings and nieces and nephews. If serious disability is delayed until extreme old ages, then the risks of being predeceased by children (or of children having health problems of their own) may increase. However, more positively, improvements in the health of older people as a whole may effectively expand the pool of potential helpers and further reductions in mortality will further delay widowhood.

Estimates of future costs and needs are generally based on current usage patterns, sometimes with some modification to take account of possible changes in health and disability. More sophisticated forecasts might also sensibly take account of changes in marital status and the availability of children. There is a pressing need for more multigenerational studies which examine support exchanges, including care provision and care receipt from all sources, and also collect data on health, kin availability and social networks, including non family social networks. Policy makers need also to consider the potential supply of formal, as well as informal, carers. Caring jobs are often underpaid, undervalued and insecure. Initiatives to promote greater flexibility in the provision of formal services may have exacerbated this trend in some countries (Glendenning 1998). Such jobs may become increasingly unattractive to members of smaller, more highly educated cohorts with a wider range of other opportunities. Finally, it is important to note that the actual level of expenditure on long term care for elderly people is still relatively low (see Table 2) and that factors other than population ageing or family change have been the major driver of increasing health care costs. In many societies, there is considerable potential for expanding the economic contribution made by older people (by curtailing early retirement and extending working life). Additionally there is ample evidence of interventions and improvements in service delivery systems that have been shown to improve health and reduce disability. Demographic changes pose challenges for support systems, but much could be done to ameliorate these and improve the quality of life of older people and their supporters through appropriate implementation of evidence based policy and practice (Wanless et al. 2006).

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Care of the Elderly and Women's Labour Force Participation in Japan

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The purpose of this paper is to assess the effects of caring for the elderly on the labour force participation of middle-aged women in Japan. A problem with this kind of analysis is that causation operates in two directions: If a women works, she may have less time to care for an elderly parent (or parent-in-law), in which case the direction of causation is from woman's work to care of the elderly parent. On the other hand, if an elderly parent needs care, a woman may stop working in order to care for the parent, in which case the direction of causation is from care of the elderly parent to woman's work. The problem of two-way causation – the simultaneity problem as it is called in economics – often leads to difficult problems of estimation of effects.

This paper circumvents the problem of two-way causation by using measures of health of the elderly in place of measures of care of the elderly. The health status of an elderly parent, as indicated by his or her ability or inability to perform a set of activities of daily living, may be viewed as an exogenous or predetermined variable, so that causation is one-way, from elderly parent's health to daughter or daughter-in-law's work.

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Following a general discussion of economic and social changes in Japan that provides the context, our analysis begins with an examination of health expectancy of Japanese elderly persons. The approach is to decompose life expectancy after age 65 into healthy and unhealthy components and also into components indicating time spent living in various kinds of coresidence arrangements that reflect the ability of daughters and daughters-in-law to care for elderly parents. The coresidence arrangements examined incorporate the work status of the daughters and daughters-in-law.

The analysis of health expectancy is followed by logistic and multinomial logistic regression analyses of the impact of severity of parental disability on the labour force behaviour of currently married daughters and daughters-in-law living in the same households as their parents or parents-in-law. In order to control for the complexity of living arrangements, which can take many forms, this part of the analysis is restricted to households consisting of either an elderly person or a couple living with either one currently married daughter or one currently married daughter-in-law and her spouse and children, if any.

The analysis relies primarily on data from the first round of the Nihon University Japanese Longitudinal Study of Ageing (NUJLSOA), which was conducted by the Nihon University Center for Information Networking in late 1999 and early 2000.

Background

At present, Japan's population is ageing rapidly, as indicated by the rapid increase in the proportion of population over age 65. This population ageing is due not only to mortality decline, but also to rapid fertility decline, which raises the proportion over 65 by reducing the proportion at younger ages. Subsequent to a short post-World War II baby boom during 1947–1949, Japan's total fertility rate (TFR) fell more than 50%, from 4.54 to 2.04 children per woman between 1950 and 1957 (Hodge and Ogawa 1991; Ogawa and Retherford 1993b). After 1957, the TFR hardly changed until the first oil crisis of 1973, when it resumed its downward trend. By 1999, it had fallen to 1.34. As fertility fell during the post-war period, mortality also declined. In 1947, life expectancy at birth was 50 years for males and 54 years for females; by 1999, it was 77 years for males and 84 years for females. Japan now has the highest life expectancy of any country in the world. At present, the large cohorts born during the late 1940s are entering the retirement ages, followed by much smaller birth cohorts entering middle age. Population ageing is thus expected to accelerate during the next few decades. At the end of 2005 Japan became the oldest national population in the world (Ogawa and Retherford 1997; Ogawa 2000).

Although Japan's current demographic situation is similar in many ways to that of other industrialized countries, there are also some important differences that relate to how the elderly are cared for. Multigenerational households are still fairly common in Japan, whereas they are very rare in the West (Ogawa and Retherford 1997; Ogawa and Ermisch 1996). According to the 1996 round of the International

Survey of Lifestyles and Attitudes of the Elderly, the proportion of the elderly at ages 60 and over living in three-generation households was only 2% in both the United States and Germany, but 29% in Japan (Management and Coordination Agency 1997). The proportion of the elderly living in multigenerational households has, however, been falling rapidly. Time-series data on households with at least one elderly person age 65 or older show that the proportion of 3-generation households fell from 54% in 1975 to 27% in 1999 (National Institute of Population and Social Security Research 2000).

Another difference is that the legal status of the elderly is more firmly protected in contemporary Japanese society than in most other industrialized countries (Martin 1989). Before World War II, the old Civil Code, reflecting Confucian values of filial piety, provided family heads with legal authority over arranged marriages and primogeniture inheritance, thus reinforcing traditional family relations based on strong obligations between individuals in direct patrilineal descent (Sano 1958). These traditional family values were further reinforced by a shame culture involving deep sensitivity to social approval and absolute duties to parents (Benedict 1964). In post-war Japan, the new Civil Code imposed by the American occupation authorities largely eliminated the legal powers of elderly family heads over other family members. Nevertheless, traditional family values and practices, though eroding under conditions of an advanced industrial society, are still prevalent in many aspects of daily life, including care of elderly parents (Ogawa and Retherford 1993a, 1997).

A factor contributing to the erosion of traditional family values in Japan has been the growth of the social security system. Japan's social security system, including both old-age pension coverage and medical coverage, has expanded greatly in recent decades. Universal pension and medical coverage was established in 1961. Benefits have greatly increased subsequently. Between 1965 and 1997, social security benefits increased from 6% to 18% of national income (Social Insurance Agency 2000). An important factor contributing to the rapid increase in social security expenditures is extremely long hospitalization of elderly patients (Ogawa and Retherford 1997). Because social pressure dictates that children should take care of their parents, adult children usually place their parents in hospitals rather than in nursing homes, so that Japan's current level of institutional (i.e., nursing home) care for the elderly is lower than that for other industrialized nations (Maeda 2000). However, if long-term hospital care is counted as institutional care, the differences are smaller. Campbell and Ikegami (1998, p. 64) estimate that when long-term hospitalization is taken into account, the level of institutionalization of the elderly does not differ much between Japan and the United States, with about 6% of the population age 65+ institutionalized in either country.

Since the mid-1980s, the government of Japan has introduced a variety of policy measures to curb the escalating costs of medical care services for the elderly. Policy measures include the abolition of free medical care services for the elderly age 70 and over by requiring a 10% co-payment. In addition, the government has promoted the establishment of geriatric hospitals for long-term care, which are less costly to the government (but more costly for elderly patients and less profitable for private doctors who own small hospitals) than care in regular hospitals. In 1989, the government launched a major 10-year project called ‘the Golden Plan’ to promote in-home care for the elderly, as part of a strategy to shift some of the costs of caring for the elderly back to families (Ogawa and Retherford 1997). On the other hand, partly to mitigate the family’s burden in providing in-home care for frail elderly persons, the government introduced a major long-term care insurance scheme in 2000 (Campbell and Ikegami 2000a).

Because of persistent family traditions and values and limited use of institutional care, the living arrangements of Japanese elderly are characterized by considerable family support, with primary responsibility falling on middle-aged adult children, usually daughters-in-law or daughters. At present, approximately one-third of married Japanese women of childbearing age (below age 50) live with either their own or their husband’s parents and/or grandparents. Seventy-five percent of these coresident households are of the patrilocal type and the remaining 25% are matrilocal, involving coresidence with the wife’s parents (Population Problems Research Council 2000).

Research shows that coresidence in a multigenerational household tends to facilitate the labour force participation of middle-aged women, inasmuch as elderly parents provide built-in child care (Morgan and Hirosima 1983; Ogawa and Ermisch 1996). When these women have to quit their jobs to take care of elderly parents, there are opportunity costs in terms of lost earnings and interrupted career development, which are higher the more the woman is paid (Gibson 1992; Ogawa and Ermisch 1996). According to the 1997 Employment Status Survey, the proportion of female workers who quit their jobs during the 12 months preceding the survey in order to provide care for a family member was 10% among those age 40–49 and 14% among those age 50–59 (Statistics Bureau 1998).

Another difference between Japan and other industrialized nations concerns the trend in women’s labour force participation (Ogawa and Clark 1995; Retherford et al. 2001). In most industrialized nations, the labour force participation rate for women has risen sharply during the past few decades or so, but in Japan the rate for women age 15 and over fell from about 51% in the mid-1960s to about 46% in the mid-1970s, then rose to about 50% in 1999 (Statistics Bureau 2000).

The absence of any substantial overall trend over this period is the product of off-setting trends for different types of female labour force participation, namely a decline in family workers and an increase in paid employment outside the home (Ogawa and Hodge 1994). The proportion of married women participating in the labour force as family workers fell from 18% in 1972 to 5% in 1999 (Statistics Bureau 2000). According to Shimada and Higuchi (1985), the rise in the proportion of married women who are paid employees has been the most rapid in the recorded experience of advanced economies. Among married women age 15–54, the proportion working as paid employees rose from 22% in 1972 to 47% in 1999. Much of the increase in paid employment has been part-time employment, consistent with the frequently heard claim that Japanese female workers are marginal workers (Martin and Ogawa 1988). At the present time, among currently married women who are working, about half work part-time and half work full-time (Ogawa and Ermisch 1996).

Rising educational levels of women coupled with expanding job opportunities in the service sector have been the main engine driving the expansion of female paid employment. In 1955, only 5% of women of eligible age were enrolled in junior college or university, compared with 15% of men. By 2000, men and women had the same enrolment rate of 49% (Ministry of Education 2001). At the tertiary educational level, however, women are considerably more concentrated in junior colleges than are men, although this difference between women and men has been diminishing rapidly in recent years.

The wages of women in Japan, as in other advanced economies, are lower than the wages of men. The sex difference in wages is, however, considerably greater in Japan than in other advanced economies. Part of the sex differential in wages can be attributed to sex differentials in work experience and part to the relatively high incidence of part-time employment among Japanese women. The majority of Japanese women retire from full-time paid employment upon marriage or first birth and return to the labour market as part-time paid employees when their children are older. As already mentioned, among married women who are paid employees, about half work full-time and half part-time. As a result of rising educational levels of women, however, the opportunity costs of leaving full-time jobs have been rapidly increasing, thus making women more inclined to remain in the labour force and less inclined to resign from their jobs when they marry. Consequently, women's wage rates relative to men's have been gradually improving in recent years, as the proportion working full-time increases and the proportion working part-time decreases. Wage data compiled by the Ministry of Labour show that although the ratio of women's to men's hourly wages fluctuated between 0.57 and 0.59 between 1973 and 1991, it has been rising throughout the 1990s, reaching 0.65 in 1999 (Ministry of Labour, various years). It is expected that the wage ratio will continue to rise in years to come, in part because of the Equal Employment Opportunity Law of 1986, which was revised and strengthened in 1999.

An important question of considerable interest to the government is how rapid population ageing, which is placing increasing burdens of elderly care on middle-aged women, will affect women's labour force participation. If middle-aged women continue to work rather than provide care, the result is likely to be greater government outlays to provide care for frail elderly persons. With these concerns in mind, the analysis that follows attempts to assess the impact of the health status of elderly parents on the work status of their daughters and daughters-in-law.

Health Expectancy of the Elderly in Japan

It is useful first to examine health expectancy after age 65 in Japan in order to get a sense of the extent of old-age disability in the country. Our analysis of health expectancy relies primarily on data from the first round of the Nihon University Japanese Longitudinal Study of Ageing (NUJLSOA). The NUJLSOA is a nationally representative survey of community-dwellers, designed to be comparable in many respects with the United States LSOA. The first round of the NUJLSOA was conducted in November 1999 using a structured questionnaire. Multi-stage random sampling was used for sample selection. The initial sample size was 6,700. Of these, 4,640 were interviewed in November 1999. Proxy respondents were allowed to answer questions in cases where the original respondent was not competent to answer questions or not available at the time of the interview. Sampled persons who could not be interviewed, but did not strongly object to being interviewed in November, were contacted again in March 2000. Two versions of the questionnaire were prepared for the March interview. One was the same as the questionnaire used in November 1999 and the other was a shorter version designed for those who were hospitalized at the time of the November interview. The shorter version was intended to avoid underestimation of response from those who were not healthy in November 1999. Only those questions that could be answered by recalling the situation in November 1999 were asked. The March 2000 revisit resulted in 357 additional completed interviews. Of these, 308 answered the long questionnaire and 49 answered the short questionnaire. The total number of completed interviews increased to 4,997 persons age 65+. In the NUJLSOA, persons age 75+ are over-sampled by a factor of two. When analyzing the data, weights are applied to restore the representativeness of the overall sample of persons age 65+.

Another source of data used for health expectancy comparisons of Japan with other countries is the International Survey of Lifestyles and Attitudes of the Elderly. Since 1981, the Japanese government has undertaken an international comparative survey every 5 years. The primary objective of this international survey is to shed light on the work and income status of the elderly, their health conditions and their living environment. In each round of the survey, both Japan and the United States have been included as two core countries for international comparison. Other countries are also included in the survey, with the choice of these countries varying from round to round. In the most recent round in 1996, Thailand, the Republic of Korea and Germany were included. Sample size has varied slightly from country to country and from round to round, but has been close to 1,000 respondents per country in each round. Respondents were selected using two-stage stratified random sampling. In each survey round, information was obtained from respondents in face-to-face interviews. In this paper, we compare only Japan and the United States.

Methodology for calculating health expectancy has been described in detail elsewhere (see, for example, Crimmins et al. 1997; and Jagger 1999). The methodology allows decomposition of life expectancy after a given age (65 in our analysis) into healthy and unhealthy components. ‘Healthy’ and ‘unhealthy’ are often measured from a simple question on the respondent’s perception of his or her own health. Another approach, which is the one used in this paper, defines ‘healthy’ and ‘unhealthy’ according to the respondent’s ability to perform each of a number of specific activities of daily living (ADLs) and instrumental activities of daily living (IADLs). An internationally accepted standard list of ADLs and IADLs is used for this purpose in the NUJLSOA. ADLs include: (1) taking a bath/shower, (2) dressing, (3) eating, (4) standing up from a bed or chair and sitting down on a chair,

(5) walking around inside the house, (6) going outside the house and (7) going to the bathroom and being able to use the toilet. IADLs include: (1) preparing meals, (2) leaving the home to purchase necessary items or medication, (3) taking care of financial matters such as paying bills for utilities or newspapers, (4) using the telephone, (5) dusting, cleaning up and other light housework, (6) taking the bus or train when going outside the home, and (7) taking medicine as prescribed (Zimmer et al. 1997). In each case, the elderly respondent (or a proxy person answering for the elderly respondent) indicates four possible answers on each ADL or IADL: no difficulty, some difficulty, a lot of difficulty, or unable. (Only those who have difficulty are asked the degree of difficulty.) In some of our regression analyses, presented in the second part of this paper, these four possible answers are scored from 0 to 3 in ascending order of difficulty. The scores are then summed over seven ADLs and seven IADLs to yield a scale that ranges from 0 to 42. The scale can be treated as a continuous variable, or scores can be grouped in different ways to construct categorical variables. In our regression analysis, our main specification of health based on this scale distinguishes four categories, as will be discussed later. We also use other specifications of disability.

In the present analysis of health expectancy, we consider just two states, healthy and unhealthy, and we utilize Sullivan's (1971) method of decomposing health expectancy into healthy and unhealthy components. The method has been described in detail by Jagger (1999). One starts with a life table for mortality, usually in 5-year age groups up to age 90+, although other age cut-offs may be used. Typically this is an official life table published by the government agency responsible for mortality statistics. Starting with this life table, person-years lived in each 5-year age group are partitioned according to the proportions of those in the age group in the general population who are healthy and unhealthy (as ascertained in our analysis from the International Survey of Lifestyles and Attitudes of the Elderly or from the NUJLSOA, plus independent information on age-specific proportions institutionalized). To calculate health expectancy at, say, age 65, one sums healthy person-years lived at 65–69, 70–74, …, 85–89 and 90+ and then divides the sum by the life table number surviving to age 65. The unhealthy component of life expectancy is calculated in the same way. The two components add exactly to overall life expectancy at 65.

Table 1 shows comparable estimates of health expectancy after age 65 in recent years for Japan and the United States, based on data from the 1996 round of the International Survey of Lifestyles and Attitudes of the Elderly. The table shows that life expectancy at 65 is higher in Japan than in the United States by 1.1 years for men and 2.5 years for women. The proportion of life expectancy that is healthy, however, is slightly lower in Japan than in the United States. For women this proportion is 84% in Japan and 88% in the United States and for men it is 78% in Japan and 83% in the United States. It should be noted that, according to the World Health Organization (WHO 2000), Japan has the both highest life expectancy and the highest health expectancy after age 65 of any country in the world.

The estimates in Table 1 are based on respondent's perceptions of their own health, as indicated by a question with the following four answer categories: (1) healthy, (2) not very healthy, but no particular illness, (3) sometimes ill and have to stay in bed,

Table 1 Health expectancy at age 65 by sex in Japan and the United States, 1996

	Health expectancy					
	Men			Women		
Country, date	Healthy	Unhealthy	Total	Healthy	Unhealthy	Total
Japan, 1996						
Years	14.2	2.8	16.9	16.9	4.7	21.5
Percent	84	16	100	78	22	100
United States, 1996						
Years	13.9	1.8	15.8	15.8	3.1	19.0
Percent	88	12	100	83	17	100

Calculated from the 1996 round of the International survey of lifestyles and attitudes of the elderly, combined with information on institutionalized persons from Hashimoto (1998) in the case of Japan and Crimmins et al. (1997) in the case of the United States. Hashimoto's data on institutionalized persons pertain to 1995. The United States data on institutionalized persons pertain to 1990.
The partitioning of person-years lived into healthy years and unhealthy years is based on a question on the respondent's perception of his or her own health (whether he or she considers him- or herself to be healthy or unhealthy).

(4) stay in bed most of the time. We have defined 'healthy' by aggregating (1) and (2) and 'unhealthy' by aggregating (3) and (4). Within the 'healthy' category, a much higher proportion of Japanese than of Americans respond 'not very healthy, but no particular illness.' A likely reason for this is that Japan has a legal requirement that employees have a mandatory health check-up each year. The check-up is thorough, involving a number of blood tests and other tests, and the employee typically receives a medical report that indicates test results and a number of associated potential health problems in the future, even though the employee has no overt illness at the time of the check-up. In the U. S., in contrast, check-ups are generally not mandatory and a much lower proportion of persons get thorough annual check-ups.

Overall, Table 1 indicates that in both Japan and the United States, approximately four-fifths of life expectancy after age 65 is spent in a healthy state, as defined in this paper.

Figures 1 and 2 show more detailed estimates of health expectancy for Japan, with the unhealthy component of life expectancy broken down into three categories of increasing disability. As indicated in the footnotes to the figures, 'healthy' means no difficulty in performing each of seven ADLs and seven IADLs. 'Unhealthy' means either institutionalized or at least some difficulty in performing at least one ADL or IADL. Within the non-institutionalized unhealthy category, 'some difficulty' indicates some difficulty on at least one ADL or IADL but not 'a lot of difficulty' or 'unable' on any ADL or IADL. 'A lot of difficulty' indicates a lot of difficulty on at least one ADL or IADL but not 'unable' for any ADL or IADL. And 'unable' indicates inability to perform at least one ADL or IADL. The proportions shown are for 5-year age groups and are the same as those used below to partition person-years lived in 5-year age intervals in the calculation of healthy and unhealthy

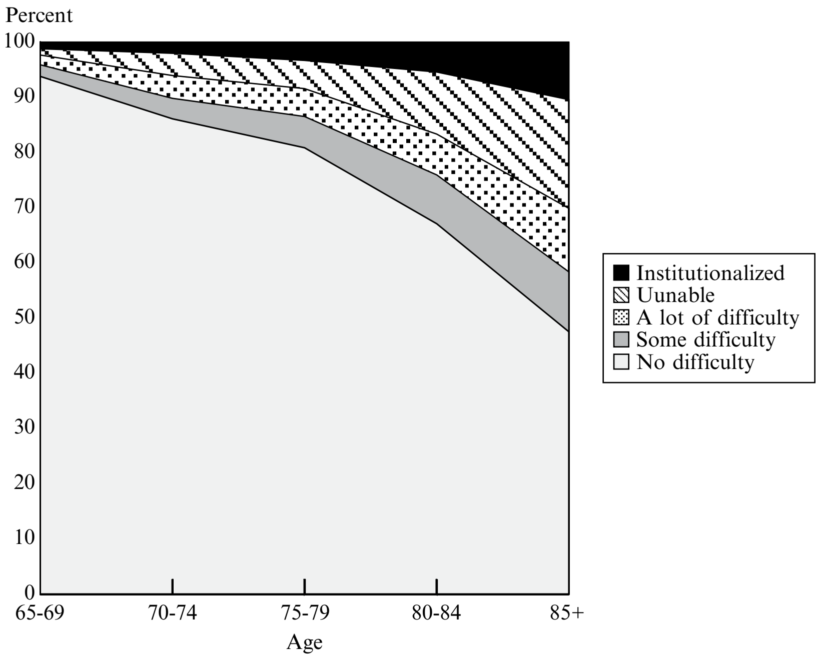

Fig. 1 Proportions healthy and unhealthy at selected ages: elderly men, Japan, 1999 (Calculated from NUJLSOA, combined with information on institutionalized persons from Hashimoto 1998). Hashimoto's data on institutionalized persons pertain to 1995. Population proportions institutionalized at each age are from (Hashimoto, 1998). Proportions healthy and unhealthy among the noninstitutional population are calculated from the NUJLSOA and then adjusted to pertain to the entire population. "Healthy" means no difficulty in performing each of seven ADLs and seven IADLs. "Unhealthy" means either institutionalized or at least some difficulty in performing at least one ADL or IADL. Within the noninstitutionalized unhealthy category, the label "unable" indicates inability to perform at least one ADL or IADL. The label "a lot of difficulty" indicates a lot of difficulty in performing at least one ADL or IADL but not "unable" for any ADL or IADL. And the label "some difficulty" indicates some difficulty in performing at least one ADL or IADL but not "a lot of difficulty" or "unable" for any ADL or IADL. The proportions shown are the same as those used to partition person-years lived in 5-year age intervals in the calculation of health expectancy in Figs. 3 and 4)

expectancy in Figs. 3 and 4. Even though ADLs and IADLs tap somewhat different aspects of disability, we have grouped them together because once an elderly person needs assistance for whatever reason, someone has to care for them.

In Figs. 1 and 2 at age 65–69, 94% of men and 89% of women report that they are healthy, according to the above definition. At age 85+, in contrast, only 48% of men and 29% of women report that they are healthy. Within the 'unhealthy' category, 'some difficulty' is the largest subcategory at age 65–69 for both men and women, whereas 'unable' is the largest subcategory at age 85+ for both men and women. Assuming that everyone who is institutionalized is 'unable', it is noteworthy that at age 85+ more than

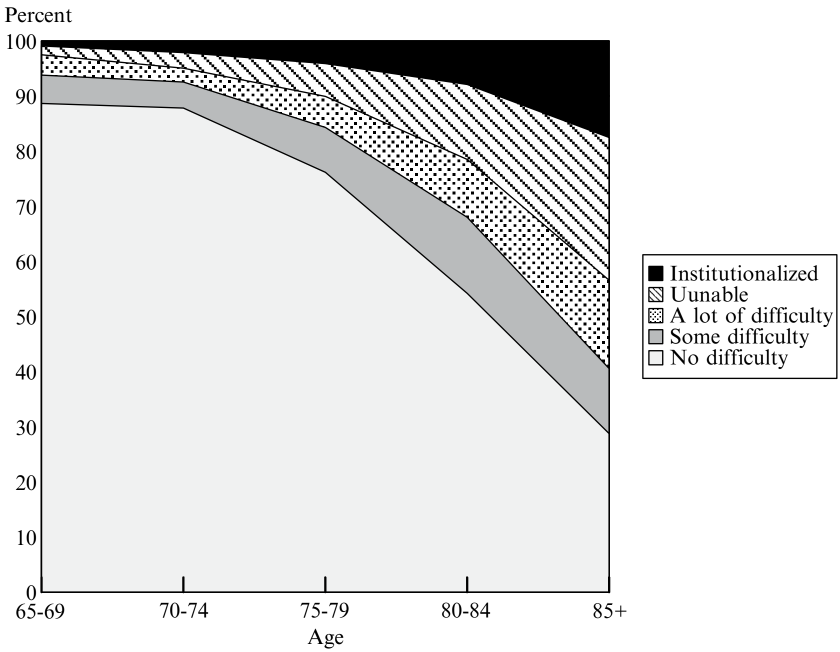

Fig. 2 Proportions healthy and unhealthy at selected ages: elderly women, Japan, 1999 (Calculated from NUJLSOA, combined with information on institutionalized persons from Hashimoto 1998). Hashimoto's data on institutionalized persons pertain to 1995. See Fig. 1)

half who are 'unable' are not institutionalized, suggesting that families shoulder more than half of the burden of caring for disabled parents. In Japan, however, there is a great deal of long-term hospitalization, which is often equivalent to institutionalization, suggesting that the percent institutionalized is underestimated and the percent 'unable', but not institutionalized, is overestimated in the two figures.

Whereas Figs. 1 and 2 decompose reported prevalence into healthy and unhealthy components in each 5-year age group, Figs. 3 and 4 decompose life expectancy into healthy and unhealthy components at exact ages 65, 70, 75, 80, and 85, by sex. The components of life expectancy corresponding to 'unable,' 'a lot of difficulty,' 'some difficulty,' and 'no difficulty' are indicated by the vertical distances between the curves. A striking aspect of these two figures is that the expected number of years spent in each category of the unhealthy state varies little by age. As age increases, the decline in remaining overall life expectancy is accounted for almost entirely by a decline in healthy years, as is also shown in the first panel of Table 2. Regardless of age, men can expect to live about three of their remaining years in an unhealthy state, and women can expect to live five to seven of their remaining years in an unhealthy state. Also regardless of age, the composition of those future unhealthy years changes little in terms of years spent in 'some difficulty', 'a lot of difficulty', 'unable', or institutionalized.

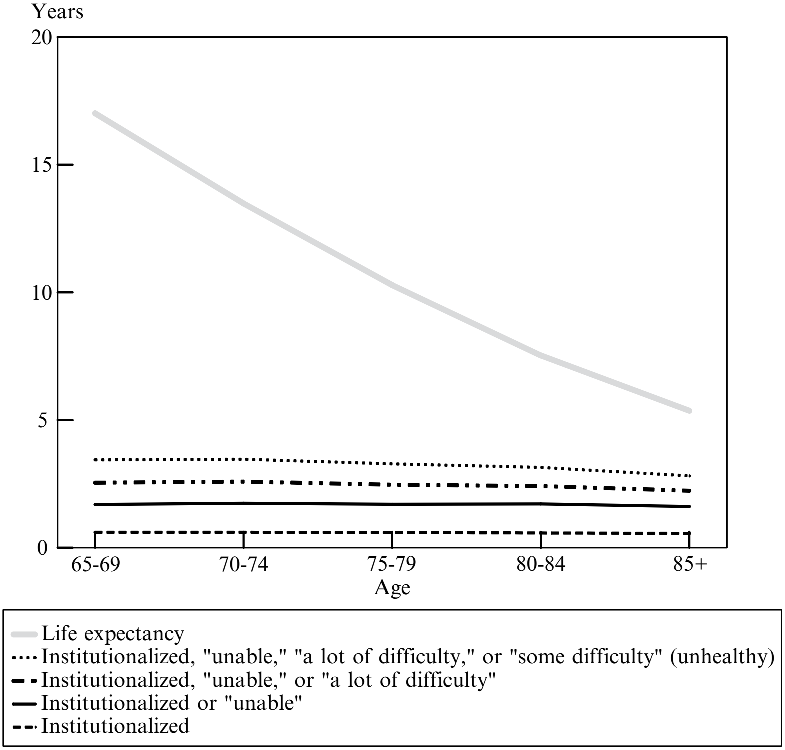

Fig. 3 Health expectancy at specified ages, cumulated over five health statuses: elderly males, Japan, 1999 (Calculated from NUJLSOA, combined with information on institutionalized persons from Hashimoto 1998). Hashimoto's data on institutionalized persons pertain to 1995. The five health statuses are defined as indicated in the note to Fig. 1. The components of life expectancy corresponding to "unable," "a lot of difficulty," "some difficulty, and "no difficulty" are indicated by the vertical distances between the curves)

As already noted, Table 2 shows that the proportion of remaining years spent in a healthy state is higher for men than for women, especially at older ages. This is a pattern that is also observed in many other developed countries (Robine 1998). At age 65, the proportion of remaining years spent in a healthy state is 80% for men and 68% for women. At age 85, the proportion spent in a healthy state is 48% for men but only 29% for women.

The Sullivan method can be used to partition remaining life expectancy not only by health status, but also by coresidence status. One simply partitions person-years lived at each age according to the proportion in each type of living arrangement instead of the proportion in each health status. The proportion in each type of living arrangement at each age is again calculated from the NUJLSOA. Coresidence status is of particular interest, because coresiding daughters or daughters-in-law are more likely to care for frail elderly parents than are non-coresiding daughters or

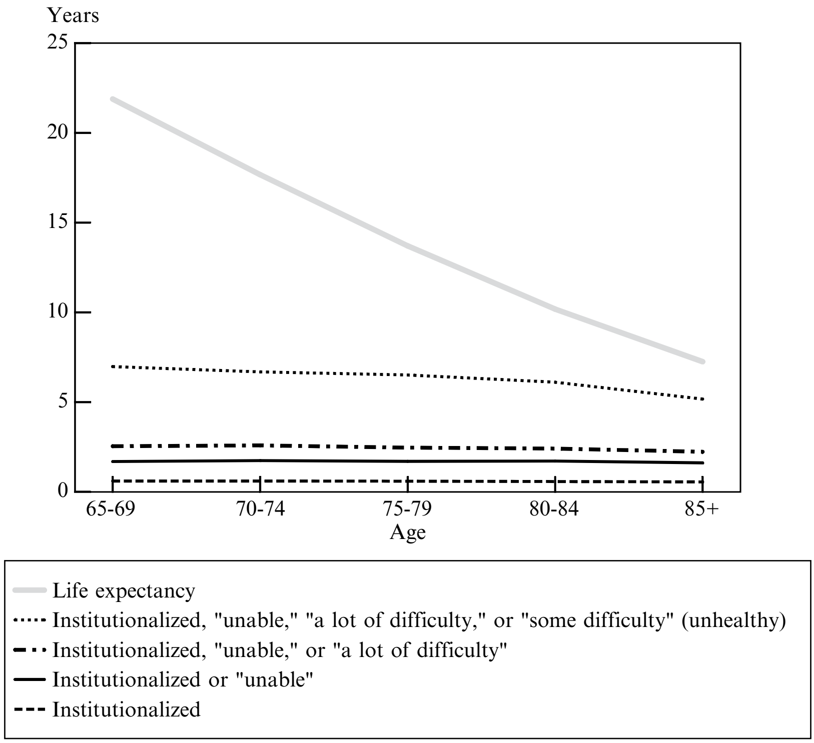

Fig. 4 Health expectancy at specified ages, cumulated over five health statuses: elderly females, Japan, 1999 (Calculated from NUJLSOA, combined with information on institutionalized persons from Hashimoto 1998). Hashimoto's data on institutionalized persons pertain to 1995. Note: See note to Fig. 3)

daughters-in-law. In partitioning life expectancy by coresidence status, we assume no differential mortality by type of living arrangement.

The second and third panels of Table 2 consider two alternative categorizations of coresidence. The first distinguishes 'living with spouse only,' 'living with spouse and others,' 'coresiding with others, but not spouse,' and 'institutionalized.' At age 65, in the case of men, 41% of remaining years are spent living with spouse only, 41% living with spouse and others, 9% living with others, but without spouse, 6% living alone, and 4% living in institutions. In the case of women, only 18% of remaining years are spent living with spouse and 19% with spouse and others. The percentage of remaining years spent living alone is more than twice as high for women as for men, and the time spent living with others, but without spouse is more than four times as high for women as for men, reflecting that on average, 65-year-old women live about 5 years longer than 65-year-old men. At age 85, the proportion of remaining years spent living with others, but without spouse is 21% for men and 63% for women.

Table 2 Decomposition of life expectancy into components: Japan, 1999

	Life expectancy at							
	65				85			
	Men		Women		Men		Women	
Components of life expectancy	Years	%	Years	%	Years	%	Years	%
Health status								
Healthy	13.6	80	14.9	68	2.8	48	2.1	29
Unhealthy[a]	3.4	20	7.0	32	2.6	52	5.2	71
Total	17.0	100	21.9	100	5.4	100	7.3	100
Coresidence (1)								
With spouse only	7.0	41	3.9	18	1.6	31	.2	2
Alone	1.0	6	3.5	16	0.4	7	1.0	14
With spouse and others	6.9	41	4.2	19	1.7	32	0.3	4
With others but w/o spouse	1.6	9	8.9	41	1.1	21	4.6	63
Institutionalized	0.6	4	1.4	6	0.6	10	1.3	17
Total	17.0	100	21.9	100	5.4	100	7.3	100
Coresidence (2)								
Coresiding with at least one daughter or daughter-in-law who works[b]	4.4	26	6.8	31	1.2	22	2.1	29
Coresiding with at least one daughter or daughter-in-law none of whom works	1.9	11	3.5	16	1.2	22	2.2	30
Not coresiding with a daughter or daughter-in-law[c]	10.7	63	11.6	53	3.0	56	3.0	41
Total	17.0	100	21.9	100	5.4	100	7.3	100

Calculated from the NUJLSOA, combined with information on institutionalized persons from Hashimoto (1998). Hashimoto's data on institutionalized persons pertain to 1995. Components may not add precisely to totals because of rounding.

[a]Includes persons who are institutionalized.

[b]Respondent is living with at least one daughter or daughter-in-law (irrespective of marital status), who is currently working either full-time, part-time, or in the traditional sector.

[c]Includes persons who are living alone and persons who are institutionalized.

The second categorization of living arrangements in Table 2 distinguishes 'coresiding with at least one daughter or one daughter-in-law who works,' 'coresiding with at least one daughter or daughter-in-law, none of whom works,' and 'not coresiding with a daughter or daughter-in-law.' At age 65, a man can expect to spend 26% of his remaining years coresiding with a daughter or daughter-in-law who works, 11% coresiding with at least one daughter or daughter-in-law, none of whom works, and 63% not coresiding with a daughter or daughter-in-law. A woman can expect to spend 47% of her remaining years coresiding, compared with 37% for men. The differences between men and women are somewhat larger at age 85, after which a woman can expect to spend 59% of her remaining years coresiding, compared with 44% for a man.

Table 3 partitions the NUJLSOA sample at ages 65–69 and 85–89 according to the proportion in each health status (healthy, unhealthy) who are currently in each type of living arrangement, defined by coresidence with and work status of daughter or daughter-in-law, by sex. The distributions by living arrangement do not differ much by health status at age 65–69, but they do differ considerably at age 85–89. At 85–89, both elderly men and elderly women – but especially elderly women – are much more likely to coreside with a daughter or daughter-in-law who does not work if they (the elderly parents) are unhealthy than if they are healthy. On the other hand,

Table 3 Distribution of the sample by health status and coresidence at age 65–69 and at age 85–89, by sex: Japan, 1999 (in %)

	Age			
	65–69		85–89	
Health and coresidence status	Men	Women	Men	Women
Healthy				
Coresiding with at least one daughter or daughter-in-law who works[a]	21	26	27	32
Coresiding with at least one daughter or daughter-in-law none of whom works	7	7	15	25
Not coresiding with a daughter or daughter-in-law[b]	72	67	58	43
Total	100	100	100	100
Unhealthy				
Coresiding with at least one daughter or daughter-in-law who works[a]	24	29	24	36
Coresiding with at least one daughter or daughter-in-law none of whom works	6	10	33	42
Not coresiding with a daughter or daughter-in-law[b]	70	61	43	22
Total	100	100	100	100

Calculated from NUJLSOA, combined with information on institutionalized persons from Hashimoto (1998). Hashimoto's data on institutionalized persons pertain to 1995. By 'working' is meant full-time, part-time, or traditional sector.

[a]Respondent is living with at least one daughter or daughter-in-law (irrespective of marital status) who is currently working either full-time, part-time, or in the traditional sector.

[b]Includes persons who are living alone and persons who are institutionalized.

the proportion coresiding with a daughter or daughter-in-law who works is only slightly higher for unhealthy parents than for healthy parents. Table 3 indicates that as parents get older, they are more likely to live with a daughter or daughter-in-law, but the increase is accounted for mainly by daughters and daughters-in-law who are not working. The proportion living with daughters or daughters-in-law who work does not increase much as parent's age increases.

The picture that emerges from this brief analysis of the components of health and health expectancy is that (1) a large majority of elderly, even at age 85–89, are in sufficiently good health that it is not necessary for daughters or daughters-in-law to quit their jobs to care for them; (2) even when parents are unhealthy, the proportion living with daughters or daughters-in-law who work changes little, compared with the proportion when parents are healthy. These findings suggest that health problems of elderly parents do not have much of an effect on the labour force participation of daughters and daughters-in-law. A more adequate examination of this question, however, requires the use of multivariate methods that statistically control for the potentially confounding effects of other variables that are correlated with the health status of elderly parents. This is the subject of the next section.

Effects of Health Status of Elderly Parents on Work Status of Coresiding Daughters and Daughters-in-Law

Analytical Framework and Brief Review of Previous Research

The past two decades have seen the formulation of several instructive economic models for analyzing a married Japanese woman's decision to participate in the labour force and her choice among alternative types of employment if she does participate. Hill (1983, 1989) developed a model in which a woman, faced with mutually exclusive choices among non-participation in the labour force and types of employment within it, compares the maximum utility attainable for each participation alternative and selects the alternative that yields the *maximum maximorum*. Using multinomial logistic regression, she fitted this model to data gathered in a small survey of women age 20–59 living in the Tokyo Metropolitan Area in 1975 and found differences in the determinants of labour force participation between paid employees and family workers. Using Heckman's (1980) procedure for correcting for sample selection bias, she also estimated equations for wages and hours of work for paid employees and family workers. Her empirical results for both employees and family workers generally confirmed the economic model's theoretical predictions. A particularly salient finding was that women's predicted wages play an important role in determining their labour supply in both the formal and informal sectors.

Using a similar analytical framework applied to data from a nationally representative sample survey conducted in 1988, Ogawa and Hodge (1994) analyzed differences in the determinants of participation of married Japanese women of reproductive age in full-time employment, part-time employment and traditional-sector work (i.e., small proprietors and family workers). Predictor variables having statistically significant effects on these various types of labour force participation included husband's annual earnings, wife's predicted annual earnings for full-time paid employment, wife's premarital work experience and patrilocal residence.

More recently, using data from a nationwide sample survey undertaken in 1990 and the standard model of female labour supply, Ogawa and Ermisch (1996) analyzed the pattern and determinants of married Japanese women's labour force participation. In this study, women's hourly pay was controlled for self-selection in a setting in which a woman chooses between full-time paid employment (s = 1), part-time paid employment (s = 2), working in the traditional sector (s = 3), and being a full-time housewife (s = 4). The basic model is

$$Y_s = \mathbf{Z}\tilde{a}_s + u_s \left(s = 1, 2, 3, 4\right) \qquad (1)$$

where Y_s is the utility associated with choosing work status s, **Z** is a vector of arguments of the indirect utility function, ã is a vector of parameters and u is a zero-mean random variable. Work status s is chosen if and only if

$$Y_s > \mathrm{Max} Y_j \left(j = 1, 2, 3, 4, \ j \neq s\right) \qquad (2)$$

The hourly wage-offer equations in full-time (s = 1) and part-time (s = 2) employment take the conventional form

$$w_s = \mathbf{X}\hat{a} + e_s \left(s = 1, 2\right) \qquad (3)$$

where e_s is a zero-mean random variable, **X** is a vector of variables that influence hourly wage offers and â is a vector of parameters. The hourly wage-offer equations are adjusted for potential selection bias using the method developed by Lee (1982).

Utilizing these hourly wage-offer equations, the expected value of hourly wages for each status was computed and incorporated as one of the exogenous variables in Eq. 1, which was operationalized in terms of a multinomial logit regression model of the determinants of choice of employment type.

Ogawa and Ermisch's findings suggest that although family structure is a more important factor in Japan than in other industrialized countries, the decision-making process involved in married Japanese women's participation in full-time paid employment is quite similar to that prevailing in other industrialized nations where human capital theory is more clearly applicable.

In the present study, we draw heavily on Ogawa and Ermisch's analytical framework. However, the NUJLSOA data set used in our analysis contains no information pertaining to a woman's annual earnings or hourly wages. For this reason, instead of estimating Eq. 3, we include woman's age and education as proxies for capturing the effect of her human capital on her choice of employment type.

Although there has been no previous research in Japan on the effect of caring for the elderly on woman's labour force participation, there have been a number of such studies conducted in other industrialized countries. Using a simultaneous equations model applied to data from the United States, Wolf and Soldo (1994) estimated the effect of caring for elderly parents on married women's labour force participation. They found that caring for an elderly parent had no effect on whether a woman was employed or on her hours of work. Using the same data set used by Wolf and Soldo, but applying instrumental-variable methods to correct for possible endogeneity bias, Ettner (1995a) found, in contrast to what Wolf and Soldo found, that care giving reduced adult children's work hours, although the effect was statistically significant only for women providing care to parents residing outside the household. A similar finding was also obtained by Stern (1995) and Ettner (1995b).

Not only are the conclusions of previous studies mixed, regarding the relationship between married women's work participation and caring for elderly parents, but also the approaches to the reverse-causation problem vary. For example, McLanahan and Monson (1990) treated the provision of parental care by married women as an exogenous variable, while Dwyer and Coward (1991) allowed for possible reverse-causation. The study by McLanahan and Monson concluded that married women's provision of care for elderly parents negatively affected married women's labour force participation, whereas Dwyer and Coward found that married women's full-time paid employment significantly reduced the likelihood of their providing assistance to their frail parents to perform activities of daily living.

As mentioned earlier, our analysis avoids the problem of reverse-causation by using parental health status in place of care giving as an explanatory variable. In this case, the direction of causation is clearly one-way, from parental health to adult daughter or daughter-in-law's work participation. Further details of our analytical model are given in the next section.

Empirical Analysis

Our empirical analysis focuses on the effects of health status of elderly parents age 65 and over on the work status of daughters and daughters-in-law. Such an analysis requires that the daughters and daughters-in-law be the units of analysis. This is potentially a problem, because in the NUJLSOA, elderly persons are the primary respondents and therefore the natural units of analysis. Moreover, in any given household, only one elderly person is the primary respondent. If other elderly persons are present (in most cases an elderly spouse), additional information is collected for these coresiding elderly persons, but not as much information as is collected for the primary respondent. Because of the sample design, it is problematic to transform the data set so that daughters and daughters-in-law are the units of analysis inasmuch as these new units of analysis are not a representative sample of daughters and daughters-in-law in the general population.

Partly because of the problem of units of analysis, we decided to restrict the sample to coresiding households consisting of either an elderly person or couple living with either one currently married daughter or one currently married daughter-in-law (but not both) and her spouse and children, if any, so that there is a one-to-one correspondence between the primary elderly respondent and a coresiding daughter or daughter-in-law. Because of this one-to-one correspondence, either the elderly respondent or the daughter or daughter-in-law can be viewed as the unit of analysis. This strategy also has the advantage of effectively controlling for coresidence, which otherwise is a variable that itself has a strong effect on women's labour force participation. We further restricted the sample to eliminate households containing any additional persons besides the married daughter or daughter-in-law and her immediate family, as well as households where either the daughter or daughter-in-law or her husband was in poor enough health that she or he could not care for anyone else in the household. The purpose of these exclusions was to restrict the possibility of care by the daughter or daughter-in-law to caring for her own children and her elderly parent(s). The exclusions effectively control for the effects of these more complicated configurations of care by eliminating them from the sub sample that is analyzed.

The two basic models are shown in Table 4 and both are fitted to the weighted data. One is a logistic regression (or logit) model, with 'working' (full-time, part-time, or traditional sector) as a two-category response variable, with 'housewife' as the reference category. The other model is a multinomial logistic regression (or m-logit) model, with a four-category response variable: 'full-time,' 'part-time,' 'traditional sector,' and 'housewife.' In this case, 'part-time' was chosen as the reference category, because it turns out that severity of parent's disability has opposite effects on full-time and part-time employment, so that choosing 'part-time' as the reference category maximizes the contrasts between the reference category and the other categories.

The predictor variables are the same in both models. Health status of the elderly parent, which is the predictor variable of primary interest, is operationalized in terms of severity of disability, which is a four-category variable, with categories 'no difficulty,' 'some difficulty,' 'a lot of difficulty' and 'unable' defined as follows: 'No difficulty' indicates that the respondent has no difficulty on any of the seven ADLs and seven IADLs discussed earlier. 'Some difficulty' indicates some difficulty on at least one ADL or IADL but not 'a lot of difficulty' or 'unable' on any ADL or IADL. 'A lot of difficulty' indicates a lot of difficulty on at least one ADL or IADL but not 'unable' for any ADL or IADL. 'Unable' indicates inability to perform at least one ADL or IADL. These are the same definitions used earlier in Figs. 1 and 2.

The remaining predictor variables, which serve as control variables, although their effects are interesting in their own right, are chosen because they are likely to be correlated with severity of disability, or because they are likely to have an effect on woman's work, or both. The predictor variables are presented in two groups, one pertaining to characteristics of the elderly parent (the primary respondent in the NUJLSOA) and the other to the daughter or daughter-in-law. In the case of categorical variables, the reference category for a variable is indicated by a dagger next to the appropriate category name in the row labels in Table 4.

Table 4 Among elderly parents coresiding with either a married daughter or a married daughter-in-law, the effect of severity of the elderly parent's disability on the probability that the daughter or daughter-in-law works: Japan, 1999 (probabilities expressed as percentages) (Calculated from the NUJLSOA)

Predictor variable	Mean of predictor variable[a]	Logit model: probability of working[b]	M-logit model: probability that the daughter or daughter-in-law is: Full-time worker	Part-time worker[c]	Traditional-sector worker	Housewife
Parent's characteristics:						
Severity of parent's disability[d]						
No difficulty[c]	.81	74	33	20	19	28
Some difficulty	.07	75	37	18	19	27
A lot of difficulty	.05	73	28	18	25	29
Unable	.07	75	42[e]	11	20	26
Parent's sex						
Male[c]	.36	72	34	20	17	30
Female	.64	75	34	18	21	28
Parent's age						
65–74[c]	.49	80	37	22	19	22
75–84	.43	68[f]	33	15	18	34[f]
85+	.08	60[f]	18	22	17	43
Parent's spouse's health						
Healthy (able to provide care)	.36	77[e]	38	15	22	25
Not healthy[c]	.14	68	34	17	15	34
Spouse dead or living elsewhere	.50	73	31	22	18	29
Parent's education						
Jr. high or less[c]	.69	75	35	18	19	27
Sr. high	.26	73	28	20	24	29
Jr. college or university	.05	67	44	14	7	35
Parent's annual income (millions of yen)[g]	2.36					
1	–	75	36	19	18[e]	27
5	–	71	29	17	22[e]	31
10	–	66	21	14	28[e]	36

(continued)

Table 4 (continued)

Predictor variable	Mean of predictor variable[a]	Logit model: probability of working[b]	M-logit model: probability that the daughter or daughter-in-law is			
			Full-time worker	Part-time worker[c]	Traditional-sector worker	Housewife
Residence						
Urban	.52	68[f]	27[f]	22	17[f]	34
Rural[c]	.48	80	42	15	21	22
Parent has non-coresident daughter residing in same locality						
Yes	.33	73	33	17	21	29
No[c]	.67	74	34	20	18	28
Daughter or daughter-in-law's characteristics:						
Relationship to parent						
Daughter[c]	.16	71	34	16	19	31
Daughter-in-law	.84	74	34	19	19	28[e]
Age						
<40[c]	.26	67	29	16	19	35
40–49	.47	77[e]	37	22	16	25[e]
50–59	.24	75	35	16	23	27
60+	.03	63	18	19	29	40
Education						
Junior high[c]	.13	73	34	16	22	29
Senior high	.59	73	27[e]	25	19	29
Junior college	.17	76	45	15	15	25
University	.10	77	52[f]	5	19[e]	24[e]
Number of pre-school children	.20					
0	–	74	36[f]	17	19	28
1	–	73	26[f]	25	19	29
2	–	71	18[f]	34	19	29

Number of elementary school children	.39					
0	–	74	36[e]	18	19	28
1	–	73	31[e]	20	20	29
2	–	71	26[e]	23	21	31
Number of children in junior high or higher	1.54					
0	–	62[f]	31[f]	12	17	40[f]
1	–	70[f]	33[f]	16	18	32[f]
2	–	77[f]	34[f]	21	20	25[f]
Husband's age						
<45[c]	.31	76	40	19	15	26
45–54	.50	75	32	19	22	26
55–64	.17	65	26	17	19	38
65+	.02	61	30	7	22	42
Husband's education						
Junior high[c]	.12	77	30	29	17	25
Senior high	.53	75	35[f]	16	22[f]	27[e]
Jr. college or university	.35	71	33	19	16	32[e]
Observed percentage in each employment category	–	71	33	19	19	29
Predicted percentage in each employment category (all predictors set at their mean values)	–	74	34	19	19	28

Probabilities are predicted values based on one underlying logit regression and one underlying multinomial logit regression. The subsample on which the table is based consists only of persons living in households containing an elderly respondent and either one currently married daughter or one currently married daughter-in-law but not both. Households with additional relatives or nonrelatives are excluded. Also excluded are households in which the daughter or daughter-in-law says that she is not healthy enough herself to provide care for another person in the household. Although the primary respondents in the NUJLSOA are elderly persons, the subsample considered here is characterized by a one-to-one relationship between the elderly respondent and either a married daughter or a married daughter-in-law coresiding in the same household. Therefore, we are able to treat daughters and daughters-in-law as the units of analysis in the logit and m-logit regressions. Values for a particular variable in any given panel in the table (e.g., the panel on severity of disability) incorporate controls for all the other predictor variables included in the regressions. These other variables are controlled by setting them equal to (i.e., holding them constant at) their mean values in the underlying regressions (Retherford and Choe 1993). The underlying logit and m-logit regressions (coefficients, standard errors, *t*-values, and observed levels of significance) are shown in Appendix Tables A1 and A2. The sample size for this analysis is 1,044 daughters and daughters-in-law, among whom 307 work full-time, 340 work part-time, 198 work in the traditional sector, and 199 are housewives

(continued)

Table 4 (continued)

Predictor variable	Mean of predictor variable[a]	Logit model: probability of working[b]	M-logit model: probability that the daughter or daughter-in-law is			
			Full-time worker	Part-time worker[c]	Traditional-sector worker	Housewife

[a]Although there is no dummy variable representing a reference category, the proportion of cases falling in each reference category is also shown. Note that the mean of a dummy variable is the same as the proportion of the subsample that is contained in the category represented by the dummy variable. The means of continuous variables, of course, cannot be interpreted in this way.

[b]Probability that the daughter or daughter-in-law is working (full-time, part-time, or traditional sector). Note that the proportion working predicted by the logit model differs slightly from the proportion working predicted by the m-logit model.

[c]Denotes a reference category in the underlying logit or m-logit regression.

[d]'No difficulty' indicates that the respondent has no difficulty on any ADL or IADL. 'Some difficulty' indicates some difficulty on at least one ADL or IADL but not 'a lot of difficulty' or 'unable' on any ADL or IADL. 'A lot of difficulty' indicates a lot of difficulty on at least one ADL or IADL but not 'unable' for any ADL or IADL. 'Unable' indicates inability to perform at least one ADL or IADL.

[e]Indicates that the underlying logit or m-logit regression coefficient is significant at the 10% level.

[f]Indicates the underlying logit or m-logit regression coefficient is significant at the 5% level or better.

[g]Includes annual income of both parent and parent's spouse (if spouse is alive and present in the household) together, but no one else.

Regarding characteristics of elderly parents, parent's sex (male, female) and parent's age (65–74, 75–84, 85+) are included as predictors in the regressions because they are likely to be correlated with severity of disability. Parent's spouse's health (healthy in the sense of being able to provide care to others, not healthy, spouse dead or living elsewhere) is included because a healthy spouse can relieve a daughter or daughter-in-law of caring for the elderly respondent.[1] Parent's education (junior high, senior high, junior college or university) is included because education is a major determinant of health. Parent's income (continuous variable measured in millions of yen[2]) is included because a higher income may relieve a daughter or daughter-in-law of the necessity of working. Residence (urban, rural) is included because previous research has shown that residence has a major effect on women's labour force participation (Shimada and Higuchi 1985; Ogawa and Ermisch 1996). 'Parent has non-coresident daughter residing in the same locality' (yes, no) is included because such a daughter might help the coresident daughter or daughter-in-law in caring for the parent, thus making it easier for the coresident daughter or daughter-in-law to work.

Regarding characteristics of the daughter or daughter-in-law, relationship to elderly parent (daughter, daughter-in-law) is included in the set of predictor variables because a daughter is more likely than a daughter-in-law to quit her job to care for an elderly parent. Age of the daughter or daughter-in-law (<40, 40–49, 50–59, 60+) and her education (junior high, senior high, junior college, university) are included because both age and education are positively correlated with earnings, which affect work attachment. Higher earnings, for which we have no direct measure, increase the opportunity costs of quitting a job to care for a parent. Number of the daughter or daughter-in-law's preschool children (continuous variable) and number of her elementary school children (continuous variable) are included because caring for young children may conflict with outside employment. Number of children in junior high or higher level of education (continuous variable) is included because many women with children at this level work to earn money for *juku* (private cram schools for studying for entrance examinations at higher educational levels) expenses, making them less likely to quit work to care for an ailing parent. (Rural women are even more likely to work to earn money for school expenses so that their children can attend school in urban areas, where they have additional lodging expenses that urban children who live at home don't have; this is the main reason why we expect rural residence to have a positive effect on women's labour force participation, relative to urban residence.) The daughter or daughter-in-law's husband's age (<45, 45–54, 55–64, 65+) and husband's education (junior high, senior high, junior college or university) are included, because they are positively correlated with husband's earnings (for which we have no direct measure) up to retirement age and negatively correlated subsequently, thereby affecting the financial necessity of his wife's working. Daughter or daughter-in-law's age and husband's

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[1] The NUJLSOA ascertained for every person in the household whether he or she was capable of caring for someone else.

[2] At the time this paper was written, the exchange rate was 117 yen to the U. S. dollar.

age are both included because of their theoretical relevance, even though they are correlated at 0.92.

The size of the subsample for this analysis is 1,044 elderly respondents or, equivalently, 1,044 daughters and daughters-in-law. The distribution of these women by work status is shown in the next-to-last row of the table: 33% work full-time, 19% work part-time, 19% work in traditional-sector jobs and 29% are housewives. The last row of Table 4 shows that the predicted percentage agrees closely with the observed percentage in each employment category. The agreement is closer for the m-logit model than for the simple logit model.

The distribution of the subsample on each of the categorical predictor variables is shown in the first column of Table 4, which shows means of the predictor variables. In the case of a dummy variable representing a particular category of a predictor variable, the mean of the dummy variable indicates the proportion of the sub sample that belongs to that category. The proportion in the reference category for each categorical variable is also shown, even though there is no predictor variable representing it in the regressions. In the case of the severity-of-parent's-disability variable, 81% have no difficulty and the remainder of the elderly respondents in the subsample are more or less evenly distributed among 'some difficulty,' 'a lot of difficulty,' and 'unable.' Almost two-thirds of the elderly respondents are female. Forty-nine percent are age 65–74, 43% are age 75–84 and 8% are age 85+. Thirty-six percent of elderly respondents have a spouse who is still healthy enough to care for others, 14% have a spouse who is not healthy enough to care for others and for 50% the spouse is either dead or living elsewhere. Sixty-nine percent of elderly respondents have only a junior high education and only 5% have gone to junior college or university. The average annual income of the elderly respondent and his or her spouse (if any) is 2.36 million yen. The sub sample is close to evenly split between urban residence and rural residence, indicating that coresidence is much more common in rural areas than in urban areas, inasmuch as the urban proportion is 78% in the country as a whole, as indicated by Japan's 1995 Census.

Thirty-three percent of the elderly respondents have a non-coresident daughter living in the same locality. Among the coresident daughters and daughters-in-law, 84% are daughters-in-law, reflecting the traditional pattern whereby the eldest son and his wife coreside with the parents. Almost half of the daughters and daughters-in-law are age 40–49 and only 3% are age 60+. Inasmuch as age 60 is the typical retirement age for women, this means that the vast majority of working daughters and daughters-in-law would have to quit their job to care full-time for an elderly parent. Fifty-nine percent of the daughters and daughters-in-law have a senior high education, but only 10% have a university education. The mean number of preschool children is 0.20, the mean number of elementary school children is 0.39 and the mean number of children in junior high or higher level of education is 1.54. Half of the husbands of the daughters and daughters-in-law are age 45–54 and only 2% are past the retirement age of 65. Slightly more than half of the husbands have a high school education and slightly more than a third have a junior college or university education (mostly university, because very few men attend junior colleges, which are attended almost exclusively by women).

The logit model shows that severity of parent's disability has no effect on whether a woman (i.e., a daughter or daughter-in-law) works. When type of work is broken down into three categories in the m-logit model, however, it is seen that 'unable' on at least one ADL or IADL sharply increases the probability that the daughter or daughter-in-law works full-time and sharply decreases the likelihood that she works part-time. Severity of disability has little effect on the probability of working in the traditional sector (small proprietor or family farm or business where the woman's place of work is usually in or adjacent to the home). We conjecture that this pattern occurs because long bouts of hospitalization frequently occur when a parent becomes 'unable' on an ADL or IADL, simultaneously freeing a daughter or daughter-in-law to work full-time outside the home and creating a need to work full-time to help defray the costs of co-payments and other costs associated with long-term hospitalization. In Japan, long-term hospitalization is often equivalent to institutionalization. Institutionalization does not enter into the analysis, however, because when an elderly person is institutionalized, they are no longer considered coresident, and the analysis underlying Table 4 is restricted to coresident households. Later we shall examine a number of alternative specifications of the severity variable in order to make sure that alternative specifications of this variable produce similar results.

The effects of the control variables are also of interest. Parent's sex has no effect on the work status of the daughter or daughter-in-law. Parent's age has a strong negative effect on the probability that the daughter or daughter-in-law is working, even after severity of disability and all the other predictor variables are controlled. The m-logit model indicates that the main effect of parent's age is on full-time work by the daughter or daughter-in-law. It is plausible that parent's age captures some of the effect of severity and that if one were to omit parent's age from the models, the effect of severity would increase. But this is not the case. When we omitted parent's age from the models, the effect of severity increased only slightly. We conjecture that the decision by the daughter or daughter-in-law to quit a full-time job is based on an accumulation of illness episodes by the elderly parent. This decision is evidently more closely correlated with the parent's age than with the severity of any particular illness episode at the time of the survey. There may also be a generational effect operating, inasmuch as older parents tend to be more traditional and more expecting of support. This greater expectation of support may influence the labour force behaviour of the daughter or daughter-in-law. This influence is probably small, however, because there is no generational effect associated with the daughter or daughter-in-law's age, which is held constant when looking at the effect of elderly parent's age.

Another predictor variable that we experimented with, but ultimately deleted from the models was whether the daughter or daughter-in-law's husband was working or not. Our hypothesis was that a nonworking healthy husband (probably retired early) would be available to care for an elderly parent and therefore make it easier for his wife to work. In other words, our hypothesis was that 'husband not working' would have a positive effect on the probability that his wife works. Even though only 3% of husbands (34 unweighted cases) in the sub sample were not working, this variable has a strong and highly statistically significant negative effect on the wife's probability of working, contrary to our initial hypothesis of a positive effect. Upon further investigation, it turned out that the severity of parent's disability was very high in the case of nonworking husbands, suggesting that the husband retired early in order to move in with the elderly parent, perhaps back in the elderly parent's home town, necessitating a major move so that both husband and wife had to quit their jobs – hence the negative effect on wife's labour force participation. Inclusion of 'husband not working' in the models reduces slightly the effect of severity of disability, because the two variables are highly correlated. Because 'husband not working' is in effect an indirect measure of severity, and because it picks up some of the effect of severity, we decided to delete 'husband not working' from the models in order to concentrate the effect of severity in the severity variable itself.

In Table 4 in the logit model, parent's spouse's health (able to provide care) has a rather small, but marginally significant, effect on the probability that the daughter or daughter-in-law is working, and the effect is positive as hypothesized, the reasoning being that the respondent's spouse is able to care for the ailing respondent, thereby allowing the daughter or daughter-in-law to work. Parent's education has no effect on daughter or daughter-in-law working. Parent's income has a negative effect, as hypothesized, especially on full-time work, but the effect is not statistically significant. Rural residence has a strong positive effect on work, especially full-time work, as hypothesized. Whether the parent has a non-coresident daughter living in the same locality has no effect on the coresident daughter or daughter-in-law's probability of working.

A coresident daughter-in-law is more likely to work than a coresident daughter, but the effect is only marginally significant in the m-logit model and not significant even at the 10% level in the logit model. A daughter or daughter-in-law is more likely to work if she is 40–49 than if she is in another age group. A daughter or daughter-in-law with a university education is more likely to work than a daughter or daughter-in-law with a junior high education, and the effect is highly statistically significant for full-time work. The effect of a university education on part-time work is negative. Number of pre-school children has a strong negative effect on mother's full-time work and a strong positive effect on mother's part-time work, but little effect on mother's overall probability of working. Number of elementary school children has similar, but somewhat smaller, effects. Number of children in junior high or higher level of education has a strong positive effect on mother's probability of working, mainly on part-time work. This is consistent with other evidence that many women tend to take up part-time work as their children get older in order to help pay for their educational expenses (*juku*, college and university). Daughters and daughters-in-law with husbands age 55–64 and 65+ tend to work less than those with husbands in younger age groups, perhaps because younger husbands tend to earn less. Husband's education has no consistent effect on the daughter or daughter-in-law's probability of working.

Table 5 tests alternative specifications of the severity-of-parent's-disability variable to see if alternative specifications of severity make any difference in the results. Twenty different specifications of severity are considered, of which 14 correspond to severity of each ADL and each IADL considered separately and six are different

Table 5 Effect of severity of elderly parent's disability on the probability that his or her coresident daughter or coresident daughter-in-law works, using various specifications of the severity variable: Japan, 1999 (probabilities expressed as percentages) (Calculated from the NUJLSOA)

Alternative specifications of the severity-of-parental-disability variable	Mean of predictor variable	Logit model: probability of working[a]	M-logit model: probability that the daughter or daughter-in-law is: Full-time worker	Part-time worker[b]	Traditional-sector worker	Housewife
Severity of parent's disability[c]						
No difficulty[b]	.81	74	33	20	19	28
Some difficulty	.07	75	37	18	19	27
A lot of difficulty	.05	73	28	18	25	29
Unable	.07	75	42[d]	11	20	26
Severity (above variable dichotomized)						
No, some, or a lot of difficulty	.93	74	33[d]	19	19	28
Unable	.07	75	42[d]	11	20	26
Severity as a continuous variable on a scale from 0 to 42[e]	2.01					
1	–	74	34[d]	19	19	28
5	–	74	39[d]	12	21	28
10	–	75	44[d]	8	22	26
Four levels of severity (0, 1–2, 3–10, 11+) on the 42-point scale						
No disability[b]	.80	74	33	20	19	28
Low disability	.07	75	34	18	21	27
Medium disability	.07	74	31	17	24	28
High disability	.06	74	45[d]	11	17	27
Two levels of severity (0, 1+) on the 42-point scale[f]						
No disability[b]	.78	74	33	20	19	28
Some disability	.22	74	37[d]	15	21	27
Two levels of severity (0–10, 11+) on the 42-point scale[g]						

(continued)

Table 5 (continued)

Alternative specifications of the severity-of-parental-disability variable	Mean of predictor variable	Logit model: probability of working[a]	M-logit model: probability that the daughter or daughter-in-law is			
			Full-time worker	Part-time worker[b]	Traditional-sector worker	Housewife
Low disability[b]	.94	74	33	19	19	28
High disability	.06	74	45[d]	11	17	27
Severity in terms of taking a bath or a shower (ADL 1)						
No difficulty[b]	.94	73	33	19	19	29
Some difficulty	.01	90	41	32	16	10[d]
A lot of difficulty	.02	80	69[h]	6	7	18[d]
Unable	.03	69	33	3	31[h]	34
Severity in terms of dressing (ADL 2)						
No difficulty[b]	.94	74	33	19	19	28
Some difficulty	.02	85	22	32	28	18
A lot of difficulty	.02	70	54	7	10	29
Unable	.02	73	38	4	29	29
Severity in terms of eating (ADL3)						
No difficulty[b]	.97	74	33	19	19	28
Some difficulty	.01	95	52	26	16	6
A lot of difficulty	.01	66	26	8	30	36
Unable	.01	67	47	15	5	33
Severity in terms of standing up from a bed or chair or sitting down on a chair (ADL 4)						
No difficulty[b]	.94	74	33	19	20	28
Some difficulty	.03	76	57[h]	8	11	24
A lot of difficulty	.01	74	42	17	13	28
Unable	.02	60	38	3	18	41[d]

Severity in terms of walking around inside the house (ADL 5)						
No difficulty[b]	.96	74	33	19	20	28
Some difficulty	.01	91[d]	82[h]	4	7	8
A lot of difficulty	.01	56	22	23	9	46
Unable	.02	69	47	0	21	33
Severity in terms of going outside the house (ADL 6)						
No difficulty[b]	.89	74	33	19	19	28
Some difficulty	.05	68	29	20	16	35
A lot of difficulty	.03	84	52	24	7	16
Unable	.03	73	37[d]	4	30[h]	29[d]
Severity in terms of toileting (ADL 7)						
No difficulty[b]	.96	74	33	19	19	28
Some difficulty	.01	81	60	0	22	18
A lot of difficulty	.01	77	53	10	15	22
Unable	.02	68	38	6	22	34
Severity in terms of preparing meals (IADL 1)						
No difficulty[b]	.92	74	33	19	19	28
Some difficulty	.02	72	39	10	23	29
A lot of difficulty	.02	83	50	15	18	17
Unable	.04	72	31	13	26	30
Severity in terms of shopping for necessary items and medications (IADL 2)						
No difficulty[b]	.88	74	33	19	19	28
Some difficulty	.04	82	37	23	20	20
A lot of difficulty	.03	68	41	12	14	33
Unable	.05	75	39[d]	9	25[d]	27
Severity in terms of paying bills (IADL 3)						
No difficulty[b]	.93	74	33	19	19	28
Some difficulty	.01	87	56	18	12	13
A lot of difficulty	.02	77	50	11	16	23

(continued)

Table 5 (continued)

Alternative specifications of the severity-of-parental-disability variable	Mean of predictor variable	Logit model: probability of working[a]	M-logit model: probability that the daughter or daughter-in-law is: Full-time worker	Part-time worker[b]	Traditional-sector worker	Housewife
Unable	.04	73	31	12	27	29
Severity in terms of using telephone (IADL 4)						
No difficulty[b]	.94	74	34	20	18	28
Some difficulty	.01	71	27	21	21	31
A lot of difficulty	.02	80	29	10	39[d]	22
Unable	.03	78	32	10	35[h]	23
Severity in terms of doing light housework (IADL 5)						
No difficulty[b]	.94	74	33	19	19	28
Some difficulty	.01	93	58	15	20	7
A lot of difficulty	.02	76	41	19	15	26
Unable	.03	73	34	12	25	29
Severity in taking the bus or train when going outside the home (IADL 6)						
No difficulty[†]	.85	74	33	20	19	28
Some difficulty	.05	80	35	19	24	22
A lot of difficulty	.04	72	29	19	22	31
Unable	.06	75	46[d]	12	16	26
Severity in terms of taking medicine as prescribed (IADL 7)						
No difficulty[b]	.96	74	34	19	19	28
Some difficulty	.01	60	53	12	0	35
A lot of difficulty	.01	61	35	9	16	40
Unable	.02	73	33	13	24	30

Each of the 20 panels of this table is based on one logit regression and one m-logit regression; overall, the table is based on 20 logit regressions and 20 m-logit regressions. The regressions in Table 5 are the same as the logit and m-logit regressions in Table 4, except that 20 different specifications of the severity-of-disability variable are used (the first specification in Table 5 being the same as that in Table 4). The other predictor variables in the regressions are not shown in Table 5, but, just as in Table 4, they are contained in the underlying regressions and are statistically controlled by setting them to their mean values in the underlying regressions when using these regressions to calculate the probabilities shown in Table 5.

[a]Probability that the daughter or daughter-in-law is working.

[b]Denotes a reference category.

[c]This panel is duplicated from Table 4. 'No difficulty' indicates that the respondent has no difficulty on any ADL or IADL. 'Some difficulty' indicates some difficulty on at least one ADL or IADL but not 'a lot of difficulty' or 'unable' on any ADL or IADL. 'A lot of difficulty' indicates a lot of difficulty on at least one ADL or IADL but not 'unable' for any ADL or IADL. 'Unable' indicates inability to perform at least one ADL or IADL.

[d]Indicates that the underlying logit or m-logit regression coefficient is significant at the 10% level.

[e]The 42-point scale is constructed as follows: On each of seven ADLs and seven IADLs, 'no difficulty' was scored 0, 'some difficulty' was scored 1, 'a lot of difficulty' was scored 2, and 'unable' was scored 3. The scores were then summed over all ADLs and IADLs to yield a severity-of-disability score ranging from 0 to 42.

[f]The percentage with 'no disability' in this panel differs slightly from the percentage with 'no disability' in the previous panel because of different numbers of missing values.

[g]Note that 'low disability' is defined differently than in the fourth panel.

[h]Indicates the underlying logit or m-logit regression coefficient is significant at the 5% level or better.

specifications of severity defined in terms of all seven ADLs and seven IADLs. In each of the twenty models shown in Table 5, the control variables are the same as those included in the models in Table 4.

The first panel of Table 5 is repeated from Table 4, with severity of disability defined as in Table 4. The second panel of Table 5 dichotomizes severity as defined in Table 4, with 'no difficulty,' 'some difficulty,' and 'a lot of difficulty' grouped into a single reference category. The original 4-category variable is collapsed in this way because the results based on four categories indicate that the main contrast is between 'unable' and the other three categories. Results using the dichotomized variable are consistent with results using the 4-category variable.

Severity as a continuous variable also produces results similar to those in Table 4. The continuous variable is constructed in the following way: On each of seven ADLs and seven IADLs, 'no difficulty' was scored 0, 'some difficulty' was scored 1, 'a lot of difficulty' was scored 2 and 'unable' was scored 3. The scores were then summed over all ADLs and IADLs to yield a severity-of-disability score ranging from 0 to 42. When percentages are shown for scores 0, 1 and 5, results are broadly similar to those obtained from the 4-category specification in Table 4. Grouping the continuous variable scores into four groups (0, 1–2, 3–10 and 11+) produces results even more similar to those obtained from the 4-category specification in Table 4. Dichotomizing severity as 0–10 and 11+ on the 42-point scale also produces results similar to those obtained from the four-category specification in Table 4. Dichotomizing severity as 0 and 1+ on the 42-point scale produces smaller effects of severity, because the effects of high levels of severity are diluted in the 1+ category. Overall, the various composite measures of severity that are based in one way or another on all seven ADLs and seven IADLs show similar effects of severity of disability on the probability that the daughter or daughter-in-law works.

Severity defined in terms of specific ADLs and IADLs produces a more erratic pattern, no doubt due in part to high sampling variability stemming from very small proportions of cases with 'some difficulty,' 'a lot of difficulty,' and 'unable,' as shown in the first column of Table 5. Because of this problem, we base our conclusions on the composite measures of severity.

Summary and Conclusion

The logit model of work participation applied to the NUJLSOA data shows that severity of parent's disability has no effect on whether a coresiding daughter or daughter-in-law is in the labour force and actively working. The probability that she works is in the neighbourhood of 75% regardless of the level of disability of the elderly parent. When employment is broken down into three categories (full-time, part-time and traditional sector) in the m-logit model, however, it is seen that 'unable' on at least one ADL or IADL sharply increases the probability that the daughter or daughter-in-law works full-time and sharply decreases the likelihood that she works part-time. In the simplest form of the basic m-logit model (two categories of severity of disability), the probability of working full-time increases from 33% when the elderly parent has 'no, some, or a lot of difficulty' to 42% when the elderly parent is 'unable' to perform at least one ADL or IADL, and the probability of working part-time falls from 19% to 11%. Only a small proportion of daughters and daughters-in-law are affected, however, inasmuch as only 7% of the daughters and daughters-in-law have a parent who is 'unable.' We conjecture that the increase in full-time work when the elderly parent is 'unable' occurs because long bouts of hospitalization (which in Japan are often equivalent to institutionalization) frequently occur when a coresident parent becomes 'unable,' thereby creating a need to work full-time to help defray the costs of long-term hospitalization while simultaneously freeing the daughter or daughter-in-law to work full-time.

Surprisingly, the effect of severity of disability is not as strong as the effect of elderly parent's age on the daughter or daughter-in-law's labour force participation. With severity and the control variables held constant in our basic logit and m-logit models, the effect of elderly parent's age is to reduce the overall labour force participation of the daughter or daughter-in-law from about 80% when the elderly parent is age 65–74 to about 60% when the elderly parent is age 85+. This effect is felt mainly through reductions in full-time work. In contrast, as already noted, severity of disability has no effect on overall labour force participation, but tends to increase the probability of full-time employment and decrease the probability of part-time employment. Daughter or daughter-in-law's age is among the control variables that are held constant when assessing the effect of elderly parent's age, so that the latter effect is not due to the daughter or daughter-in-law being closer to retirement the older the elderly parent is. We conjecture that the decision by the daughter or daughter-in-law to quit a full-time job as the parent gets older is based mainly on an accumulation of illness episodes by the elderly parent, and not so much on severity of disability at any particular time (e.g., at the time of the survey). The accumulation of illness episodes is positively correlated with the elderly parent's age. If the elderly parent becomes frail to the point of being unable to perform at least one ADL or IADL, however, the probability that the daughter or daughter-in-law works full-time increases and the probability that she works part-time decreases, for reasons already described. It thus appears that, regarding effects on daughter or daughter-in-law's labour force participation, the parental age variable captures the effects of the general increase in frailty that occurs with advancing age, whereas the severity variable captures the effects of parental inability to perform basic activities of daily living. These two effects appear to be largely independent, inasmuch as the effect of severity increases only slightly when parental age is deleted from the models.

Overall, the analysis suggests that the burden of caring for a disabled elderly parent has rather small effects on the labour force participation of coresiding daughters and daughters-in-law. Moreover, at any given time, only about 7% of coresiding daughters and daughters-in-law have a parent who is unable to perform at least one ADL or IADL. The analysis is based only on a minority of middle-aged women who coreside with at least one elderly parent, however, so that further research that includes non-coresiding as well as coresiding daughters and daughters-in-law is needed to test the generality of these findings.

It is possible that the rather weak effects of parent's health on daughter or daughter-in-law's labour force participation may become even weaker in the future, for the following three reasons. First, because the supply of male labour has been diminishing since 1998 due to earlier declines in fertility, an increasing proportion of middle-aged women are expected to be drawn into the labour market to meet Japan's future manpower requirements (Ogawa 2000; Mason and Ogawa 2001). Second, Japan recently established the world's largest and most comprehensive programme of mandatory long-term care insurance in April 2000, with a view to promoting the 'socialization' of care of the elderly (Campbell and Ikegami 2000b). When the first round of the NUJLSOA was conducted, this long-term care insurance plan was not yet in effect. We are planning to undertake a study to assess the impact of this insurance scheme on family caregivers by using subsequent rounds of NUJSLOA. Third, married Japanese women's norms of care for elderly parents have been weakening (Retherford et al. 1996). This normative shift, if it continues, may also weaken the effect of elderly parents' health status on the labour force participation of their daughters and daughters-in-law.

Table A1 Underlying logit regression from which probabilities in column 2 of Table 4 were calculated (logit regression of woman's work status on selected predictor variables)

Predictor variable	Coefficient	Std. error	*t*	Significance level
Parent has some difficulty	0.0752	0.2899	0.26	0.80
Parent has a lot of difficulty	−0.0224	0.3221	−0.07	0.94
Parent is unable	0.0590	0.2977	0.20	0.84
Parent is female	0.1078	0.1755	0.61	0.54
Parent is age 75–84	−0.6236	0.2049	−3.04	0.00
Parent is age 85+	−0.9753	0.3562	−2.74	0.01
Parent's spouse healthy	0.4257	0.2287	1.86	0.06
Parent's spouse not healthy	0.2443	0.2242	1.09	0.28
Parent's spouse dead or living elsewhere	−0.0821	0.1846	−0.45	0.66
Parent has senior high education	−0.3717	0.3377	−1.10	0.27
Parent has jr. coll. or university education	−0.0457	0.0292	−1.57	0.12
Parent's annual income (millions of yen)	−0.6165	0.1565	−3.94	0.00
Urban residence	−0.0602	0.1584	−0.38	0.70
Parent has non-coresident daughter residing in the same locality	0.1645	0.2002	0.82	0.41
D or DIL is daughter-in-law[a]	0.4932	0.2553	1.93	0.05
D or DIL is age 40–49	0.3750	0.3493	1.07	0.28
D or DIL is age 50–59	−0.1891	0.5509	−0.34	0.73
D or DIL is age 60+	0.0027	0.2832	0.01	0.99
D or DIL has senior high education	0.1482	0.3352	0.44	0.66
D or DIL has junior college education	0.2057	0.3735	0.55	0.58
D or DIL has university education	−0.0784	0.1560	−0.50	0.62
Number of D or DIL's preschool children	−0.0759	0.1192	−0.64	0.52
Number of D or DIL's elem. sch. children	0.3668	0.0925	3.97	0.00
Number of D or DIL's children in jr. high or higher	−0.0199	0.2579	−0.08	0.94

(continued)

Table A1 (continued)

Predictor variable	Coefficient	Std. error	*t*	Significance level
D or DIL's husband is age 45–54	–0.5411	0.3821	–1.42	0.16
D or DIL's husband is age 55–64	–0.6889	0.7325	–0.94	0.35
D or DIL's husband is age 65+	–0.1139	0.2916	–0.39	0.70
D or DIL's husband senior high	–0.3407	0.3205	–1.06	0.29

See source note to Table 4.
This table amplifies the logit regression results shown in Table 4.
[a]D denotes daughter, and DIL denotes daughter-in-law.

Table A2 Underlying m-logit regression from which probabilities in columns 3–6 of Table 4 were calculated (m-logit regression of woman's work status on selected predictor variables)

Predictor variable	Coefficient	Std. error	*t*	Significance level
M-Logit equation for full-time/part-time				
Parent has some difficulty	0.1969	0.3676	0.54	0.59
Parent has a lot of difficulty	–0.0639	0.4407	–0.15	0.88
Parent is unable	0.8176	0.4327	1.89	0.06
Parent is female	0.0916	0.2239	0.41	0.68
Parent is age 75–84	0.2589	0.2393	1.08	0.28
Parent is age 85+	–0.7047	0.5176	–1.36	0.17
Parent's spouse healthy	0.2534	0.2968	0.85	0.39
Parent's spouse dead or living elsewhere	–0.3266	0.2904	–1.12	0.26
Parent has senior high education	–0.3259	0.2439	–1.34	0.18
Parent has jr. coll. or university education	0.4772	0.5372	0.89	0.37
Parent's annual income (millions of yen)	–0.0260	0.0515	–0.50	0.61
Urban residence	–0.7813	0.1960	–3.99	0.00
Parent has non-coresident daughter residing in same locality	0.0786	0.2006	0.39	0.70
D or DIL is daughter-in-law[a]	–0.1801	0.2680	–0.67	0.50
D or DIL is age 40–49	–0.0670	0.3203	–0.21	0.83
D or DIL is age 50–59	0.2389	0.4391	0.54	0.59
D or DIL is age 60+	–0.2031	0.9661	–0.21	0.83
D or DIL has senior high education	–0.6741	0.3548	–1.90	0.06
D or DIL has junior college education	0.3184	0.4234	0.75	0.45
D or DIL has university education	1.6781	0.6129	2.74	0.01
Number of D or DIL's preschool children	–0.7004	0.2225	–3.15	0.00
Number of D or DIL's elem. sch. children	–0.2881	0.1648	–1.75	0.08
Number of D or DIL's children in jr. high or higher	–0.2394	0.1183	–2.02	0.04
D or DIL's husband is age 45–54	–0.2367	0.2982	–0.79	0.43
D or DIL's husband is age 55–64	–0.3541	0.4796	–0.74	0.46
D or DIL's husband is age 65+	0.7090	1.5372	0.46	0.64
D or DIL's husband senior high	0.7433	0.3450	2.16	0.03
D or DIL's husband jr. college or university	0.5396	0.3917	1.38	0.17
M-Logit equation for trad. Sector/part-time				
Parent has some difficulty	0.0367	0.3808	0.10	0.92
Parent has a lot of difficulty	0.1413	0.4217	0.34	0.74
Parent is unable	0.5045	0.4463	1.13	0.26

(continued)

Table A2 (continued)

Predictor variable	Coefficient	Std. error	t	Significance level
Parent is female	0.0140	0.2321	0.06	0.95
Parent is age 75–84	0.8223	0.2623	3.13	0.00
Parent is age 85+	0.6574	0.4722	1.39	0.16
Parent's spouse healthy	−0.1757	0.3064	−0.57	0.57
Parent's spouse dead or living elsewhere	−0.4029	0.2964	−1.36	0.17
Parent has senior high education	−0.0307	0.2440	−0.13	0.90
Parent has jr. coll. or university education	0.5119	0.5364	0.95	0.34
Parent's annual income (millions of yen)	0.0655	0.0472	1.39	0.16
Urban residence	0.1198	0.2056	0.58	0.56
Parent has non-coresident daughter residing in same locality	0.1642	0.2077	0.79	0.43
D or DIL is daughter-in-law[a]	−0.3055	0.2733	−1.12	0.26
D or DIL is age 40–49	−0.6406	0.3368	−1.90	0.06
D or DIL is age 50–59	−0.2066	0.4609	−0.45	0.65
D or DIL is age 60+	0.4386	0.8136	0.54	0.59
D or DIL has senior high education	−0.4615	0.3713	−1.24	0.21
D or DIL has junior college education	−0.1030	0.4464	−0.23	0.82
D or DIL has university education	1.0422	0.6290	1.66	0.10
Number of D or DIL's preschool children	−0.3201	0.2073	−1.54	0.12
Number of D or DIL's elem. sch. children	−0.0640	0.1614	−0.40	0.69
Number of D or DIL's children in jr. high or higher	−0.5289	0.1246	−4.24	0.00
D or DIL's husband is age 45–54	0.0005	0.3286	0.00	1.00
D or DIL's husband is age 55–64	0.4638	0.5040	0.92	0.36
D or DIL's husband is age 65+	1.4977	1.3835	1.08	0.28
D or DIL's husband senior high	0.6580	0.3660	1.80	0.07
D or DIL's husband jr. college or university	0.6935	0.4080	1.70	0.09
M-Logit equation for housewife/part-time				
Parent has some difficulty	0.1064	0.4092	0.26	0.79
Parent has a lot of difficulty	0.3979	0.4498	0.89	0.38
Parent is unable	0.6643	0.4731	1.40	0.16
Parent is female	0.2993	0.2551	1.17	0.24
Parent is age 75–84	0.3306	0.2754	1.20	0.23
Parent is age 85+	−0.1403	0.5312	−0.26	0.79
Parent's spouse healthy	0.5385	0.3510	1.53	0.13
Parent's spouse dead or living elsewhere	−0.0479	0.3421	−0.14	0.89
Parent has senior high education	0.1607	0.2645	0.61	0.54
Parent has jr. coll. or university education	−0.7243	0.7990	−0.91	0.36
Parent's annual income (millions of yen)	0.0862	0.0503	1.72	0.09
Urban residence	−0.5282	0.2196	−2.41	0.02
Parent has non-coresident daughter residing in same locality	0.2849	0.2222	1.28	0.20
D or DIL is daughter-in-law[a]	−0.1930	0.2984	−0.65	0.52
D or DIL is age 40–49	−0.4577	0.3745	−1.22	0.22
D or DIL is age 50–59	0.2189	0.4928	0.44	0.66
D or DIL is age 60+	0.7149	0.8889	0.80	0.42
D or DIL has senior high education	−0.6005	0.3877	−1.55	0.12
D or DIL has junior college education	−0.3572	0.4867	−0.73	0.46
D or DIL has university education	1.1238	0.6637	1.69	0.09

(continued)

Table A2 (continued)

Predictor variable	Coefficient	Std. error	*t*	Significance level
Number of D or DIL's preschool children	−0.3429	0.2389	−1.44	0.15
Number of D or DIL's elem. sch. children	−0.0536	0.1813	−0.30	0.77
Number of D or DIL's children in jr. high or higher	−0.2134	0.1320	−1.62	0.11
D or DIL's husband is age 45–54	0.3612	0.3596	1.00	0.32
D or DIL's husband is age 55–64	0.3190	0.5441	0.59	0.56
D or DIL's husband is age 65+	1.4115	1.4590	0.97	0.33
D or DIL's husband senior high	0.8343	0.3885	2.15	0.03
D or DIL's husband jr. college or university	0.3993	0.4477	0.89	0.37

See source note to Table 4.
This table amplifies the m-logit regression results shown in Table 4.

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Family and Kinship Networks in the Context of Ageing Societies[1]

Michael Murphy

Introduction

Populations in contemporary industrialised societies have passed through a unique demographic regime, the demographic transition, the principal features of which are:

1. A decline in fertility from a level of about five children per woman in the nineteenth century (Coale and Watkins 1986) to a level of about two children per woman, conventionally referred to as 'replacement level fertility', achieved around 1970, followed by a period with fertility below this level with no real signs of increase to previous levels. While countries have shown some variations in the timing and magnitude of their patterns, the similarity in trends is more striking than the differences.
2. Mortality has declined over the last century, from a value of expectation of life at birth (e_0) around 1900 of about 40 years to a value about double that today. In the first part of the century, improvements were particularly marked at younger ages, but more recently, substantial improvements have been experienced at older ages as well (Caselli 1994; Charlton and Murphy 1997; Vaupel 1997).

These factors have led to the well recognised ageing of populations, initially dominated by the decline of fertility, but more recently compounded by mortality improvement at older ages.

[1] This paper was originally prepared for a conference in 2001. The simulations therefore show the effect of continuing the demographic trends observed around that time, they are not forecasts as such, but are used to indicate the sorts of patterns that would be expected if those trends of that period were to continue. Additional subsequent work using similar approaches may be found in Murphy (2003, 2004, 2006, and forthcoming).

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While population change is determined solely by fertility, mortality and migration (although the latter has tended to be relatively unimportant at the national level), the first demographic transition has been succeeded by a series of changes that are of a magnitude and coherence to be designated a ‘Second Demographic Transition’ (Van de Kaa 1987; Lesthaeghe 1995), which has probably been the most striking demographic phenomenon in industrialised societies during the past half century. These developments involve changing living and partnership arrangements, some of which are closely bound up with the changes in fertility and mortality noted above: for example, effective, available and acceptable contraception is implicated in both fertility and partnership trends. The Second Demographic Transition has not only had a major influence on behaviour among younger age groups, the associated fertility decline has also reinforced the ageing of these societies in conjunction with mortality improvement at older ages.

This complex of changes may be summarised as:

1. A substantial reduction in nuptiality, with later ages at marriage, and lower propensities both to marry for the first time and to remarry after a broken marriage.
2. An increase in non-marital cohabitation, as a prelude to, or increasingly as an alternative to, formal marriage. Such unions tend to be more fragile than marriage and less usually include childbearing.
3. Marital unions are subject to higher rates of breakdown, so that a large fraction of marriages in many industrialised countries can be expected to end in divorce.
4. Increases in the proportion of births occurring outside marriage, some – but not all – of which take place within cohabiting unions.

While different populations exhibit variability in their experiences of this more recent transition, their movements are generally in the same direction. Even countries such as Japan or Greece, where extra marital births were historically low and remain so, the proportions have increased substantially in relative terms in recent decades, from 0.8% and 1.3% in 1975 to 1.4% and 3.7%, respectively, in 1998 (Ministry of Health and Welfare 1999; Eurostat 1999). Moreover, countries that had been considered demographically traditional, such as Ireland, have sometimes adopted these emerging patterns with enthusiasm. For example, the proportion of births outside marriage in Ireland was 1.6% in 1960, but 26.6% by 1997 (Eurostat 1999).

While these changes have occurred in all industrialised societies, the magnitude and timing have varied. In many countries, fertility started to decline around the first part of the 1960s and cohabitation and extra marital births increased. Table 1 shows some period indicators for some large European countries between 1965 and 1995 covering a broad range of demographic regimes, from Scandinavia, the former Eastern Bloc, Western, Southern and Central Europe (Coleman 1996). The similarity in trends is striking and paralleled by those in non-European industrialised societies, including the USA, Australia and, to a lesser extent, Japan. France and Britain have essentially identical values on these variables in both years, although other indicators, such as proportion of women who are childless, can show greater differences. Scandinavian societies have gone further along the path of the

Table 1 Period indicators of demographic change in selected European countries, 1965 and 1995 (Council of Europe, various)

	Total first marriage rate		Total divorce rate		Births outside marriage (%)		Total fertility rate	
	1965	1995	1965	1995	1965	1995	1965	1995
France	0.99	0.49	0.11	0.36	5.9	37.6	2.84	1.70
Germany	1.11	0.56	0.12	0.33	5.8	16.1	2.50	1.25
Italy	1.03	0.63	0	0.08	2.0	8.1	2.59	1.17
Poland	0.91[a]	0.65	0.07	0.14	4.4	9.5	2.52	1.61
Slovak Republic	0.88	0.57	NA	NA	5.3	12.6	2.80	1.52
Spain	0.99	0.60	0	0.15	1.7	11.1	2.97	1.18
Sweden	0.95	0.44	0.18	0.52	13.8	53.0	2.42	1.73
United Kingdom	1.00	0.54	0.11	0.40	7.3	33.6	2.86	1.71

[a] 1970 figure

Second Demographic Transition and although the countries of Southern and Eastern Europe are somewhat slower on some indicators, their fertility is lower and the pace of fertility decline faster than elsewhere in Europe in that period.

Changing fertility, mortality and partnership behaviours will obviously affect those directly involved, but they can also have a profound effect on national population structures. The likely impact of macro-level changes in the first part of the twenty-first century have been extensively studied using standard population projections (e.g. United Nations Department of Economic and Social Affairs 2001) and the substantial socio-economic impact of population ageing is well recognised (see other chapters of this volume). However, the implications of these changes for other aspects of population structure have received less attention and even basic socio-demographic projections such as by marital status are produced by few countries.

In addition to societal (macro-level) and individual (micro-level) effects, among those most directly affected by changes in partnership behaviour are close kin (mezzo-level); for example, if a couple divorces, this will affect not only the relationships between the former partners and their children, but also between those not directly involved such as children and the children's grandparents. Certain types of kin may become more common and others less so – in a true one-child family society, no one would have a brother, sister, aunt, uncle, nephew or niece, whereas they may have more living grandparents as mortality improves. Some types of relationships that were rare in the past may become common and societal norms may have to adjust to new situations. In this paper, I will discuss how these patterns of family and kin constellations over the period 1950–2050 have changed and would change if trends observed at the end of the twentieth century were to persist using a demographic microsimulation model.

As with all demographic projections, some of the future is determined by the past, with the proportion declining as the projection horizon increases. In particular, when one looks at the situation of elderly populations in decades to come, some of their characteristics are already completely determined, such as the number of children born to women currently aged over 50. This chapter considers changes in people's availability of different types of kin, using mainly British data, but, as noted earlier, these experiences are common to a greater or lesser extent in all industrialised societies, so they may provide insights for other countries as well. Britain was chosen because suitable data have been estimated for the model used later, including data not currently available in most countries, such as time series of rates of entry into and exit from cohabitation (Murphy 2000). Britain tends to have an intermediate position on most of the indicators of Table 1, which may make generalisation to other societies more appropriate than the experience of countries with more extreme demographic regimes. However, in order to show how sensitive these outcomes are to alternative regimes, alternative scenarios with higher levels of partnership formation and lower levels of dissolution are also presented.[2]

The next section describes the microsimulation approach that I use and the results are presented in section on "Changing patterns of kin availability, 1950–2050". Finally, I discuss the implications of these findings.

Methods and Data

Demographic microsimulation is the principal method used to elucidate kinship patterns in historical, contemporary and future populations (Smith 1987; Wachter 1987; Wolf 1994; Zhao 1996; Van Imhoff and Post 1998). This analysis uses the Berkeley SOCSIM demographic microsimulation model (Wachter 1987; Hammel et al. 1990). In this application, an initial population of size 40,000 with the population distribution of England in 1751 obtained from Wrigley and Schofield (1981) is projected up to 2050. This population is subject to appropriate rates of fertility, mortality and nuptiality (including divorce) for the period since 1751 (I do not include migration). In recent decades, cohabitation has become increasingly important and it is also included in the model (Murphy 2000).

A series of assumed rates are used for the period 2000–2050. It is necessary to specify appropriate rates for the model, but this is more complicated than for standard population projections where specifying constant scenarios is straightforward. In such cases using constant fertility and mortality rates will lead to constant values of the summary fertility (TFR) and mortality (e_0) values in the periods ahead. However, if constant fertility and partnership rates are used as in the model here, they will not lead to constant values of summary indicators such as the TFR. The rates are chosen to continue the main trends which have been observed in the last part of the

[2] Some micro simulation results concerned with the implications of low fertility in Italy for numbers of sibs and parents/children have recently been published (Tomassini and Wolf 2001), but they do not consider issues of partnership and the types of wider kin relations discussed here. However, even in Italy with its exceptionally low fertility, only about 20% will have no sib in years to come, rather higher than the figures for Britain.

twentieth century. Mortality is expected to continue to improve with life expectancy at birth for men and women increasing by about 6 years over the first half of the twenty-first century. Patterns of fertility and partnership are expected to remain relatively constant over this period, so that the total fertility rate (TFR) is assumed to be about 1.9 children per woman, the proportion of births occurring outside marriage remaining at about 40% (most of which will occur within a cohabiting union) and the average age at first marriage being about 30 years for men and about 27 years for women. Cohabiting unions will account for about half of unions formed in the future, although a high proportion will be short-term and/or convert into marriage. These values are summarised in Table 2.

The SOCSIM model is closed (Wachter 1987) so that partners have to be found within the existing simulation population using an algorithm to ensure a realistic distribution of spousal age differences. Over time, a full set of kinship links is constructed as the individuals marry and procreate, so that any kinship relationship through blood or marriage may be traced through living and/or dead kin.[3]

While information on coresident groups, including families, is readily and widely available from data sources such as surveys and censuses, and projections of these groups are available from household projections and/or special family projection models (Murphy and Wang 1999), much less is known about non coresident kin although the greater instability of family life means that family members outside the household will become much more common in future. This chapter is concerned with such wider kinship and family networks, whether coresident or not, rather than family structures that use the standard statistical definition of a family as a closely-related *coresident* group, since households are not identified in SOCSIM. With additional assumptions, it is possible to infer information about coresidence. For example, following partnership breakdown, it is much more likely that young children will live with their natural mother than their natural father, but such information does not arise as part of this analysis.

Figure 1 shows some comparisons of the proportion of the British population with different types of kin from a specially commissioned survey in 1999, which collected information on kin and kin exchanges (Grundy et al. 1999). Figure 2 shows that the simulated population compares well with the observed population values by marital status in the 1951 and 2001 Census. Although the simulation is based on an initial 1751 population and estimated rates for 300 years (in the early period based on unpublished values from the Cambridge Group for the History of Population and Social Structure and later data from British official statistics supplemented by especially estimated cohabitation rates), there is a close fit between the observed and model values. Thus, the model values appear to form a satisfactory

[3] Note that this is not possible where a woman gives birth without an identified partner (in this analysis, any birth outside of a cohabiting or marital union), since such fathers are regarded as unknown by the program. Thus, data for certain types of kin presented here, such as the proportion with surviving parents, show the proportion with a known surviving parent (although alternative calculations excluding children with missing fathers have also been made).

Table 2 Summary of simulation parameters

	Size of population			Life expectancy at birth (e_0)		Average age at first marriage		
Year	Living	Cumulative total	TFR (per 1000)	Males	Females	Males	Females	Births within marriage (per 1000)
1750	40,000	40,000	–	41.9	40.6	28.5	25.6	–
1775	47,394	72,195	5,538	40.6	40.7	28.0	24.5	948
1800	63,401	121,638	5,494	40.1	41.4	27.5	24.1	947
1850	126,684	289,866	5,670	41.3	43.9	26.8	24.2	949
1860	150,731	344,285	5,435	42.7	44.2	26.7	24.2	957
1870	177,291	405,837	4,989	44.2	46.4	26.6	24.2	958
1880	205,917	472,450	4,489	43.2	46.3	26.6	24.2	964
1890	232,362	543,680	3,823	44.0	47.1	26.7	24.3	961
1900	257,655	614,779	3,350	48.5	52.0	26.3	24.4	961
1910	286,675	686,537	2,598	44.5	55.1	27.2	24.8	956
1920	300,391	747,939	2,093	56.8	60.7	26.7	24.5	951
1930	314,115	799,907	1,783	59.4	63.9	26.9	24.5	959
1940	319,161	845,361	2,154	61.0	67.9	26.2	23.6	927
1950	329,090	897,885	2,368	68.1	73.6	24.8	23.2	945
1960	341,156	949,742	2,659	69.9	75.8	24.0	22.8	912
1970	359,433	1,009,042	1,960	70.7	76.6	24.9	22.4	874
1980	363,370	1,057,186	1,843	73.0	78.4	27.4	24.4	785
1990	367,642	1,104,734	1,734	77.2	81.7	29.2	26.8	642
2000	376,537	1,150,282	1,847	80.0	85.0	30.2	27.9	580
2010	386,993	1,194,826	1,882	83.5	86.5	30.3	28.4	602
2020	396,487	1,238,154	1,890	86.2	89.8	30.4	28.8	596
2030	404,729	1,279,903	1,903	85.5	87.7	30.5	28.6	594
2040	398,653	1,320,561	1,896	88.5	89.1	30.4	28.7	598
2050	394,463	1,360,265						

Columns of TFR to births within marriage are average values in the interval between the year in column 1 and the next date in column 1. Values for TFR and the proportion of extra-marital births in period 1750–1775 are not shown because the initial population is unmarried

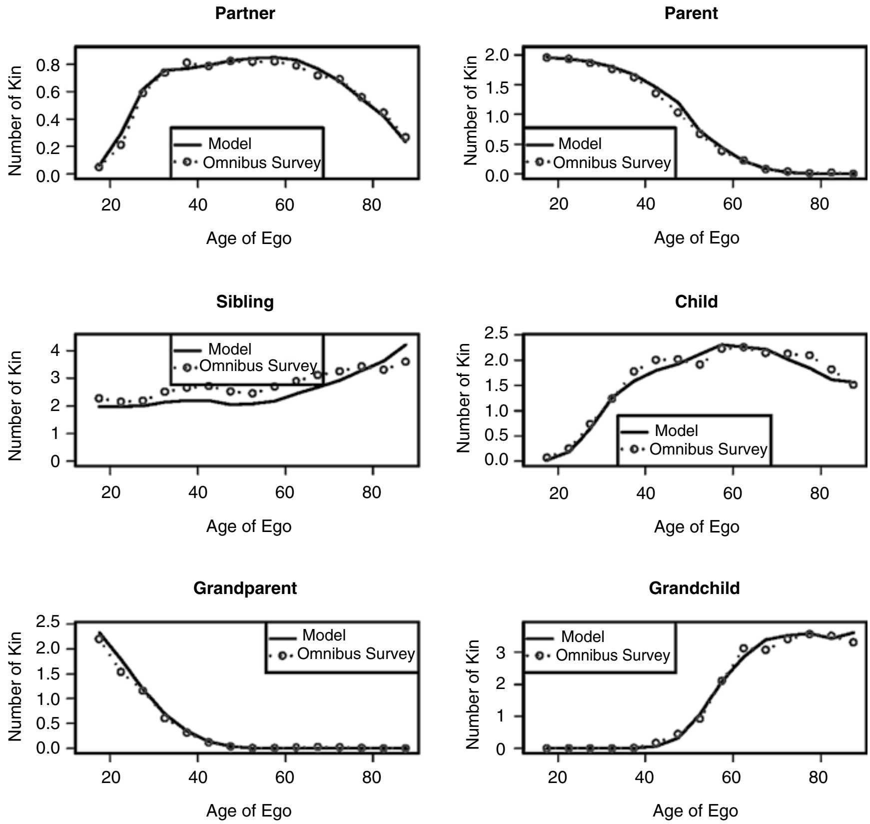

Fig. 1 Average number of living kin: comparison of survey and model data

basis for investigating those aspects of family and kin structures over this extended period for which no directly observed data exist.

This simulated population covers the period 1751 to 2050. The output from the SOCSIM program is in the form of a linked list of demographic events and networks. It is therefore possible to recreate the demographic history and kinship networks that would have been observed at any point during the simulation period. I use a computer program that censors the simulated population at various time points to construct the demographic situation at those periods, but relating to the same underlying population. The years chosen are 1950 and 2000, together with the end date of 2050, to produce the populations that would have been alive at those dates, including information only about kin born before the relevant date. The initial population size was set at 40,000 individuals in order to reduce sampling variability. After the 300 years for which the simulation is run, the size of living population is 390,000 and total number of people in the simulation population is 1.36 million (Table 2). For each type of kinship relationship, the relevant egos and their kin were identified: for example, in the case of sibs in a sibship size of N, there are 0.5 $N(N-1)$

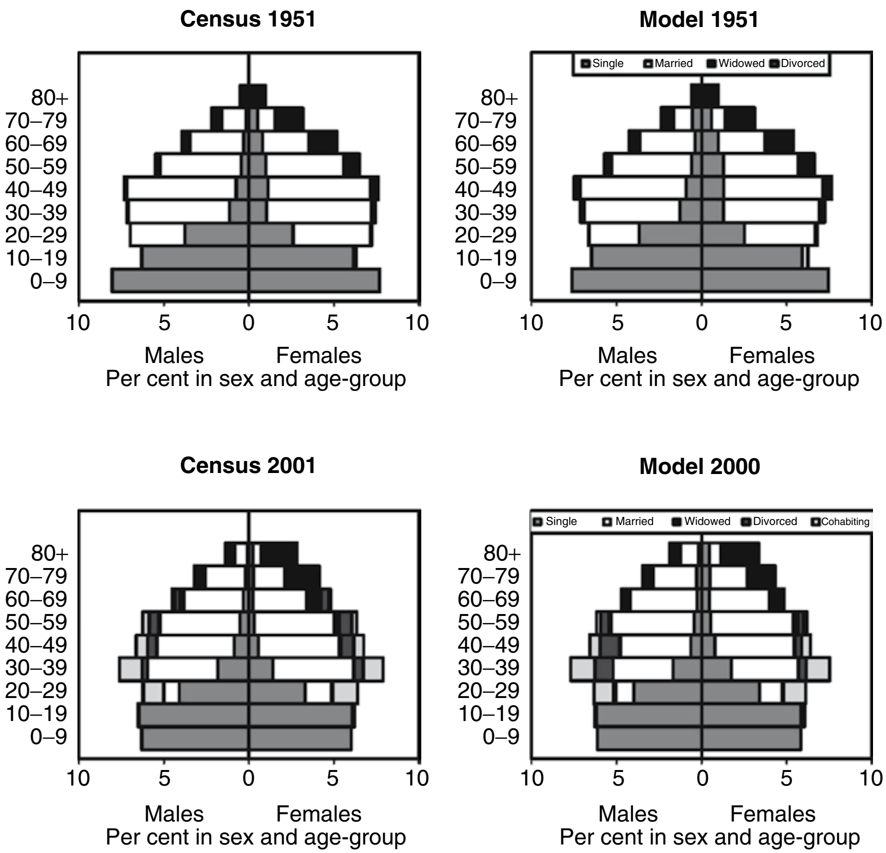

Fig. 2 Maritial status distributions around 1951 and 2001: comparison of England and Wales Census and model data

such sib pairs. It is then possible to calculate the summary measures such as the average number of kin of individuals ('egos') in a given age group and the proportion of such egos that have one or more of the relevant kin type.

The principal trends in family and kinship structures will now be considered in the context of the ageing of contemporary populations.

Changing Patterns of Kin Availability, 1950–2050

Partnership

In the North Western European marriage system (Hajnal 1965, 1982), historically marriage was relatively late and high proportions, up to one third, never married although marriage was more common in other societies such as those of Southern and Eastern Europe (Coale and Watkins 1986; Coleman 1996). Marriage rates were particularly low in the 1920s and 1930s for reasons including shortages of men following the 1914–1918 War and poor economic conditions at the time. However, in the period from 1945 to about 1970 many countries experienced an unprecedented marriage boom, with higher proportions marrying and at earlier ages than in earlier or later periods: indeed the synthetic index of the Total First Marriage Rate was over 1.0 in a number of countries. The subsequent decline in marriage has been substantial (Table 1). While cohabitation has increased, this has generally not been sufficient to offset the decline in marriage so that the overall proportions of young people in partnerships have declined (Murphy 1993). While it is impossible to prove that this reduction in marriage is only a temporary phenomenon and that marriages were merely postponed and so will occur later, such a suggestion is becoming increasingly implausible as marriage rates continue to show no tendency to recover.

Using the assumptions for the future set out in Table 2, Fig. 3 shows that the highest proportions currently in a partnership, marital or cohabiting, are found among those aged about 55 in 2000, people who were aged 25 when marriage rates peaked in Britain around 1970. The proportions in a partnership are high because of their lifetime experience of high marriage rates, low divorce rates compared with later cohorts and lower mortality than earlier cohorts. For those at the same age of 55 in 2050, under the assumption of largely constant partnership behaviour in the

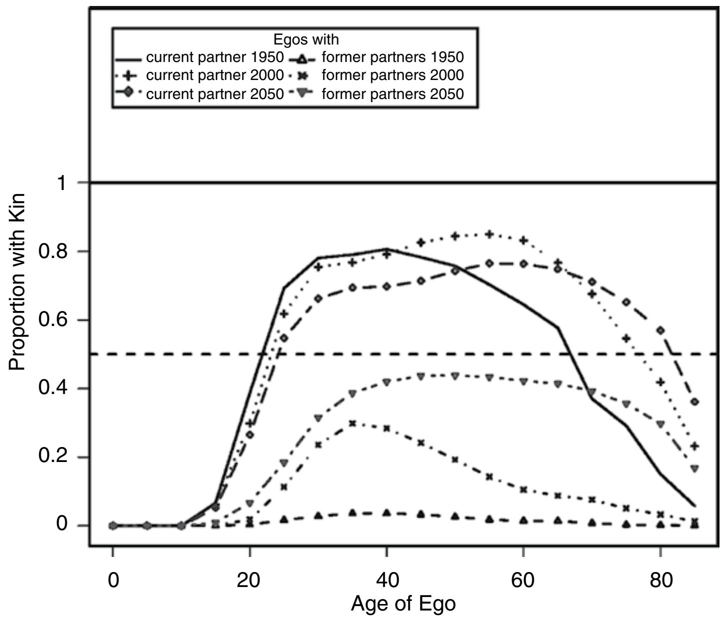

Fig. 3 Proportion with living partners by age of ego

twenty-first century, the proportions in a partnership would be about 15% points lower, with about one third not being in a partnership at that age. However, at older ages the patterns are different, with the highest proportions in a partnership likely to be found among those alive in 2050 since improving mortality has an important influence on the availability of a partner at older ages, especially for women (Grundy and Murphy 2006), which is more than sufficient to offset their lower lifetime marriage rates compared with earlier cohorts. Of all cohorts born in the twentieth century, those born around 1940 are likely to be the most advantaged in terms of having a living partner at older ages.

One trend that has started to emerge in the last half century and will be reinforced in the next one is the existence of living *former* partners following cohabitation breakdown or divorce. The data presented here suggest that the numbers of such cases were trivial in 1950: since there is no information on cohabitation for 1950, this will be, to some extent, an underestimate, although the evidence starting to become available from the 1950s suggests that rates would have been low then (Murphy 2000). However, in 2000 about 20% of those aged between the late 1920s and mid-1960s have a living former partner. As these people age, this figure will decline only if former partners die more quickly than former partners are created by partnership breakdown. If present trends continue as set out in Table 2, having a living former partner would be even more common in 2050. Although smaller proportions of non-elderly people will have a current partner, they are likely to have had considerably more living lifetime partners, peaking for those aged around 50, approaching the age at which issues such as the equitable way of dividing resources obtained during the working life between current and former partners may start to become a pressing issue.

Natural Parents and Children

Following partners (who, by definition, are likely to live together), the second most important kin relationship is that of parents and children who often provide the most contact and support for each other. Figure 4 shows the proportions and Fig. 5 the average number of such kin.[4] The much higher mortality experienced by the parents of those in 1950 leads to half of those in their early 1940s having lost both parents, an event likely to happen just above age 60 for those by 2050. While the increase of those with living parents between 1950 and 2000 was concentrated mainly among *young* adults, reflecting the substantial improvements in mortality of working age adults over the period, in the next 50 years, the main change is that those of late working age will be much more likely to have parents alive than people today.

[4]As noted in section on “Methods and data”, ‘missing’ fathers are treated as equivalent to ‘dead’ fathers in some cases. Therefore, these charts are confined to cases where both parents are identified (in any case, analysis of such cases would arise more naturally in discussion of lone parenthood than of parental survival).

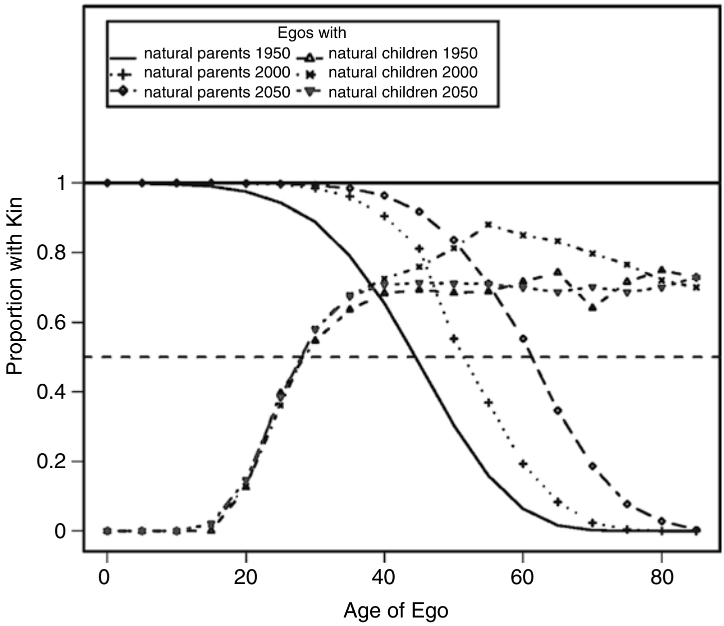

Fig. 4 Proportion with living natural partners and children by age of ego

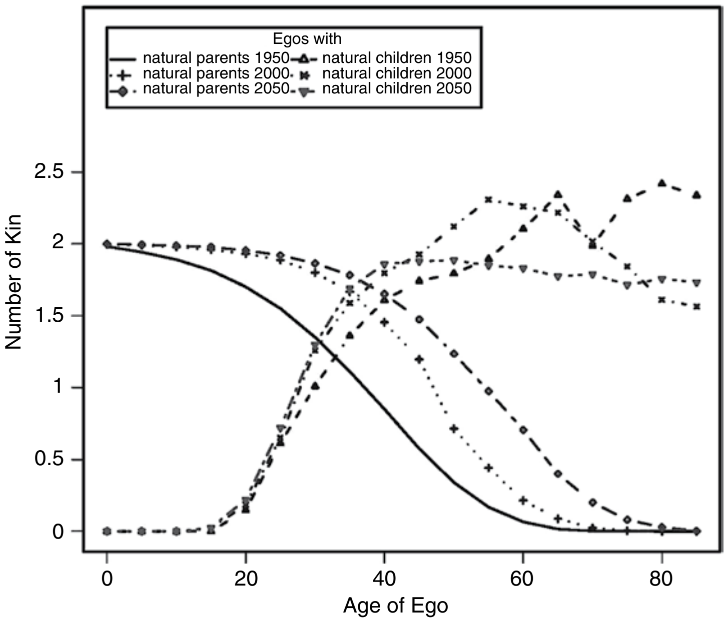

Fig. 5 Average number of living natural partners and children by age of ego

For example, the average number of parents alive for those aged 55 in 2050 is likely to be double the number in 2000 and four times the number in 1950 (Fig. 5).

Although there must be one child and one parent in a given parent–child relationship, the overall trends for living children and living parents are rather different. Since mortality of young people is relatively low, it has little impact as the number of living children for all of those except at the oldest ages (Grundy and Murphy 2006). Therefore the existence of surviving children largely reflects fertility of their parents, so that the peak of about 2.4 children is found for older people in 1950 (who started having their children in the high fertility phase before the 1914–1918 War) and for those aged around 55 in 2000 (who were having their children at the peak of the baby boom in the mid-1960s). In contrast, compared with earlier cohorts, those born 50 years later might be expected to have about 1.8 living children on average, at age 60. The average level of fertility is not the only determinant of having living children; mortality is relevant and so is the distribution of family sizes. The proportions of those aged around 60 with living children is much higher in 2000 than in 1950, reflecting the fact that in the early part of the twentieth century there were high rates of childlessness offset by high marital fertility, whereas in the 1960s there were fewer people at both ends of the family size distribution (Fig. 5). The main result is that the proportion of those aged 60 with a living child could be one fifth lower in 2050 compared with the peak value of about 90% in 2000.

There is also an ageing of generational relations. In 1950, the crossover point – where people were more likely to have a living child than a living parent – was below age 40, by 2000, it is about age 45 and it is likely to be about 50 by 2050. These trends will also affect relationships separated by more than one generation, which will be compounded over generations, a topic I now turn to.

Grandparents and Grandchildren

One of the consequences of mortality improvement is that intergenerational relations spanning more than one generation become more important. In 1950, a child aged under 5 was likely to have an average of two and a half grandparents alive (mainly grandmothers). This had risen to three and a half by 2000 (Fig. 6). Children today are likely to have at least three living grandparents for most of their childhood. In 1950 half of those aged 20 had no grandparent, whereas this point is not now reached until after age 30.

For later cohorts, more children have grandparents and they have more of them, but the converse does not hold: indeed the average number of, and proportions with, grandchildren are likely to decline in the first half of this century. Figure 6 shows that the largest number of grandchildren is found among those born around 1940 who have the special position of being at both the fertility and nuptiality peak. Potential grandparents born later have two succeeding generations of lower fertility,

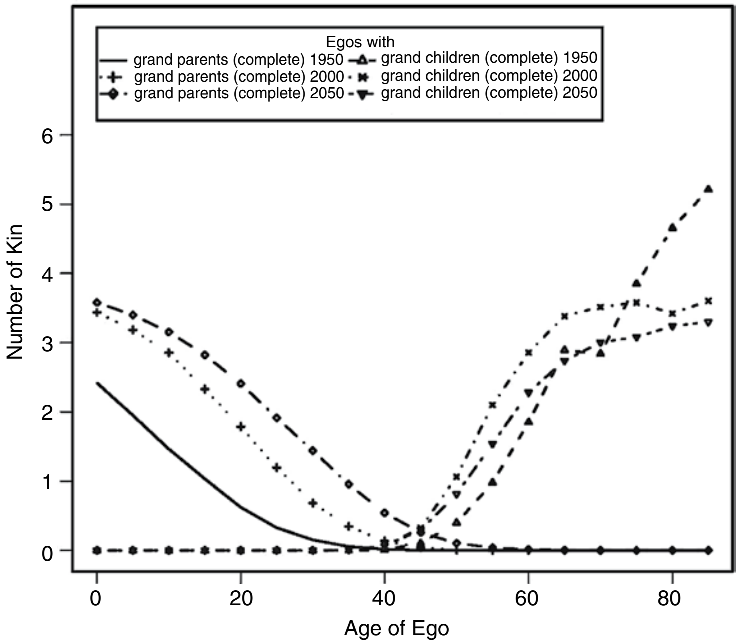

Fig. 6 Average number of living grand parents and grand children by age of ego

so they might have only half as many grandchildren, about two on average, at age 60. Although lower fertility is one reason for such a substantial fall, a more important factor is the increase in age at parenthood over the period, since to be a grandparent at 60 requires that the average age at birth in two successive generations is under 30, which is increasingly unlikely, especially for men: thus grandparenthood occurs later. Indeed, the median age of grandparenthood (the age at which half had a living grandchild) was around 55 in 2000, but it is likely to be over age 70 by 2050, due to the combined impact of reduced fertility and later childbearing. Such a change will mean that grandparents will be much older on average when they have grandchildren and retired rather than working when this occurs.

The remarks above about the grandparental relationship can also be made even more forcefully about great-grandparenthood. In 1950, well under 20% of those aged under 5 had a living great-grandparent compared with a likely figure of about 80% for 2050. This high value reflects the fact that even though great-grandparents are old, each child has eight possible great-grandparents, so the chance of at least one of these eight being alive is becoming substantial, especially since, by definition, they must have been alive at the birth of their own child, so only probability of death after the age of childbearing affects the chance.

Sibs

In the hierarchy of kin relationships, sibs are probably the next most important after parents and children – for example, one has the same genetic relationship, 50% in common, with a full sib (100% for monozygotic twins) as with a parent or a child. Figure 7 shows the number of ever-born and living sibs, for total (both full, i.e. those with both natural parents in common, and half, i.e. those with only one in common) sibs. Older people in 1950 had nearly eight ever-born sibs on average, although because mortality rates for infants and children remained high through the nineteenth century, the number of living sibs was reduced due to death. For those born around 1900, about two thirds of their sibs were still alive at age 50 reflecting the improved mortality of the twentieth century.

The figure of seven to eight ever-born sibs appears high for those born in the second half of the nineteenth century, especially as total fertility rates (TFRs) of the order of four to five children per woman are quoted for this period. However, the sibship size figure reflects the fact that there were relatively high proportions childless and consequent higher family sizes among the parous population, and because in the calculation of sibship sizes, each child is counted once in every sib ship, so it is multiply counted in cases of large sib ships, whereas it is counted only once in family size calculations irrespective of family size (Preston 1976). In fact, this figure for

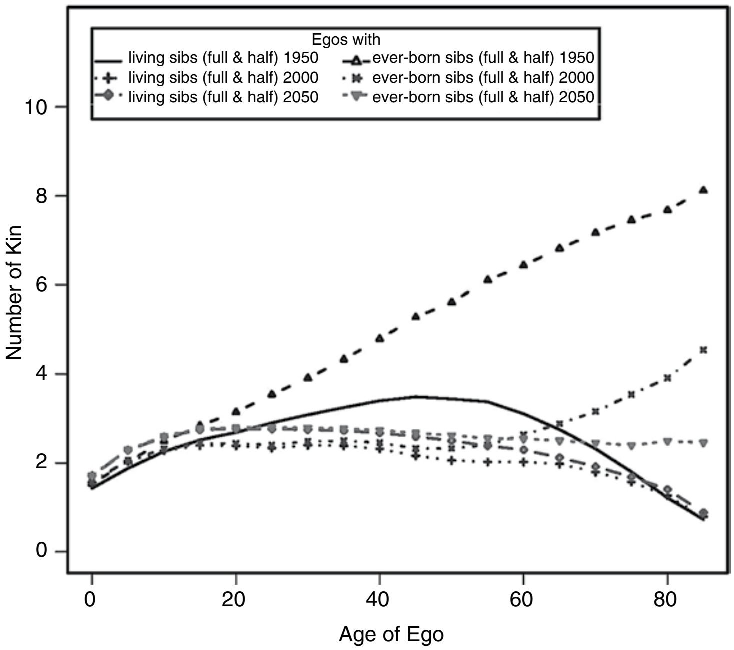

Fig. 7 Average number of living full and half sibs by age of ego

ever-born sibs is almost identical to one calculated from the maternity data collected in the 1911 Census of England and Wales for completed fertility of married women, so referring to births around the same period (General Register Office 1917).

The decline in fertility from the end of the nineteenth century leads to the sharp drop in number of ever-born sibs from about eight to two over a period of just 50 years. This represents a massive change in the childhood experiences of people in a relatively short time. Even today, those aged about 80 were brought up in family sizes about twice the size of those aged about 60.

Although the *childhood* experiences of these groups over a 100-year period, as reflected in ever-born sibship size, are so different, their *adult* experiences, as reflected in living sibship size, are much more similar (an analogous point that having a sib will remain very common in the context of the much lower fertility regime of Italy was made by Tomassini and Wolf (2001)). Apart from those aged over 60 in 1950, all groups have about an average of two living sibs. The improvement in mortality over this period means that people aged 80 and over in 1950 have fewer living sibs than those in either 2000 or 2050, even though they had much larger numbers of sibs when they were children.

The proportions with sibs are shown in Fig. 8. The lower variability in childbearing in the 1950s and 1960s (and lower mortality) compared with the start of the twentieth century is reflected in the historically high proportions with at least one sib, even

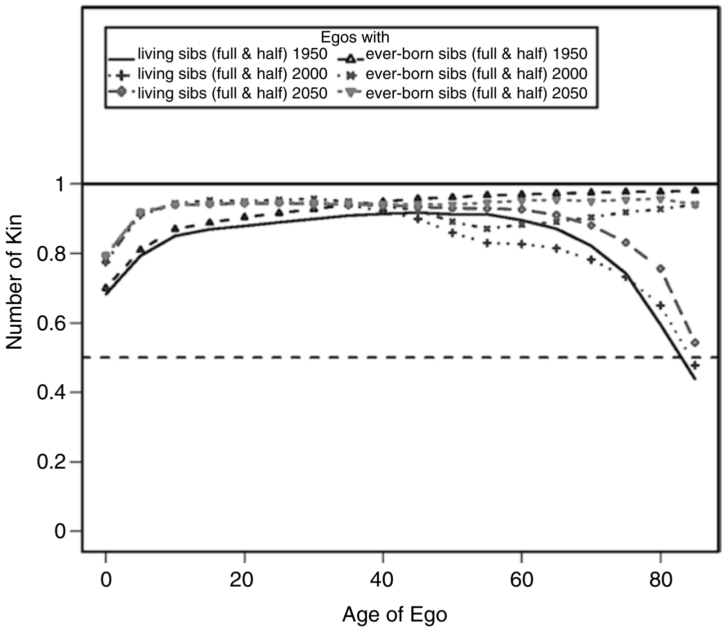

Fig. 8 Proportion with living full and half sibs by age of ego

with the much lower overall fertility levels than in the earlier period. The figures for 1950 and 2000 are very similar apart from the dip for those aged around 60 in 2000, echoing the low levels of fertility around 1940. What is most striking is that this situation may change substantially by 2050: among those aged under 50 (few of whom are born yet and therefore this result is based on assumptions about future childbearing), about one third may have no sib. At first sight, this may appear inconsistent with the rather similar average number of sibs for those people in 2000 and in 2050: this topic will now be considered when the role of stepfamilies is introduced.

Step-families

Partnership breakdown is one of the key emerging issues in contemporary demography and society (Seltzer 1994). At present rates, 40% of marriages will end in divorce within 30 years in Britain (Table 1 and Haskey 1996). In addition, about 40% of births occur outside marriage, with about two thirds of these to cohabiting couples. Some of these extra-marital births may subsequently be brought up in a stable union with the parents continuing to cohabit or to marry later. However, some will either be born to non-coresident parents or the couple may split up. Thus, a substantial proportion of children are likely to find that one or both of their natural parents will form a new partnership so that they will become a stepchild (Cherlin and Furstenberg 1994; Haskey 1994).

Figure 9 shows the proportions of people in each age group who are stepchildren and stepparents as defined above (since coresidence is not included, stepchildren and stepparents as defined here do not have to live together). In earlier times, with divorce and cohabitation relatively rare, stepfamilies were overwhelmingly the result of a widowed parent remarrying, which would often happen later in life after the children had left home. The 1950 figures for children are about 5% (the higher figures for 5–9 year-olds possibly reflecting wartime mortality of fathers) and the figure rises as more elderly parents remarried, before falling as these stepparents died. The figures for children are about twice as high in 2000, with about 15% of teenagers having a stepparent. Unlike the 1950 situation, the proportions in 2000 then decline with age as these older cohorts were subject to lower rates of partnership breakdown when they were young compared with younger cohorts in 2000, which would be more than sufficient to offset the additional years at risk of the older generations. If these trends continue, the proportions with a stepparent would be expected to double over the next 50 years, leading to about one third of teenagers having a stepparent by 2050. If partnership breakdown and reformation rates among older working age groups continue at a similar level, a substantial proportion of children will gain a stepparent as young adults, but rates of partnership reformation among older people are not high and are offset by mortality of stepparents.

Repartnering also determines the proportions that become stepparents. The proportions of young adults who are stepparents are low since this requires that a prior

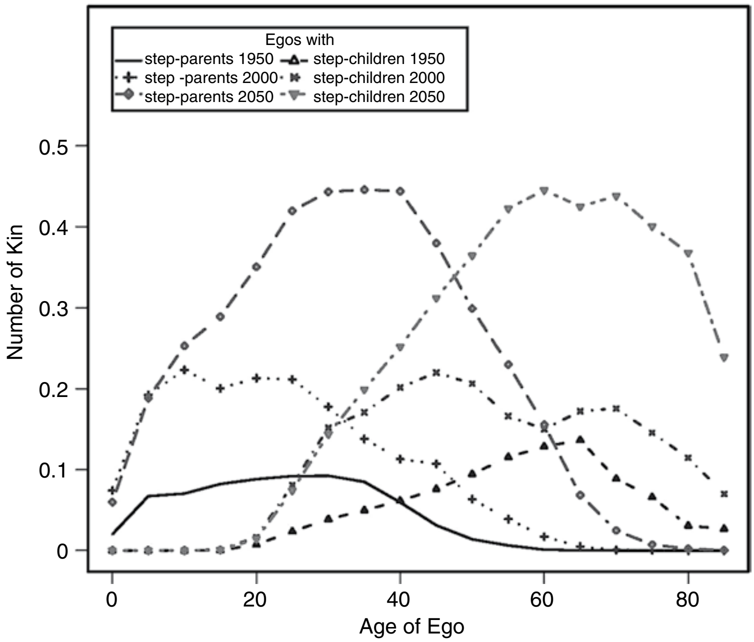

Fig. 9 Average number of living step-parents and step-children by age of ego

family has to have been formed and dissolved. The proportions rise with age for those in 1950 and 2050, but the 2000 group shows a characteristic hump in the 40s reflecting the fact that this group experienced much higher rates of breakdown and reformation than those 20 years older, as in the case of their children's experience noted above.

While considerable discussion in the area of reconstituted families has been given to stepfamilies, little attention has been given to 'supplanted' parents – living natural parents whose former partner and parent of their child(ren) has subsequently repartnered. Indeed, there appears to be no term in either common parlance or kinship terminology that identifies this relationship. For all concerned, this is a situation where another person has undertaken some of the roles and relationships of the natural parent.[5]

Figure 10 shows the proportions with such a supplanted relationship. The proportions of children and young adults with a stepparent and a supplanted parent are similar,

[5] This paper is not concerned with coresidence, so 'family' refers to a kin group rather than to the statistically convenient, but socially deficient, definition of a family as a coresident nuclear unit. A situation where a couple splits up leaving the children with the mother, and she forms a new partnership, is different from one where the father does so, since the child will be in a very different relationship with the new partner in these two cases. I do not discuss coresidence here, in part because this has been considered in detail elsewhere (Murphy and Wang 1999).

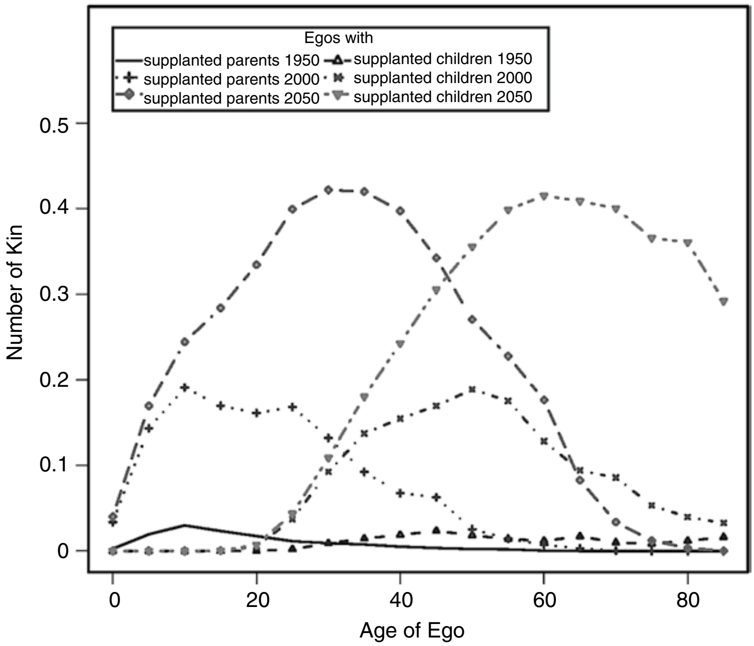

Fig. 10 Average number of living supplanted parents and children

although not identical for a number of reasons including that one can have a stepparent with a dead natural parent, that the new partner could be dead and the natural parent alive, or that a person with a missing father can have a stepfather, but not a supplanted father. However, the main difference, which is apparent at older ages, is that there are relatively fewer supplanted parents compared to stepparents at older ages in 1950 and 2000 than in 2050, largely because repartnering usually followed the death of a spouse, rather than partnership breakdown, in earlier times. However, this is likely to change substantially by 2050. While today's 70 year-olds largely escaped the increase in the divorce rates of the 1970s and later, the same age group in 2050 will have lived their whole life under such conditions and the proportion of new partnerships following the death of one partner is likely to fall substantially.

Stepsibs

In the earlier discussion of sibs, it was noted that the average number and proportions of those with sibs in 2000 and 2050 appeared to be inconsistent. The reason for this is that stepsibs accounted for about 7% of sibs of those under age 30 in 1950, but by 2000 this proportion had about doubled to 15% and by 2050, about 40% of those in their 1920s might be expected to have a step sib, accounting for about one third of all sibs. However, a half sib will appear twice in these calculations (once for the father's children and once for the mother's children), whereas a full sib will appear once only.[6] Under the assumptions of these projections, by 2050 about one third of young adults will have no full sib, double the proportions in 1950 and 2000. However, over one third of them would have a half sib, more than double the figures for 1950 and 2000.

Alternative Scenarios for Industrialised Countries

As Table 1 shows, the patterns in Southern and Eastern Europe have not progressed as far along the path of the Second Demographic Transition. Therefore, in addition to the baseline scenario labelled 1, two alternative scenarios, labelled 2 and 3, were prepared using different assumptions for the period 2001–2050. Scenario 2 has higher values of partnership formation, obtained by doubling the rate of entry into partnerships, but leaving all the other parameters unaltered. Scenario 3 has lower rates of partnership breakdown, obtained by halving partnership dissolution rates and doubling the rate of conversion of cohabiting into marital unions: since marriages are more stable than cohabiting unions, this will decrease the overall dissolution rate.

Table 3 shows the results of these alternative scenarios. The overall population size by 2050 with Scenario 2 is about 20% higher than with Scenario 1, since there are more women married in the fertile age ranges and marital fertility is higher than non-marital fertility, so that the TFR is about 25% higher. The average age at marriage would be 2 or 3 years earlier, although most couples would cohabit before marriage. The lifetime experiences would be very different in the three cases, in the low breakdown scenario, half of partnerships would end in the death of a (married) spouse and only about one in six would end in the breakdown of a married or cohabiting union, compared with one in three in Scenarios 1 and 2.

While these changes over the previous half century would lead to substantial differences in the marital status of younger women and men up to at least age 70, this is much less so among the oldest group, those aged 85 and over, who would have been 35 and over when these assumed changes took place. This reflects the fact that a considerable part of one's life course concerned with partnership and fertility has been established by the late 30s.

The assumptions used in these two alternative scenarios are based on substantially different patterns, representing a return to the conditions of some decades before 2000 in the case of most Western European societies. While there is evidence

[6] For example, if four parents, males A and B, and females C and D, have four children with parents AC, AC, BD, BD, the average number of sibs is one, but if the parents are AC, AD, BC, BD, the average is two.

Table 3 Marital status distribution (per 1,000) by alternative partnership regimes, 2001–2050; women 45–49 in 2050

	Age group			
	25–29	45–49	65–69	85+
Baseline				
Single	410	184	192	163
Married	317	571	590	340
Cohabiting	256	202	172	50
Divorced	17	40	14	29
Widowed	0	4	32	419
High partnership				
Single	160	96	90	142
Married	715	686	721	360
Cohabiting	24	106	110	48
Divorced	101	107	36	35
Widowed	1	5	43	415
Low breakdown				
Single	343	119	126	154
Married	548	745	710	355
Cohabiting	92	126	128	51
Divorced	16	9	1	15
Widowed	0	2	35	425

recently that divorce may be stabilising in some countries, there is as yet no evidence of a reversal of the trends that occurred between around 1970 and 2000. It would therefore appear that while the characteristics of their kin may change markedly in decades to come, many of the demographic characteristics of elderly populations will not change substantially under a range of different demographic regimes in years to come.

Conclusions and Implications

Of all demographic analyses, those concerned with kin availability are most sensitive to long-term population trends. Whether one has a living grandparent or grandchild is affected by fertility, mortality and nuptiality over a period close to a century. For this reason, the first widespread demographic transition that occurred in the late nineteenth century is only just starting to lose its impact, whereas it was still clearly seen in the 1950s, for example in numbers of sibs of elderly people. These relatively recent experiences may still influence some of our thinking about ideal forms of generational relations: while large families are not now widely endorsed, I suspect that large numbers of grandchildren still are. In the past, the relative rarity of remarriage with the former partner alive may have led to the emphasis on step parenthood, but much less on the characteristics of, and impact upon, supplanted parents. While the rights of access to their children by natural parents, even those who have had little input to childrearing or support, is accepted, natural grandparents, who may have made a substantial contribution to their grandchildren's welfare, have no such rights at present.

Apart from the effects of changing kin relations due to earlier changes in partnership regimes, the ageing of populations will have an independent and sometimes reinforcing impact. It is not clear if the expectation that a couple who marry in their mid-1920s are likely to remain a couple for 60 years in the absence of divorce may actually act as a stimulus for divorce. What is clear is that the time spent in the post-marital state will increase as longevity improves and divorce remains high and remarriage low.

The changing demographic regime, which causes the ageing of populations, will have two main impacts on kin relations, apart from the issue of availability of kin. The first is that there will be an ageing of generational relationships: events that formerly occurred early in life are being pushed back, such as the experience of one's parents' deaths, or the age of becoming a grandparent. The second is that patterns of repartnering will lead to more partial relationships involving step and supplanted parents, half sibs, former partners and step and supplanted children. Some scholars have seen these new more fluid forms of family life as a positive development that will provide a wider pool of kin with which to interact (Wachter 1997), whereas others have been more sceptical about the enduring nature of ties between kin who have no longer a direct connection (Finch 1989).

While the social implications of these trends remain unclear, what is inescapable is that not only is the population ageing, but many of the kin relationships are also ageing as a consequence.

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Part V
Time Use and Labor

Historical Trends in the Patterns of Time Use of Older Adults

Anne H. Gauthier and Timothy M. Smeeding

'Working less and living longer'[1] – a phrase that sums it all up for many societies! As a result of increasing life expectancy, earlier age at retirement and shorter working weeks, the average lifetime hours devoted to paid work represents today a much smaller proportion of total lifetime hours than in the past (Mathers and Robine 1997; Auer and Fortuny 2000). In Britain, estimates suggest that the fraction of lifetime hours devoted to paid work by men has declined from 50% in 1856 to 20% in 1981 (Ausubel and Grubbler 1999). Knowledge about the ways older adults spend their time after retirement is, however, very limited. There have been cross-sectional analyses of the patterns of time use of older adults (Altergott 1988; Gauthier and Smeeding 2003; Herzog et al. 1989), but we know little about how these patterns of time use have changed over time. Empirically, this is a most intriguing question. On the one hand, we know that older adults have been retiring earlier, but on the other hand, we also know that their ability to work at older ages has increased as a result of increasing life expectancy and lower incidence of morbidity (Crimmins et al. 1999; Waidmann and Manton 1998; Manton and Gu 2001; Cutler 2001). This raises the question of what, in fact, they did with this former work time.

The paper is divided into five sections. In the first section, we review the literature on the changing balance between work and leisure and summarize some of the main demographic and economic trends. In the next section, we present our theoretical model and point to factors that may be expected to have altered the patterns

[1] From the title of Ausubel and Grubbler (1999).

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of time use of older adults. The sections "Data and Methods" and "Findings" follow. We conclude the paper in the last section with a summary of our finding and we point to future avenues of research.

Review of Literature

The trend towards early retirement has been extensively documented (Guillemard and Rein 1993; Gendell 1998). Between 1950 and 1995, the average age at retirement for male workers has decreased by more than 5 years in several Western European countries including Austria, Finland, France and the Netherlands (Auer and Fortuny 2000). For example, the average age at retirement for men in the Netherlands has decreased from 66.4 years old in 1950 to 58.8 years old in 1995 – the largest decrease in industrialized countries. The decrease in the average age at retirement has been smaller in countries like Sweden, the United Kingdom and the United States, and very small in Japan (less than 1 year). Data from the late 1990s, however, suggest that the early retirement trends may be levelling off (OECD 2000). In fact, data from the United States suggest a recent increase in the return to work after retirement (Herz 1995; Quinn and Burtless 2000) – although the United States may still be an exception among most industrialized countries. The situation for women is very different. Contrarily to men, the employment rates of women age 55–59 years old has increased during the 1980s and 1990s in several countries, and the employment rates of those age 60–64 years old has remained stable (the exception being Finland and Sweden where they have decreased) (OECD 2000).

This trend towards early retirement (for men) has been explained by various factors including financial incentives to retire early (for instance, as part of companies' downsizing exercises), disincentives to continue working at older ages (the so-called tax on work), restricted work opportunities for older workers, discrimination against older workers, dismissal or redundancy (especially in periods of recession), disability or illness and family responsibilities (Samorodov 1999; Gruber and Wise 1998a and b; OECD 2000). For example, among retired men aged 55–64 years old in the European Union in 1995, illness or disability represented up to 25% of all reasons given for being retired, as compared to 30% for redundancy or dismissal (Auer and Fortuny 2000).

The other trend that has been well documented is the long-term decrease in the hours of work for all cohorts. From 1850 to 1950, the average workweek has decreased from about 70 to 40 h (Wilensky 1961). A downward trend has also been observed between the late 1950s and the late 1980s in most countries – at least in the manufacturing sector (Gershuny 1992). On the other hand, between 1976 and 1993, the average hours of work for wage and salary workers in non-agricultural industries in the United States have remained stable (Rones et al. 1997). These data, however, pertain to workers of all ages and are, moreover, dictated by national policies about the maximum number of hours of work and by companies' needs.

With regard to older workers, a different type of question needs be addressed in this context: whether older workers retire abruptly from the labour market by suddenly ceasing to work full-time, or whether they instead retire gradually by reducing their hours of work or by opting for part-time work. Data from the OECD suggest that the percentage of older male workers aged 60–64 years old who hold part-time jobs has increased in several countries since the mid-1990s. The increases are, however, small, leaving the OECD to conclude that gradual retirement is not common, or at least not yet common in the rich nations of the world (OECD 2000).

If the decrease in time devoted to paid work at older ages obviously means an increase in time devoted to non-paid work, it is unclear which of the non-work activities have most benefited from this 'freeing up of the golden years'.[2] As will be discussed in the theoretical section, time 'freed up' from paid work can be reallocated to active leisure, but can also be reallocated to unpaid work, housework, passive leisure and personal activities (such as sleep and naps). Empirical evidence is limited. Earlier studies suggest that as they age, older people reduce their informal social interaction, membership in voluntary groups and volunteering (e.g. Chambré 1987). Studies also suggest that as they grow older, people reduce activities that require intense physical activities and spend more of their time at home (Kelley 1997). Data from the United States suggest that between 1975 and 1995 time devoted to all forms of leisure by seniors aged 65 years old and over has increased by about 10 h per week – but that 'about half of the newly acquired free time … goes to TV viewing' (Robinson et al. 1997: 20). During the same period, evidence from time-use surveys also suggests that time devoted to social organizations has slightly decreased for Americans aged 18–64 (Robinson and Godbey 1997). This result is in fact in line with the argument stated by Putnam (2000), according to which Americans have been disengaging themselves from communities and opting instead to 'bowl alone'. On the other hand, results from the Multinational Time Use Study suggest that since 1974, working-age adults in several countries have increased their time allocation to eating out, going out to pubs and bars, visiting friends and going out to cinema, theatre, or other events (Gershuny 2000).

In conclusion, while the time use literature contains rich information on the patterns of time use of working-age adults, we have relatively little information on the historical trends in older people's active time.[3] The literature includes important cross-sectional analyses of small samples of older adults (e.g. Palmore 1979; Larson et al. 1985; Moss and Powell Lawton 1982), as well as cross-sectional analyses of larger nationally representative samples of older adults (e.g. Klumb and Baltes 1999; Herzog et al. 1989). However, none of these studies has been able to historically

[2] From the title of Robinson et al. (1997).

[3] One reason why we know relatively little about the patterns of time use of older adults, as opposed to younger adults, is that the earlier harmonized version of the Multinational Time Use Archive (MTUS) was restricted to the population age 20 to 59 years old, even though the original time use surveys covered a wider age range. We are currently expanding this archive. The results presented in this paper are among the first ones based on this expanded archive. For details, see the web site of the MTUS: http://www.timeuse.org/mtus/

assess the extent to which older adults' improved health, longevity, education and wealth have been accompanied by more time devoted to active and productive pursuits.

In this paper we use data from time use surveys from three countries, the Netherlands, the United Kingdom and the United States, to examine trends over time in the patterns of time use of older people. Until recently, the cross-nationally comparable version of these surveys was restricted to the working age population (see, for example, Gershuny 2000). By extending the analysis to the older population, we therefore present the first results of this new multinational time use dataset.[4]

Theoretical Model

The traditional micro-economic theory of allocation of time distinguishes two types of activities: work and non-work (Becker 1965). The allocation of time between these two types of activities is assumed to be a function of the cost of, and preference for, work and non-work, subject to an income constraint. There are, however, major demand and supply factors that may affect this general model in the context of older workers, especially the opportunity for work at older ages and the physical ability to work at older ages.

The first of these factors, the opportunity to work at older ages, has received increasing attention in recent years (see, for example, Hicks 1996/7, 1998). Public and private policies, it is argued, have promoted early retirement and have provided disincentives to stay in employment at older ages. In particular, Gruber and Wise (1998a,b) have documented the existence of various work disincentives in pension plans and various policies. As such, these structural factors have been argued to be preventing older people from living an active life, defined as 'the desire and ability of many seniors to remain engaged in economically and socially productive activities' (The Denver Summit of the Eight 1997).

The second of these factors emphasizes the ability to work at older ages. As suggested above, early retirement for health or illness still accounts for a non-negligible share of early retirement. However, recent studies have documented a decrease in the prevalence of disability at old ages (Mathers and Robine 1997; Waidmann and Manton 1998; Rand 1998). Crimmins et al. (1999) have estimated that the probability of being unable to work for men at age 69 in the United States has decreased from 26.5% in 1982 to 20.4% in 1993. For women, the respective figures are 24.9% and 19.1%. Moreover, Freedman and Martin (1998) have found that the decrease in functional limitations was observed among all seniors, including those aged 80 years old and over. The percentage of people having difficulty seeing, lifting, climbing and walking has declined in all age groups between 1984 and 1993. Cutler (2001) claims that there is now clear and overwhelming evidence that the average health of the older population is improving.

[4] This new version of the dataset is now available to researchers. Information may be obtained on the MTUS website: http://www.timeuse.org/mtus/

To these factors, one has also to add the increase in the education level of the elderly population: a factor that may also be expected to have altered the patterns of time use of the older population (Denver Summit 1997; US Census Bureau 1995). This factor may not have led to an increase in paid work at older ages, but it may be expected to be associated with an increase in active leisure pursuits at older ages. This trend may be expected because of the link between higher education level and the decrease in the prevalence of health limitations, thus allowing people to have an active life at older ages (Crimmins et al. 1999), the link between higher education level and physical activities (Pate et al. 1995) and the link between higher education and higher income, thus allowing older people to 'consume' more expensive leisure activities, such as cultural activities and travel for pleasure (Robinson and Godbey 1997). All these factors may be expected to have increased the time allocated to 'active' leisure activities, such as sport and fitness and 'consumptive' leisure activities. Furthermore, the link between higher education and less physically demanding jobs may increase the number of older workers who feel that they can meet the physical challenges of their jobs at older ages.

On the other hand, it should be kept in mind that caring responsibilities (especially caring for a frail relative or spouse) may restrict older people's opportunities to participate in leisure activities – especially among women (Lechner and Neal 1999).

In short, some opposing forces may be expected to have altered the allocation of time at older ages in recent decades. While the private and public policies in force are expected to have led to early retirement and to a decrease in time allocated to paid work, the decrease in disability and in health limitations and increasing education levels at older ages, are expected to have increased the ability to work or to pursue active leisure activities. The increase in the average education level of the older population is also expected to have increased time allocated to active pursuits. On the other hand, some older people (mostly women) may be expected to continue facing reduced opportunities to pursue active leisure activities as a result of caring responsibilities. As will be seen below, the time use data provide mixed evidence of an increasing trend towards active ageing. While some increase in active pursuits were observed, they were also accompanied by increases in more passive types of activities, especially watching television.

Data and Methods

In this paper, we use data from time budget surveys carried out in the United States, the United Kingdom and the Netherlands since the 1970s.[5] These surveys are highly comparable in that they all relied on the diary as mode of data collection.

[5]A time-use survey was carried out in 1965 in the United States. This survey is not analyzed in this paper because the sample is restricted to households in which there is at least one member actively involved in the labour force. This nature of the sample thus creates a bias towards employed people and is therefore not comparable to the other surveys.

Table 1 Technical information on the time use surveys

Country	Year	Age	Sample size[a]	Response rate(%)	Diary(day)	Survey period(months)
Netherlands	1975	12+	1,309	79	7	1 (Oct)
	1980	12+	2,730	54	7	1 (Oct)
	1985	12+	3,263	54	7	1 (Oct)
	1990	12+	3,158	49	7	1 (Oct)
	1995[b]	12+	3,227	20	7	1 (Oct)
UK[c]	1975	5+	3,545	60	7	4 (Aug/Sep, Feb/Mar)
	1987[d]	16+	1,996	70	7	1 (July)
	1995[e]	16+	1,875	93	1	1 (May)
USA	1975	18+	2,406	72	1	3 (Oct-Dec)
	1985	18+	5,358	55	1	12
	1993[f]	0+	9,386	63	1	12

[a]Unless indicated otherwise, the sample size refers to the total number of individuals of all ages
[b]A different survey procedure was used in 1995. The response rate for that year is not fully comparable with those of previous years
[c]For the UK, data for 1961 are also available, but are not fully comparable because they do not cover the 24 h during the diary day
[d]UK 1987: The sample was not drawn from the entire population, but instead from six 'work' areas
[e]UK 1995: This is the response rate of the achieved Omnibus sample. No information was available on the actual response rate of the Omnibus sample
[f]Formally, USA 1992/4

Sources: Authors' tabulation from information contained in Fisher (2000) and various country-specific documents

In each survey respondents were asked to keep a log (or to recall) every spell of activity, including the nature of the activity and its duration, during a 24-h period. As shown in Table 1, the surveys differed in terms of the type of diary and the mode of data collection, but these differences have been shown not to be affecting the comparability of the data (Robinson and Godbey 1997). On the other hand, differences in terms of response rate and the sampling period may potentially affect the comparability of the data (Gershuny 2000). The response rates in the Dutch surveys, for example, are much lower than in the other countries. Moreover, there are cross-survey differences in the period during which the data were collected. In the Netherlands, the data were consistently collected in the month of October. Thus, while the Dutch data do not provide yearly averages, they do not introduce within-country distortions. This is not the case with the United States and the United Kingdom for which there are substantial differences in the data collection period across surveys. And while these differences have been ignored in recent analyses of historical trends in patterns of time use (see, for example, Gershuny 2000), we suspect that these differences are behind some of the unusual trends observed in the United Kingdom (and discussed in section on "Findings").

There is no established typology of activities in the literature. Ideally, we would like to distinguish activities according to their economic value (have seniors' 'productive' contribution decreased?), according to their contribution to seniors' physical health (are seniors living a healthier life?) and according to their degree of social engagement (are seniors ‘bowling’ alone?). Since activities may serve different purposes, such a classification is not possible. In this paper, we use a simple typology that approximates some of the above dimensions. More precisely, four broad categories of activities are distinguished: paid work, housework, active pursuits and passive activities. These categories are listed below, along with their main sub-categories. This list encompasses all activities carried out during 1 diary day, and their sum is consequently equal to 24 h. The list is furthermore restricted to primary activities; secondary activities are not taken into account.

1. Paid work (including travel to work)
2. Housework (including cooking, washing up, gardening, shopping)
3. Active pursuits
   (a) Childcare
   (b) Civic and volunteer work
   (c) Religious activities
   (d) Sport and fitness
   (e) Social activities
   (f) Cultural and other out-of-home leisure activities
   (g) Education and reading
   (h) Hobbies
4. Passive activities
   (a) Watching television
   (b) Passive leisure activities (including listening to the radio and to tapes and relaxing)
   (c) Personal activities (including sleep, bathing, eating)

This classification calls for some clarification and explanation. First, it should be noted that ‘childcare’ was included in the active pursuits category rather than the housework category (where it often appears in the literature). This decision is justified by our wish to capture seniors’ possible reallocation of time to unpaid and volunteer work. While childcare may be an unavoidable responsibility for parents with young children, for seniors it may be a form of ‘volunteer work’ or a form of active consumption and enjoyment (the so-called joy of grandparenthood). Second, education is also considered as an active pursuit in that it entails exercise of the mind. Our focus being on patterns of time use of elderly, we were interested in the extent to which elderly may participate in lifelong learning and may enrol in classes after retirement.

We should also note that the category ‘passive’ is not restricted to relaxing, but encompasses other activities that require a low-level of physical activity (such as watching television and listening to the radio), as well as personal activities (such as eating, dressing, bathing, etc). Note, however, that dining out is not included in this passive leisure category and instead appears in the active pursuits category, more precisely in the sub-category ‘other out-of-home leisure activities’.

Although our interest is in the patterns of time use of the older population, we carry out the analysis for the population age 25 years old and above in order to provide a broader perspective. Our analysis is strictly descriptive and aims at unravelling historical trends in time devoted to the four broad categories of activities. More precisely, the aim is to see how older adults reallocate their time around the time of their retirement and how has this reallocation changed over time (if at all). Undoubtedly, this type of inquiry would be best answered through longitudinal data. In this case, we are forced to infer information from cross-sectional data and assume that, over their life-course, individuals would follow the same patterns of time use as the older cohorts observed at one point in time.

It should be noted that the results presented in the next section are broken down by age and gender but not by employment status since being part, or not, of the labour force, is already captured by our measure of time spent in paid work. There were, however, additional reasons for not considering employment status, reasons that are mainly related to the 'fuzziness' of the concept of retirement at older ages. First, as pointed out in the literature review, work after retirement is an increasing trend, at least in the United States (Herz 1995). And while some of these work returnees may continue to declare themselves as retired (especially if the work is part-time or irregular), others may declare themselves as employed. Thus, restricting the analysis to the formally retired population, for instance, would miss part of these returnees. Second, while withdrawal from the labour market still happens abruptly for some workers, a trend towards gradual retirement involving part-time work has been documented (Smeeding and Quinn 1997). Ignoring these part-timers would thus give us an incomplete picture of the patterns of time use of older adults.

And finally, in the time use surveys the information on retirement comes from a question about the main activity carried out during the week prior to the survey. In some surveys, respondents were given a wide choice of answers including retired, unable to work because of disability, homemaker, etc. Again, the retired population drawn on the basis of this question would capture only part of the economically inactive population. It remains that the decline over time in the labour force participation of older adults has altered the composition of the older population in terms of employment status. Part of the changes in the patterns of time use that we will observe in the following section is therefore likely to result from changes in the composition of the population rather than changes in the allocation of time after retirement. This is a tricky issue. But since the timing and nature (gradual or abrupt) of retirement ultimately reflect a decision in terms of allocation of time, we feel justified in confounding the two components.

In the analysis below, we present daily averages of patterns of time use. These daily averages were compiled on the basis of data that have been weighted in order to correct for sampling issues and to ensure an equal sampling of every day of the week.[6] One should however keep in mind that the daily averages are not representative

[6] The weights also control for sampling issues such as non-response and over-sampling. It should be noted that although the weights ensure an equal representation of every day of the week at the aggregate level for the total sample, some unequal sampling of the days of the week are observed for smaller sub-groups of the respondents (even after weighting).

of all the days of the year since the data collection was, in several surveys, not spread across the 12 months of the year.[7]

Findings

Results for the four main types of activities appear in Figs. 1, 2, 3, 4. Before commenting on specific results, we begin by noting that the overall patterns of time use have been remarkably stable since the 1970s.[8] Overall, both younger and older adults today spend their time in a very similar way than they did some 30 years ago – at least when broad categories of activities are considered. However, this does not mean that there have been zero changes, especially amongst the old. Below, we comment on the trends and inter-country differences, activity by activity. The links between these findings and the theory outlined earlier are discussed at the end of this section.

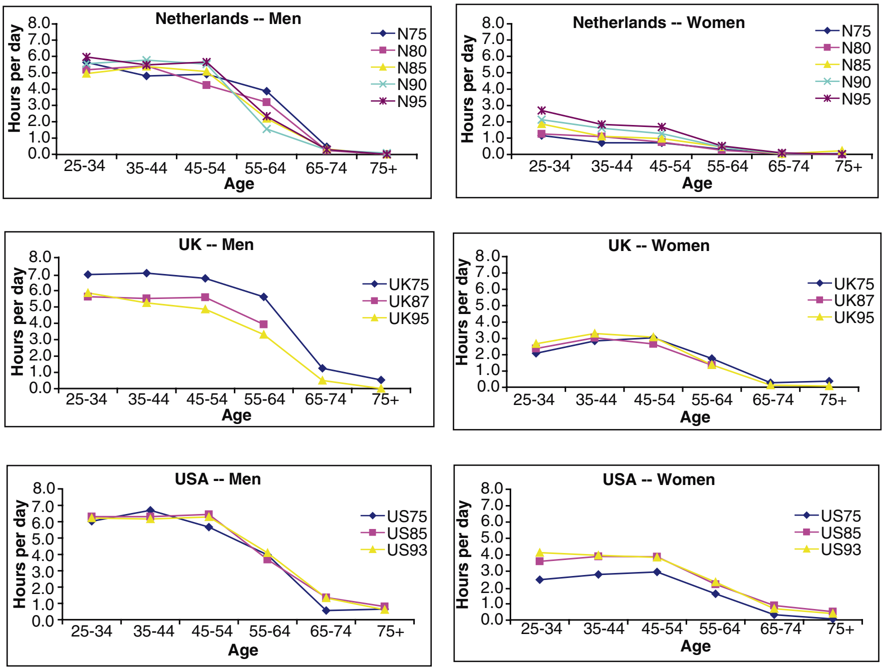

Fig. 1 Mean time devoted to paid work by country, gender, age and year

[7] It should be noted, that even if data were collected for the 12 months of the year, we are likely missing major holidays when respondents were not available to keep their diary.

[8] It should be noted that we do not test for the statistical significance of the historical trends. Our analysis is purely descriptive. In future analyses we intend to adopt a different approach.

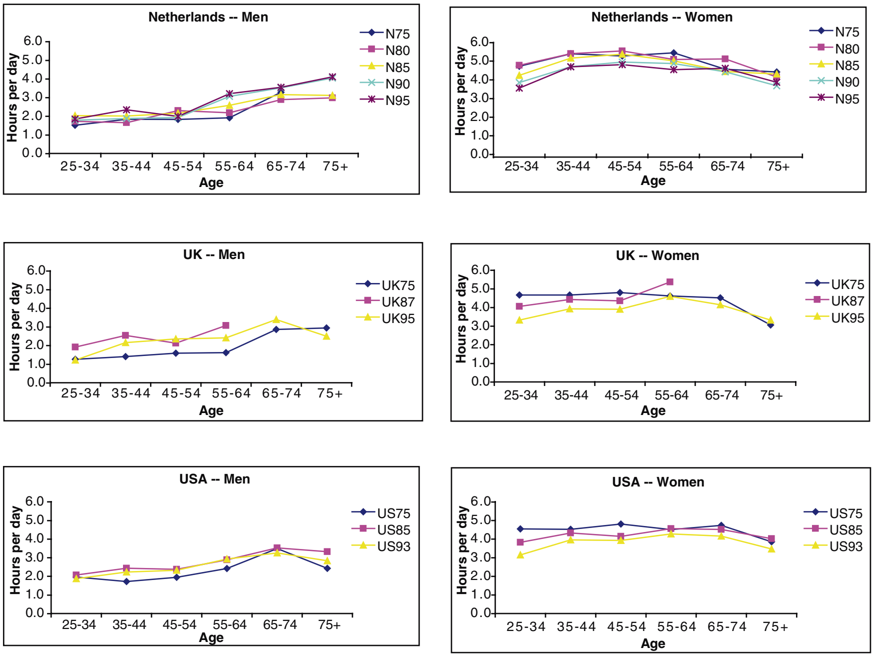

Fig. 2 Mean time devoted to housework by country, gender, age and year

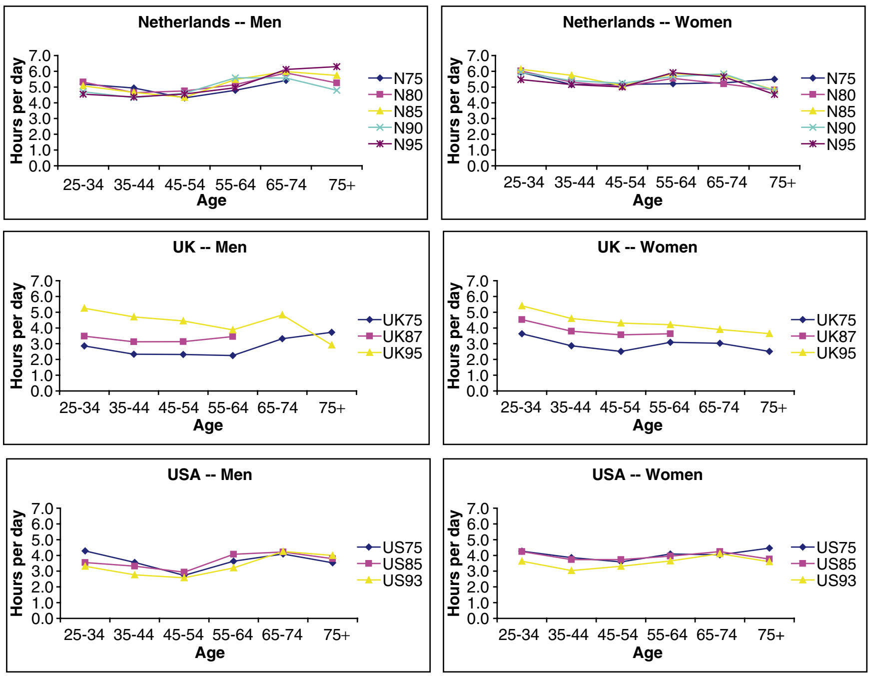

Fig. 3 Mean time devoted to active pursuits by country, gender, age and year

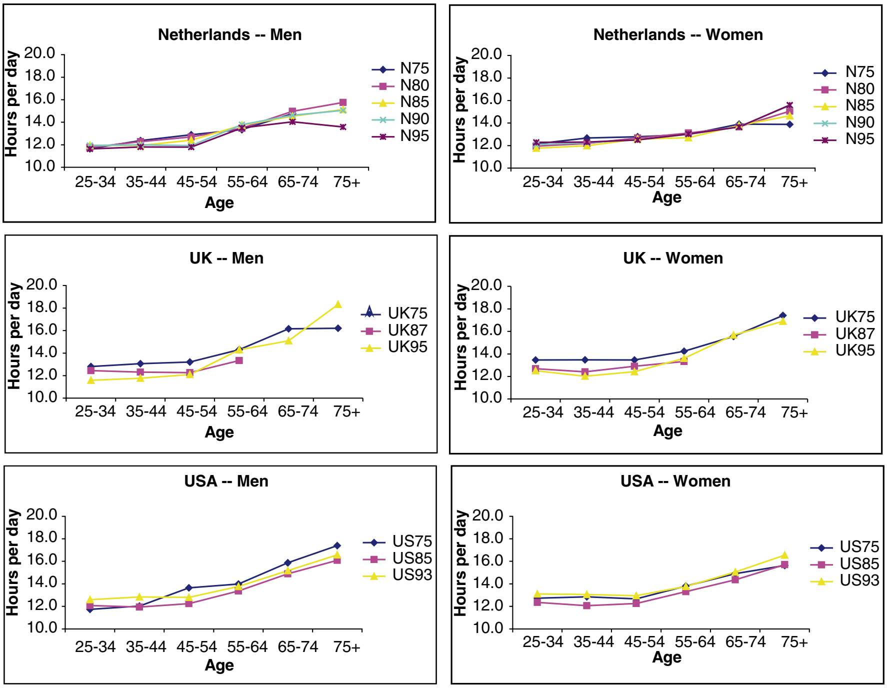

Fig. 4 Mean time devoted to passive activities by country, gender, age and year

Paid Work

Trends in time devoted to paid work, by age, gender and country, appear in Fig. 1. The data refer to daily averages calculated over the 7 days of the week. Time spent on paid work shows a familiar age profile in all three countries, with a steep decline from age 45–54 years old (especially among men). While time spent on paid work varies around 5–6 h per day for men at age 45–54 years old (the equivalent of 35–42 h per week), it falls to less than 1 h per day by the age of 65–74 years old.

In terms of trends, Dutch men devoted more time to paid work at ages 45–54 in the 1990s, as compared to the 1970s, while the pattern was reversed at ages 54–64 with men devoting less time to paid work in later years. The lower number of hours of paid work at ages 54–64 recorded in 1995, as compared to 1975, reflects the well-known trends towards earlier retirement and lower labour force participation at older ages. Time spent on paid work at age 55–64 was 3.8 h per day for Dutch men in 1975 and 2.4 h per day in 1995. A decrease in the time devoted to paid work at older ages is also observed in the United Kingdom. In fact, results for the United Kingdom reveal substantially less time devoted to paid work at all ages for men in 1995 as compared to 1975. As indicated above, we feel less confident about the results for the United Kingdom in view of large cross-survey differences over the period when the data were collected.

In contrast, in the United States men of all ages (with the exception of those aged 75 and over) were found to be devoting slightly more time to paid work in 1993 as compared to 1975. For example, men aged 45–54 years old devoted 6.3 h per day to paid work in 1993 as compared to 5.7 in 1975. This increase in time devoted to paid work was also observed at older ages, but from a lower base. For example, men aged 65–74 years old devoted 0.6 h per day for paid work in 1975 and 1.3 h per day in 1993. These results are in line with data from the International Labor Office showing an increase since 1980 in the annual hours worked per person in the United States (ILO 2001).

The trends for women differ substantially from those of men in each of these nations. Since the 1970s, time spent by women on paid work has increased, rather than decreased, especially among younger and middle-aged women. The change is especially large in the United States. At age 45–54 years old, time spent on paid work by American women has increased from 2.9 h per day in 1975 to 3.8 in 1993. At older ages, on the other hand, time spent on paid work remains low and has not substantially changed between the 1970s and 1990s. A similar trend is observed in the Netherlands.

In terms of cross-national comparison, the amount of time devoted to paid work varies substantially across countries. At age 45–54, time devoted to paid work by men varies between 4.7 h per day in the United Kingdom (in 1995) and 6.3 in the United States (in 1993), a 34% higher value in the United States. For women, also aged 45–54, time devoted to paid work varies between 1.7 h per day in the Netherlands (in 1995) and 3.8 in the United States (in 1993). At ages 65–74, large cross-national differences are also observed with American men devoting 1.3 h per day to paid work in 1993, as compared to 0.3 h for Dutch men and 0.5 for British men (in 1995). These results are in line with data from the OECD (2000) showing that in the mid- to late-1990s the employment/population ratio for men aged 65–69 years old was highest in the United States and substantially lower in the Netherlands and the United Kingdom.

Older men are therefore more likely to be devoting time to paid work in the United States than in the other two countries. Similar trends are also observed for older women. Whether this cross-national difference is due to differences in financial support of the elderly or to differences in opportunities for work at older ages is unclear. We tend to think that the more flexible and less secure labour market institutions in the United States, including greater numbers of part-time jobs, are the reason for much of this difference. However, it could also be due to the fact that social retirement institutions, including early retirement provisions, disability programmes and unemployment insurance programmes also differ greatly amongst these three nations (Smeeding and Quinn 1997).

Housework

Time spent on housework appears in Fig. 2 and, as expected, reveals very different patterns for men than for women. There are two main differences. First, at all ages and at any point in time men devote fewer hours to housework than women. For example, men aged 45–54 years old in the United States devoted 2.3 h to housework per day in 1993, as compared to 3.9 for women. The gender difference in the allocation of time to housework is obviously not new. What is, however, new is the fact that the gender gap has declined in all of these nations. In the United States, the ratio of male to female hours of work devoted to housework was 0.6 in 1993, as compared to 0.4 in 1975, for adults aged 45–54 years old, indicating large changes upward in men's hours of work devoted to housework and downward changes in women's hours. A reduction in the gender gap was also observed in the Netherlands and the United Kingdom.

Second, time spent on housework increases with age for men (with older men spending slightly more time on housework than younger men), while a flatter age-profile is observed for women. American men aged 25–34 years old devoted 1.9 h per day to housework in 1993, as compared to 3.2 at ages 65–74. Similar trends are observed in the Netherlands and the United Kingdom. For women, the age-profile is flatter and older women devote about the same time to housework as younger women. In the United States, women aged 25–34 years old devoted 3.1 h per day to housework in 1993, as compared to 3.5 for women aged 75 and over.

In terms of cross-national comparison, the differences across countries are less than 1 h per day. At age 55–64, time spent on housework varies between 2.4 h per day for men in the United Kingdom (in 1995) to 3.2 h per day in the Netherlands (in 1995), while for women the difference is only from 4.3 h per day for women in the United States (in 1993) to 4.5 h per day in the Netherlands (in 1995).

The analysis so far thus suggests that in the United States, men have increased their allocation of time to both paid work and housework since the 1970s. Women, on the other hand, have increased their allocation of time to paid work, but decreased their allocation of time to housework. If we combine both paid work and housework, men and women appear to be devoting their time in a remarkably similar way in the United States. American men aged 55–64 years old devoted 7.0 h to paid work and housework in 1993, as compared to 6.5 for women of the same age. The comparable figures for 1975 are 6.4 and 6.1 respectively.

Active Pursuits

We now turn to the activities that we label 'active pursuits' and that encompass unpaid work (e.g. childcare, volunteer work), consumption-related leisure activities (e.g. travel for pleasure, cinema, restaurant), education and hobbies. In view of older adults' better health and increasing wealth, we expect older adults to be devoting more time to these activities than in the past. Results for all active pursuits appear in Fig. 3 and reveal relatively flat age patterns, with younger adults devoting about the same amount of time to active pursuits as do older adults. In the United States, young men aged 25–34 years old devoted 3.3 h per day to active pursuits in 1993, as compared to 4.0 for older men aged 75 and over. The comparable figures for women are 3.6 h per day at ages 25–34 and also 3.6 h per day at ages 75 and over.

In terms of historical trends, adults of all ages appear to be spending slightly less time on active pursuits in the United States in the 1990s as compared to the 1970s. The only exception is men aged 75 and over who appear to be devoting more time to active pursuits in 1993 as compared to 1975. Results for the other two countries differ substantially. Dutch men and women appear to be devoting much more time to active pursuits than their American counterparts. At ages 55–64, Dutch men devoted 4.9 h per day to active pursuits in 1995 (5.9 for women) as compared to 3.2 for American men in 1993 (3.6 for women): a stunning difference of about 2 h per day. This difference in the allocation of time to active pursuits between the United States and the Netherlands – at all ages – suggests that we may be observing more of a cultural phenomenon than an ageing phenomenon. The United Kingdom appears between these two extremes with men aged 55–64 years old devoting 3.9 h per day to active pursuits in 1995 (4.3 for women).

Like Americans, Dutch men and women appear to be devoting slightly less time to active pursuits in the 1990s as compared to the 1970s (again very old men are the exception). In contrast, British men and women appear to be devoting substantially more time to active pursuits in the 1990s as compared to the 1970s, with the exception of older men aged 75 and over. According to our results, British men aged 55–64 years old were devoting 3.9 h to active pursuits in 1995, as compared to 2.3 in 1975. For men, the results are in fact the counter-image of those observed for paid work (which showed a strong decline between 1975 and 1995).[9]

Active pursuits obviously represent a very large category of activities. And so, we comment on disaggregated results by sub-category of activity and focus mainly on historical trends (data not shown, but available from the authors on request).

One of the main questions driving this paper is simply, what have older persons been substituting for time spent in earlier years in paid work? Trends since the 1970s, suggest an overall increase in time devoted to volunteer activities in the Netherlands and the United Kingdom, but not in the United States. Time devoted to this activity is, however, small, around 0.1–0.2 h per day. Among older adults, the highest figures were observed for British women aged 55–64 years old with 0.4 h per day of volunteer work in 1995 and for Dutch men aged 65–74 years old also with 0.4 h per day in 1995. Time devoted to childcare by older adults (another form of unpaid work) is also very low, around 0.1–0.2 h per day. A higher figure was observed for American women aged 55–64 years old in 1975, with 0.7 h per day. By 1993, this figure had however declined to 0.1 h per day.[10]

The trends with regard to social activities are more consistent across countries. Overall, adults of all ages appear to have devoted less time to social activities since the 1970s. There are some exceptions, but the overall trend is one of decline.

[9] Although these results may capture a genuine trend, we also suspect a problem of incomparability amongst the British surveys (see our earlier comment to this effect).

[10] In the analysis, we also computed separate figures for time devoted to religious activities. Once averaged over the 7 days of the week, the figures are however too small to reveal any trend.

For instance, at ages 55–64, both men and women in all three countries have reduced their allocation of time to social activities. The magnitude of the change is small, around 0.2 h per day, but the direction of the change is consistent. In contrast, results suggest an overall increase in other out-of-home leisure in the Netherlands and the United Kingdom. In these two countries, older adults have been devoting less time to social activities, but have been devoting more time to other out-of-home activities (including dining out, going to the cinema and travelling for pleasure). This is, however, not the case in the United States where an overall decrease in time devoted to out-of-home leisure has been observed. For instance, American men aged 55–64 years old were devoting 1.0 h per day to out-of-home leisure in 1975, but only 0.5 in 1993. A similar trend was observed at ages 65–74 and 75 and over, and for women.

The trends with regard to sport and fitness are completely different with an overall increase in the Netherlands and the United States, but not in the United Kingdom. The figures are again small, but the trend is consistent. At ages 55–64, American men devoted 0.2 h per day to sport and fitness in 1975. By 1993, this figure had increased to 0.5 h per day. The allocation of time to this sub-category of activity even increased among the older adults aged 75 and over. American men aged 75 and over devoted 0.1 h to sport and fitness in 1975 and 0.3 in 1993.

As to hobbies (including reading newspapers and magazines), the trends are mixed with some groups having increased their allocation of time to this activity, while others having decreased it. For example, Dutch men aged 65–74 years old have increased their time spent on hobbies from 2.0 h per day in 1975 to 2.6 in 1995. American women aged 65–74, on the other hand, have kept their allocation of time to hobbies constant between 1975 and 1993, at 1.7 h per day. In most cases, the magnitude of the change is in fact small.

Finally, the last sub-category of active leisure considered in this paper is education, including attending classes and studying.[11] We computed figures separately for this sub-category of activities in order to capture any trends towards lifelong learning. Figures are very small, less than 0.2 h per day on average (at older ages). In most groups, time devoted to this activity has remained stable. Small increases were observed in some groups, but we cannot be confident that they capture statistically significant trends.

In summary, then, the general trend between the 1970s and 1990s has been for older adults to devote more time to active pursuits. The major exception is, however, the United States where older adults have decreased the time that they allocated to active pursuits. The results for the United States lend, in fact, some support to Putnam's 'bowling alone' thesis. American men and women have apparently become less engaged in social activities: they have been going out less, socializing less and doing less voluntary work. While this evidence is suggestive, the nature of the data do not allow us to make a direct test of Putnam's thesis. In particular,

[11] Note that reading books is included in hobbies. It is assumed here that reading books for education purposes would have been reported by respondents as education-related.

the data do not say whether these trends resulted in older adults spending less time with others and more time alone.[12] Obviously, more analyses would be needed to systematical test this hypothesis. It is nonetheless clear that older Americans have been devoting their time differently from older adults in the Netherlands and the United Kingdom, especially when it comes to the allocation of time between paid work, housework and active pursuits.

Passive Activities

The last category of activities is restricted to passive activities. It encompasses personal activities, such as sleeping, eating, bathing, dressing and personal services (e.g. health care) and other activities that require a low-level of physical activity, such as watching television, relaxing and listening to radio and tapes. Time spent on this activity appears in Fig. 4 and reveals a very strong increase with age, especially after the age of 45–54. Between the age of 25–34 years old and 75 years old and over, time devoted to passive activities by American men increased from 12.6 h per day to 16.6 (in 1993). The comparable figures for women are 13.1 and 16.5. Similar trends are also observed in the Netherlands and the United Kingdom. Cross-nationally, there are non-negligible differences, but they tend to be smaller than the differences between younger and older adults. For example, at the age of 55–64, time devoted to passive activities varied between 14.3 h for British men (in 1995) and 13.8 h for American men. At the age of 75 and over, however, time devoted to passive activities shows larger cross-national differences and varies between 13.6 for Dutch men (in 1995) and 18.3 for British men (in 1995).

Since the 1970s, slightly less time has been devoted to passive activities. The trends are, however, not uniform and the magnitude of the change tends to be small. For example, American men aged 75 years old and over were devoting 16.6 h per day to passive activities in 1993, as compared to 17.4 in 1975. The trend for American women is opposite, with time devoted to passive activities increasing from 15.6 h per day in 1975 to 16.5 in 1993.

Again, passive activities are a large category and it is instructive to disaggregate it into sub-categories of activities (data not shown, but are available from the authors). Personal activities (including sleeping, bathing, eating) account for the largest sub-category, with around 10–11 h per day for older adults. Not surprisingly, personal activities show a strong increase with age, with older adults devoting more time to this activity than younger adults. Older adults may be sleeping less, but are apparently napping more and taking longer time to bathe, dress, eat and conduct normal basic daily activities. On the other hand, between the 1970s and

[12] The time use surveys routinely collect data on with whom each of the activities is carried out (alone, with family members, with others, etc). The harmonized version of the time use surveys currently does not contain this information even though it is present in most of the original (non-harmonized) surveys. This is something that we intend to exploit in future analyses.

1990s, time spent on personal activities has declined in the Netherlands and the United States, at all ages. While pressures to devote time to other activities may explain the decline in time devoted to personal activities by younger adults, for older adults the decline is likely related to better health and fewer limitations to the activities of daily living. This trend was however not observed in the United Kingdom.

The second largest sub-category is television watching, which accounts for between 2 and 4 h per day on average. In all countries, this category of activity also increases substantially with age as older adults devote more time to this activity than do younger adults. For example, American men aged 25–34 years old devoted 2.3 h per day to watching television in 1993, as compared to 4.2 for men aged 75 and over. Furthermore, time devoted to this activity has increased since the 1970s for both men and women in all three countries. The only exception is Dutch men whose allocation of time to watching television has not followed any systematic trend. The increase in time spent watching television is relatively large for American men, and especially at the end of the age spectrum. American men aged 75 and over devoted 4.2 h per day to this activity in 1993, as compared to 3.0 in 1975.

Finally, the last sub-category of passive activity encompasses activities such as relaxing and listening to the radio or tapes. This sub-category represents on average less than 1 h per day. Again, seniors devote more time to this activity than younger adults. American men aged 25–34 years old devoted 0.3 h per day to such passive activities in 1993 as compared to 1.1 for men aged 75 and over. Since the 1970s, time devoted to this activity has decreased in the Netherlands and the United Kingdom, but has increased in the United States. The changes are, however, small. American men aged 75 and over devoted 0.8 h to passive activities in 1975, as compared to 1.1 in 1995.

Passive activities, on average, have followed mixed trends since the 1970s. While time devoted to personal activities and passive leisure has decreased since the 1970s (in most groups), this decrease has been offset by a strong increase in time spent watching television.

Overall Summary

The above results suggest relatively complex patterns of time use: patterns that vary by age, gender and country and that display various historical trends. In order to provide a summary picture, we return to our main results and focus strictly on older adults aged 55 and over. We also restrict our comments to a comparison of the earlier surveys (1970s) and later ones (1990s). To simplify the analysis, we ignore possible variations between these two points. Theoretically, we expected the improvement in health, education and wealth to have led older adults to live a more active life in the 1990s as compared to the 1970s. Is it the case? First of all, it is clear that the answer to this question depends entirely on the definition of 'active' life. Three alternative definitions are considered below. Summary results appear in Table 2.

Table 2 Historical trends in time devoted to active life, 1970s vs. 1990s by country, gender, and age according to three definition of active life

Age/country/gender	All inclusive definition (paid work, housework, active pursuits)[a]	Intermediate definition (paid work, active pursuits)	Restrictive definition (active pursuits)
Age 55–64 years old			
The Netherlands – men	=	−	=
The Netherlands – women	=	+	+
UK – men	=	−	+
UK – women	+	+	+
USA – men	+	−	−
USA – women	=	+	−
Age 65–74 years old			
The Netherlands – men	+	+	+
The Netherlands – women	+	+	+
UK – men	+	+	+
UK – women	+	+	+
USA – men	+	+	+
USA – women	=	+	=
Age 75 years old and over			
The Netherlands – men[b]	+	+	+
The Netherlands – women	−	−	−
UK – men	−	−	−
UK – women	+	+	+
USA – men	+	+	+
USA – women	−	−	−

Where +: increase, −: decrease. =: no change. These trends were based on a minimum difference of 0.2 h per day

[a] The only excluded category is passive activities

[b] For Dutch men aged 75+, the comparison was made between 1980 and 1995 instead of 1975 and 1995 because the sample of men of that age was too small in 1975

If we define 'active' life as the sum of paid work, housework and active pursuits (column 1 of Table 2), results suggest that only older adults aged 65–74 years old have led a more active life in all three countries in the 1990s as compared to the 1970s (American women are the exception). The situation for older adults aged 55–64 years old and those 75 years and older is mixed, with some groups having increased their total allocation of time to paid work, housework and active pursuits, while some having decreased it or kept it constant. Looking down column 1, British women and American men appear to be the only ones to have systematically increased their total allocation to paid work, housework and active pursuits at all ages. The situation for the other groups is again mixed. For example, American women have kept their allocation of time to these three activities constant at age 55–64 and at age 65–74, and decreased it at age 75 and over. Overall, it is, however, important to keep in mind that the magnitude of these changes is small. For instance, older American men have increased their total allocation of time to paid work, housework and active pursuits by 0.2 h per day at age 55–64 between 1975 and 1993, by 0.6 h per day at age 65–74 and by 0.8 h per day at age 75 and over. The magnitude tends to vary across age, gender and country, but is usually less than 1 h.

If we exclude housework from our ‘active life’ definition and confine it to paid work and active pursuits (column 2 of Table 2), a different picture emerges for adults aged 55–64 years old, but not at older ages. According to this definition, all older adults aged 65–74 years old have led a more active life. It is also the case for women aged 55–64 years old in the Netherlands, the United Kingdom and the United States, and for British women, Dutch men and American men aged 75 and over. But once again, the magnitude is relatively small. Between the mid-1970s and mid-1990s, Dutch women aged 55–64 years old have increased the total time devoted to paid work and active pursuits by 0.9 h per day, British women by 0.8 h per day and American women by 0.2 h per day. Dutch men aged 55–64 years old, on the other hand, have reduced their total allocation of time to paid work and active pursuits by 1.3 h per day. The comparable figures for British and American men aged 55–64 years old are, respectively, 0.8 h per day and 0.3 h per day.

Finally, if we confine the definition of active life to time devoted to active pursuits (column 3 of Table 2), again all older adults aged 65–74 years old appear to have led a more active life (with the exception of American women who kept their allocation of time constant). Dutch women and British men and women aged 55–64 years old also appear to have led a more active life. This is, however, not the case for American men and women and Dutch men of the same age. Among adults aged 75 and over, only British women, Dutch men and American men appear to have increased their allocation of time to active pursuits. With regard to the sub-categories of active pursuits, and restricting here our comments to adults aged 65–74 years old, Dutch men and women have increased their allocation of time to voluntary work, sport and fitness, out-of-home leisure and hobbies, but have reduced their allocation of time to social activities. Results are similar for British men and women aged 65–74 years old with the exception of sport and fitness, for which time allocation has either decreased or remained stable. A somewhat different pattern is observed for older American adults. Older American men aged 65–74 years old have increased their allocation of time to fewer activities, namely sport and fitness, social activities and hobbies, while American women have increased their allocation of time only to sport and fitness and social activities.

Conclusion

We started this paper with well-known demographic and economic trends: on the one hand people’s life expectancy, health and ability to work at older ages have increased over time, while on the other hand, people have been retiring earlier and labour force participation at older ages has decreased (especially for men). From this starting point, the paper asks the question of what have been the trends in people's allocation of time since the 1970s? More particularly, we were interested in the extent to which the decrease in time devoted to paid work at older ages had been accompanied by more time devoted to volunteer work, unpaid work, consumption-related leisure activities and other forms of active and engaging leisure activities. From a theoretical perspective, we were expecting more time to be spent actively today in view of the better health, education, mobility and income of elderly as compared to 30 years ago.

Results presented in this paper suggest that there is no single answer to the question: have older people led a more active life? Results appear to vary by country, gender and age and are highly sensitive to the definition of 'active' life. Overall, results suggest that all older adults aged 65–74 years old have led a more active life and this regardless of the definition of active life used (American women are the exception). Results are, however, mixed for adults aged 55–64 years old and 75 years old and over. In this later group, most elderly people appear to have decreased time devoted to an active life. The only exceptions are British women, Dutch men and American men.

We do not have a satisfactory explanation at this point for these findings, and especially for the cross-national differences. In particular, it is not clear the extent to which the results obtained in this paper are a consequence of changes in micro- or macro-level factors that have altered the opportunities and constraints of older adults from being economically and socially more active (OECD 1998). What is, however, clear is that the reallocation of time does not follow simple patterns. The decrease in time devoted to paid work is not necessarily accompanied by an increase in time devoted to active pursuits, and the increase in time devoted to active pursuits does not go hand in hand with a decrease in time devoted to passive activities. Future research will, perhaps, help us solve these puzzles.

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An Economic Analysis of Age Discrimination: The Impact of Mandatory Retirement and Age Limitations in Hiring on the Utilization of Human Resources in an Ageing Society

Atsushi Seike

Introduction

Japan's population is now rapidly ageing. Given this situation, every system established under the so-called pyramid-shaped population, with its large younger population and smaller old population, needs substantial revision. In short, a revision in which institutions become free from age is necessary. One of the most important changes needed to cope with an ageing population is an age-free employment system, for two main reasons.

One reason is the necessity to promote the employment of older workers. As the percentage of older people in the population increases rapidly and the younger population drastically decreases, the burden of the cost of the ageing society per worker will skyrocket if the current employment system remains in which workers up to age 60 are expected to support society by paying taxes and social security premiums. It is very important for us to establish an age-free society in which older workers who are willing and able can continue working and therefore continue supporting the ageing society as contributors of taxes and social security premiums rather than as pensioners.[1]

Based on this concept, Japan, the U.S. and several European countries are now trying to promote the employment of older people. Even in the European countries that used to have pension policies to discourage older people from continuing to work thus providing more job opportunities for younger people, there has recently been a growing interest in promoting the employment of older people as a means to cope with their substantially ageing populations.

[1] For details see Seike (2001).

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Their pension policies have in the 1990s been changed to encourage, not discourage, older people to continue working. The U.S. government has had a policy of promoting the employment of older people for several decades. Its most salient aspect was the introduction of the Age Discrimination in Employment Act (ADEA). This law was first enacted in 1967 to deal with age discrimination against people up to 65. The age limit was raised to 70 in the 1978 revision, then lifted altogether in the 1986 revision. This has created an employment environment where there is no mandatory retirement. In Japan, there has been a higher motivation among older people for working, as shown in their labour force participation rate. Government policies have acted to expand job opportunities for older people, making full utilization of their motivation to work. The Employment Stabilization Act for the Elderly was first enacted in 1986 and has since been revised several times. Thus, in the advanced countries, a consensus now appears to be forming promoting employment of older people, at least in general terms. The problems are in the details, particularly concerning employment practices of private firms. A widespread practice that causes problems is mandatory retirement, which requires workers to leave a firm regardless of their willingness or ability to continue working.

The second reason for the necessity of an age-free employment system is the increasing importance of labour mobility among middle-aged and older workers. Job security has weakened due to the increasing pressure of market competition both in Japan and abroad, leading to an increasing possibility of job change among middle-aged and older workers. They will have to move from employers who are no longer able to maintain employment to employers who can expand their employment in mid-career. Moreover, the shrinking younger population will make it difficult for us to change our industrial structure by shifting young worker flow; that is, in the established way in which growing sectors recruit many younger workers while declining sectors do not. It will be necessary for us to have larger numbers of middle-aged and older workers, who have worked for a firm or an industry for many years, change their job in mid-career to meet the changing industrial structures.

One other age-oriented employment practice, age limitations in hiring, will also be a serious obstacle to an age-free employment system. For middle-aged and older people seeking jobs, age limitations in hiring substantially reduce the possibility of finding jobs. Changes in working conditions of older workers, e.g., reduced wages, or improved ability as a result of retraining in new skills, will be meaningless if the applications of middle-aged and older workers are rejected merely because of age.

This paper provides an economic analysis of the negative impacts of mandatory retirement and age limitations in hiring on the utilisation and mobility of an older workforce and proposes several policies based on the analysis. Section II discusses the negative impact of mandatory retirement on the utilization of an older workforce. Section III considers the negative impact of age limitations in hiring. Finally, Section IV describes reasons employers keep such systems as mandatory retirement and age limitations in hiring and provides several policy proposals.

The Negative Impact of Mandatory Retirement on the Utilization of Older Human Capital

Mandatory retirement is a widely accepted employment practice in Japan. According to the Survey on Employment Management by the Ministry of Labour, 90.2% of Japanese firms with 30 or more employees practiced mandatory retirement in 1999. By law, the mandatory retirement age should not be below 60 and, again according to the Survey on Employment Management, 91.2% of firms with mandatory retirement set this legal minimum age of 60 as their mandatory retirement age.

Mandatory retirement is the practice that requires workers to leave a firm simply because of age. This practice adversely affects utilization of an older work force in two aspects. One is by reducing the motivation of older people to continue working. As is widely known, mandatory retirement does not necessarily mean a complete retirement from the workforce. Many older workers after leaving primary employers through mandatory retirement continue working in secondary job opportunities. However, it is also known that mandatory retirement is one of the most important determinants for complete retirement from the labour market. A number of labour economists in Japan have estimated equations for labour supply of older people and found that the experience of mandatory retirement significantly reduces the labour force participation possibilities of older people. Table 1 is an extract of estimated parameters that represent the impact of the mandatory retirement experience on probabilities of participating in the labour force. All parameters are estimated by using micro-level data from the Employment Status Survey of the Elderly from the then Japan Ministry of Labour in each designated year shown in the table.

As seen in the table, the mandatory retirement experience has a significant negative impact on the labour force participation of older people. Though the magnitude of impact, i.e. the size of parameters, varies with the year of data and the age group of data samples, the mandatory retirement experience reduces the

Table 1 The negative effect of mandatory retirement on labor force participation (Author's tabulation)

	Observation year Estimation sample	Coefficients on the probability of labor force participation
Seike (1993a)	1983–men aged 60–69	–0.1774***
Abe (1998)	1983, 1998, 1992– Men aged 60–69	–0.227***
Ogawa (1997)	1980, 1983, 1988, 1992– Men aged 60–64	–0.1283***
Ogawa (1998)	1983, 1988, 1992– Men aged 60–64	–0.0975**(probit coefficients)
Ohishi (2000)	1996–men aged 60–69	–0.269***
Ohga and Nakamura (1999)	1992, 1996– Men aged 60–64 with spouse Men aged 65–69 with spouse	–0.277*** –0.308***

***Statistically significant at the respective level of 1%

probability of labour force participation of men aged 60–69 by about 20% *ceteris paribus*. Furthermore, people who completely retire from the labour market after mandatory retirement represent relatively higher human capital.

Figure 1 shows a distribution of wages calculated on the basis of the labour supply equations for older people.[2] The calculated wages can be considered a comprehensive indicator of human capital under which higher calculated wages represent higher human capital. The comparison was made between retired men with mandatory retirement experience and working men without mandatory retirement experience.

The calculated wages of retired men with mandatory retirement experience tend to be higher than those of working men without mandatory retirement experience. This means that the retired men with mandatory retirement experience retain higher human capital than working men without mandatory retirement experience. The result implies that mandatory retirement causes a loss also in human capital from a labour market perspective.

In addition, mandatory retirement obstructs full utilization of the abilities of older workers who would like to continue working beyond the mandatory retirement age. First of all, wages actually paid to workers who have mandatory retirement experience are low relative to their potential abilities. I observed this negative impact of mandatory retirement on full utilization of the human capital of older workers by using the method of switching regressions to differentiate a primary group of higher wage people and a secondary group of lower wage people. If the coefficient for the variable that represents having mandatory retirement experience is significantly negative, mandatory retirement would differentiate the wage functions, and therefore

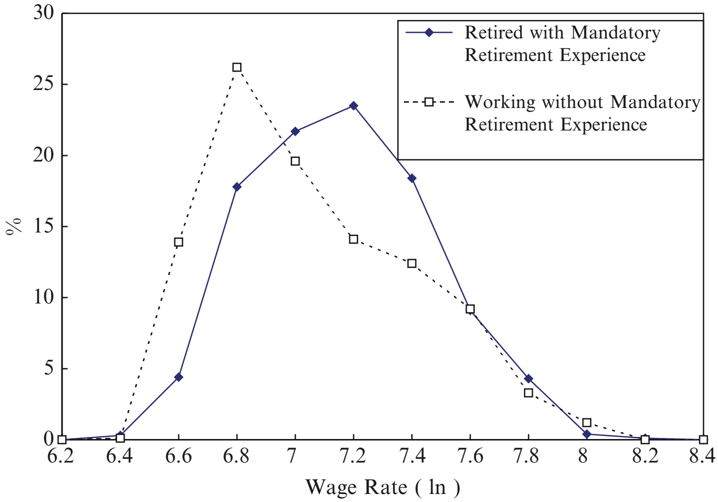

Fig. 1 Wage rate for older workers with and without mandatory retirement experience (men aged 60–69) (Seike and Yamada 1998)

[2] We estimated the labor supply equation by using the Heckit model which had been originally developed in Heckman (1979). For details, see Seike and Yamada (1998).

the degree of human capital utilization among older people. And if the coefficient for the variable that represents having mandatory retirement experience was significantly negative in wage equations, mandatory retirement would reduce wages for each group of people. The data set used here is from the 1992 Employment Status Survey.

Table 2 shows the results. As seen in the table, estimated coefficients for the mandatory retirement experience are negative with high statistical significance. This indicates an important role in differentiating groups of people in terms of wages actually received. Namely, older workers with mandatory retirement experience are more likely to be assigned to the secondary group in which the wages actually received are lower than in the primary group. And in the case of both the primary and the secondary group, the mandatory retirement experience reduces the level of wages.

There should be no difference in human capital for a worker before and after mandatory retirement, yet the results imply that older workers with mandatory retirement experience tend to be working under circumstances where they cannot

Table 2 Estimated results of the switching regression model on wages actually received by older workers (Seike and Yamada 1998)

Variable	Primary	Secondary	Switch
Constant	6.169***	7.806***	−0.280
AGE	0.003	−0.021***	−0.013
HEALTH	−0.011	−0.141***	−0.371*
FAMILY			−0.027
NOMOGAGE			−0.077
METRO	0.486***	0.240***	−0.120
MANDRET	−0.265**	−0.104***	−0.500***
PENSION			−0.024***
REGULAR55	0.488***	0.064**	0.134
GOV55	−0.131	−0.011	−0.098
LARGE55	0.428***	0.123***	0.237*
SMALL55	−0.627***	−0.053**	−0.334***
MGR55	0.131	0.351***	1.156***
PRO55	−0.310	0.251***	0.978***
OTHER55	−0.725***	0.060*	0.545***
SERVE55	−0.982***	0.012	−0.136
SAMEJOB55	−0.065	0.264***	
SAMEFIRM55	0.549***	0.142***	
Covariance with switching error	1.118	−0.059	(Normalized to 1)
Log likelihood			−3160.73
Sample size			3308

AGE = Age, HEALTH = Health problem, FAMILY = Family size, NOMOGAGE = No mortgage, METRO = Metropolitan resident, MANDRET = Mandatory retirement, PENSION = Public pension (0000 yen), REGULAR55 = Regular worker at age 55, GOV55 = Employed by government at age 55, LARGE55 = Employed by large firm at age 55, SMALL55 = Employed by small firm at age 55, MGR55 = Managerial occupation at age 55, PRO55 = Professional occupation at age 55, OTHER55 = Other white collar occupation at age 55, SERVE55 = Service occupation at age 55, SAMEJOB55 = Same occupation at age 55, SAMEFIRM55 = Employed by same firm at age 55

***, **, *Statistically significant at the respective levels of 1%, 5%, and 10%

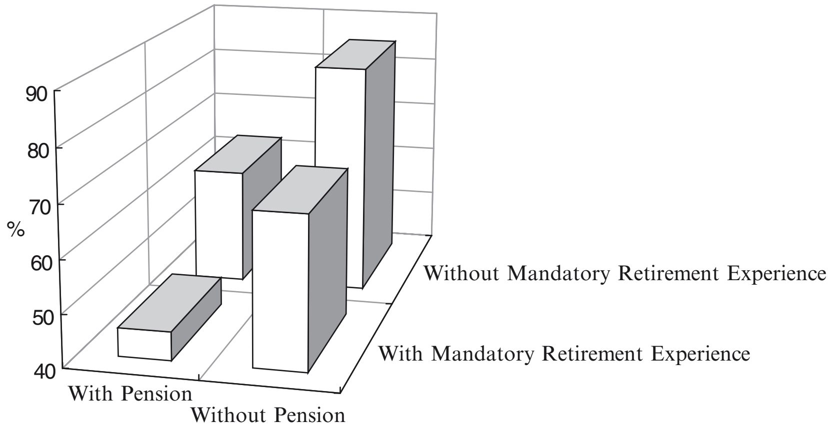

Fig. 2 Proportions of workers by pension and retirement experience who have the same occupation as at age 55 (Same as Fig. 1)

take advantage of their full potential. Older workers who have potentially higher abilities are often assigned to low wage jobs that require relatively lower abilities.

Another condition affecting older workers and the utilization of their potential abilities is whether or not they can continue working in the same kind of occupation. Figure 2 shows the proportion of workers aged 60–69 working in the same occupation as they were at age 55. Among those who are not receiving a public pension, as presented in the right-hand column of this graphical exposition, 70% of workers with mandatory retirement experience are working in the same occupation as they were at age 55, while the proportion for workers without mandatory retirement is 85%. Among those receiving a public pension, as shown in the left-hand column of Fig. 2, a similar comparison between workers with mandatory retirement and those without reveals that only 45% of workers with mandatory retirement experience are working in the same occupation as they were at age 55, while the proportion for workers without mandatory retirement experience is 60%. These observations suggest that the possibility of working in the same occupation is correlated with public pension eligibility which is, in turn, highly correlated with the mandatory retirement experience. For these reasons, the sample is separated into those receiving a public pension and those who are not.

The Negative Impact of Age Limitation in Hiring on Labour Mobility

The foregoing discussion indicates that the practice of mandatory retirement has negative impacts not only on incentives for labour force participation, but also on the utilization of the potential abilities of older workers even when they continue working after mandatory retirement. That is one aspect of the problem with an employment

Table 3 Job openings/applicants ratios (numbers below each ratio are job openings) (Japan Employment Stabilization Bureau, Ministry of Labor 2000))

Age group	July 2000	August 2000	September 2000
~19	1.75	2.01	2.21
	97,161	104,950	112,306
20–24	0.72	0.79	0.85
	212,223	228,910	242,541
25–29	0.62	0.67	0.72
	239,041	257,753	272,565
30–34	0.86	0.92	0.97
	224,022	241,162	255,388
35–39	1.03	1.11	1.15
	182,135	195,772	207.966
40–44	0.89	0.97	1.02
	135,243	144,736	154,600
45–49	0.47	0.5	0.55
	93,833	100,189	107,380
50–54	0.27	0.29	0.31
	63,995	68,071	73,173
55–59	0.15	0.16	0.18
	40,124	42,611	45,747
60–64	0.07	0.07	0.08
	26,384	27,780	29,652
65~	0.19	0.21	0.23
	8,512	8,844	9,449
Total	0.54	0.58	0.63
	1,322,673	1,420,778	1,510,767

practice that relies on the age of workers. Another employment practice having a serious negative effect is age limitations in hiring when employers offer job openings in the labour market. Particularly for those who become unemployed in mid-career, such age limitations in hiring seriously constrain job opportunities.

Table 3 shows the difficult state of job opportunities for middle-aged and older unemployed from July to September 2000. The job openings/applicants ratio significantly drops after the age range of 45–49. This table also shows that the reason for this decline is the sharp fall in the number of job openings after that age range. According to a survey by the Japan Institute of Labor (2000), 90.2% of job openings have age limitations in hiring in Japan. This survey also found that the average age of limitation in hiring was 41.1 years old.

Age limitations in hiring are also demonstrated by analyzing advertisements of job openings in general newspapers, an economic newspaper, a tabloid and a sports newspaper in July and August 2000. Table 4 shows the results. About 80% of job openings in the general newspapers and the economic newspaper included age limitations. On the other hand, about 40% to 50% of the openings appearing in the tabloid and the sports newspaper had limitations.

Among advertised job openings with age limitations in the general newspapers, only one third of job openings are open to those over 45 years old. In the case of

Table 4 Age limitations in job opening advertisements in newspapers (%)

	General newspapers			Economic newspaper			Tabloid newspaper			Sports newspaper		
Age limitations	Total	Regular employee	Irregular employee	Total	Regular employee	Irregular employee	Total	Regular employee	Irregular employee	Total	Regular employee	Irregular employee
Without age limitations	22.5	21.8	24.3	17.5	15.9	23.6	58	57.1	58.3	45.3	19.4	48.5
With age limitations	77.5	78.2	75.7	82.5	84.1	76.4	42	42.9	41.7	54.7	80.7	51.5
~30	15.6	17.4	10.4	27	27.2	26.2	0	0	0	53.6	40	56.2
~35	20.5	21.3	18.3	36.9	38.3	31	0	0	0	27.6	32	26.7
~40	16.9	16.1	19.1	23.9	24.4	21.4	15	0	20	11.4	14	10.5
~45	11.8	10.2	16.5	8.6	9.4	4.8	0	0	0	4.8	14	3.1
~50	11.1	12.6	7	0.5	0	2.4	7.7	33.3	0	1.0	0	1.2
~55	12	11.7	13	0.5	1	0	23	66.7	10	0	0	0
~60	6.9	6.3	8.7	0.9	0	4.8	15	0	20	1.3	0	1.6
~65	5.1	4.5	7	0.4	0	9.5	39	0	50	0.7	0	0.8

General newspapers are the *Yomiuri Shinbun*, *Asahi Shinbun* and *Mainichi Shinbun* on July 23 and August 27, 2000
The tabloid and the sports newspaper are the *Gendai* and *Tokyo Sports* respectively on July 22 and August 26, 2000

the economic newspaper, only one quarter of the openings are open to those over 40 years old. The table also shows that the job openings for regular jobs are biased towards relatively younger applicants both in the general newspapers and the economic newspaper. The tendency observed is that the job openings appearing in the general newspapers and the economic newspaper are quite similar to what is observed in the job openings/applications ratio shown in Table 3. On the other hand, the tendency of the tabloid and the sports newspaper are different. There are relatively many advertisements of job openings for middle-aged and older people in the tabloid, while there is a heavy bias towards relatively younger people in the sports newspaper. This may reflect a difference in reader characteristics by population between the two kinds of papers.

Thus, both government surveys and advertisements in newspapers clearly show a significant presence of age limitations in hiring in Japan. There is substantial constraint of job opportunities for those aged 40 and over. As a result, it is very difficult for middle-aged and older unemployed to find new jobs.

Figure 3 shows the results of the Special Survey of the Labour Force by the Statistics Bureau of the Management and Coordination Agency in February and August 2000, in which the reasons for being unable to take up a job were asked of the unemployed. The top reason for those unemployed and over 35 years old was 'age limit.' Particularly in cases of those over 45 years old, about 40% of unemployed aged 45–54, about 50% of unemployed aged 55–64 and about 60% of unemployed aged 65 years old and over gave 'age limit' as the reason. Since there is almost no possibility of middle-aged and older unemployed not being able to apply for a job because they are too young, 'age limit' means too old to apply. The fact that the proportion of unemployed who gave this reason increases after age 45 is consistent with the fact that job openings decrease after this age group, as observed above.

Furthermore, Fig. 4 shows that age limitations in hiring have a significant impact on the duration of unemployment as well. The proportions of middle-aged and older unemployed who gave age limitation as their reason for being unable to take up a job increases as the range of duration of unemployment in each age group increases. The negative impact of age limitations in hiring on taking up a job seems to be particularly serious for middle-aged and older unemployed with longer durations of unemployment.

Necessary Reform of the Employment System for an Age Free Labour Market

Mandatory retirement and age limitations in hiring will be major obstacles in the ageing society. To cope with the negative effects of these employment practices that rely on age, it will eventually become necessary to eliminate these practices; namely, to introduce legislation against age discrimination in employment, such as ADEA in the U.S. Under what circumstances will mandatory retirement and age limitations in hiring be eliminated?

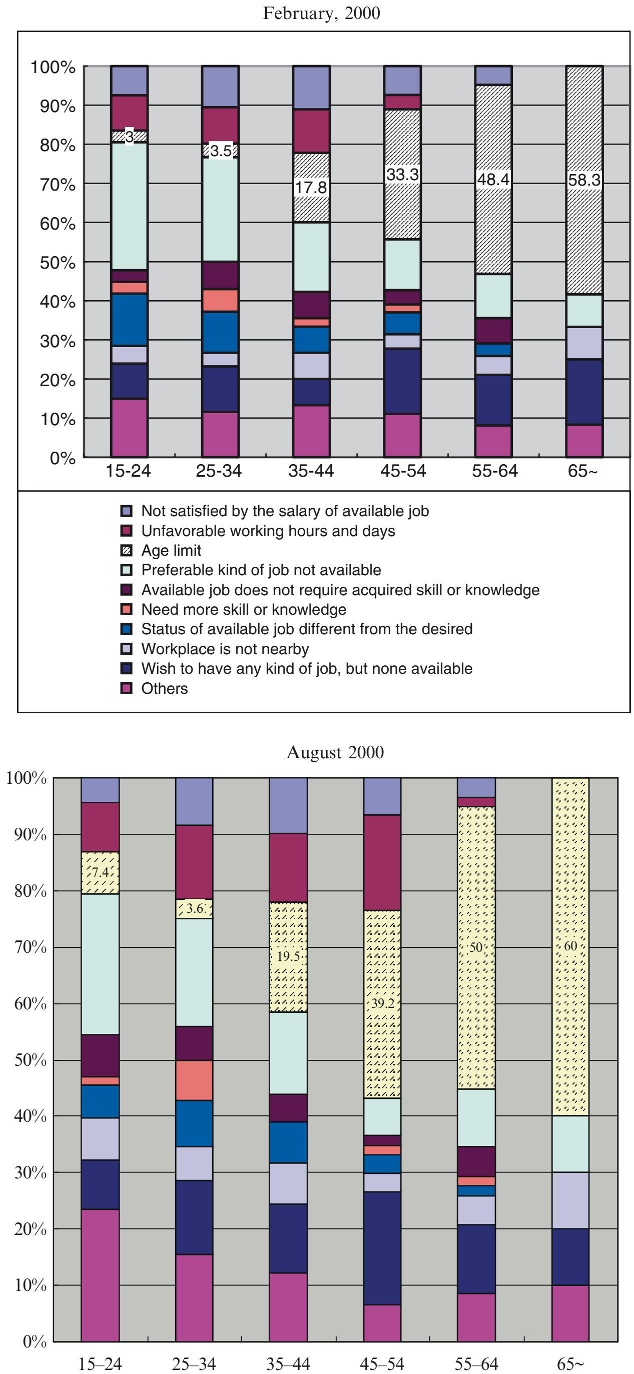

Fig. 3 Proportions of unemployed persons by reasons of failure to find a job by age (Japan Statistics Bureau, Management and Coordination Agency 2000)

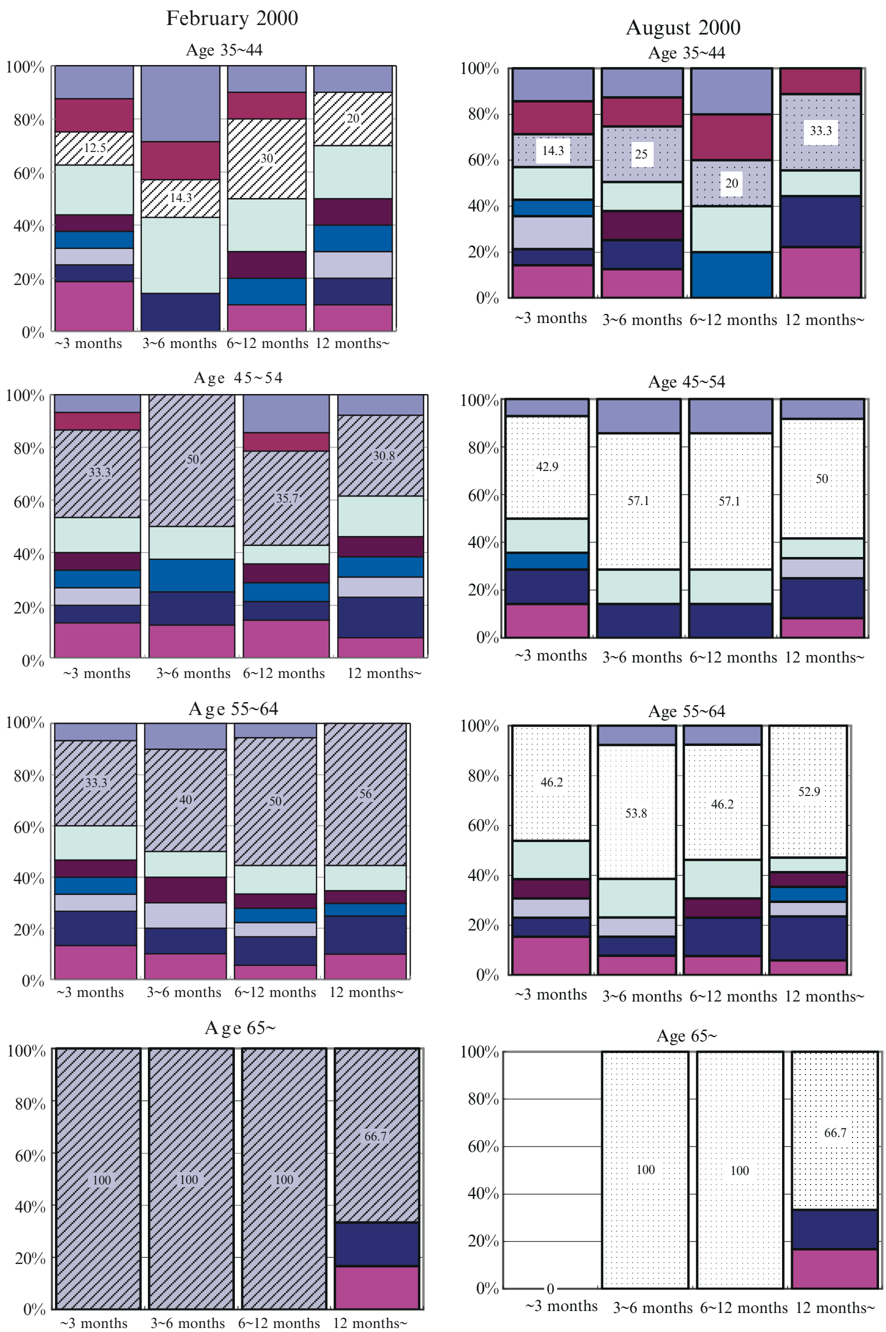

Fig. 4 Proportions of unemployed persons by reasons of failure to find a job and duration of unemployment

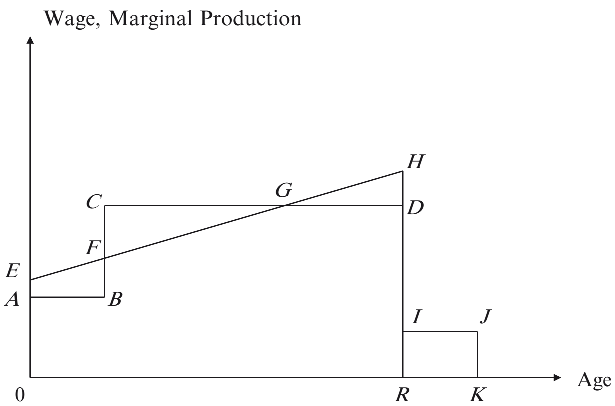

Fig. 5 Relationship between productivity and wage (Lazear 1979). Modified from the original

There are, of course, reasons for employers to maintain mandatory retirement and age limitations in hiring. First of all, as Lazear (1979) clearly described, the seniority-based wage system needs mandatory retirement. The basic argument here is illustrated in Fig. 5. This figure shows that, for regular workers on a long-term employment contract such as the Japanese lifetime employment system, a simple wage determination system where wage rates increase with the age of the worker (EH in Fig. 5) makes economic sense for both the employers and the workers. A newly employed worker with low marginal productivity gets paid more than the productivity warrants (EF versus AB), but the situation reverses as the worker's skill level increases (CG versus FG). The situation reverses again as the wages increase with age (GD versus GH). Under this kind of wage system, mandatory retirement (at age R) is a necessity. At age R the worker retires and begins receiving his company pension (IJ), which ends at age K. The parameters of this wage system, the slope of the wage rate, the mandatory retirement age' the amount and the pay period of pension are set for each type of worker so that the accounting identity equates total worker contribution to the firm to the total wages the worker receives.

This shows not only the reason for the necessity of mandatory retirement, but also the reason why employers are reluctant to employ middle-aged and older applicants. It is costly for employers to employ middle-aged and older workers who did not accumulate 'deposit' (FCG) in the seniority wage scheme. And employers have incentive to get rid of middle-aged and older workers by making a lump sum payment equal to the difference between productivity and the wage of the worker.

The above discussion indicates that in order to eliminate mandatory retirement and age limitations in hiring, substantial reform of the seniority-based wage system will be necessary. We require a shift to a system in which workers' current contributions to the employer and current wages are equated at each point in time (or some approximation to such a system). And, in fact, the Japanese wage system is now moving in that direction. Figure 6 from the Labour White Paper in 2000 of the Ministry of Labour shows that the age-wage profile of standard male Japanese workers has grown less steep over the past two decades.

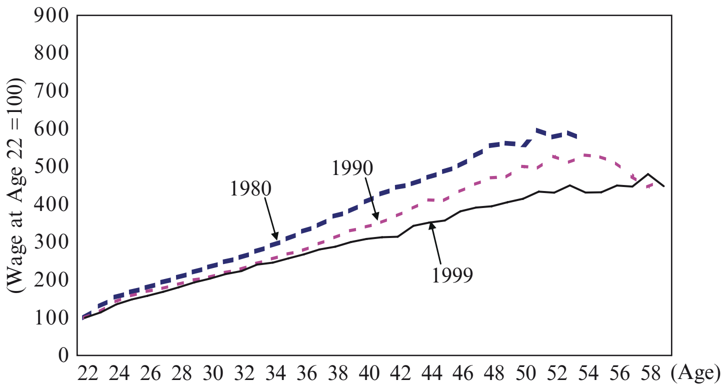

Fig. 6 Age-wage profile of male standard workers (with college degree) (Japan Ministry of Labor 2000)

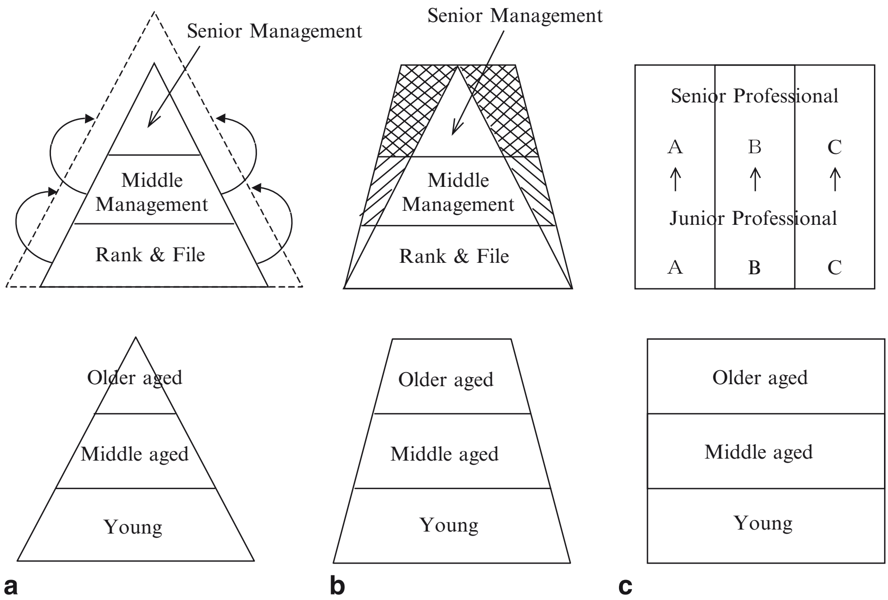

Fig. 7 Shift in personnel structure (Seike 1993b)

Another reason for employers to have mandatory retirement and age limitations in hiring is the seniority-based promotion system. That is the current promotion system by which most, if not all, employees in the same cohort get promoted to higher managerial positions. Under this promotion system, it is necessary for employers to get rid of older workers to vacate positions for their junior workers.

This seniority-based promotion system is also changing gradually due to the changes in economic circumstances and the population structure itself. Figure 7a shows that such promotion practices presume an ever-growing workforce, which is no longer sustainable. The reality now is that many firms are having to carry middle-aged and older workers with quasi-management titles and no work responsibilities, as shown in Fig. 7b. Such redundant managerial ranks may also end up getting structured out. Given that the present low-to-no-growth situation is likely to persist for the Japanese economy for some years to come, a more realistic scheme for firms' personnel structure would be to promise no managerial positions as workers get older, as shown in Fig. 7c.

In this new system, as workers develop specialized skills over time they get treated as specialists in their own fields. And as long as they have such skills and are paid wages just equal to their contributions to the employer, there is no necessity for employers to have mandatory retirement or age limitations on hiring.

Labour market policies should encourage this trend in business to establish, eventually, an age-free labour market in the ageing society. As one measure, an anti-age discrimination act would be worth considering. Announcement of the introduction of such legislation in the future will accelerate reform in business towards an age-free employment system including wages and the promotion system.

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