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AGEING SOCIETIES – MATURE PEOPLE GESUNDES ALTERN ALS CHANCE?

SYMPOSIUM 10. MAI 2011
Anlässlich der Feierlichen Sitzung der Österreichischen Akademie der Wissenschaften

ÖAW: Forschung und Gesellschaft 4

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Ageing Societies – Mature People
Gesundes Altern als Chance?

Symposium10. Mai 2011
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Preface

As children grow up, they not only get older but also acquire new skills, gain strength and learn to better understand the world around them. After the age of 25, however, bodily strength enters a slow decline and certain skills also start to weaken, with an acceleration around age 60-70. But learning and accumulating experience can continue over the rest of life, if we choose to keep an open mind. Hence, getting older in years can also provide opportunities, if we choose to utilize them.

At the level of societies, for generations the "demographic metabolism" assured innovation through the replacement of older people by younger cohorts with new ideas and new skills. As this process slows down through higher life expectancy and lower fertility challenges arise for maintaining the productivity of economies and the quality of life of the ageing populations.

Adjusting our individual life cycles and our social institutions to these changes is one of the greatest challenges of our times and therefore was also chosen as the topic of this symposium.

Wolfgang Lutz
Organizer

PROGRAMM /PROGRAM

Seite / Page

Vorsitz: Theodor Tomandl

14:00	Sarah Harper | *Oxford Institute of Ageing, Oxford, UK* ***Exploring the Implications of Global Ageing***	22
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15:30	Alexia Fürnkranz-Prskawetz | Institut für Demographie der ÖAW, Wien / Institut für Wirtschaftsmathematik der TU Wien ***An Economic Perspective on Ageing***	39
16:15	Kaffeepause	
16:45	**Podiumsdiskussion** ***Wie kann unsere Gesellschaft die Potenziale älterer Menschen besser nutzen?*** Helmut Denk | Präsident der ÖAW Alexia Fürnkranz-Prskawetz | ÖAW / TU Wien Eleonora Hostasch | Bundesministerin für Arbeit, Gesundheit und Soziales a.D. Wolfgang Lutz | ÖAW / IIASA / WU Wien Bernd Marin | Europäisches Zentrum für Wohlfahrtspolitik und Sozialforschung, Wien Moderation: Theodor Tomandl	
18:00	Erfrischungen	

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Aging from a Biomedical Perspective

Old age is associated with a decrease of organ function, which is the basis for age-related impairments such as decreased eye sight, hearing problems or frailty. Age-related biological changes are also the basis of age-related diseases such as atherosclerosis, type II diabetes, osteoporosis or Alzheimer's disease [1]. The decreased function of the immune system additionally leads to the frequent occurrence and severity of infectious diseases [2]. All these problems increase the number of hospitalizations which are frequently the cause of a loss of independence and the necessity of care. In view of the present demographic situation it seems essential that as few elderly persons as possible need care and that as many as possible stay healthy. In spite of this obvious necessity and the increasing awareness of middle-aged and elderly persons to "look after themselves", a large percentage of elderly persons is still suffering from age-related impairments and diseases. In order to improve this situation, big state-of-the-art research initiatives are needed. These initiatives will have to clarify age-related changes of molecules, cells, organs and organ systems. This knowledge will help us better to understand how biological mechanisms of aging lead to impairments and diseases and how new treatments to extend healthy lifespan can be found.

To demonstrate how age-related changes of molecules, cells, organs and organ systems can be studied, the example of the aging immune system is discussed. In this system an important event is the involution of the thymus, which starts soon after birth, accelerates around puberty and is almost complete between the age of 40 and 50 (Fig.1). The thymus is the maturation organ for T lymphocytes, an important type of immune cells. The consequence of thymic involution is the incapacity of an organism to generate new T cells. Elderly persons are therefore dependent on the T cell repertoire generated earlier in life. Multiple re-utilizations of pre-existing T cells lead to changes in the repertoire, as "young" naïve T cells decrease and "senescent" effector T cells accumulate [3]. Senescent effector T cells have a decreased diversity and are pro-inflammatory. The pro-inflammatory properties have been shown to support the development of age-related diseases [1] and to endanger the success of vaccinations [4]. To prevent impairments and diseases which are due to the biological aging process, new treatments are needed to extend healthy lifespan. Short-lived model organisms such as yeast, the nematode

C.elegans and the fruit fly Drosophila melanogaster are studied to define which molecules / intracellular signaling processes should be targeted by these treatments. Using these model organisms it has been shown that gene products which regulate the carbohydrate, amino acid and oxygen metabolism are of particular importance to extend healthy lifespan [Fig.2; 5]. Attempts to influence nutrient-sensitive pathways were therefore an important goal. As a first step, the effects of caloric restriction (CR) were studied. It was found that pronounced CR over a relatively long time increases healthy and maximal lifespan in different species, namely yeast, worms, flies, mice and monkeys [6]. Humans have not yet been tested, but it seems likely that CR protects them from age-related diseases. The major signaling pathways that mediate the effects of CR on longevity have recently been studied in order to be able to target them with drugs and thus avoid the need of starvation. It has been found that four different signaling pathways are most important for the effect of CR: Insulin/IGF-I; target of Rapamycin (TOR); AMP-activated protein kinase (AMPK); and sirtuins [7]. Sirtuins are DNA-silencing molecules which are stimulated during CR. Substances capable of stimulating sirtuins were thus investigated [8]. Resveratrol, a natural stimulator of sirtuins, occurs in food such as red wine, red grapes, rhubarb roots and peanuts at relatively high concentrations. Resveratrol has been shown to prolong lifespan in several species, but its effects in humans are not yet fully understood. To design drugs with more specific activity, Sirt1 activating peptides were tested for their suitability as CR-mimetics. They are small compounds with Sirt1 activation efficacy up to 3 magnitudes greater than that of resveratrol. They have been synthesized and shown to be metabolically beneficial in experimental animals. Some of these compounds are already in phase II clinical trials in humans to treat metabolic disease, and new compounds are still being identified and developed. A second group of CR-mimetics are substances which inhibit mTOR signaling. mTOR signaling is reduced during CR. Rapamycin is a drug which induces immunosuppression at high concentrations and is used in transplant patients. Rapamycin, which characteristically inhibits mTOR complex1, has been tested in mice and has been shown to be able to extend the median and maximal lifespan even when treatment starts relatively late in life [9]. Rapamycin is also capable of improving the quality of the immune response in different species [10].

In summary, recent developments in biomedical aging research allow the following conclusions:

(a) During the last decade our understanding of molecular mechanisms that regulate biological aging and lead to age-related impairments and disease has been dramatically improved;

(b) Therapeutic strategies to extend healthy lifespan are no longer utopia;

(c) But, this should not detain us from improving our present situation by measures such as keeping physically and mentally fit and looking for the right social environment.

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Figure 1: Aging of the immune system

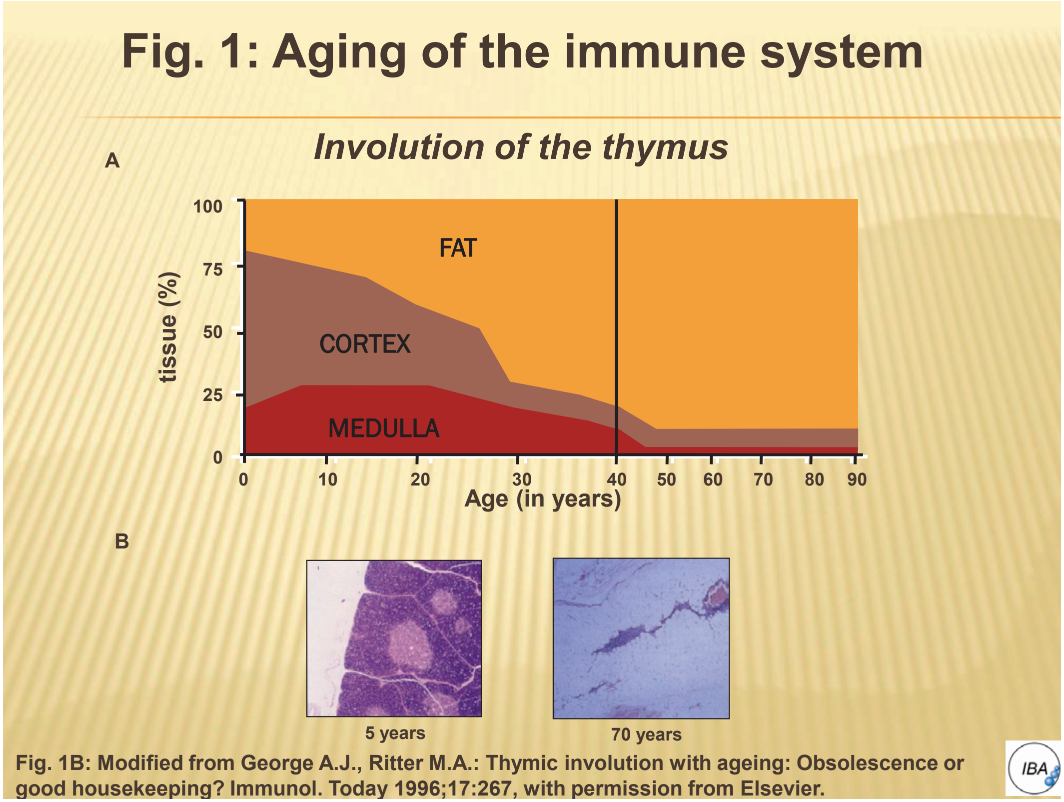
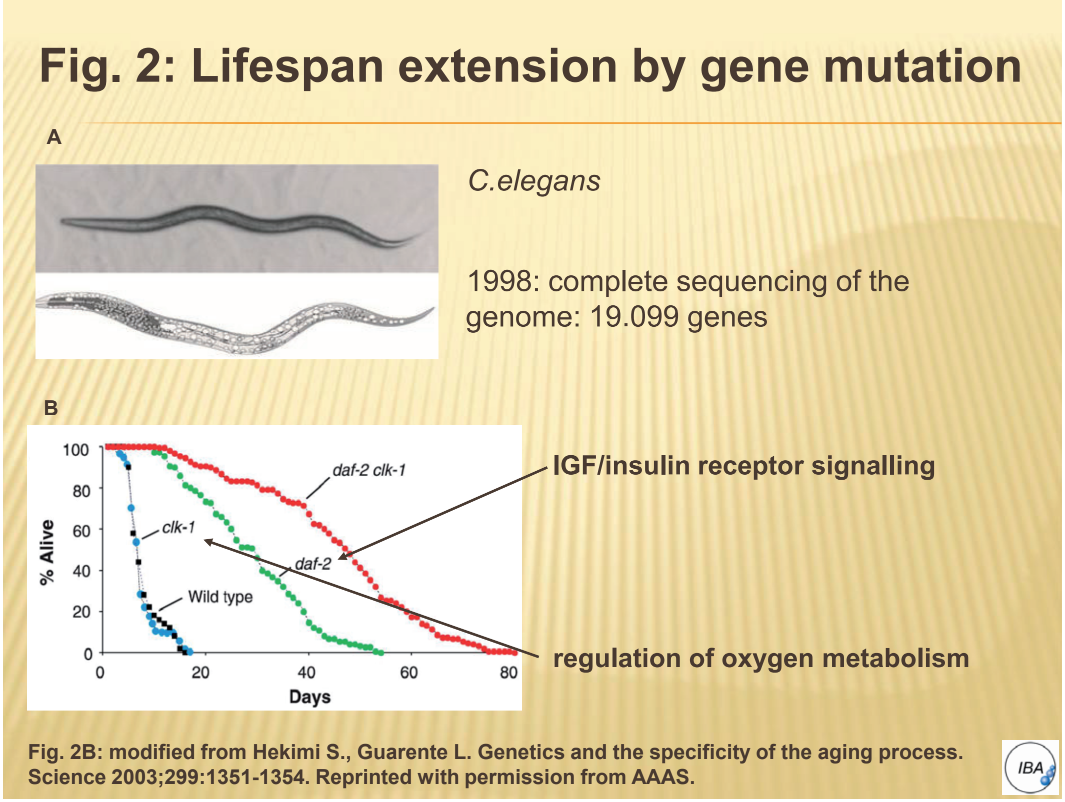


Figure 2: Lifespan extension by gene mutation



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Rethinking Age and Aging

The literature on population aging in developed countries is exploding. Serious concerns have been expressed about the challenges to current economic and social arrangements associated with an ever more elderly population. In contrast to the growth of interest in population aging, the concepts used in analyzing it have remained static. In Sanderson and Scherbov (2005, 2007) we presented a new forward-looking definition of age called "prospective age". The traditional age measure is a backward-looking one. It tells us how many years a person has already lived. But this is an incomplete measure because it ignores changes in life expectancy.

Why is someone aged 60 considered to be middle-aged today while 200 years ago a person of the same age would be considered elderly? The reason is that young and old are relative notions and their common reference point is life expectancy. In 1800 only about 1/3 of women would survive until age 60, while today in developed countries more then 90% of women will celebrate their 60th birthdays. Prospective age measures how old people are, not only from the date of their birth, but also in relation to their lengthening life expectancies.

For many crucial social questions, such as the viability of public pension systems, we need to know not only how old people are, but how many remaining years of life they are expected to have. From an individual perspective, expected remaining years of life affects a host of decisions from saving and investment to the acquisition of new skills. In an era of increasing life expectancies, we obtain a much more complete picture of population aging by combining the backward-looking approach embodied in the traditional age measure with the forward-looking one using prospective age.

In order to understand the concept of prospective age let us imagine two people, one alive in 1950 and the other in 2000. If these two people both were 40 years old, then naturally each would have lived 40 years by those two dates. People who share a prospective age, on the other hand, share a remaining life expectancy. If a 40 year old person in 1950 had a remaining life expectancy of 30 years, and a 50 year old person in 2000 also had a remaining life expectancy of 30 years, then the 50 year old in 2000 would have a prospective age of 40, using 1950 as a year of reference. In this case, all people who had a remaining life expectancy of 30 years would have a prospective age of 40 (again using 1950 as the reference year).

Figure 1 illustrates the concept of prospective age with an example of prospective ages for Austrian population of females. Each line corresponds to a different prospective age where 2000 is selected as a standard year. For example line marked as 70, shows at which age (Y axis) remaining life expectancy was the same as for a 70 year old female in the year 2000. We read from this chart, that a 70 year old person had in 2000 the same remaining life expectancy as a 65 year woman in 1970. Or if we take a line that corresponds to the prospective age 40 at a standard year 2000, then we can seee that a woman at age 40 in 2000 had the same remaining life expectancy as a 30 year old woman had around 1947. This gives support to the famous sayng that 40s is a new 30s.

Like a constant dollar is used to compare values from one period to another by taking inflation into account, prospective age serves an analogous purpose by comparing ages and taking the increase in life expectancy into account. Any kind of financial data that can be represented in dollar terms can be converted into constant dollars by using an appropriate price index. Similarly, age can be converted into prospective age through the use of appropriate life tables

The most commonly used measure of population aging is the change in the median age of the population. If, for example, the median age of a population were to rise from 40 to 45 over the half century from 2000 to 2050, we are lead implicitly to think that the average person in the population of 2050 would behave like a 45 year old in 2000, but because of life expectancy increases this is unlikely to be the case. A 45 year old in 2050 might well behave in many ways like a 35 year old in 2000, because the 45 year old could have the same remaining life expectancy as a 35 year old person in 2000. It is precisely because many behaviors depend on the number of years left to live that it is important to supplement the usual backward-looking definition of age with a forward-looking one.

In Figure 2 we present median age and prospective median age for female populations of Austria and Germany over the period 1955–2045. The median ages for 2005 are taken from UN projections and we calculated prospective median ages using UN assumptions regarding expected increases in life expectancy (United Nations, 2004). While median age have been rising for both countries during 1955–2005, prospective median ages have remained virtually constant or even declined.[1]

Even though we consider UN assumptions somewhat conservative with respect to life expectancy growth[2], we see that the increase in prospective median age is much less dramatic than in conventional median age. While, according to UN assumptions, the median age in Austria increases in the projection period from 37 to 50, prospective median age increases only from 37 to 43. The case of Germany is similar.

In Figure 3 we present median age and prospective median age for low mortality European countries. Prospective median age is based on mortality and population projections that were developed in the framework of European demographic data sheet (European Demographic Data sheet 2010). Mortality assumptions are more optimistic in those projections (life expectancy continues to grow at a pace observed in the last 50–60 years. While the conventional median age rises during projection period, prospective median age by 2050 is even lower then it used to be in 2009.

For many countries of the world, where the increase of the median age is accompanied by an increase in life expectancy, prospective median age will behave as we have observed it here – it will increase, if it increases at all, much less dramatically than median age.

Another widely used measure of aging is the proportion of people who reach age 65 and older. In Figure 4 we present an average of proportion of people 65 and older for low mortality OECD countries. This proportion more then doubled during the last century. Of course here we consider everyone who reaches age 65 as being old. However life expectancy at age 65 also changed dramatically in the course of the last century. Figure 5 presents evidence of that. In 1900 a person who reached age 65 would on average expect to live another 12 years. In 2009 the person at age 65 would expect to live about 19 years, 7 years more then in 1900. But we still consider both of them to be at the onset of being old.

We see that in the 70s, life expectancy at age 65 reached 15 years. So someone at age 65 with 15 years of remaining life was considered old. Let's assume, like in the 70s, that someone with remaining life expectancy 15 years or less is old. In Figure 6 we present what the proportion of old people would look like with this definition of elderly people. The historical trend of aging looks very different, compared to the trend presented in Figure 4. Virtually there is no increase of proportion of olderly people observed if we define an old people those who have remaining life expectancy 15 years and less. In fact the concept of

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1 In our calculations we used 2000 as a reference year for each country.

2 In our own projections we usually use scenarios where life expectancy in developed countries grows at a speed of 2 years per decade.

age when RLE is equal or less then 15 years is close to the concept of prospective age and corresponds to a constant prospective age without defining any standard year.

Our calculations show that there will be important dimensions in which aging will occur much more slowly than is apparent from the conventionally computed median age figures or proportion of population above certain fixed age. For instance, retired people are already more likely to take courses to help them enjoy new leisure time activities if they have more expected years of life. It is not a big surprise these days to see people studying to get their second or even first university degree at ages approaching 50. That would have been very unusual a century ago, but it will certainly continue to become more common in the future. Requests for and the provision of certain medical procedures also depends on the number of remaining years of life. One example of this is knee replacement surgery, which is now often performed on people above the age of seventy. It would not make much sense to do this if the operation did not significantly increase a person's number of years of mobility.

It is important to have a forward-looking measure of age not only because many behaviors are influenced by a person's expected remaining years of life, but because important economic and social magnitudes depend on it as well. For example, medical expenditures are especially high in the last years of life. In forecasting these expenditures, it is important to take into consideration that, with increasing life expectancies those last years of life happen at an ever older age. Forecasting medical expenditures only on the basis of chronological age produces figures that are too high and could lead to erroneous policy decisions. The same is true with respect to forecasts for specific health-related items, such the need for nursing home beds.

Prospective age also helps in assessing future policies concerning the age at the entitlement to a full public pension. By computing the prospective age at the current entitlement age and holding it constant in population forecasts we demarcate the border between policies that allow an increase in the expected number of years receiving a pension and those that do not. In the case of Germany, we found that increase in pension age to 73 years by 2050 would correspond to retirement at a constant prospective age. The conventional old-age dependency ratio (OADR) and the prospective old-age dependency ratio (POADR), where the age at retirement would correspond to constant prospective age, are shown for Germany at the Figure 7. Slow increases in the age of eligibility for a public pension to an age less than 73 in 2050 would allow each successive generation to have more years of pension receipt and, at the same time, to help finance those additional years with a longer working life. Sharing the cost of more years of pension between the older and younger generations is both intergenerationally equitable and would significantly aid in making the public pension system more sustainable. Forecasts for the OADR and POADR for low mortality Europena countries in presented in Figure 8.

Prospective age can also be useful in determining likely changes in the concerns of future voters. Thus, for many reasons, supplementing the concept of age with the concept prospective age allows us to analyze aging more deeply than if we were to use only one age measure. The broader view of aging that we recommend, incorporating both backward-looking and forward-looking measures is crucial if we are to understand and react appropriately to the challenges of population aging.

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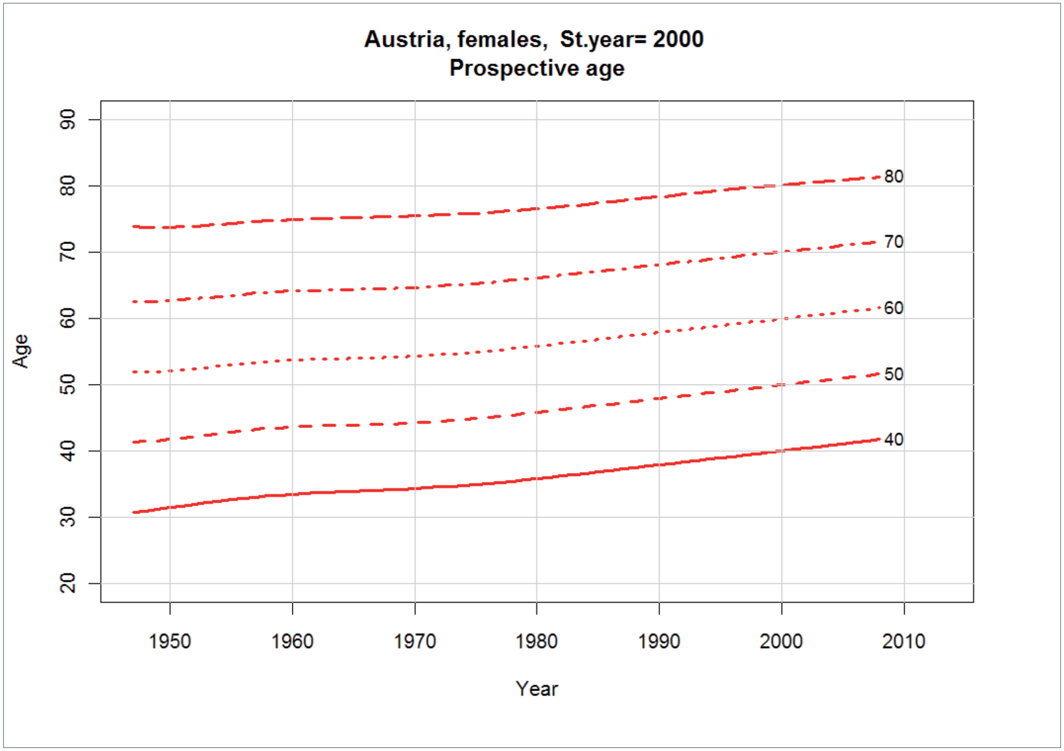
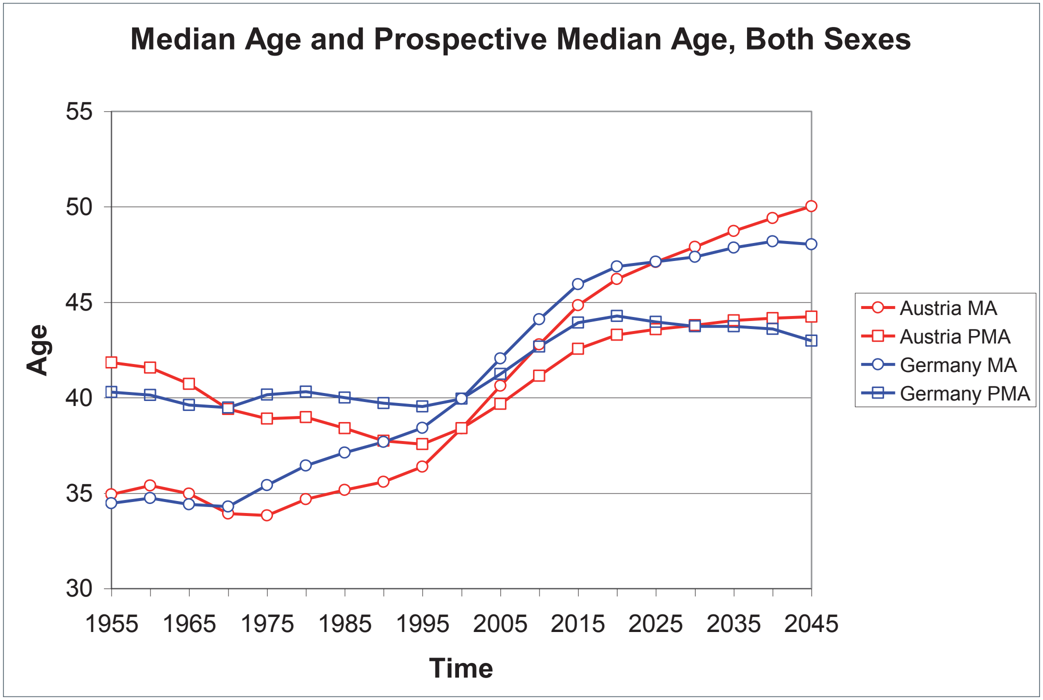
Figure 1: Prospective ages for Austrian females



Each line indicates prospective age with 2000 selected as a standard year. Remaining life expectancy is constant along each line.

Figure 2: Median age and prospective median age for Austria and Germany, 1955–2045



Source: United Nations, 2004 and author's calculations

Figure 3: Projected Median age and Prospective Median Age (average for low mortality European countries), 2009–2050

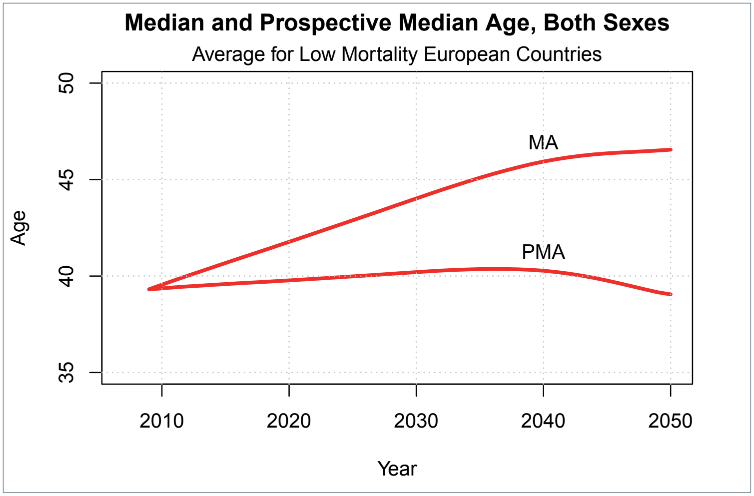


Figure 4: Proportion of people 65+ (average for low mortality European countries), 1900–2009

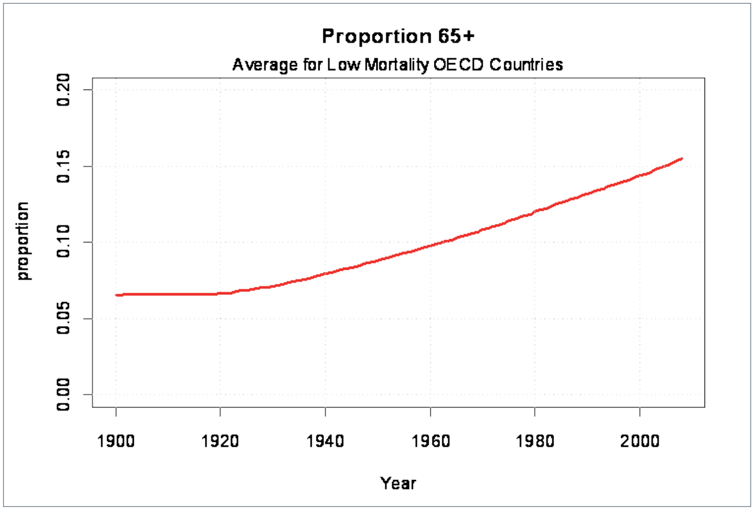


Figure 5: Life expectacny at age 65 (average for low mortality European countries), 1900–2009

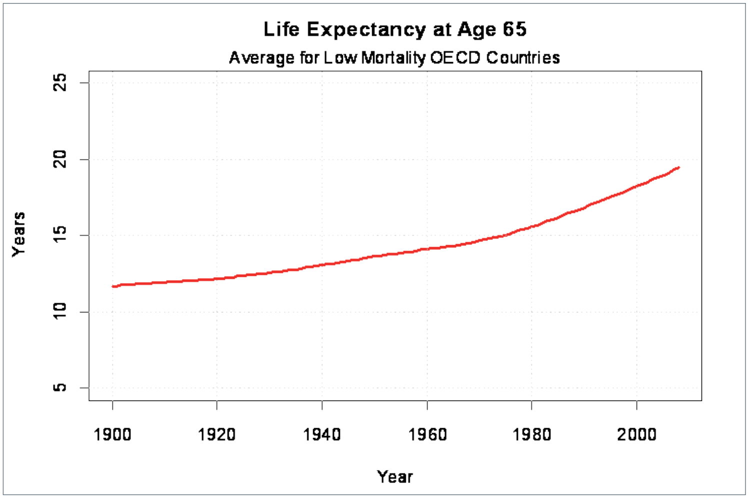


Figure 6: Proportion of people at the ages when average remaining life expectancy is 15 years or less (average for low mortality European countries), 1900–2009

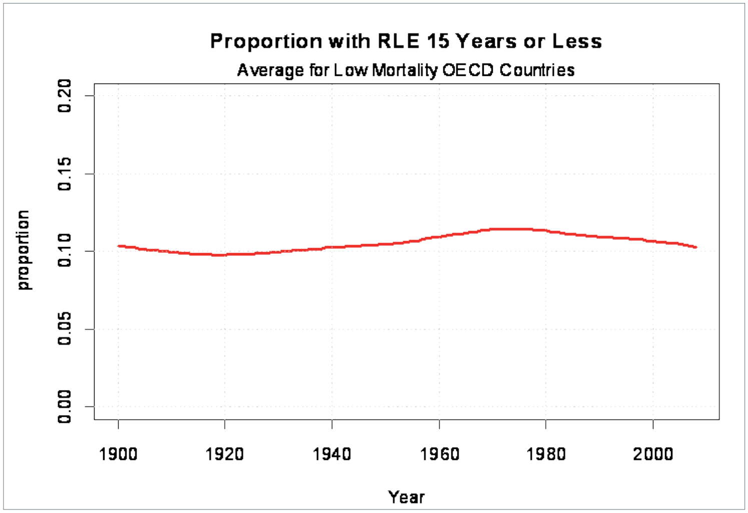


Figure 7: OADR and PAODR for Germany, 2000–2050

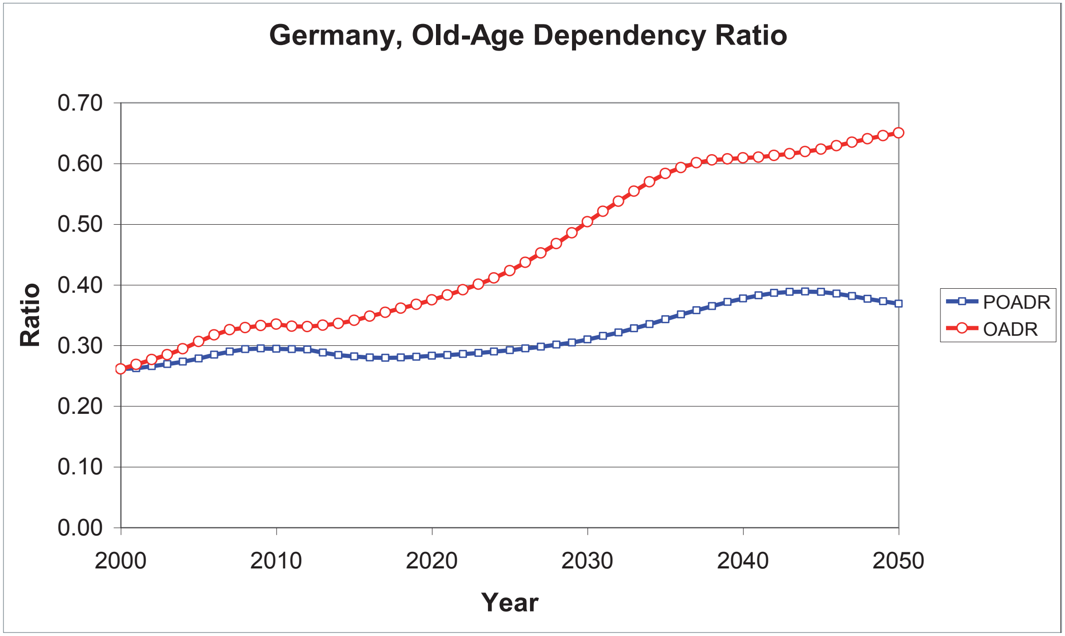
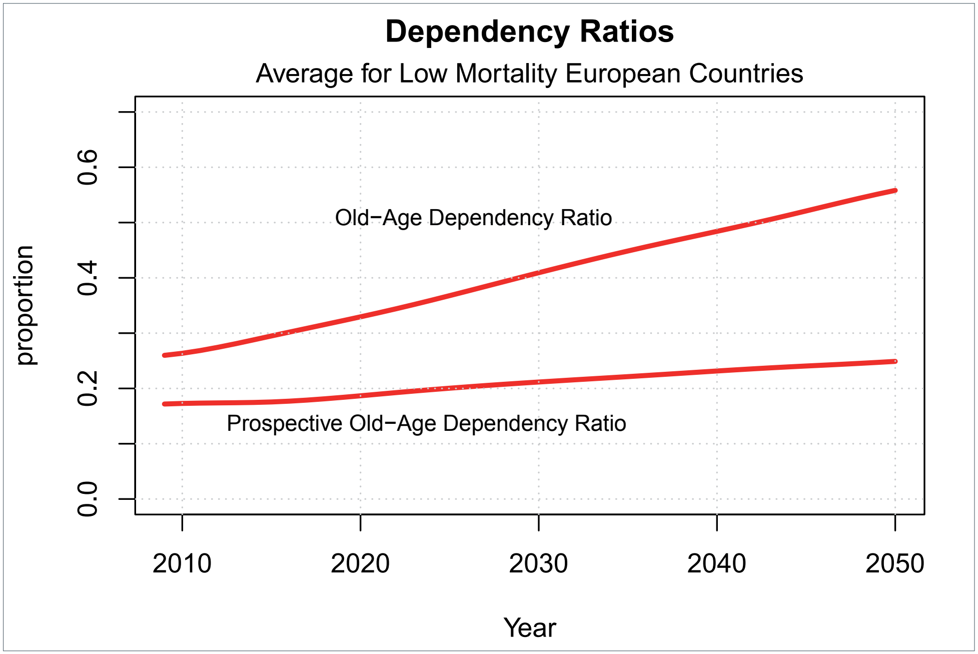


Figure 8: OADR and PAODR for Low Mortality European Countries, 2000–2050 (Author's projections)



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Age Structural Change and the Demographic Transition

Introduction

Public concern over population changes, particularly but no longer exclusively in Europe, has not only focused on size, whether increasing or declining over time, but has also highlighted the predicted growth in the numbers of older people – the ageing of the population. The latter half of the 20th century thus saw the more developed countries, experience population ageing to a degree unprecedented in demographic history. If we take the proportion of the population aged 65 and over in the world's oldest countries with the exception of Japan, the top 20 all are European. Europe reached maturity at the turn of the millennium, with more people over 60 than under 15. It is predicted that Asia will become mature by 2040 and the Americas shortly after. By 2050 the number of the world's older people will outnumber the young and the percentage over 60 will have reached more than a fifth of the total global population (21%). The total number of individuals 60 and over will have reached 2 billion. The numbers of those aged 80 and above will show an even greater increase, rising from 69 million to 379 million by 2050. By this definition the Asian/Pacific region, is already the oldest world region and by 2050 will alone hold two-thirds of the world's 2 billion elders.

A more sophisticated approach is to move from considering the total number of older people, to understanding the proportion of old and younger dependents within a population and the relationship of this to non-dependents. Taking an age-structural transition perspective, allows us to consider the cohort composition and how this will alter over time. Three broad groupings may be identified: youth dependents aged under 15; working age population (WAP) aged 15–64; and elderly dependents aged 65 and over. The combination of these within a population will to an extent influence the productivity and economic growth of that population. Globally the growth rate of the older population is faster than that of the total population. Due to the health variation of global populations and their potential inclusion or non-inclusion of older adults within a nation's working age population, the UN uses both 60 and 65 as a definition of old age. Age 80 is now recognised as being of significance in terms of estimating the "oldest-old" – a group with increasing propensity to disability.

There have always been individuals who have lived to 100 but very few. Increases in life expectancy from birth have been a constant feature of all developed countries for the past two centuries. There has been a rapid fall in mortality in younger years. This has been achieved through the reduction in infant, child and maternal mortality, driven primarily by public health initiatives, and the fall in deaths from infectious diseases, through vaccination and medication programmes. The result has been more and more people living to early old age. What is new, however, is the rapid and currently continuous fall in late life mortality rates among those over 65 and more recently over 85. The rise of geriatric medicine and the considerable influence of pharmaceuticals on these age groups have been significant here. Life expectancies at birth are predicted to rise across the globe reaching 84 years for developed regions and 77 years for less developed ones by the middle of the century. Already 65 year old men in the UK have on average a life expectancy of 82, rising to 88 for healthy individuals in high socio-economic groups, while 65 year old women have a life expectancy of 85 on average, rising to 88.5 by 2050.

What is also of significance is that this longevity is occurring in the context of ageing populations, driven as well by falling fertility rates. Most countries of the developed world are now in the late stages of the demographic transition, resulting in the decrease in both mortality and fertility rates, which typically is associated with economic development. Mortality rates fall first, including infant mortality, enabling the survival of large birth cohorts into adulthood. Falls in fertility arise both through economic development leading to family planning, education and employment opportunities for women; but also appear directly linked to a response to falling infant mortality rates themselves. Population growth levels off and the profile of the population ages as late life mortality rates fall and individuals survive to increasingly older ages. The steady increase in life expectancy is thus occurring in the context of population ageing, whereby falling fertility rates have led to increasing percentages of older dependents, and falling percentages of economically active workers. The fact that increasing longevity is occurring within populations, which are themselves ageing, has clear implications for providing for this longevity.

The context of the demographic transition

The current demographic profile of most regions of the world is population ageing – or more accurately age-structural transition – associated with the late stage of the demographic transition. There is significant debate both around the drivers of this transition and the identification of a second demographic transition. Typically associated with economic development, this is the decrease in both mortality and fertility rates. Mortality rates fall first, including infant mortality, enabling the survival of large birth cohorts into adulthood.

Population growth levels of, and the profile of the population ages as late life mortality rates fall and individuals survive to increasingly older ages. There is some indication that during the late stages of the demographic transition, demographic inertia may set in whereby a well-below replacement level of fertility becomes established over several cohorts. This would lead to a decline in population numbers were populations not maintained by in-migration. Such societies also experience a change in their dependency ratios which is a measure of working age population to dependent age populations, both old and young, and or support ratios which measures working age to elderly dependents.

The regions of the world are in different but converging stages of demographic transition. Most countries of the Developed World are now in late stage, with a steady structural ageing of their populations, experiencing an increase in the percentage of older populations. Those in the Developing World – especially in Asia and some parts of Latin America - are experiencing steady falls in both fertility and mortality rates, and are predicted to rapidly structurally age over the next couple of decades. Most countries in the Least Developed World still retain high rates of mortality and fertility. As a consequence some authors have attempted to recategorise the globe in terms of its demographic development.

The role of fertility decline

These age structural changes have emerged primarily from falls in Total Fertility Rates (TFR), that it the number of children per reproductive women – requiring 2.1 for replacement. In 1950 Europe's total fertility rate was 2.5 children per reproductive woman, falling to 1.5 by 2010. Future European fertility is difficult to estimate but is projected to settle between 1.34 and 2.34 children per woman by 2045 . Alongside the well recognised low fertility of Western Europe, with all countries bar France below replacement level, and southern Mediterranean countries in particular at 1.2 and 1.3, we see a similar pattern emerging in Asia. Singapore and Korea have now fallen to below 1.2, while Hong Kong, at below 1, now has the lowest TRF in the world. Other regions of the world are following suit with TRF of at or approaching replacement rate in several Latin American countries, and even parts of the Middle East and Africa.

There is a debate among demographers as to whether it is falling mortality – especially infant mortality – which is fuelling the fall in fertility: once women realise that they do not need to have 8 children to raise 2 or 3 to adulthood, and giving birth to 8 children means raising all 8 with a tremendous drain on household resources, then they will finds the means to prevent themselves having so many children, Others argue that falling fertility is directly associated with rises in education level, and that education not only gives women the means to reduce their own fertility, but also the understanding that it is acceptable to do so. The role of availability of contraception is seen by some to be key in both these debates, as is religion.

Others point out that fertility decline in many industrialized countries has been accompanied and partly propelled by postponement of marriage and parenthood, rises in cohabitation, nonmarital births, and divorce, increased acceptance of diverse sexual lifestyles, and a growing independence of women. Others have focused on the development of broader 'postmodern' values of individualism, secularism, and the desire for self-fulfillment. There may also be region-specific explanations.

The concept of a further stage of demographic development has recently been introduced which propose that whilst development promotes fertility decline at low and medium human development index (HDI) levels, it may promote fertility increase as advanced HDI levels, arguing that in many countries with very high levels of development (around 0.95) fertility rates are now approaching two children per woman. This is as yet an untested thesis.

The role of mortality fall

Mortality rates in the Developed World are declining at all ages and for both sexes. With every year that passes, there is an increase in the proportion of successive birth cohorts that reaches retirement age. Premature mortality among males (<65) declined from 24.4% in 1984-6 to 16% in 2004-6; and among females from 14.9% to 11.1% over the same period. Declining mortality at older ages is one of the main drivers of the growth in the relative size of the older population. Since most deaths now occur in later life, it is the continuing improvement in late life mortality that is contributing most to increasing life expectancy at birth. Over the last 20 years in the UK, male life expectancy at birth has increased by 5.6 years, with 75% of this being added post 65. Death rates in older men have fallen by fifty percent for men in their 60s and by one third for those in their 70s. Death rates among older women have followed a similar trend, though the gains have been not quite so large. Such mortality improvements are also found for men in their 80s and 90s. Interestingly, women have not had such an improvement.

Debate also focuses around question of gender and socio-economic inequalities, role of public health and medicine. One approach involves an assessment of the impact of the increasing diffusion of 'healthful living' on mortality. For example the role of changes in to smoking behaviour in explaining changing patterns of mortality in the developed world in the second half of the 20th century.

There remain important differences of opinion on the question whether life expectancy is approaching a limit. Where some authors think that combined life expectancy is unlikely to exceed 85 years, others put it at 100 years by the end of the century, or even beyond.

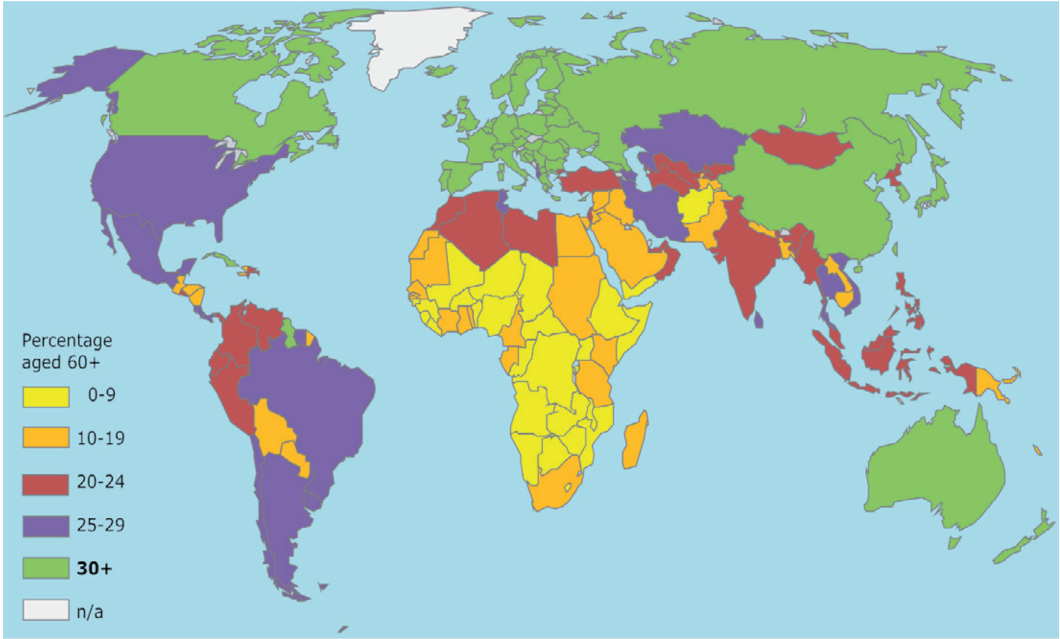
Innovations in new fields such as the new genetics, pharmacogenomics and nanotechnology clearly have the potential to provide some of the additional power that is needed to maintain current momentum in disease prevention and cure as a driver of mortality improvements in later life. Two further potential drivers of future improvements in mortality: regenerative medicine; and age-retardation. The development of these technologies will likely lead to significant break throughs in life extension.

The future: healthy or disabled life extension?

We also need to consider health life expectancy or disability free life expectancy as this has particular implications for projected dependency ratios, with current predictions for Europe and the US forecasting that both men and women in their early 70s can expect to live well into their 80s, enjoying most of those years disability-free. However, others argue that for both men and women the increases in 'healthy life expectancy' (HLE), and 'disability-free life expectancy' (DFLE) in particular, have not kept pace with total gains in life expectancy, including the argument that the medical and scientific advances which are leading to increased life expectancy are also enabling societies to keep individuals alive longer with disabilities and frailties.

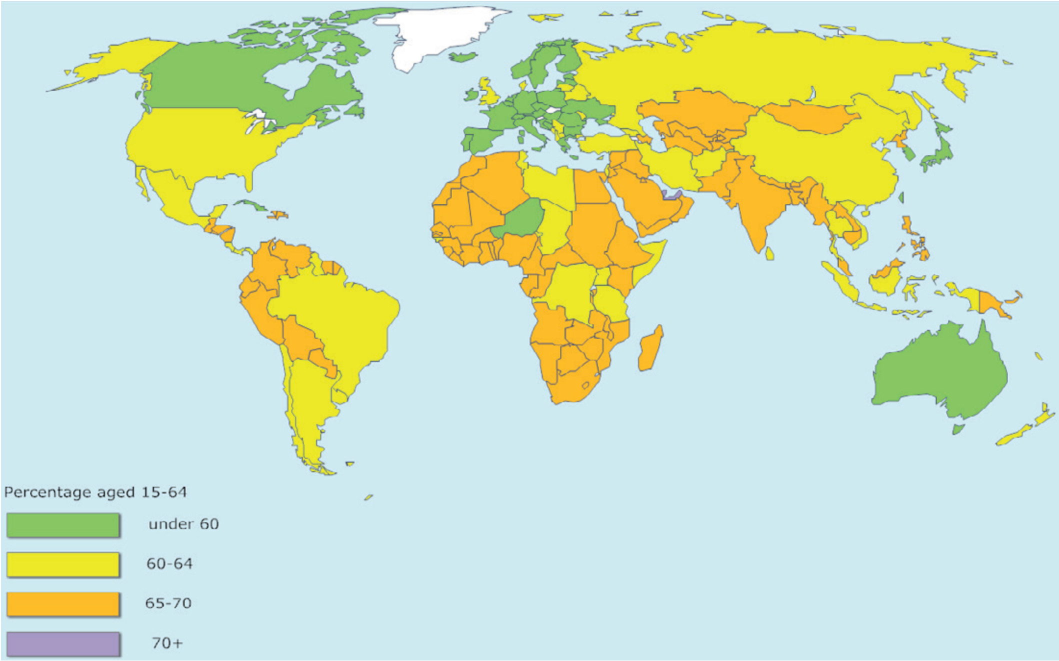
Key to these assertions is the debate around the compression of morbidity. This hypothesises that as we postpone the onset of chronic conditions, so we will compress the morbidity associated with these. There is now some agreement that morbidity compression is occurring, and that current increases in life expectancy may lead to an increase in disability prevalence, but a fall in the severity. The UK, for example, has seen an increase in life expectancy, Healthy Life Expectancy and Disabled Life Expectancy over the past 30 years. While male life expectancy at 65 rose by 4 years between 1981 and 2006, the period of disability rose from 5.4 years to 7 during this time, however the rise in the proportion of disabled life which this led to was negligible rising from 41.5% to 41.7%. For women life expectancy at 65 rose by 2 years, the period of disability rose from 8.4 years to 9.3, an actual proportionate fall from 49.4% to 48.9%. While some argue that there is a limit to reasonably expected mortality improvements from efforts around disease prevention and cure others point out that life extension is the unintended – but inevitable – by product of controlling and conquering chronic disease.

Percentage of total population aged 60 years or over in 2050



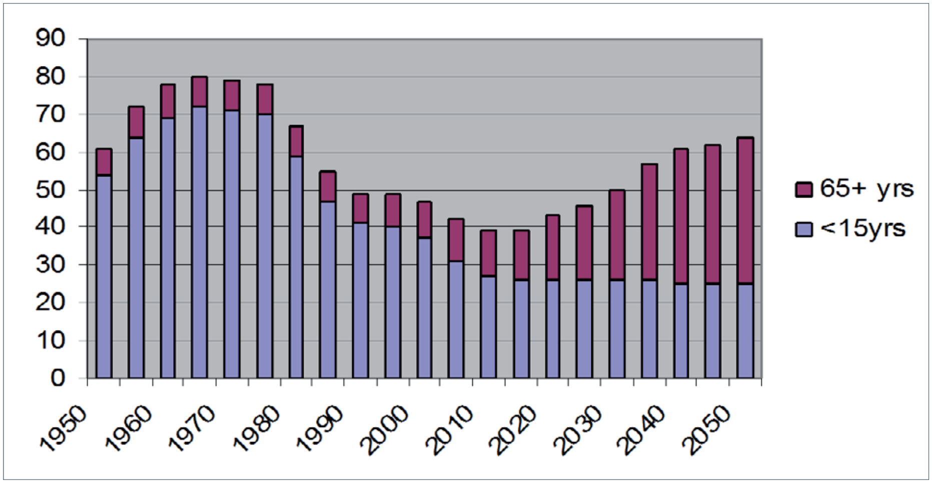
Source: UN Population Projections 2008

Population aged 15-64, 2050



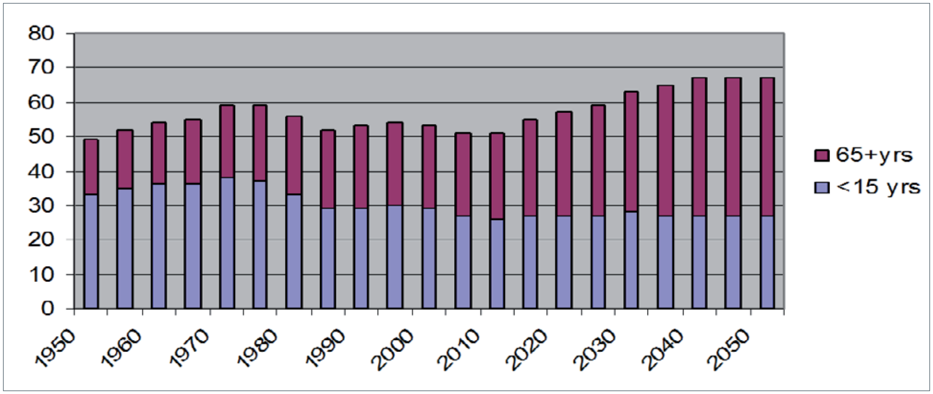
Source: UN Population Projections 2008

Total dependency ratios for China



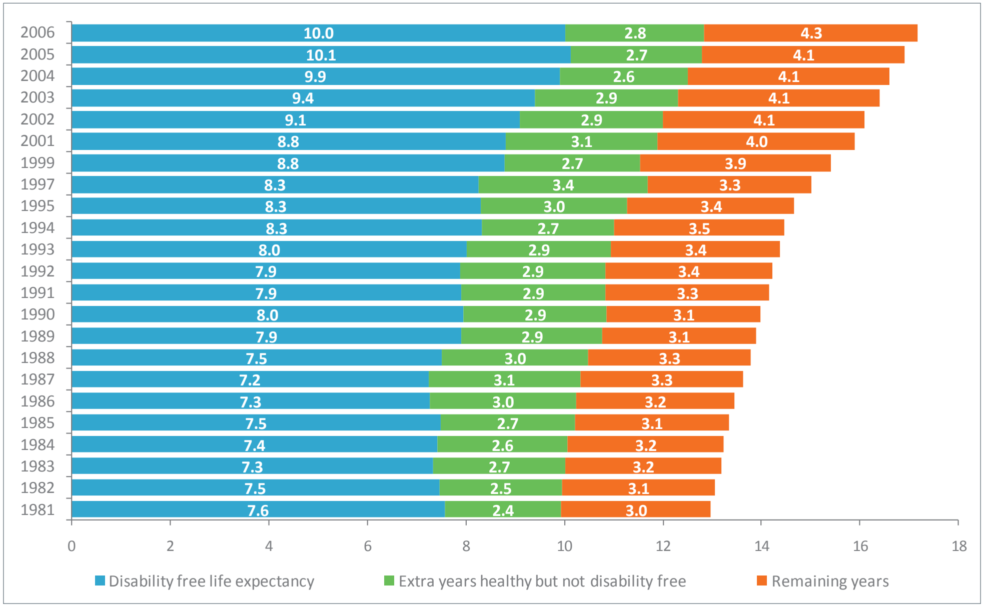
250% increase in **old-age dependency ratios** between 2005 and 2050

Total dependency ratios for UK

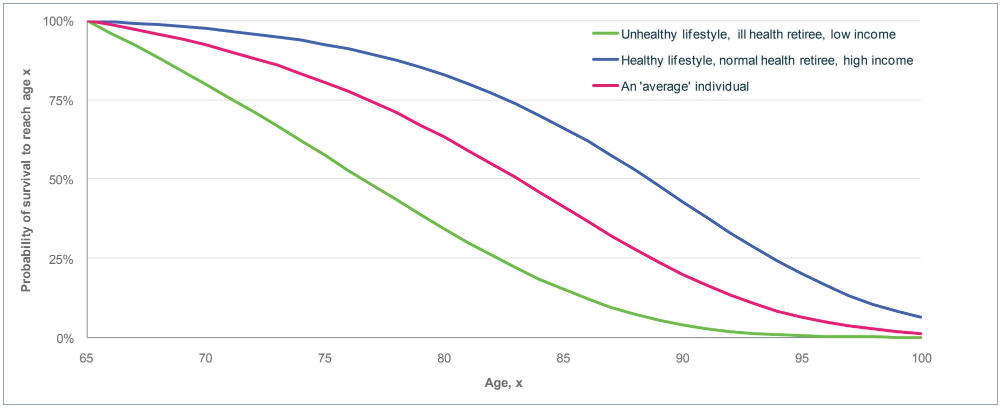


66% increase in **old-age dependency ratios** between 2005 and 2050

Understanding Longevity
Life Expectancy Men



Understanding Longevity
Proportion of 65 year old men expected to survive to each older age



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Cognitive Aging from an Integrative Lifespan Perspective

Cognition is an essential component of health and well-being across the lifespan. The study of cognitive aging is an increasingly interdisciplinary endeavour given the profound implications that changes in cognition can have in terms of workplace productivity (e.g., Skirbekk, 2008), health, independent living, social interactions, and well-being. The development and maintenance of optimal cognitive functioning is a major public health goal.

The study of cognitive aging has long focused on several related questions. When does aging-related change in cognitive functioning begin? What is the impact of early life characteristics (e.g., childhood cognition) and contexts (e.g., parental SES, educational attainment) on later life cognition and change in cognition? What causes aging-related changes in cognition (i.e., underlying pathology /disease condition; inactivity) and what should be considered "normative"? Can these changes be prevented, delayed, or treated? For example, does engagement in intellectual activities delay aging-related cognitive decline? It is increasingly understood that the answers to these questions require a variety of longitudinal designs to capture early life influences on later life changes, key events and lifestyle choices throughout the lifespan, and the identification of change-points that indicate an accelerated change relative to an individual's characteristic level of performance. There is also good evidence that social changes across subsequent birth cohorts, over at least the last 80 years, is likely to have a major influence on between-person age differences and may moderate aging-related change and cognitive impairment.

Attempts to answer these questions regarding the development and aging of cognitive functions across the lifespan has contributed to a rich array of substantive and methodological debates and advances. Recent advances include application of innovative developmental designs, improvements in measurement for detecting within-person change, statistical advances in dynamic modeling and population inference conditional on mortality, and comparisons across birth cohorts and cultures. While we may not yet have definitive answers to many of these fundamental questions, the field of investigation is increasingly emphasizing the need for longitudinal studies with recognition of the necessity of focusing on within-person change and variation in cognition, health, and aging (e.g., Alwin & Hofer, 2011; Hofer & Alwin, 2008, Hofer & Piccinin, 2010).

Understanding Aging: Confounds Associated with Study Design

There are many unresolved questions (i.e., inconsistent associations, small effects, causal direction unknown) in the field of cognitive aging. For many years, research on understanding changes in cognition with age was based predominantly on comparison of individuals differing in age (i.e., cross-sectional designs and analysis). While the between-person comparative approach has led to highly consistent findings regarding the interdependency of aging-related changes, many of these findings are likely to be spurious and related to confounds with average between-person trends (i.e., due to mean trends; e.g., Hofer, Berg, & Era, 2003; Hofer, Flaherty, & Hoffman, 2006; Hofer & Sliwinski, 2001; Kraemer et al., 2000). Inference from cross-sectional designs are additionally confounded by birth cohort effects (e.g., Schaie, 2008) and mortality selection (e.g., Kurland, Johnson, Egleston & Diehr, 2009), which greatly limit the opportunities to understand patterns and determinants of individual and population change. Longitudinal designs are essential for the quantification of individual differences in patterns and rates of within-person change. Such data provide important opportunities for examining the interdependency among developmental processes and the influences of risk and protective factors across the lifespan. Longitudinal data can also be used to facilitate understanding of how between-person differences at a particular age or time period arise through individual differences in change processes (e.g., Hofer, Flaherty, & Hoffman, 2006).

When does aging-related cognitive decline begin and why?

Distinctly different lifespan trends have been observed across different types of cognitive abilities (Horn & Cattell, 1967). Fluid ability (Gf) is age vulnerable, with population average age-related decline seen in early to middle age. Gf is indicated by measures that tap the ability to solve novel problems (i.e., tasks that cannot be performed automatically) including mental operations such as drawing inferences, concept formation, classification, generating and testing hypothesis, identifying relations, and comprehending implications. On the other hand, crystallized knowledge (Gc) abilities are relatively age maintained and show increases over much of the lifespan. Gc abilities refer to acquired knowledge of the language, information and concepts specific to the dominant culture. Gf and Gc abilities have distinct characteristics but are related to other types of cognitive capabilities (Horn, 1978) including Processing Speed (Gs), Episodic Memory (Gsm), Long-Term Storage and Retrieval (Glr), Spatial Reasoning (Gv), Auditory Processes (Ga), Quantitative Reasoning (Gq).

While the general pattern of Gf declining before Gc has been demonstrated in both cross-sectional (between-person age differences) and longitudinal (within-person age changes) designs, these designs typically produce quite different findings regarding the age at which decline in abilities begin in the population. For example, cross-sectional studies (e.g., Salthouse, 2009) report decline in Gf in the mid-20s and Gc abilities after age 60. However, longitudinal studies (e.g., Schaie, 1996) typically find that Gf is maintained until the mid-50s and Gc abilities in the early 60s. These differences, associated with research designs, have been a longstanding issue and debate (e.g., Horn & Donaldson, 1976; Schaie & Baltes, 1976). Proponents of the findings regarding early life declines (e.g., Salthouse, 2009) have typically focused on the effect of repeated testing as the reason for why earlier age differences are not observed in longitudinal designs (but see Hoffman et al., 2011; Sliwinski et al., 2010; Thorvaldsson et al., 2006 for issues regarding retest effects). However, this is unlikely to account for the major differences in results across these designs.

Social change, improvements in social and cultural environments over the last century, is a much more likely reason for differences in population change-points indicating cognitive decline. Flynn (1984, 1987) provided evidence for a steady increase in intelligence scores (approx. 3 IQ points or one-fifth of a standard deviation per decade) across birth cohorts in the US and many European countries. While there is no clear consensus as to the cause of these increases, potential causes include schooling, test sophistication, nutrition, stimulating environment, fertility patterns, and infectious diseases.

The important point is that these differences in cognitive test scores across birth cohorts may be explanatory of between-person age differences (e.g., Lee et al., 2008) as these same cohorts are those that comprise a majority of our current longitudinal studies of aging.

Recent reports have shown that the effect of increases in IQ may have levelled off or begun to decline (e.g., Teasdale & Owen, 2005). These cohort effects likely relate to early life contextual differences and should have an effect on between-person age differences. To the extent that these same contextual differences influence not only these relatively recent birth cohorts but previous birth cohorts that comprise many of our current longitudinal studies of aging, we would predict a levelling off of the increases in life expectancy after around 2030.

While there continue to be methodological and substantive disagreements regarding some of these basic questions, the analysis of individual differences in cognitive decline and impairment has produced sufficiently systematic results across study designs regarding potential moderating factors associated with cognitive outcomes. A number of risk factors associated with aging-related cognitive decline have been identified (for recent summary, see Williams, Plassman, Burke, Holsinger, & Benjamin, 2010). Factors associated with increased risk for decline include dementia, head injury, cardiovascular disease, diabetes, ApoE 4 genotype, depression, vision and hearing deficits, and smoking. Decreased risk of decline is associated with physical activity, cognitive engagement, social interaction, Mediterranean diet, educational attainment, socioeconomic status, and having a higher childhood IQ.

What is the impact of early life influences on cognitive decline?

A number of long-term longitudinal studies with information on childhood abilities and contextual characteristics provide a basis for understanding how early life contextual influences impact later life cognitive and physical functioning. Recently, analysis of these studies has focused on the roles of parental socioeconomic status, education, work-related demands, and social engagement in providing protection (e.g., cognitive reserve) that may increase cognitive capabilities and protect against cognitive decline. However, there is some debate about how important selection processes are to the interpretation of these effects (e.g., selection into higher education related to childhood cognition). It is important to disentangle these competing roles of education, early life cognitive capability, and social class on later life outcomes. For example, the debate relating education to cognition over the life course is complex and posits a variety of models from education as selective to education as beneficial for cognitive capabilities and brain reserve (e.g., Deary & Johnson 2010; Richards & Sacker 2010).

To what extent can we understand "normative" aging-related cognitive decline by accounting for changes in health?

Recent work has demonstrated that some of what were considered normative cognitive aging effects are actually attributable to nonnormative processes (e.g., preclinical dementia, Sliwinski et al., 1996). Nonnormative processes are likely to be very important determinants of cognitive aging, especially in very old age (> 80 years), as recent longitudinal evidence has shown that cognitive loss is strongly linked to disease onset in the case of preclinical Alzheimer's disease, and that cognitive function is relatively stable prior to that time (Hall, Lipton, Sliwinski & Stewart, 2000; Sliwinski et al., 2003).

By definition, normative causes of cognitive loss occur in most individuals as they age. However, there is compelling evidence for the operation of processes that cause cognitive loss in a subset of aging individuals. The development of preclinical dementia (Sliwinski et al., 2003), and the progression of subclinical cardiovascular disease and respiratory dysfunction have all been demonstrated to substantially impact rates of cognitive decline (e.g., Spiro et al., 2011). Moreover, these processes, though increasing in prevalence and severity with age, are not strongly correlated with chronological age in cross-sectional analysis.

Besides the catastrophic impact of dementia on cognition, a long list of other diseases in late life may compromise cognitive functioning and thereby everyday life (e.g., Nilsson et al., 2002). These other diseases are likely to have more modest effects, except when they contribute to the risk of dementia. Diabetes, cardiovascular disease and cerebrovascular events are all prominent risk factors for dementias. The more complex morbidity patterns and the increased probability of death with age provide a challenging situation in which to identify normal age changes and the impact of disease-related, pathological changes. Indeed, distinguishing between primary and secondary aging (e.g., Birren & Cunningham, 1985) becomes more difficult in late life because physiological changes lead to greater propensity for disease-related changes. Comorbidity increases with age, which compounds the difficulty of evaluating the relative importance of specific health-related changes such as those related to diabetes, hypertension, stroke, and depression. An important point is that the identification of normative cognitive changes depends on the identification of nonnormative changes associated with health conditions.

Integrative Analysis of Longitudinal Studies of Aging (IALSA)

A key challenge facing development of theories about processes of aging is to describe and explain the changes that occur within aging individuals and how these processes are modified by different contexts (birth cohort, culture, and country). Some of the critical tasks in cumulating scientific evidence, and to advance the field along the lines described above, require comparison across independent scientific studies. Numerous longitudinal studies on aging now permit formulation and empirical test of hypotheses about the processes influencing intraindividual change and variation. Various collaborations, developed with different structures and levels of linkage among investigators and data, are summarized in Piccinin & Hofer (2008).

There are clearly many benefits to collaborative endeavours related to longitudinal studies on aging, most notably the opportunity for simultaneous evaluation of longitudinal data to test, replicate, and extend prior findings on aging (Gallacher & Hofer, 2011; Hofer & Piccinin, 2009; 2010). Given the key issue of cross-study comparison, harmonization of variables and statistical models are critical aspects, as are the evaluation of alternative models on the same data to permit direct comparison of results across models and the determination of why results might differ. Longitudinal research by itself is challenging, and coordinating analysis across studies more so given the diversity of study designs, samples, and variables. These challenges are not insurmountable, however, and there is great promise for the integration of theoretical perspectives for within-person aging (with emphasis on both health and aging), developments in statistical analysis of within-person data, and collaborations with colleagues on the numerous completed and ongoing longitudinal studies of aging (Hofer & Piccinin, 2010).

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An Economic Perspective on Ageing[1]

Motivation

Most countries in Europe have experienced an impressive increase in life expectancy accompanied by a rise in the number of healthy life years. To study the economic perspectives of the ageing process we need to differentiate between the process of ageing at the individual level and population ageing, i.e. an increasing share of people at older ages (Prskawetz and Fent 2011).

At the individual level we observe great heterogeneity of the ageing process by education, work history, family forms, underlying institutional conditions, etc. At the same time a longer, healthy lifespan will affect microeconomic decisions including education, employment, savings, investment and retirement. These decisions themselves will be influenced by the underlying institutional conditions (family, labour, and pension policies, for example), prevailing norms and values, as well as the current economic situation.

At the aggregate level, low fertility and longer lifespans will change the age structure of most industrialised countries. Given current retirement regulations, the share of the working age population will decline while the share of pensioners will increase. The baby boom generation's retirement from the workforce will further intensify this process. Structural changes in the age distribution of populations will in turn influence the compensation of labour, physical capital and human capital. The economic structure of a country and the possibilities for substitution among production factors will determine the specific economic effects. Depending on the prevailing social security system (including health care, pensions, long-term care insurance) the redistribution of resources between generations will change as well.

After this brief glimpse into potential economic effects of individual and population ageing, we will now briefly discuss the role of an ageing population for economic growth and look at some ways in which individual ageing will influence the economic life cycle. Moreover,

1 I am grateful to Bernhard Hammer, Inga Freund, Werner Richter and Joze Sambt for proofreading and assistance in preparing the figures.

we will introduce a new method to bring age into the system of national accounts. We close with an overview of opportunities and challenges that ageing will pose for economics.

Ageing and Economic Growth

The relation between economic growth and the growth rate of the population has been extensively disputed in economics. While early studies based on the neoclassical growth model argued for a negative association, the lack of any clear evidence between both variables led to the neutralist view in the 1960s and 1970s. During the last two decades, however, the picture has changed showing that demography matters if we consider the change in the age structure of the population (Kelley and Schmidt 2005). As argued among others by Bloom et al. (2011, p. 13) "… based on the fact that people's economic needs and contributions vary over the various stages of life … key drives of economic growth such as aggregate labour supply, productivity, consumption, and savings will tend to vary depending on where most people fall in the life cycle."

Starting from the decomposition of output per capita into output per worker times the ratio of workers to the total population, one can similarly decompose the growth rate of output per capita into two parts: (a) The growth rate of output per worker and (b) the growth rate in the number of workers minus the growth rate of the total population. The latter term is referred to as the accounting effect or alternatively the first demographic dividend. In the case where the growth rate of the working age population exceeds the growth rate of the total population, the first demographic dividend is positive and fosters economic growth in the short run. The extent of the first demographic dividend will be determined by the demographic change, but also by the labour force participation and its compositional change (increasing female labour force participation, part-time work, etc.). Figure 1 presents the first demographic dividend for Austria from 1960 through 2060. Instead of simply relating the growth rate of the working-age population to the total population we weight the working-age population by age profiles of wage and labour force participation (as measured in 2005) to obtain the effective number of workers. Similarly we weight the total population by age-specific consumption needs (measured in 2005) to arrive at the effective number of consumers. Figure 1 clearly demonstrates that the first demographic dividend was positive in Austria from the early 1970s to the beginning of the 2000s, and has become negative since. Hence, the positive effect of the baby boom of the 1950s and 1960s that entered the labour market in these years has vanished when the smaller cohorts of the 1990s entered the labour force and will further decline when the baby boom starts to retire.

In addition to the accounting effect a change in the demographic structure will also affect the growth rate of output per worker, often termed the (labour) productivity or behavioural effect. However, institutional settings as well as social and labour market policies might not allow and support these behavioural effects. As Bloom et al. (2011, p. 29) argue, “[t]he problem of population ageing is more a function of rigid and outmoded policy and institutions than a problem of demographic change per se.”

The Economic Life Cycle

Let us briefly review how economic theory helps to relate not only aggregate but also age-structured demographic processes to economic development. The economic theory that suggests a link between an individual’s age, consumption and saving decisions originated with the permanent-income hypothesis (Friedman 1957), followed by the life cycle hypothesis (Modigliani and Brumberg 1954 and Ando and Modigliani 1963). The permanent-income hypothesis states that an individual’s consumption is likely to depend on permanent rather than currently disposable income. The life cycle model is concerned with how the savings of individuals lead to the accumulation of wealth at the individual level and of the capital stock at the national level. The savings of individuals rest on the hypothesis of smooth consumption patterns over the course of their lives in the face of varying income.

Another line of research, closely linked to the theories just mentioned, is the framework of the overlapping generations (OLG) model. This framework is well-suited to investigate the economic consequences of ageing, both at the individual and economy-wide level. The reason is that OLG models are based on households’ and firms’ optimal reactions to movements in the demographic structure and alternative institutional settings, such as the prevailing labour market and pension systems.

To illustrate how economic theories like the life cycle model have advanced our understanding of the effect of demographic changes on the economy, let us consider a simple example. How would an economist proceed if asked about the consequences of increasing life expectancy on savings? Let us assume that we rationally foresee our life expectancy and make savings in order to ensure a smooth consumption path over our life cycle. A little bit more formal consider an agent who works for T_w years and spends T_o years in retirement and old age. During his working time he earns an income of y. The hypothesis of consumption smoothing implies that the agent wants to have c units of consumption during his whole life of T_w+T_o years (for simplicity we ignore the period of childhood). Equating total consumption to total income earned over the life cycle: $c^* (T_w+T_o) = y *T_w$, the savings rate $s=1-c/y$ can be calculated and is equal to $T_o/(T_w+T_o)$. Aggregate savings are therefore determined by the demographic structure and increasing in the number of years spent in retirement. In Table 1 we calculate the savings rates for two populations that differ in their life expectancy. The resulting savings rate clearly indicates that for the longer lived society, savings rates are much higher. Of course, in practice one usually does not observe the simple savings behaviour that we have just outlined as the prevailing pension system, the replacement rate of wages during retirement, one's own income level, risk aversion, etc. are all factors that will impinge on the savings rate.

Another link between the age structure of a population and economic development runs through age-specific productivity. As we heard in the other talks at the symposium, age variation in productivity is rather complex and will be determined not only by health, cognitive abilities, education, skill level and work experience, but also by firm-specific characteristics. While there are obvious arguments why older workers are less productive – for instance, outdated human capital and lower mobility – characteristics such as job experience, firm-specific human capital, less job fluctuations and optimal job matching are in favour of the argument that older workers do not depress productivity. A promising way to measure age-specific productivity at the firm level are matched employer-employee data sets where socio-demographic information (age, sex, education, occupation, etc.) about employees at the firm level is combined with important characteristics that are specific to the firm (age of the company, economic sector, turnover, etc.). Value added per capita among employees, taken as a measure of labour productivity, can then be related to the age structure and other socio-demographic features of the employees as well as the company-specific characteristics. Recent work (Göbel and Zwick 2009) in this direction indicates a negative correlation between productivity and the percentage of younger employees, and shows that the percentage of older employees does not correlate with productivity. Of course, aspects of local labour markets and the general country-specific labour market policy also play an integral part in determining the productivity of older employees.

National Transfer Accounts

As the previous chapter has shown, the economic life cycle hypothesis provides the underlying economic theory to relate changes in the age structure to economic development. The economic life cycle can be summarised through the age profiles of consumption and work. A typical characteristic of the life cycle in modern societies are phases of economic dependency at the beginning and end of the life cycle as consumption exceeds wage income in these ages. The difference between consumption and labour income is central to the concept of National Transfer Accounts (NTA) (Lee and Mason 2011) and is termed the life cycle deficit. In childhood/adulthood as well as in old age the life cycle deficit is positive, while it is negative during the working years. The question arises how the life cycle deficit is financed, how far young and old people are dependent on their families, on the state or their own assets. Obviously a shift in the size of the young and the old – as a consequence of the ageing process – asks for an adjustment of the inter- and intra-generational transfer system. As Mason and Lee (2007, p. 130) argue, "[t]he mechanisms by which assets are shifted across age groups is important because it determines whether the population ageing leads to accumulation of assets or to the expansion of public and private transfer programs."

National Transfer Accounts – which have been developed for 34 countries all over the world – offer the method and data to study the economic life cycle. Based on data from 2005, Figure 2 presents per capita (panel A) and aggregate (panel B), i.e. weighted by the population number in each age group, age profiles of consumption and labour income in Austria. Starting from age 23 onwards up to age 58, i.e. only for 36 years, the life cycle deficit is negative producing a surplus of labour income exceeding the consumption level. Characteristic for Austria are the early entry into work and the early entry into retirement. The overall life cycle deficit of the elderly constitutes about 22.8% of the total wage income while the corresponding number for the young is about 19.9%. These numbers clearly show the role of intergenerational age-specific redistribution of resources by the state or through private transfers.

Age reallocation for Austria in 2005 is plotted in Figure 3. For children and adults the overall life cycle deficit is covered mainly (60%) by transfers within the family and by 40% by public transfers. Older individuals on the other hand are more dependent on the state with 85% of their total life cycle deficit being financed by public transfers; the remaining 15% are financed through asset-based reallocation. Based on these findings one can estimate the future burden of an ageing population for financing the re-allocation of resources across generations. Keeping the 2005 age schedule of the life cycle deficit constant and applying the population projections of Eurostat, Figure 4 indicates the increase of the life cycle deficit as a percentage of the total labour income of young and elderly persons. According to these assumptions the life cycle deficit of the older population would increase to 46% of the total labour income by 2060.

Opportunities and Challenges

Low fertility and further increases in life expectancy will lead to an ageing of the population in most European countries. At the same time, individual ageing will be characterised by an increasing number of healthy life years. In order to meet the challenges of population ageing, we must make use of the opportunities of individual ageing. Population ageing poses the challenge to reform our current system of reallocation of resources across ages (including the pension, health and elderly-care system as well as investments into education). At the same time population ageing also constitutes an opportunity for the labour market, educational policies and family policies. With an increasing shortage of labour supply, the pressure to integrate female, unemployed and elderly workers back into the labour force, and also into society, has increased. At the same time, family policies are continuously being reformed to adjust to the changing life course of females and males and its increasing variability. To foster and sustain productivity in an ageing society, investment in education and, broadly speaking, human capital is indispensable. In order for these policies to be successful we need to obtain a better understanding of the effect of longer life on individual behaviour as it is constrained and shaped by economic social settings.

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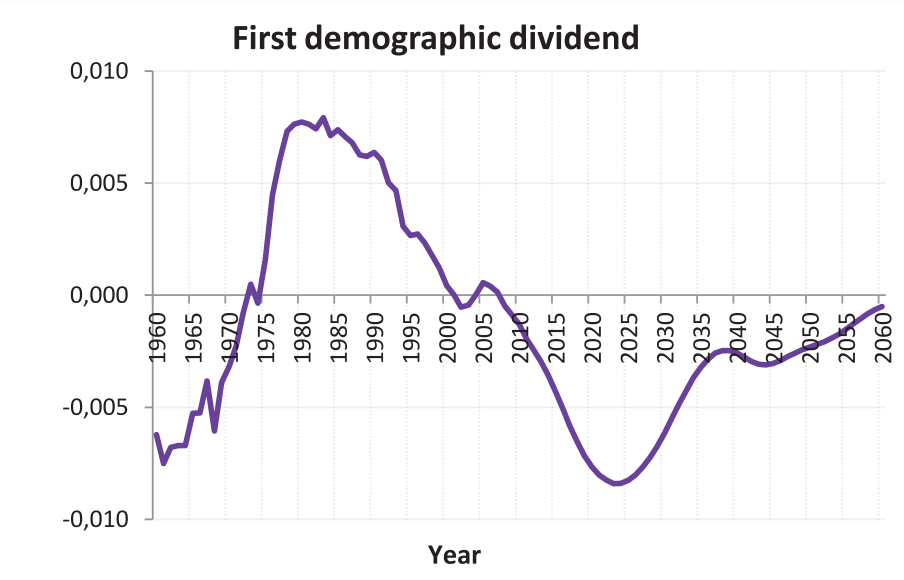
Figure 1: First demographic dividend (difference in growth rate of effective number of workers and effective number of consumers), Austria 1960–2060



Source: EUROSTAT population projections; author's own calculations

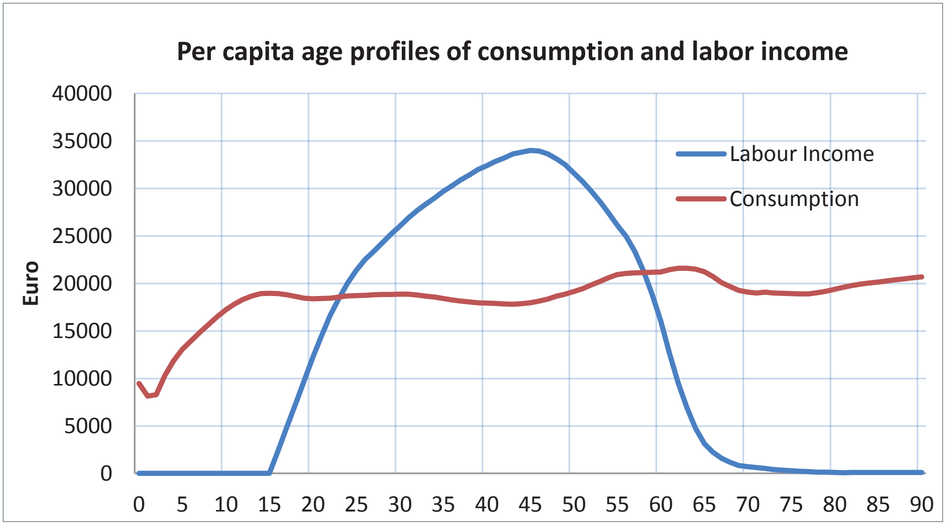
Table 1: Person years lived in each age group under high and low mortality

Age group	e_0=25	e_0=75
0-15 years	8.3	14.7
15-65 years	15.7	47.4
65+ years	1.0	12.9
Savings rate	**0.06**	**0.21**

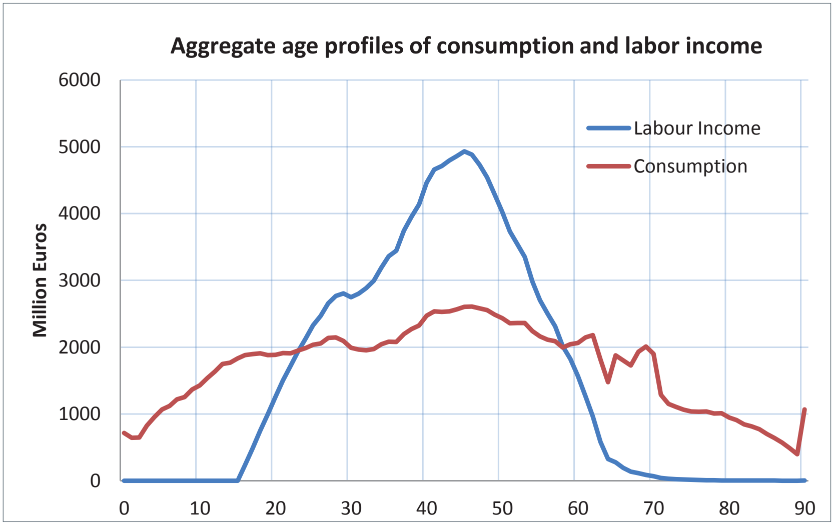
Source: Lee 1991, lecture notes

Figure 2: Per capita (A) and aggregate (B) age profiles of consumption and labour income in Austria, 2005

A:

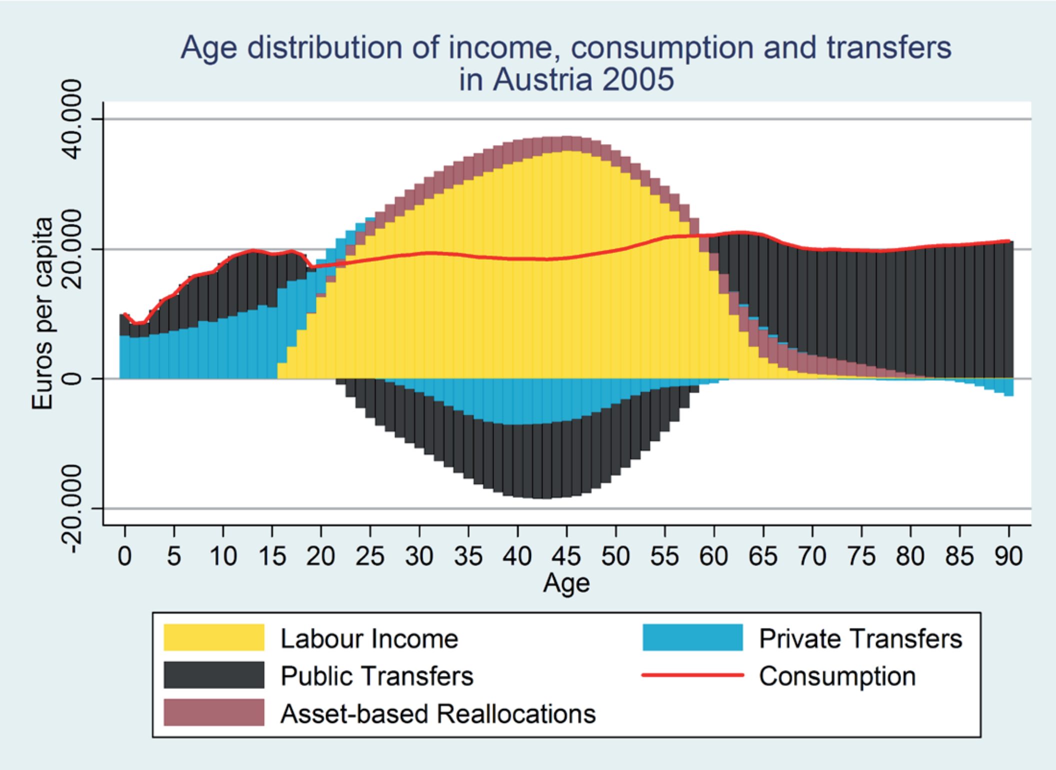


B:



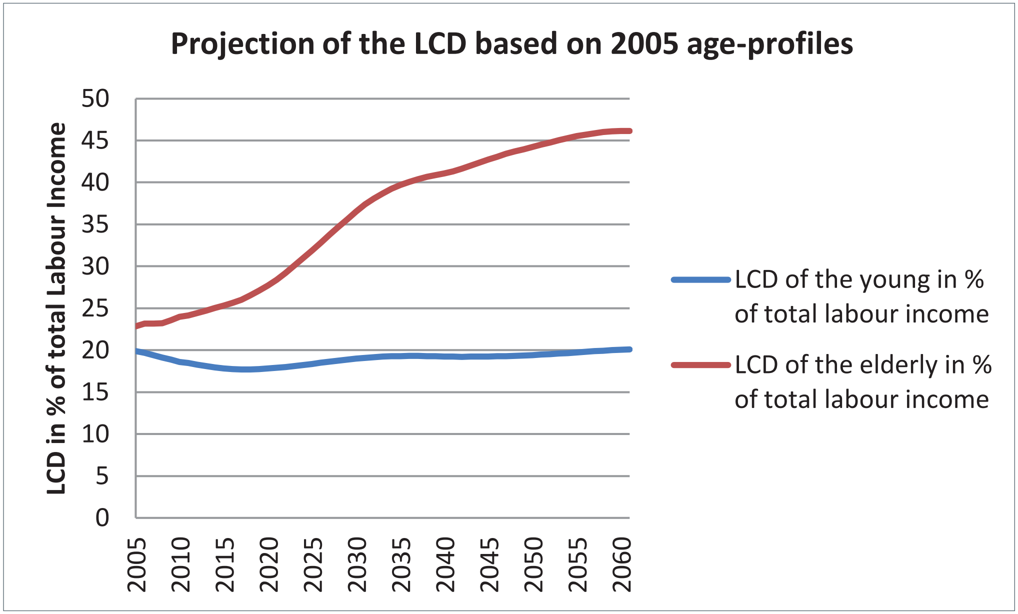
Source: author's own calculations, Hammer and Prskawetz 2011

Figure 3: Age reallocation in Austria, 2005



Source: author's own calculations, Hammer and Prskawetz 2011

Figure 4: Projections of life cycle deficit (LCD) measured in percentage of total labour income based on age profiles of 2005



Source: author's own calculations, Hammer and Prskawetz 2011