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The Global Demography of Aging: Facts, Explanations, Future

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The Global Demography of Aging: Facts, Explanations, Future

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Dara Lee Luca

August 2016

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

The Global Demography of Aging: Facts, Explanations, Future

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August 2016

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ABSTRACT

The Global Demography of Aging: Facts, Explanations, Future*

Population ageing is the 21st century's dominant demographic phenomenon. Declining fertility, increasing longevity, and the progression of large-sized cohorts to the older ages are causing elder shares to rise throughout the world. The phenomenon of population ageing, which is unprecedented in human history, brings with it sweeping changes in population needs and capacities, with potentially significant implications for employment, savings, consumption, economic growth, asset values, and fiscal balance. This chapter provides a broad overview of the global demography of aging. It reviews patterns, trends, and projections involving various indicators of population aging and their demographic antecedents and sequelae. The chapter also reviews theories economists use to explain the behavioral changes driving the most prominent demographic shifts. Finally, it discusses the changing nature of aging, the future of longevity, and associated policy implications, highlighting some key research issues that require further examination.

JEL Classification: J11, J14, N30

Keywords: population aging, economic demography, longevity

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Contents

1. Introduction
2. Population ageing
   2.1. Trends and projections
   2.2. How reliable are population projections?
3. The demographic transition and population ageing
   3.1. The historic demographic transition
   3.2. The ongoing demographic transition in developing countries
4. The demographic determinants of population ageing
   4.1. Decline in fertility
      4.1.1. Theoretical framework
      4.1.2. Developed countries
      4.1.3. Developing countries
      4.1.4. The future of fertility
   4.2. Increase in life expectancy
      4.2.1. Developed countries
      4.2.2. Developing countries
      4.2.3. The future of mortality
   4.3 Migration as a determinant of the age structure
5. The nature of ageing
   5.1. The rise of non-communicable diseases
      5.1.1. The prevalence and economic costs of dementia
      5.1.2. The risk factors of NCDs and policy implications
   5.2 Compression or expansion of morbidity?
   5.3 Living arrangements for the elderly
      5.3.1. Developed countries
      5.3.2. Developing countries
6. Open research questions
7. Concluding Remarks

References

Figure 1 – World Population by Age Group, 1950-2100

Figure 2 – Population share of the 60+, by level of development, 1950-2100
Figure 3 – Population Share of the 60+ and 80+ in China, India, Brazil, and Nigeria, 1950-2100
Figure 4: Old dependency ratio, by level of development, 1950-2100
Figure 5: Change in M/F ratio, 60+ population, by level of development, 1950-2100
Figure 6: Total Fertility Rate, by level of development, 1950-2100
Figure 7: Life Expectancy, by level of development, 1950-2100
Table 1: Change in UN forecast of 2050 elderly population, from 1994 to 2010

1. Introduction

The world is experiencing a sea change in its population age structure. People are living longer lives, and the share of older people in the total population is expanding rapidly. Between 2005 and 2050, the proportion of the population aged 60 and older will increase in every country in the world. The number of centenarians worldwide will more than double by 2030, with nearly 3.4 million centenarians alive by 2050.

Population ageing has many societal and policy implications. The demographic shift threatens to lower labor force participation and savings rates, increase health expenditures, and strain pension and health schemes. The rising prevalence of noncommunicable diseases disproportionately burdens the elderly, and whether the additional years resulting from increased longevity will be characterized by ill health is unclear. Living arrangements for the elderly must be considered, and many are concerned that reduced labor force participation and savings and strains on pension and healthcare systems will slow economic growth.

However, demographic change has historically spurred behavioral adjustments, and technological and institutional innovations may yet mitigate the effects of population ageing. Examples of such innovations include modified retirement policies, women-friendly work policies, changes in healthcare systems, increased educational investments in people, and more private savings, among others.

This chapter has two main objectives. First, it provides an overview of demographic change in the world today, including differences and similarities over time, geographical region, and stage of development. Variations in fertility and life expectancy (including healthy life expectancy improvement) are central here. Second, it introduces economists' attempts to explain the changes in behavior, especially in reproductive behavior, that have generated these population dynamics.

We begin by presenting key facts and trends regarding past and projected future population ageing in Section 2. The data and figures presented will serve as anchors for the analyses in this and subsequent chapters in this volume. Section 3 reviews the history of the demographic transition and its interaction with population ageing. Section 4 reviews the economic literature on different hypotheses and their supporting evidence explaining recent decades' decline in fertility and increase in life expectancy. We also discuss different views on the future of fertility and longevity and the role of migration as a determinant of the population age structure. Section 5 discusses how ageing is changing in terms of the types of illnesses the elderly face and the effects on living arrangements. Section 6 discusses several open research questions followed by some concluding remarks.

2. Population Aging

2.1. Trends and Projections

This section documents some salient facts and trends in population ageing. Overall, major changes have occurred in the world's age and population structure over the last half-century, with the increase in population shares at advanced ages being a prominent feature. Figure 1 depicts population pyramids from 1950 to 2010 and projections until 2100 (United Nations Population Division, 2015).[1]

As is evident, the pyramid shape representative in 1950 and 1980 is giving way to a more dome or beehive-like shape, as the population at younger ages shrinks over time. The youth bulge seen in the earlier snapshots, combined with declining fertility and increasing life expectancy, is causing the proportion of the elderly in the population to increase. The elderly population is poised to increase dramatically both in size and share of total population in the first half of the century and is projected to continue to increase, albeit at a slower speed, toward the end of the century.

(*Insert Figure 1 here*)

As a whole, the world's population has grown quickly in the last half-century, more than doubling from around 2.5 billion in 1950 to more than 7 billion today. It is projected to reach more than 9 billion by 2050 and 11 billion by 2100. Population growth at younger ages (0–14) has flattened out over the last few decades. The size and share of the working-age population (15–59) have grown steadily since 1950, but its growth has been fueled mostly by developing countries. In more developed countries, the population share of 15–59-year-olds has been somewhat level and is in fact projected to decrease to around 50 percent by 2100.

In contrast, the 60+ and 80+ age groups are growing rapidly both in absolute numbers and as a share of the total population, and both figures are higher now than at any time in history. The number of people aged 60+ increased from 200 million in 1950 to around 760 million today. By 2020, this number is projected to rise to 1 billion, by 2050 to 2 billion, and by 2100 to 3 billion. The number of people aged 80+, or the "oldest old," grew markedly from 14 million in 1950 to around 108 million today and will be over 900 million by 2100 if current projections prevail. Because the oldest old tend to have higher rates of severe chronic health problems that are costly in terms of both dollar amounts and time, the rapid growth of this cohort has important implications for individuals, families, and governments. Older age cohorts, moreover, are

[1] The projections displayed in Figure 1 are based on the United Nations' (UN) medium-fertility scenario. If fertility rates in the coming decades are lower than the "medium scenario" estimate, the share of elderly in the population will rise even further.

beginning to account for a substantial proportion of the total population, as Figure 2 shows. Indeed, people aged 60+ are expected to constitute a greater population share in all countries between 2000 and 2050.

While the phenomenon of population ageing is taking place throughout the world, considerable heterogeneity exists across nations and among regions.[2] Most developed countries already have large elderly cohorts, with 20 percent of the population aged 60+. This proportion will rise to more than 30 percent in the next four decades. Among developed countries, Japan currently has the largest proportion of people (30 percent) aged 60+. This distinction is expected to hold in 2050, when the figure will reach 44 percent. In the developing world, only 10 percent of the population is currently aged 60+, but this will soon change. By 2050, this proportion is expected to more than double. While the ageing transition has occurred over at least a century in developed countries, developing countries are projected to reach nearly similar levels of population ageing by the middle of this century.

(Insert Figure 2 here)

We now focus on the elderly population in the world's two population superpowers (China and India) and the largest population developing country populations in Latin America (Brazil), and Africa (Nigeria). Figure 3 shows the expected growth of the elderly population in these countries, which had elderly population shares ranging from 5 to 7 percent in 1950. In all four countries, population ageing will be a major demographic trend between now and 2100, but the extent will vary substantially. We pay particular attention to China and India because of their sheer size; their combined population accounts for 40 percent of the world's total population. Population ageing in these two countries has been rapid and will continue in the first half of the next century. By 2050, the 60+ age group is projected to constitute 20 percent of India's population and 36 percent of China's, totaling more than 750 million people. By 2100, these numbers will be 34 percent and 40 percent for India and China respectively. The pace of ageing will be especially rapid in China, where the absolute number of the population aged 60+ grew by 67 percent between 2000 and 2015 and is projected to more than triple to close to 400 million by the end of this century. The projected combined elderly population of these two countries will be close to 1 billion by 2100.

Brazil represents a swiftly developing South American country, where the large and rapid decline in fertility and increase in longevity of the past several decades will propel its elderly

[2] In presenting figures and tables, we follow the United Nations' classification of regions based on their recent economic development status: more developed or less developed. The less developed regions include all the countries of Africa, Asia (excluding Japan), and Latin America and the Caribbean, and Melanesia, Micronesia, and Polynesia. The more developed regions comprise Australia/New Zealand, Europe, Northern America, and Japan (United Nations Statistics Divison, 2014). We refer to countries belonging to the group of more developed regions as "developed countries" and countries in the group of less developed regions as "developing countries."

population to more than triple from less than 20 million in 2010 to close to 70 million in 2050. Nigeria provides a valuable counterpoint from the sub-Saharan African region, where the HIV/AIDS epidemic has played a large role in shaping the demographic structure. As a consequence, Nigeria's elderly population has grown much more slowly over the last half-century. The share of the 60+ population essentially remained flat between 1950 and 2015 at roughly 5 percent, although it is projected to more than double by the end of the century. This contrast is especially stark when compared with other developing countries of a similar size.

Figure 4 depicts the old-age dependency ratio (OADR), which measures the ratio of persons aged 65+ per 100 working-age persons (15–64). This metric, which we express in percent terms, helps gauge the pressure on the productive population to support the elderly and is hence an important indicator for governments and policymakers. For all countries, the old-age dependency ratio is currently at 12.6 percent, meaning there is roughly one elderly person for every eight working-age persons. This ratio is projected to increase to close to 40 percent by the end of the century. In developed countries, the OADR is currently at approximately 25 percent and is expected to increase to 50 percent by 2100. There is approximately one elderly person for every 10 working- age persons in developing countries currently, but this ratio will increase to closer to 1 for 3 by 2100.

Changes in the sex composition of the population will accompany population ageing. Overall, more male than female babies are born, but male mortality rates are higher than female mortality rates at all stages of life. While biology can explain part of this difference, differential behavior and risk factors play larger roles (Rogers et al., 2010; Seifarth et al., 2012). The resulting predominance of women among the elderly has been a longstanding and widely recognized phenomenon. However, this predominance is now diminishing with health improvements at all ages and medical advances in treating cardiovascular disease (which is concentrated among men). Figure 5 depicts the UN's population estimates and the forecast of the male to female ratio for the 60+ population from 1950 to 2100. Among the elderly, females will continue to outnumber males, in both developed and developing countries, although the sex ratio of the elderly in developed regions has increased rapidly since the mid-1980s. In developing regions, the sex ratio of the elderly has increased slightly since 1965 and is projected to remain roughly level or to increase slightly. Gender imbalance at older ages has policy implications in terms of living arrangements and the financial security of widows, especially in developing countries amid changing norms for the care of the elderly. We discuss some of these issues in Section 5.3.

2.2. Reliability of Population Projections

The data used in this chapter comprise mainly population data and projections from the United Nations (UN). In addition to the UN estimates, many governments also produce population estimates for their own countries. Several other agencies, including the U.S. Census Bureau and

the World Bank, produce global estimates as well. These population projections are important tools for government policymakers and private planners to gauge future demand for various resources and to allocate funds. Demographic forecasts have heightened awareness of population ageing, and increasing concern over adequate funding of pensions and health care systems have led to landmark reforms in these arenas throughout the world. So a peripheral, but important, question is how accurate are population projections?

We focus on the UN population estimates as they are the most widely used. The first thing to note is that UN population projections are not static. They change every two years to reflect new data from censuses, demographic surveys, vital and population registers, and various other sources.[3] In instances when a large amount of new census data become available, updated fertility and mortality data can lead to significant revisions in the estimates of future population size. Table 1 shows that the projections for the 60+ and 80+ populations in absolute numbers and in shares of total population have changed significantly, even in recent years. The greatest percent change occurred for the population aged 80+ by 2050 between the 1994 and 2010 forecasts. The UN estimate of the size of this age group has risen by 20 percent or more since 1994, for the world and across both developed and less developed regions, highlighting the magnitude to which estimates can change within a somewhat short period of time.

While the accuracy of current population projections cannot be assessed, the success of previous projections can be compared with historical or current population figures. Since the 1950s, the UN has provided 12 estimates for the global population in year 2000. Only one of these projections was off by more than 4 percent. Errors in projections have also decreased over time (National Research Council, 2000). However, projections for individual countries and specific age groups have had much more varied levels of success.[4] In particular, producing accurate projections for developing countries and for the youngest and oldest age groups has been challenging for several reasons. First, data for developing countries are somewhat limited and unreliable, and errors in baseline estimates play a dominant role in projection accuracy, especially in shorter forecast horizons (National Research Council, 2000). Second, many developing countries are still undergoing demographic transition, which means fertility and mortality are both still high and changing rapidly, leading to more room for projection error (Lutz, Sanderson, and Scherbov, 2008). Relatedly, UN assumptions about future trends in fertility and mortality rely mainly on empirical regularities in past trends in countries that have already completed the demographic transition; whether these assumptions are appropriate for developing countries that are still undergoing demographic transitions is not clear (Bongaarts, 2009).

[3] For a detailed review of the methodology the UN uses to calculate its population estimates, refer to Lutz and Samir (2010) and Bongaarts (2009).

[4] Projections of world population tend to be more accurate than individual country projections because country errors tend to cancel out in aggregate and because world population projections are not subject to migration errors.

Projections for intermediate age groups between 15 and 64 have in general been fairly precise, with error not exceeding 2 percent. Population projections for the very young and very old, however, have historically been too high and too low, respectively. Projections of total fertility have been too high, leading to upward bias in population projections for the very young. And as mortality improvements continue to be larger than forecasted for most of the world (exceptions are sub-Saharan Africa and the former Soviet Union), the projected population of the 80+ has been consistently underestimated. While almost all demographers agree that the proportion of the 80+ population will increase significantly over the next century, the magnitude of the increase is uncertain as future trends in old-age mortality continue to be highly debated (see Section 4.2 for a discussion of the future of longevity). Further, because UN population estimates do not incorporate different mortality scenarios, the uncertainty of the elderly population is likely understated. Finally, net migration also tends to be poorly projected, affecting estimates of the size of the working-age population (as migrants tend to be young adults) and the old-age dependency ratio, but for most countries the flow of migration has been slow enough to avoid a major impact on population estimates.

The assumptions used in making population estimates have changed since 2010. For example, prior to the 2010 revision, the assumption was that the total fertility rate in countries adjusting from high to low fertility will eventually approach a fertility floor of 1.85, regardless of their current position in the transition. Similarly, for countries already below replacement fertility levels, the assumption was that fertility would recover at a uniform pace that would converge to the fertility floor of 1.85 children per woman. The new approach does not adopt a set fertility floor and assumes that the projected pace of the decline depends on the country's current level of fertility, country-specific historical trends, and past trends of other countries that have already undergone fertility transitions (United Nations, 2014). As demographers become more proficient in predicting broad fertility and mortality trends—the key determinants of future population size—population estimates will also become more accurate. Regardless, because population projections still rely primarily on past trends and the implicit assumption that the conditions currently influencing fertility, mortality, and migration will persist in the future, population projection data carry substantial uncertainty and should be interpreted with caution.

While policymakers frequently use population projections, little is known about how uncertainties in these estimates are dealt with. A survey conducted by the European Commission among policy experts who use demographic data found that they tend to ignore the issue of uncertainty even though they were aware of it. In theory, policymakers have several methodological options, as discussed in Lee and Tuljapurkar (1998). The standard method is to use high-, medium-, and low-probability scenarios, although demographers tend to eschew this approach because of its strong assumptions. Beyond methodological issues, how much, if at all, the alternatives affect policy decisions is unclear. Lack of agreement and knowledge on how to tackle uncertainty in practice seems to be a barrier (Ahn et al, 2005). Future research calls for

more studies to understand the impact of past errors on policy adoption and to provide a framework for approaching and incorporating uncertainty in policy planning.

3. The Demographic Transition and Population Aging

The age structure of the population changes as a natural consequence of the demographic transition, which we briefly overview in this section. The demographic transition comprises three stages. The starting point occurs in a Malthusian world where both mortality and fertility are high and population growth is near zero, as high death rates offset high birth rates. Then, in the first stage of the demographic transition—when mortality begins to decline while fertility remains high—mortality declines most at the youngest ages, causing the proportion of children in the population to increase. Mortality decline thus initially renders populations younger rather than older in a phase that can persist for decades. Second, fertility begins to decline, such that the population growth rate also declines (but remains positive). This second stage may last 40 or 50 years. As fertility declines, the working-age population grows faster than the population as a whole, reducing the total dependency ratio. In the third stage, mortality and fertility both reach low equilibrium levels, and the overall population stops growing and sometimes declines. In this third stage, increasing longevity leads to a rapid rise in the elderly population while low fertility slows the growth of the working-age population. After completion of all three stages of the transition, population growth returns to near zero as fertility and mortality stabilize at low levels. The entire transition typically takes more than a century to complete and results in a much larger population size. The demographic transition is projected to be complete in all countries by 2100 (Lee, 2003).

Although the stages of the demographic transition are the same, the experience of developed nations is distinct from that of the developing world in its timing, determinants, and economic considerations. We therefore separate our following discussion by level of development.

3.1. The Historic Demographic Transition

We now briefly review the historic demographic transition of the developed world. In Western Europe, the first stage of the demographic transition—mortality decline—began around 1800. Population growth in Europe was slow and uneven for centuries, averaging 0.3 percent per year before 1700 (Lee, 2003). In perhaps the most widely studied case, mortality decline in England started around the middle of the eighteenth century. By 1820, life expectancy at birth in England reached 41 years, an increase of six years from the previous century, and remained stable for the next 50 years through the Industrial Revolution. Mortality continued to fall more rapidly after 1870, so that life expectancy had risen to 50 years by the early twentieth century and continued to climb until reaching around 80 years today (Cutler et al., 2006). With some variations in timing, other developed countries experienced similar transitions.

Although considerable debate remains, the fall in mortality has been attributed primarily to three broad reasons. First is the improvement in living standards as a byproduct of economic development as reflected in measures such as higher caloric intake and better access to health care and medicine (Fogel, 1997; Preston, 1975). The second explanation relates to the role of targeted social policy measures, such as the development of public health infrastructures such as water sanitation and vaccination programs (Preston, 1975; Cutler et al., 2006). Finally, education appears to have played an important role in the diffusion of knowledge on good health practices and the increasing acceptance of the germ theory of disease (Lleras-Muney, 2005).

Fogel (1997) argues that nearly all mortality reduction between the late eighteenth century and the late nineteenth century can be attributed to improved nutrition (via increased income). As agricultural yields improved during the eighteenth century, the caloric intake of the average individual and adult height increased significantly as mortality declined. However, while income growth and caloric availability likely played an important role, the timing of economic growth and the onset of the modern mortality decline did not align consistently (Easterlin, 2004). Further, as Preston notes in his seminal 1975 article, life expectancy has been increasing over time even holding income fixed, and proposes instead that public health measures could explain more of the historical mortality decline. Similarly, Cutler et al. (2006) argue that the cross-country differences in health stem from institutional ability to implement known technologies and adopt new ideas about personal health, rather than from variations in income.

Consistent with this hypothesis, Murtin (2013) finds that schooling, rather than income per capita, is the primary determinant of the mortality transition using aggregate panel data. Lleras-Muney (2005) exploits compulsory schooling law changes in the United States to account for schooling and finds that education is indeed linked to lower mortality. Of course, these theories are not necessarily mutually exclusive, making precise accounting difficult. But overall, most of the decline in mortality can be attributed to better health technology, higher wealth, and improved education, with varying degrees of importance depending on the time and context. We revisit this topic in Section 4.2, where we discuss in greater depth the specific reasons behind more recent increases in life expectancy.

Population growth is the next stage of the transition, as mortality falls and fertility remains high. The modern expansion of human population began around 1800, rising from around 1 billion to 2.5 billion by 1950.

Then fertility begins to fall following the decline in mortality and subsequent population growth. Most presently developed nations began their fertility transitions in the late nineteenth or early twentieth centuries, with a median fertility decline of about 40 percent from 1870 to 1930 (Coale and Treadway, 1986). The causes of fertility decline remain hotly debated, but neoclassical economics emphasizes the gradual evolution in the demand for children (Becker 1981; Galor and Weil, 2000). This explanation highlights the rising opportunity cost of

childbearing stemming from factors including increases in female labor force participation and wages, the returns to schooling, and demand for child quality. Other factors that affect the supply of children, such as availability of and advancement in contraceptive technology, also have been shown to have significant impacts on fertility, but are unlikely to be dominant forces. We discuss these and other theories and their respective merits in Section 4.1.2.

In the final stage of the transition, mortality and fertility fall to long-run low levels and population growth returns to zero or even falls below zero. Most developed countries have now reached this final stage of their transition. Many Western European countries, such as Spain, Italy, and Germany, currently have birth rates below the population replacement rate of 2.1 births per woman. Some countries, including Russia and Japan, face significant population declines because birth rates and net migration rates have fallen below crude death rates.

Because the demographic transition occurred earlier in developed countries, the phenomenon of population ageing also began earlier there. The 60+ population share was already at 12 percent in 1950 (higher than the current share in less developed regions), has doubled to approximately 24 percent today, and is projected to continue to rise at a similar pace until the middle of this century, when population ageing is expected to slow.

3.2. The Ongoing Demographic Transition in Developing Countries

Although separated by roughly a century, the demographic transition in developing countries mirrors that in developed nations, but at a much more rapid pace. The limited available pretransitional data from India and Taiwan indicate that total fertility rates were typically six or higher, and life expectancy was highly variable and averaged in the low 20s (Preston, 1975). While many developing countries did not begin the mortality transition until sometime in the twentieth century, life expectancy gains were quite rapid once their transitions commenced. In China and India, life expectancies have risen by nearly 30 years since 1950. In African countries overall—where economic progress has been slower—life expectancy rose by more than 13 years from the 1950s to 1980s, before stalling in the face of the HIV/AIDS epidemic.

For most developing countries, the second stage of the demographic transition—fertility decline—typically began in the post–World War II period or later (Lee, 2003). Fertility transitions in East Asia were particularly early and rapid, while those in South Asia and Latin America have been slower (Casterline, 2001). Below replacement rates are observed not only in the developed world, but also in various emerging countries including Brazil, Taiwan, Korea, and China. We delve into the reasons for fertility and mortality declines in developing countries in the past few decades in Sections 4.1 and 4.2.

From 1950 to 1990, fertility and mortality rates declined roughly in tandem, although the birth rate was still around twice as large as the mortality rate, leading to a large population boom in developing countries. Whereas the population growth rate in Europe has not exceeded 1

percent and exceeded 1.5 percent only briefly in the United States in the modern era, population growth in developing countries reached historically unprecedented rates, attaining a peak of 2.5 percent in the 1960s. Population growth in developing countries has since slowed as fertility continues to decline.

As the youth bulge progresses through the age structure, combined with sustained low levels of fertility and rising longevity, many developing countries are now beginning to witness rapid population ageing. While today's proportions of older people typically are higher in more developed countries, the most rapid increases in older populations are occurring in the less developed world. Whereas the elderly population share took more than a century to double in developed countries such as France, countries such as China and Brazil are expected to achieve the same in around a quarter of the time (Kinsella and Gist, 1995). Between 2015 and 2050, the 60+ population in less developed countries is projected to increase by 177 percent as compared with an increase of 41 percent in more developed countries.

4. The Demographic Determinants of Population Aging

As described in the previous section, the interplay of declining fertility and increasing longevity within the demographic transition is the root cause of population ageing. However, how these factors affect ageing and their implications are different. A fertility decline reduces the numbers of the very young, which translates into smaller cohort sizes of the young and working age population as time goes on and low birth rates continue. Holding longevity constant, lower fertility implies higher OADR and may impose higher resource costs on the population. However, an increase in life expectancy raises the average age of the population and the share of elderly population by increasing the numbers of surviving older people. If rising longevity due to reductions in old-age mortality is associated with improved health and productivity of the elderly, then the economic pressures of population ageing may be less severe.

Of these two forces, fertility decline has played a larger role in population ageing (Weil, 1997; United Nations, 2001). Weil (1997) shows that at least two-thirds of the increase in the U.S. elderly population is due to fertility decline. Bloom et al. (2010b) show that the fertility decline had a much larger impact on the age structure in 1960–2005 using a sample of Asian countries, even in China where life expectancy increased by 31 years (approximately 70 percent) in the same period.

Migration also plays a role in determining the age structure of open economies. Immigrants tend to be young and of working age, so to the extent that population ageing is viewed as a problem to be solved, changes in immigration policy have been touted as a possible solution to ameliorate its effects. However, as we will discuss shortly in Section 4.3, the flow of immigrants necessary to ease the pressures of population ageing is unfeasibly large.

4.1. Decline in Fertility

Fertility decline has been the most important demographic driver of population ageing (United Nations, 2001). Figure 6 depicts the total fertility rate (TFR), defined as the average number of children that a woman would bear over her lifetime, in the world, in more developed regions, and in less developed regions from 1950 to 2010 and projected until 2100. Globally, TFR has fallen from five children per women in 1950 to roughly 2.5 today and is forecasted to fall even further in the next few decades. From 2005 to 2010, 50 countries (out of 202) had TFRs of 4.0 or higher. The fertility rate is projected to fall to roughly 2.2 by 2045–2050 even among currently developing countries, and only one country (Niger) is expected to have a TFR higher than 4.0. Current projections show fertility rates across more developed and less developed regions further converging, with TFR at 1.88 and 2 for developed and developing regions by the end of this century, respectively. Figure 1 shows the impact of falling fertility, demonstrating the shrinking base of the population pyramid as the shares of 0 to 14-year-olds worldwide declines and the correspondingly widening top of the pyramid as the population of elderly people grow in both absolute numbers and percent of total population.

This section highlights recent trends in fertility and some leading explanations for the trends within the economic literature. We begin by presenting a basic theoretical model proposed by Becker (1960) in Section 4.1.1, which has been used as the primary framework in economics to understand fertility. We then provide several explanations with supporting evidence for the continuing fertility decline in the developed world in the post–WWII era in Section 4.1.2. We move on to discuss the fertility transition in the developing world in Section 4.1.3, where the bulk of the fertility decline occurred in the last half-century as many countries began the second phase of their demographic transitions. The economic literature on fertility is expansive, and we limit the discussion herein to how fertility is related to ageing and to the post-WII modern era.[5]

4.1.1. Theoretical Framework

We begin with the basic Becker framework to explain the demand for children (Becker, 1960, 1981, 1992), as it has become the canonical model in economics for understanding fertility. In the simplest model, the number of children is treated analogously to other consumer (normal) goods in a basic neoclassical two-good utility (U) maximization framework. Parents choose the number of children (n) and goods (Z) to maximize $U = U(n, Z)$, subject to a budget constraint ($\pi_c n + \pi_z Z = I$), where the cost of child rearing and indirect opportunity costs determine the price of children (π_c), and π_z is the unit cost of goods (Z). The cost of child rearing comprises direct and indirect costs. Examples of direct costs include clothing, education, and food. Indirect costs include opportunity costs, such as foregone earnings of women who take time off from the

[5] For further discussion of the historical aspects of the fertility transition, Guinnane (2011) provides an excellent review.

labor market to care for their children. In this framework, the usual first-order conditions determine the optimal quantities of *n* and *Z*, where the demand for children depends on the relative price of π_c/π_z. Simple comparative statics then implies that an increase in the relative price of children would reduce the demand for children (and increase the demand for other commodities), holding real income constant. An increase in pure income would raise the demand for children, but if the higher income reflects an increase in wages, then the substitution effect may dominate the income effect, so that the number of children demanded is reduced.

Becker then augments this simple model by including the quality of children as a variable, as denoted by expenditures on children. The household thus seeks to maximize a utility function comprising the quantity of children (*n*), the quality of children (*q*), and the quantities of all other goods (*Z*). Both quality and quantity of children are normal goods, and the household budget constraint is now ($\pi_c qn + \pi_z z = I$), where π_c is the constant cost of a unit of quality, and *q* the total quality of each child. It can be shown that income elasticities of demand for *n*, *q*, and *Z* must satisfy $\alpha(\varepsilon_n + \varepsilon_q) + (1-\alpha)\varepsilon_Z = 1$, where α is the share of family income devoted to children, and ε_n, $\varepsilon_q$and ε_z are income elasticities with respect to *n*, *q*, and *z*, respectively. If children are normal goods, then total expenditures on children will increase with income ($\varepsilon_n + \varepsilon_q > 0$). However, if ε_q is large enough, it is possible that $\varepsilon_n < 0$. In other words, higher income is expected to be associated with a greater demand for children. However, greater demand for children may be offset at least in part by greater resource endowments per child (i.e., increased quality of children) rather than by an increase in the number of children.

Becker and Lewis (1973) present a more generalized version of the Becker (1960) model. The authors introduce fixed costs of *n* and *q*, such that the budget constraint is now $\pi_n n + \pi_q q + nq\pi_c + \pi_z z = I$, where π_n and π_q are the fixed costs of each child and the unit of quality, respectively. The shadow price of an additional child, p_n, then becomes $\pi_n + \pi_c q$, and the shadow price of an additional unit of quality, p_q, is $\pi_q + \pi_c n$. Hence, p_n is an increasing function of *q* and p_q is an increasing function of *n*. Because the household chooses *n* and *q*, the shadow prices are endogenous. The important takeaway from the model is that quantity and quality are closely related, because the shadow price of quality depends on quantity and the shadow price of quantity depends on quality. As an example, if π_q decreases due to an increase in education subsidies, then the fall in p_q induces an increase in quality. This in turn induces an increase in p_n and thus a somewhat large decrease in quantity.

Of course, Becker was not the first to suggest that economic costs and benefits affect the fertility decision. For example, Notestein (1953) attributed the fertility transition to several broad social and economic changes, including urbanization leading to changes in the economic benefits and costs of children and the emergence of new economic roles for women that are incompatible with childbearing—all ideas that can be formalized within the Becker model. Most existing

economic frameworks build upon or can be largely reconciled with Becker's seminal model, including much of Becker's later work (Becker and Tomes, 1976; Barro and Becker, 1989), Easterlin (1975), Willis (1973), Michael and Willis (1976), among others.[6] In addition, most existing fertility theories in economics and other fields can be traced to the basic tenet of the Becker model, i.e., that the demand for children has a downward-facing slope like any normal good and as the "price" of children increases, fertility will decline. The empirical evidence (some of which we will discuss below) is overall consistent with the model's main prediction: as the price of children increases (or decreases), the quantity demanded, or fertility, decreases (or increases). As such, we believe that the Becker model is the most useful and parsimonious framework to have in mind when examining fertility trends.

4.1.2. Developed Countries

As noted in Section 3.1, the bulk of the fertility decline in developed regions began in the late nineteenth or early twentieth centuries as they experienced their demographic transitions. By 1950, total fertility rates in the developed world had already fallen to 2.8 and declined further to 1.7 by 2010. The demographic transition in the developed world is more or less complete (Bongaarts, 2009). The completion of the demographic transition has left fertility rates in most developed countries at below replacement levels. In some countries in Europe and Asia, fertility rates fell to the "lowest low"—defined as fewer than 1.3 children per woman—in the 1990s (Kohler et al., 2002). As a result, several countries such as Japan now face population declines. Distinct variation in fertility trends also exist across industrialized nations. For example, North America has had higher fertility than Western Europe (1.89 versus 1.66 children per woman), and projections suggest that this divergence between the two principal regions of the North will persist into the near future.

For developed countries in the last stage of their demographic transitions, the most significant dynamic change in the modern era is the ageing demographic associated with the "baby boom." The United States and other developed countries experienced baby booms in the decade following World War II, when birth rates increased dramatically for two decades and led to a sharp and transitory deviation from the long-term trend of declining fertility, followed by the baby bust, which returned birth rates to pre-boom (or lower) levels. By the 1970s, fertility had fallen to replacement or even below replacement levels in most developed countries. As the baby boom cohorts continue to approach retirement age, they will account for much of the oncoming ageing population in developed regions. After a slight slowdown in population ageing in the past

[6] This is not to say that significant differences do not occur among these models, or that no detractors of the Becker model exist. In particular, the earlier work by Easterlin and Becker differed in their assumptions of preference formations, although the basic ideas behind the two schools of thought remain similar and complementary. In particular, rather than assuming homogeneous preferences, Easterlin suggests that attitudes toward both children and other goods and services vary depending on the individual. See Sanderson (1976) for a more detailed discussion.

two decades, driven by low fertility in the 1930s, population ageing will accelerate rapidly in the next few decades due to the graying of the baby boom cohorts (Figure 2). In the United States, the baby boomers began turning 65 in 2011 and are now driving growth at the older ages of the population. There were approximately 76.4 million baby boomers in 2012, representing close to one-quarter of the entire U.S. population. By 2029, when all the baby boomers will reach retirement age, more than 20 percent of the total U.S. population will be over the age of 65. Just as this generation had an impact on the educational system and the labor market during their school-age and economically productive years, the boomers' retirement and savings choices will have significant implications for the labor market and pension spending across developed nations. However, although the size of the baby boomers' cohorts will decline through mortality, this shift toward an increasingly older population is expected to persist, although much less rapidly, due to the longer-term trends in declining fertility.

4.1.2.1. The Cost of Children

Most reasons cited for the decline in fertility in the developed world pertain to the "price" of children. The challenge in empirical identification is then to find exogenous variation in the proxies for said price. The price of children may refer to the direct costs (childcare, costs of schooling) and indirect costs, namely the opportunity cost of time needed for childbearing and childrearing mostly on the mother's part.

As wages for women increased in the post-war era, more women were drawn into the labor force. Within the Becker framework, the intuition is that the substitution effect of increasing women's relative wages dominates the income effect, such that women work more and reduce their fertility. The rise in women's wages could also induce a quantity-quality tradeoff that would further imply fewer children. As the unified growth theory (which employs the Beckerian quantity-quality framework) emphasizes, technological change may have decreased the comparative advantage of males in physically intensive tasks, raised the demand for female labor, and therefore increased the opportunity cost of fertility (Galor and Weil, 1996).

Because fertility and labor supply are likely jointly determined, the challenge in empirical identification is then to find exogenous variation in the proxies for the "price" of children. Using data from Sweden, Schultz (1985) finds that exogenous increases in women's relative wages can explain a quarter of the decline in fertility from 1860 to 1910. Butz and Ward (1979) suggest that the rise in male wages in the post-war period, which increased household income, followed by a sharp increase in female wages (which increases the cost of children assuming women are the primary caretakers) can help explain the baby boom and bust in the United States. More recently, Jensen (2012) finds that young women in rural India with more labor market opportunities were significantly less likely to get married and have children. Somewhat surprisingly, although the rise of female wages and labor force participation has been credited extensively as a major reason for the fall in fertility (Becker, 1960; Galor and Weil, 1996; Schultz, 2001), little

systematic research has been done to identify the causal rather than correlative impact of female wages and labor market structure on fertility.[7]

The price of children has also been examined via the lens of direct cash allowances for families with children, parental leave benefits, availability of childcare facilities, and related pronatalist polices. In the Becker model, these policies may result in a reduction in the cost of children (e.g., public subsidy) or as an increase in income (e.g., transfer payments), which should imply an increase in the demand for children (either in quantity or quality). Overall, fertility behavior seems to respond to targeted financial incentives such as child subsidies, but not welfare benefits (Buttner and Lutz, 1990 ; Cohen et al., 2007; Milligan, 2005 ; Gauthier, 2007).[8] Results examining the impact of family-friendly work policies are mixed, and the estimates, when positive, are typically small (Gauthier, 2007). As governments and private organizations become more attuned to the needs of working parents, more research needs to be conducted on how alternative policies such as expanding paternal leave benefits or flexible work schedules may affect fertility. Recent studies on paternity leave have found that increasing paternity leave increases fertility slightly (Feyrer et al., 2008), but does not change the traditional household division of labor (Cools et al., 2015).

Studies focusing on the direct costs of childrearing in terms of childcare prices and availability have also yielded mixed results (Gauthier, 2007). For example, Mörk et al. (2013) examine the impact of Swedish childcare reform, which effectively reduced user fee costs. The authors find that fertility increased by approximately 10 percent among childless couples. However, Schlosser (2005) examines the introduction of free public preschool in Israel on Arab mothers' labor supply and fertility and finds no effect on fertility but a positive effect on labor supply. In yet another study, Furtado and Hock (2010) demonstrate that lower wages in the childcare sector due to low-skill immigration are associated with higher fertility among highly educated women in the United States. Bauernschuster et al. (2014) find evidence that a substantial expansion of public childcare for children under three in Germany increased birth rates, suggesting that policy may be effective in reversing low fertility. Because lower childcare costs represent a pure reduction in the cost of having children for women already in the labor

[7] However, the reverse relationship of the impact of fertility on female labor supply has been examined more thoroughly. These papers attempt to isolate the causality of child quantity through various natural experiments, such as the exogenous event of twinning (Rosenzweig and Wolpin, 1980) or by exploiting parental preferences for a mixed sibling sex composition (Angrist and Evans, 1998), and typically find that more children lead to lower female labor supply, with some heterogeneous effects by education and age.

[8] Studies using macrolevel data have generally concluded the impact of government policies is most likely on the timing of births rather than completed fertility (Gauthier, 2007).

force, effects on fertility may also be observed in certain contexts where rates of female labor force participation are already high.[9]

4.1.2.2. The Role of Education

Several theoretical models, including the unified growth theory proposed by Galor and Weil (1999, 2000) and Galor and Moav (2002), emphasize the idea that increasing demand for human capital is a driving force behind the decline in fertility. The empirical evidence is consistent with the theory: education and fertility are consistently negatively correlated in both macro- and micro- level data (Strauss and Thomas, 1995, Martin, 1995). Murtin (2013) finds average years of primary schooling to be the most dominant long-run determinant of the fertility transition, rather than income standards or child mortality.

How might education affect fertility? First, the increasing returns to education, which can be interpreted as lowering the cost of quality, lead parents to substitute child quantity for child quality (Becker et al., 1990). Second, the increasing quantity and quality of schooling of women, especially in higher education after WWII, may have increased female wages and labor market opportunities, hence increasing the cost of childbearing (as we touched on in Section 4.1.3.1). Third, education may affect a woman's fertility and child-investment choices by improving a woman's knowledge of contraceptive technologies and healthy pregnancy behaviors (e.g., limiting smoking or drinking).

Overall, fairly strong evidence shows that education affects fertility. Rosenzweig and Schultz (1989) demonstrate that a woman's education explains the ability to use contraception effectively. Currie and Moretti (2003) evaluate a woman's educational attainment using the availability of colleges in her county and show that higher maternal education improves child health outcomes and reduces parity. Monstad et al. (2008) use a similar natural experiment in Norway to show that more schooling leads to a postponement in childbirth, but not in completed fertility. One exception to these results are McCrary and Royer (2011), who use age-at-school-entry policies as identification and find that increasing schooling does not affect the probability of motherhood or age at first birth. One possible explanation to explain the difference in results is that education affects fertility nonlinearly and also at different stages of the transition and economic development. While education clearly seems to play an important role in determining fertility, the extent to which the increasing returns to schooling and rise in women in higher education can explain the post-war fertility trends and contribute to the ageing phenomenon in developed regions deserves more investigation.

[9] A reduction in childcare costs tends to have confounding effects, and the net effect on fertility is difficult to determine. On one hand, it represents a reduction in direct costs of childrearing, potentially leading to higher fertility. On the other hand, it may also increase female labor supply by encouraging mothers to enter paid work and thus reduce fertility.

4.1.2.3. The Accessibility of Birth Control

The role of fertility regulation in explaining fertility has also been intensely debated. While demographers have historically emphasized contraceptive technology in the decline in fertility, economists have been more skeptical. For example, Westoff and Ryder (1977) attribute the decrease in fertility to a "contraceptive revolution" that began with the invention of the birth control pill ("the pill"). In contrast, Becker (1991) argues that major changes in fertility were caused by shifts in the demand for children, and improvements in birth control methods were mainly an induced response to decreased demand for children rather than a cause of the decreased demand. Other economists have also pointed out that historical fertility transitions in the nineteenth and early twentieth centuries occurred without the advancement of new contraceptive technologies (Guinnane, 2011; Lee, 2003).

Nonetheless, recent research suggests that access to birth control technology contributed to the decline in fertility in the modern era. In particular, the pill and legalized abortion—both of which arguably allow women to control their fertility more directly relative to other methods such as condoms and *coitus interruptus* (withdrawal)—seem to have played significant roles. Bailey (2010) uses state and time variation in legal access to birth control ("Comstock" laws) in the United States and finds that as much as 40 percent of the total change in the marital fertility rate from 1955 to 1965 could be attributed to the advent of the pill. Further, Bailey (2006, 2013) and Goldin and Katz (2002) find that the pill significantly altered labor market and fertility decisions and even relative wages for women in the United States. Similar, but more suggestive, evidence exists for Europe (Murphy, 1993).

Legalized abortion also appears to have been a contributing factor to declining fertility. Levine et al. (1999) use state and time variation to find that legalization of abortion led to a 5–8 percent decline in birth rates, with a larger decline among teens and nonwhite women. Access to legalized abortion may also have affected fertility indirectly, via increased schooling investments among cohorts who were exposed to abortion reforms (Angrist and Evans, 1996). Nonetheless, unclear is to what extent the results from these studies, which have mostly been set in the West, can be extrapolated to currently developing countries, as the legalization of oral contraception and abortion in the West coincided with various concurrent forces, including increased demand for women's work, improvements in the quality of education for women, lessened discrimination against women, and shifting norms about the role of women. That said, studies using panel aggregate data and other settings outside the developed world also support that abortion affects fertility. For example, using a cross-country panel analysis, Bloom et al. (2009) find that removing legal restrictions on abortion significantly reduces fertility and increases a woman's labor supply. Pop-Eleches (2006) finds that an abortion ban in Romania in 1966 led to a doubling of birth rates.

4.1.2.4. The Baby Boom and Bust

As the baby boom cohorts approach retirement age, they will increase the rate of population ageing in developed regions. The causes of the baby booms and subsequent busts in the Western world are hotly contested. The puzzle in part stems from the concurrence of rising fertility with increasing urbanization, educational attainment, and women's labor force participation—trends typically associated with declining fertility and counter to the standard Becker framework. Perhaps the most well-known economic theory to explain the baby boom and bust is Easterlin's "relative income hypothesis" (1961). Easterlin theorizes that couples choose to have children based on a ratio of potential earning power and the desire to obtain material objects. The economic stability of the country and the way that people are raised to value material objects determine this ratio. The "relative income" theory explains the baby boom by suggesting that the late 1940s and the 1950s brought low desires to have material objects because of the Great Depression and World War II. Plentiful employment opportunities after the war gave rise to a high relative income, which encouraged high fertility. The next generation had a greater desire for material objects; however, an economic slowdown in the United States resulted in fewer job opportunities. This combination resulted in lower fertility rates, or the baby bust. An important implication of Easterlin's hypothesis is that the cohort size should be negatively correlated with fertility rates, but the empirical support for this notion has been mixed (see Macunovich, 1998, for a review). Critics of the Easterlin model have emphasized the faulty prediction of the model that the United States should experience another baby boom in the 1990s. In reality, fertility rates did not change markedly in the 1990s.

Other intriguing theories have been proposed to explain baby booms. Greenwood et al. (2005) suggest a new and specific price-based explanation for the baby boom. In an overlapping generations framework, they argue that a burst in the productivity of household technology in post–World War II United States led to a reduction in the shadow price of childbearing. These so-called "engines of liberation," such as microwaves, dishwashers, and other innovations, lowered the cost of having children and led to a pronounced rise in fertility between 1940 and 1960. However, Bailey and Collins (2011) do not find any support for this hypothesis. They find similar baby booms and busts in populations without such innovations, including the Amish, who use modern technology less than other U.S. households. Further, they find that county-level appliance ownership and electrification negatively predict changes in fertility, suggesting that advances in household technology are not responsible for the U.S. baby boom.

Butz and Ward (1979) provide an empirical framework in the spirit of Becker that emphasizes the distinction between male and female earnings. Their analysis suggests that the baby boom of the 1950s can be explained as a response to rising male income, whereas the subsequent baby bust was primarily due to the increases in female wages and income. Assuming that the husband's time is not an important input in the child production function and that

children are normal goods, an increase in the husband's market wage shifts the household budget out and leads to a higher demand for children. In contrast, an increase in women's wage increases the price of children because it increases the opportunity cost of childrearing (and bearing). While not without detractors (see for example Macunovich, 1995), Butz and Ward's article has become one of the canonical articles on U.S. fertility due to its simplicity and conformity with the Becker framework. Their article was published in 1979, so an updated analysis using newer and longer time series data, and perhaps using data from other developed countries, would be very useful in understanding fertility in more recent decades.

4.1.3. Developing Countries

The experience of population growth and fertility has been markedly different in developing regions, where many countries are still experiencing their demographic transitions. Less data on developing countries' mortality and fertility in their pretransitional periods are available, but from what we know total fertility rates were typically at six or higher and life expectancy was highly variable and averaged in the low 20s (Bhat, 1989). However, once the fertility transition began in developing regions, the pace of fertility decline that has occurred was remarkably rapid: TFR fell from 6.0 to 2.7 in 1965–1970 and 2010–2015, after staying at around six children per woman since 1950. Recent evidence from Asian countries suggests that some developing countries may be on a trajectory toward even lower long-run fertility than high-income countries. Korea, Singapore, and Hong Kong all have estimated TFRs close to 1.0 in 2010, compared with values ranging from 3.5 to 6.0 children per woman in 1970. Latin America has undergone a less dramatic decline, where TFR remains above replacement at 2.15, although exceptions exist, such as Brazil, where TFR is now at 1.82. Sub-Saharan Africa provides a contrasting example, where TFR remains high at 5.1 children per woman.

Baby booms and busts also occur in developing countries, but more as a consequence of changes in fertility associated with ongoing demographic transitions, where dropping fertility rates tend to follow rapid declines in infant and child mortality. The lag between falling mortality and fertility created a "baby boom" generation, which was larger than the cohorts that preceded and followed it.

This change in age structure has important implications for economic growth: an initial surge in young dependents soon translates into an increase in the proportion of the working-age population. This phenomenon is known as the "demographic dividend" (Bloom et al., 2002). Because labor supply and savings are higher among working-age adults, economic growth increases dramatically as a baby boom generation moves through the age structure. The eventual ageing of these baby boom cohorts, which are affected by increasing longevity over time, will play a large role in driving rapid population ageing in the coming decades. As developing nations reach the end of their demographic transitions, the equilibrium phenomena of lower fertility and higher life expectancy will continue to increase the proportion of older people in the population.

Many of the reasons for declining fertility in developing countries apply to the earlier decline in developed regions. The following sections discuss several reasons that are more distinct to the experience of developing countries in recent decades.

4.1.3.1. The Decline in Child Mortality

A decline in fertility often follows falling child mortality. Many countries experienced this during their demographic transitions, including England and Sweden in the nineteenth century and India and other developing countries more recently. Declining child mortality has therefore often been proposed as an important determinant for the decline in fertility, although what the standard fertility framework would predict as a result of a decline in child mortality is unclear. On one hand, lower child mortality could be interpreted as a reduction in the cost of children because it reduces the number of births needed to produce a surviving child. This would imply a resulting increase in fertility. On the other hand, when mortality is stochastic and parents want to avoid the result of few (or zero) surviving children, a precautionary demand for children, or "child hoarding", results (Neher, 1971; Nugent, 1985). Sah (1991) and Kalemli-Ozcan (2003) suggest that when hoarding is taken into account, declining child mortality can have a strong negative impact on fertility. A decline in child mortality may also induce a quality-quantity interaction. For example, parents might substitute efforts to prevent child death with expenditures on other aspects of quality, because the rate of return on such expenditures would increase. If total parental expenditures increased, the effective price of quantity could increase and the demand for surviving children would decrease (Becker, 1960). However a decline in child mortality also reduces the price of child quantity, which tends to stimulate fertility, particularly if the precautionary demand for children is modest (Galor, 2012).

The evidence supporting the causal effect of child mortality on fertility is mixed. Using panel data from 118 countries, Angeles (2010) shows that a fall in lagged child mortality of one standard deviation is associated with a decline in TFR of 1.13 children per woman. However, using a large panel of countries, Murtin (2013) finds that education, rather than child mortality or economic growth, has been the main socioeconomic determinant of the decline in fertility since 1879. The difficulty in identifying the causal impact of child mortality is that it is often associated with drops in adult mortality and survival, which may in turn affect parental demand for children. Decline in adult mortality may also play a role by extending the time horizon over which returns to human capital investments can be reaped, which may encourage investment in child quality and simultaneously lower fertility. Further, child mortality and fertility may be endogenously determined. A growing literature indicates that education affects both child health and fertility (Breierova and Duflo, 2004; Chou et al., 2010; Osili and Long, 2008). A less discussed issue is the impact of declining child morbidity, which could be viewed as a reduction in the cost of child "quality." Per the Becker framework, this would then induce a fall in child quantity. Bleakley and Lange (2009) find that large-scale hookworm eradication in the U.S.

South in the early twentieth century not only improved the health and human capital outcomes of the affected children, but also decreased fertility in the treatment areas relative to control areas. Overall, however, the evidence is insufficient to conclude that the decline in child mortality is a major determinant for the fall in fertility, and more research is needed.

4.1.3.2. Anticipated Future Support from Children

Old-age security is frequently cited as a rationale for childbearing among traditional societies. Per this argument, anticipated future support from children is an important component of the fertility decision. Hence, child hoarding and replacement effects may be especially strong in developing countries where child mortality is somewhat high and limited credit markets and societal institutions for old-age support exist (Caldwell, 1976; Nugent, 1985).

The empirical evidence supporting this hypothesis is surprisingly scarce. A few studies argue and provide evidence that fertility in developing countries has declined due to a lessened need for old-age support from children as a result of development and modernization. Using cross-country data, Entwistle and Winegarden (1984) show that fertility varies inversely with the level and breadth of publicly provided old-age support. In rural Mexico, Nugent and Gillaspy (1983) find some evidence of fertility reduction when farmers were given access to a government-backed pension program.[10] More research is certainly needed to understand whether the gradual shift away from family-based old-age support in developed countries will also occur in developing countries and how much the growing availability of substitutes for old-age security affects the decline in the demand for children. We return to a related issue on the living arrangements for the elderly in Section 5.3.

4.1.3.3. Contraceptives and Family Planning Programs

One major difference between the fertility transitions in developed and developing regions is the introduction of contraceptives and family planning programs. Family planning programs were highly popular from the 1970s to the mid-1990s, but fell out of vogue by the 2000s (Population Council, 2012). Such policies can range from more coercive interventions, e.g., China's one-child policy, to providing contraceptive information and services, such as the Family Planning and Health Services Project in the Matlab region of Bangladesh.[11] How much the availability of modern contraceptives and family planning policies played a role in the fertility decline in developing countries is yet another topic of heated discourse. Supporters argue that family planning policies and the availability of modern contraceptive technology, coupled with an "unmet need" for birth control, has contributed significantly to the fertility transition, accounting

[10] The issue of endogeneity is ever present. Pension programs are also likely introduced as a consequence of lower fertility and higher demand for government-financed old-age support.

[11] China ended its one-child policy in November 2015, and how much fertility will increase, if at all, remains to be seen. Accessed: http://www.nytimes.com/2015/10/30/world/asia/china-end-one-child-policy.html?_r=0.

for more than 40 percent of the decline during 1960–1965 to 1985–1990 (Bongaarts, 1997). Detractors contend that programs that are either coercive or simply lower the cost of contraception have limited success in altering fertility preferences, but most agree that more comprehensive, educational campaigns can be effective (Pritchett, 1994; Simmons, 1996; van Ginneken and Razzaque, 2003).

The empirical evidence of the aggregate impact of family planning policies is mixed. Boulier (1985) uses cross-national data to show that the expansion of family planning programs from 1965 to 1975 resulted in significant fertility decline. However, both Schultz (1994) and Tsui (2001) find that family planning efforts have only a small effect on total fertility rates. Studies of specific programs have yielded more insight. The Bangladesh MATLAB program, an experimental maternal, child health, and family planning program, suggests that treated villages experienced fertility declines of 17 percent and that the decline in fertility persisted for nearly two decades (Joshi and Schultz, 2012).

However, because MATLAB introduced other community health services as well (such as immunizations), disentangling the impact on fertility of family-planning aspects of the program from these other services is difficult. A similar quasi-experimental program that took place in Ghana in 1993 led to comparable reductions in fertility rates (Debpuur, et al. 2002). Colombia's large-scale Profamilia family planning program is estimated to have led to 9–12 percent of the total decline in fertility during the period of interest (Miller, 2010). Jones (2011) exploits arguably exogenous shocks in contraceptive availability in Ghana resulting from cuts in U.S. funding to show that a reduction in supply leads to an increase in realized fertility of 10 percent. An interesting experimental study conducted in Zambia found that women who were given access to contraceptives with their husbands had lower contraceptive use and more births than women who were given access to contraceptives alone, suggesting that intrahousehold tensions regarding fertility may be an important factor when determining contraceptive uptake (Ashraf et al., 2014). Overall, these studies show that contraceptive accessibility and family planning programs do matter, but are unlikely to be a major contributor to the rapid decline in fertility observed in most developing countries.

4.1.3.4. Education

The role of education has arguably played an even more important role in the fertility decline in developing regions. As governments and international organizations such as the World Bank and the UN have continued to emphasize education as a primary driver of economic growth, the quantity of schooling in many developing regions has increased considerably. As Murtin (2013) has found using aggregate data, education, rather than income growth or the fall in child mortality, is the most robust explanatory factor of fertility. In Section 4.1.3.2, we discussed the mechanisms through which education may reduce fertility and some of the supporting evidence from developed regions. The evidence from micro studies set in developing countries also

supports this hypothesis. Duflo et al. (2014) conducted a large randomized evaluation in western Kenya to show that education subsidies reduced teen pregnancy. Chicoine (2012) exploits a policy change in Kenya that lengthened primary school by one year to find similar results—the reform led to more schooling, delay in marriage, and reduced fertility. Brievora and Duflo (2004) use a large school construction program in Indonesia to estimate the causal impact of education on fertility and find that schooling leads to lower fertility.

4.1.3.5. The Impact of Social Media

A recent strand of economic research has focused on how other factors have altered preferences toward smaller family sizes. Social media, for example, appears to have played a role in shaping preferences. La Ferrara et al. (2012) show that exposure to soap operas featuring families that are much smaller than reality have led to a decline in the number of births by around 10 percent. Similarly, Jensen and Oster (2009) find that the introduction of cable television leads to an improvement in the status of women and lower likelihood of pregnancy. While the digital divide between high- and low-income countries remains large, Internet use and information technology services continue to grow rapidly in many developing countries (Chinn and Fairlie, 2010), and examining how access to such other forms of information affect fertility preferences and health behaviors will be interesting.

4.1.4. The Future of Fertility

In the coming years the rate of fertility will be a crucial determinant of the structure of the future ageing population—yet another subject of debate. Figure 6 shows the projection of TFR (medium variant) to 2100, which depicts fertility leveling after 2050 for less developed regions. For more developed regions, fertility appears to converge to what appears to be a long-run equilibrium of slightly below replacement level. This projection is consistent with one view that the pace of fertility decline will slow but continue as developing countries approach the end of the fertility transition, that fertility near the replacement level will prevail in the long run, and that some variation across countries will occur depending on socioeconomic conditions (see Bongaarts, 2002, for a discussion). Morgan (2003) argues that despite ideological and structural changes to society, biological dispositions will still compel families to have two children. However, with TFR going below replacement levels in many countries (as of 2010–2015, 170 out of 233 countries have below replacement TFR), much skepticism exists regarding its recovery to above 2.1 (Lesthaeghe and Willems, 1999). Kohler et al. (2006) argue that the lowest-low fertility that has been concentrated in parts of Europe and Asia will spread to other parts of the world. They also predict that lowest-low fertility will continue for several decades, although they anticipate a slight reversal as seen in some European Union (EU) countries such as Italy and Spain. Lowest-low fertility has dramatic implications for the population: combined with sustained low mortality, persistent TFR levels at or below 1.3 imply a reduction of the annual number of births by 50 percent and a halving of the population size in less than 45 years

(Kohler et al., 2006). Prevailing below replacement fertility also has compounding effects on population decline in the sense that shrinking cohorts imply declining numbers of potential parents. However, recent signs of recovery have been seen in cohort fertility in many regions of the world, even in regions with where lowest-low fertility has been observed (Myrskylä et al., 2013).

Because no compelling theory of reproductive behavior exists in low-fertility societies, much of the predictions about future fertility remain unfortunately speculative. Certainly, past predictions about current fertility have not held up to scrutiny. Further, while the economic research in recent years has been successful in identifying causal determinants of fertility, the most rigorous research occurs at the micro level and is context specific, so that the degree of external validity is unclear. As we have reviewed, the empirical evidence is also often mixed depending on the setting. Further, impacts on fertility have often been economically small. Many unanswered puzzles remain at the macro level as well—for example, why does the United States have higher fertility than both Canada and the EU when the United States does not have subsidized daycare and has one of the least generous parental leave policies?

Finally, whether governments should design policy to directly intervene in individual fertility choices remains controversial, although many examples of such population policies exist (both to increase and to decrease fertility). Also unclear is whether governments should aim to increase population in countries with below replacement fertility; after all, population control was the goal for neo-Malthusians and remains so for many governments today in developing countries. Nonetheless, policies such as helping women reconcile tensions between work and family life may be valuable to society in other aspects with the additional "benefit" of increasing fertility.

4.2. Increase in Life Expectancy

The second key factor behind population ageing is increasing life expectancy. As Figure 7 shows, global life expectancy increased from 47 years in 1950 to over 65 today and is projected to reach 83 years by 2100. Both developed and developing countries are seeing rises in life expectancy—developed regions witnessed an increase of more than 10 years since 1950–1955 to 78.3 in 2010–2015, whereas developing regions experienced a remarkably rapid increase exceeding 20 years over the same period, from 41.5 to 68.8. In particular, countries in East Asia have had the most dramatic gains. The increase in life expectancy is responsible for a significant portion of the increase in population ageing, although its role has not been as large as the fertility decline. Bloom et al. (2010a) calculate one-fifth of the projected rise in India's 60+ population between 2000 and 2050 is attributable to rising life expectancy during that period. An analogous exercise for China shows that increasing life expectancy is responsible for one-seventh of the rise in China's elderly population.

The convergence in life expectancy between more and less developed regions, however, has stalled for two reasons. First, the HIV/AIDS epidemic and armed conflicts have led to decreased life expectancy in some African countries over the last few decades. Second, the collapse of the Soviet Union led male life expectancy in Russia and Eastern Europe to fall dramatically in the 1990s, so much so that a 10-year life expectancy gap now exists between men and women in Russia. Nonetheless, the gap in life expectancy at birth between developed and currently developing regions is projected to shrink to approximately seven years by 2100. Combined with the decline in fertility, the rise in life expectancy will result in a sharp increase in the population share of the elderly.

In Section 3, we discussed several reasons for the historical decrease in mortality in the nineteenth and early twentieth century, including economic growth, public health interventions, and medical innovations, including antibiotics and sulfa drugs and success in reducing communicable diseases (Cutler et al., 2006; Cutler and Miller 2005; Jayachandran et al., 2010; Sickles and Taubman, 1993; Wolpin, 1997). These reductions mainly occurred in early and middle life. We now turn our attention to increases in longevity in the last half-century.

4.2.1. Developed Countries

Unlike the earlier decline during the nineteenth and early twentieth centuries, the decline in mortality in the latter half of the twentieth century has been concentrated in late life. Increase in longevity in recent decades in the developed world is mostly attributed to advances in medical technology, especially those that led to reductions in cardiovascular disease mortality (Cutler et al., 2006). In the United States, cardiovascular disease mortality has declined by more than 50 percent since 1960, and cardiovascular disease mortality reductions account for 70 percent of the seven-year increase in life expectancy between 1960 and 2000. The development of bypass surgery in the 1960s, angioplasty in the 1970s, and new medications to treat hypertension have all contributed to the reduction in cardiovascular disease mortality (Cutler and Kadiyala, 1999).

In addition to advances in medical technology, the decline in smoking is widely acknowledged as a major factor in reducing cardiovascular disease (Cutler and Meara, 2001). U.S. smoking rates have halved since the U.S. Surgeon General's landmark 1964 report on the harms of smoking. The existing research has shown that higher taxes dramatic reduction in smoking has sparked a large body of literature examining the impact of different smoking cessation policies, and the research suggests that cigarette taxes, smoking bans, and comprehensive advertising bans can be effective in lowering smoking consumption (Chaloupka and Warner, 2000; Evans et al., 1999; Saffer and Chaloupka, 2000).

Continuing declines in infant mortality, mainly due to improved neonatal medical care for low birth-weight babies, account for an additional 19 percent of the increase in life expectancy since 1960 in the United States (Cutler and Meara, 2001).

In sum, improvements in medical technology and the reduction in smoking are responsible for the bulk of the increase in life expectancy. Other contributing factors include continual declines in infant mortality; reduced mortality from external causes, primarily motor vehicle accidents; reduced mortality from pneumonia and influenza; and a slight decrease in cancer mortality. While we use the United States as a case study, improved medical technology and reduced smoking led to a similar decline in adult mortality in other developed countries (Cutler et al, 2006).

4.2.2. Developing Countries

Life expectancy is lower in developing countries (Figure 7), but has been on a rapid upward trajectory. For many developing countries, life expectancy increased more than 20 years in just a few decades from 1960 to 2000. In India and China, life expectancies have risen by nearly 30 years since 1950. In sub-Saharan African countries, life expectancy rose by 13 years from 1950 to 1990, before stagnating in part due to the HIV/AIDS epidemic.

The decrease in mortality in developing countries post–World War II occurred fairly rapidly: adult mortality fell from approximately 300 to 100 deaths under age 50 per 1,000 alive at age 15. In developed countries, the number fell only from 102 to 62. Child mortality declined even more in less-developed regions, from 247 deaths under age 5 per 1,000 live births in 1950 to 65 in 2010, which likely played the most important role in increasing life expectancy in developing countries (Soares, 2007). However, a large gap in child mortality remains between developed and developing countries; 99 percent of global child deaths occur in developing countries. Overall, mortality reductions in developing countries in the modern era took place across the entire age distribution, with significant improvements in the survival of both children and adults (Soares, 2007).

The determinants of mortality in low-income countries also differ significantly from those in high-income countries. In the latter, the current leading causes of deaths are noncommunicable diseases (NCDs) such as cancer and cardiovascular diseases, while in the former infectious diseases still play a dominant role in deaths, although the incidence of NCDs is also growing rapidly in low-income countries.[12] Modern-era mortality reductions experienced by developing regions are similar to those developed regions experienced in the beginning of the twentieth century (Becker et al., 2003).

Specifically, life expectancy has increased mainly through a decline in influenza-related disease (e.g., pneumonia), infectious diseases, and diarrheal diseases (Palloni and Wyrick, 1981; Preston, 1980; Soares, 2007).

[12] In Section 5.1, we return to the changing nature of ageing.

The existing evidence suggests public health infrastructure, including the development of water supply, sewerage, and immunization, can explain roughly 50 percent of the mortality decline in developing countries since WWII (Preston et al., 1981). Much of the mortality decline appears to have occurred independently of improvements in income and nutrition, especially where health programs have become less reliant on countries' economic conditions but more dependent on the concerns of the developed world or international organizations (Heuveline, 2001; Preston, 1980; Soares, 2007). Increases in educational attainment, and in particular, women's education also appear to have played important roles (Cutler et al., 2006; Preston, 1980; Soares, 2007). Numerous studies using microdata have demonstrated that female schooling has strong explanatory power of child mortality (see Soares, 2007, and Fuchs et al., 2010, for a review). Growing causal evidence that exploits natural experiments in school expansions and compulsory schooling laws on child mortality also highlights the negative impact of schooling (Breierova and Duflo, 2004 ; Chou et al., 2010; Lleras-Muney, 2005). Relatedly, the diffusion of knowledge such as the germ theory and simple changes in health behavior appear to have significantly reduced mortality rates (Preston, 1996).

Mortality declined rapidly in less-developed regions, in part because the earlier development of modern medical technologies and public health measures in currently high-income countries enabled somewhat quick diffusion to the rest of the world (Cutler et al., 2006). At the same time, much more can clearly be done from a policy perspective to further reduce mortality in developing countries. Due to lack of financial incentives, pharmaceutical research on diseases that affect low-income countries, such as malaria and tuberculosis, is limited. Because of high costs, antiretroviral therapy only reaches a small percent of the millions of HIV/AIDS–infected patients in sub-Saharan Africa (Kremer, 2002).

4.2.3. The Future of Mortality

As with fertility, the views regarding the trajectory and nature of mortality over the coming decades range widely. Oeppen and Vaupel (2002) suggest that, based on the average life expectancy gain of 2.4 years per decade, record life expectancy could reach 97.5 years by the middle of this century and 109 by 2100. More tempered estimates suggest average life expectancy will approach 90 years by the end of the twenty-first century (Lee and Carter, 1992; Tuljapurkar et al., 2000).

While most scholars believe that advances in medical technology and public health improvements will continue to drive down mortality rates at all ages, there is considerable dissent on the speed and magnitude of these trends, as well as the role of biology on these trends (Carnes and Olshanksy, 2007). More pessimistic scholars suggest that achieving further life expectancy gains may become increasingly difficult as human longevity approaches its biological limit of about 85 years (Fries, 1980; Carnes and Olshanksy, 2007). They also argue that past life expectancy improvements in the first half of the twentieth century were largely

driven by reductions in infectious disease mortality among children and young adults in the first half of the 20th century, and it would be unlikely to see the same large reductions among the current major causes of death, such as heart disease and cancer (Bongaarts, 2006). In fact, Olshansky et al. (2005) argue that with growing obesity rates in the United States, we may expect to see life expectancy decline by close to a year in the first half of this century.

4.3. Migration as a Determinant of the Age Structure

Finally, we discuss migration as a factor to explain changes in the population age structure. According to some analyses, international migration is now the dominant determinant of the size, rate of change, and composition of populations in developed countries. This holds true especially in Europe, where fertility is persistently low compared with the United States, Canada, and Australia. Within the 15 original European Union countries, the net demographic effect of international migration in recent years has been to add between 1.4 and 1.9 million persons per year to the total population, and net immigration far outpaces the rate of natural increase (the excess of births over deaths) (Coleman, 2008). Further, migrants tend to be of prime working age and hence boost the labor force population of the receiving country (Zlotnik, 2012).

Not only do migrants directly affect the age structure and labor force of the host country, but their differential fertility or mortality also compounds these effects. For example, immigrants may increase fertility in the recipient country because they tend to have average higher fertility (Blau, 1992; Coleman, 1994). The TFR of many countries in Western Europe has been elevated by 0.1 or more due to the higher average fertility of immigrants, although substantial variation in fertility rates exists among immigrants from different origin countries. Immigrants from Pakistan, Bangladesh, Turkey, Morocco, Tunisia, and countries in sub-Saharan Africa have higher fertility than their European counterparts and have contributed to elevating total fertility in recipient countries. From 2001 to 2006, TFR in England and Wales increased from 1.63 to 1.86, and births from 594,634 to 669,601. Sixty-four percent of that increase is attributable to births to immigrant mothers (Coleman, 2008). As the children of immigrants move through the age structure, they will reduce the proportion of elderly in the population, ceteris paribus.

As the later chapter on migration will further discuss, accurate migration data remain scarce even for developed countries, and hence the impact of immigration on the age structure is difficult to quantify. Policymakers have touted immigration as the panacea to population ageing in the face of low fertility in developed countries—with certain caveats. While immigrants tend to be younger, immigrants also age, so the immigration flow required to maintain the age structure increases progressively over time. Coleman (2008) simulates the old-age dependency ratio based on several migration scenarios and shows that even with aggressive projections of "replacement migration," the potential support ratio continues to decline.

A similar United Nations Population Division (2001) study attempts to quantify the migrant flow required to maintain 1995 support ratios for several countries, and these simulations indicate that very large net migration flows are necessary. For example, in the case of the United Kingdom, an average annual net inflow of 1.2 million migrants would be required to maintain the support ratio at the present level of 4.15 until 2050. (The average annual number of net migrants in the United Kingdom from 2008 to 2012 was 201,000.) An inflow of such magnitude would hardly be sustainable, as this would imply that the United Kingdom's population would reach 100 million by 2030, 200 million by 2070, 300 million by 2090, and so on (Shaw, 2001).

We can also look to the past to investigate the long-run equilibrium effects of migration. LeBras (1991) analyzes the demographic impact of post-war migration in several OECD countries. By simulating a counterfactual population projected from 1946 with the assumption of zero migration, the author compares the projected with the actual realized population structure in the early 1980s. He finds that international migration did indeed reduce population ageing in the sense that the actual median age is lower than the projected median age. However, the reduction is small (less than one year), and the proportion of the population over age 65 was reduced by less than 1 percent over the study period, during which substantial net migration gains occurred (LeBras, 1991).

In turn, international migration has exacerbated population decline and hastened population ageing for origin countries. This is because migration is selective of prime working-age individuals, leaving origin countries with smaller populations and higher dependency burdens (Zlotnik, 2012). Several countries in Eastern Europe have experienced negative net emigration, including Latvia, Lithuania, Bulgaria, Romania, Poland, and Slovakia. Such patterns can reverse quickly, however. For example, Russia lost 110,000 people to net emigration in 2003, but by 2007 net immigration had risen to 241,000, much of it from Central Asia (Coleman, 2008).

The overall evidence suggests that migration has not been a major driver of population ageing, nor it is a sufficient "cure" for revitalizing ageing societies with low fertility rates. Although international migration has generally contributed to reducing population ageing in host countries, the effect is small even when migration flows are large, and the estimated net migration flows needed to sustain current support ratios are unrealistically large.

The final trend we note is "out-migration," which refers to movement away from particular regions or cities within countries, a familiar pattern in both developed and developing countries. Rural to urban migration in developing countries is particularly marked. We discuss the impact of out-migration on living arrangements of the elderly in Section 5.3.

5. The Nature of Aging

As people live longer, considerable debate concerns the quality of life in later years. Can we expect additional years to be characterized by both physical and mental health, or will they be characterized by disabling chronic illnesses? Who do the elderly live with, and who supports them financially and physically? This section describes the changing nature of ageing and some potential implications for research and policy.

5.1. The Rise of Noncommunicable Diseases

As discussed in Section 3, infectious diseases were the dominant cause of death for much of human history. As mortality has fallen sharply over time, the global disease landscape has also shifted dramatically. For example, the top three causes of death in 1900 in the United States were influenza, tuberculosis, and gastrointestinal infections, while heart disease, cancer, and noninfectious airway diseases were the top three in 2010 (Jones et al., 2012). In particular, the prevalence of chronic conditions—known as noncommunicable diseases (NCDs)—has risen at an alarming rate during the past two decades in both developed and developing countries. NCDs and ageing are intrinsically linked: age is a well-established risk factor for NCDs, and the burden of NCDs lies primarily with the elderly because NCDs are generally long lasting and slow growing.

NCDs include a wide range of chronic conditions, but the four most prominent NCDs (as measured by their contribution to disability adjusted life years, or DALYs) are cardiovascular disease, cancer, chronic respiratory diseases, and diabetes. The World Health Organization (WHO) estimates that these four NCDs alone were responsible for the deaths of more than 31 million people worldwide in 2010 (Alwan, 2011). Dementia, which is characterized by progressive cognitive decline that interferes with independent functioning, is another chronic disease of ageing. While NCDs have typically been viewed as “diseases of affluence,” roughly 80 percent of all NCD deaths now occur in low- and middle-income countries, and NCDs are the largest cause of death in most developing regions, excluding Africa (Alwan, 2011).

As populations age, annual NCD deaths are projected to rise substantially, reaching 52 million by 2030. Annual cardiovascular disease mortality is projected to increase by 6 million and annual cancer deaths by 4 million. In contrast, annual deaths from infectious diseases are projected to decline by 7 million over the next 20 years (Alwan, 2011). Co-morbidities are also increasing; many of the most common NCDs frequently occur simultaneously with other conditions, and growing numbers of people have more than one condition, especially if they smoke. In the United States, an estimated 85 percent of all health care is used by people with at least one chronic condition, and two-thirds of all Medicare spending is on people with five or more chronic conditions (Benjamin, 2010).

5.1.1. The Prevalence and Economic Costs of Dementia

Although not one of the four best-established NCDs, we devote a subsection to dementia because of its rising prevalence and severely disabling nature—the disability weight for dementia was estimated to be higher than for all health conditions except spinal-cord injury and terminal cancer (WHO, 2003). The potential costs of dementia are also huge, both in terms of direct medical and care costs, as conditions associated with dementia are typically progressive and irreversible, as well as indirect costs such as lost productivity of family carers, as care of dementia patients can be extremely time intensive. Understanding the risk factors and prevalence of dementia is therefore a high priority for policymakers, but data challenges abound—primarily the paucity of quality data and the uncertainty in ascertaining dementia. Recent credible estimates place the prevalence of dementia at around 14 percent for the U.S. 70+ population using data from the Health and Retirement Survey (Hurd et al., 2013; Plassman et al., 2007). Estimates of the prevalence of Alzheimer's disease range from 4.3 percent among the 75+ population in 1997 (Brookmeyer et al., 1998) to 9.7 percent among the 70+ in 2002 (Plassman et al., 2007). Prevalence estimates of European dementia are typically slightly lower, ranging from 6 to 9 percent among the elderly (Lobo et al., 1999 ; Ott et al., 1995). Projections suggest that the prevalence of Alzheimer's will more than triple in the next few decades in the United States (Brookmeyer et al., 1998; Hebert et al., 2003). Global estimates remain speculative—some of these estimates rely mainly on expert opinions—but they suggest that the prevalence in developing regions is currently lower but will grow rapidly in the next several decades, tripling for some Asian countries including India and China.

With growing prevalence come increasing concerns about the burgeoning costs of dementia. Estimates of the total monetary cost of dementia range from $150 billion to more than $215 billion, which is comparable to the financial burden of heart disease (the current most costly disease in the United States), and these estimates are projected to roughly triple by 2050 (Alzheimer's Association, 2010; Hurd et al., 2013). The monetary cost per adult is projected to increase by approximately 80 percent by 2040 (Hurd et al., 2013). However, such projections typically derive age-specific incidence rates from community-level studies and apply those rates to population projections to predict future prevalence rates assuming that prevalence rates are static, which may not be realistic. Advances in care and medical technologies may alter the costs of dementia. Also not clear is whether the prevalence of dementia has increased solely because of population ageing *per se*, or whether prevalence among the elderly population has also grown over time, and, if so, why. Regardless, the impact of dementia will clearly be felt more forcefully in coming decades as the population share of the elderly continues to rise. We will return briefly to the impact of dementia on the household in Section 5.3.

5.1.2. The Risk Factors of NCDs and Policy Implications

The increasing prevalence of NCDs suggests a clear need for new approaches to prevent and treat such conditions. From a public finance perspective, the growing prevalence of NCDs accompanying population ageing may lead to much larger health costs. Moreover, because of the changing demographic structure, any increased health costs may need to be financed by a relatively smaller working-age population. Hence, curbing the growth of NCDs has become a major concern for health policymakers.

Considerable scope for intervention exists. Although nonmodifiable conditions such as genetic makeup, age, and sex determine some risk factors, individuals can avoid NCDs and improve health outcomes in concrete ways (Bloom and Shannon, 2014). For example, the key underlying causes of death globally from NCDs are high blood pressure, tobacco use, high blood glucose, physical inactivity, and overweight/obesity—all conditions that are at least partially rectifiable or avoidable.

The prevalence of these modifiable risk factors varies by region, gender, age, and income level (Alwan, 2011). For example, the disease consequence of smoking occurs disproportionately among the elderly, because they tend to have been smokers for a long time. While the benefits of smoking cessation are proportionately less among the elderly and may manifest more slowly than among younger smokers, cessation remains the most effective way of altering smoking-induced disease risks at all ages, including those over the age of 60 years (Burns, 2000).

Overweight/obesity is more prevalent in high-income countries, where more than half of all adults are overweight and just over one-fifth are obese. However, overweight/obesity has recently started to affect lower-income countries: the increase in prevalence from 1980 to 2008 was twice that of the corresponding increase in upper-middle and high-income countries (Finucane et al., 2011). In fact, Mexico has the highest rate of obesity in the world with a 32.8 percent adult obesity rate, just overtaking the United States at 31.8 percent (United Nations Food and Agricultural Organization, 2013). Although obesity is less of a problem among today's elderly than among adults and children, obesity prevalence is growing progressively among older age groups in some countries, including the United States (Arterburn et al., 2004). And as the current overweight cohorts age, obesity will become a much more dominant problem among the elderly.

In terms of potential policy recommendations, regular physical activity, limited tobacco use, and healthy diet are obviously needed changes. In particular, physical activity is important for the elderly not only for its direct cardiovascular health benefits, but also for its associated lower risks of cognitive impairment, Alzheimer's disease, and dementia of any type (Laurin et al., 2001). Smoking in high-income countries has decreased dramatically due to both government regulation (such as curbing smoking in public spaces, imposing cigarette taxes, and launching

extensive media campaigns), and believing that similar results can be achieved in developing countries is not unreasonable. Promoting exercise and healthy eating in both children and adults remains a major challenge worldwide. In the United States and United Kingdom, experiments with "nudging" – the use of behavioral economics to steer people towards more desirable decisions by presenting choices in different ways – have shown mixed success, e.g., front-of-package labeling or calorie posting designed to help consumers make healthier food choices (Bollinger et al., 2010; Downs et al., 2009). The impact of more controversial efforts such as the "soda ban" (banning of soft drinks in cups larger than 0.5 liters) in New York City have yet to be fully evaluated. Systematic research, perhaps via randomized-control trials, is needed to understand which interventions are most effective.

5.2. The Question of Compression or Expansion of Morbidity

As life expectancy and the epidemic of NCDs continue to rise, how do health and quality of life of the elderly change as people get older? If people live longer, but the additional years lived are spent in disability or ill health, then the impact of population ageing on medical spending will be substantially more severe. A related key question concerns at what stage of life morbidity sets in. The notion of "compression of morbidity," in which morbidity is thought to condense in the years near the end of life, has remained a source of debate since Fries first introduced it in 1980. Fries suggested that the same forces that led to the decrease in mortality would also result in a postponement of disease and disability, so that ill health would be compressed into a shorter period of time prior to death. Other scholars, such as Gruenberg (1977), posit the opposite, where reduced mortality will lead to a pandemic of chronic diseases and an expansion of morbidity. Manton (1982) proposes a dynamic equilibrium where the prevalence of disability would increase as mortality falls, but the severity of disability would decline, resulting in indeterminate impacts on disability-free and disabled life expectancies.

The empirical evidence supporting these theories is mixed. Crimmins and Beltrán-Sánchez (2010) argue that the evidence supporting the compression thesis is limited. For example, the incidence of a first heart attack has remained somewhat stable between the 1960s and 1990s and the incidence of some of the most common cancers has been increasing until recently. Cai and Lubitz (2007) find increases in the active life expectancy and decreases in life expectancy with severe disability using US data between 1992 and 2002. Crimmins, Hayward, and Saito (1994) also find increases in the length of disability-free life, but no change in the length of disabled life when comparing the 1984 and 1994 cohorts of the Longitudinal Studies of Ageing.

Based on data from the Medicare Current Beneficiary Survey (MCBS), which covers a representative sample of the entire U.S. elderly population in 1991–2009, recent work by Cutler, Ghosh, and Landrum (2013) suggests that significant evidence exists for the compression of morbidity. As the MCBS is linked to time of death data, one advantage of this study is that the

authors can define precise measures of disability-free and disabled life expectancies (whereas past studies have not been able to link health to an individual's life stage). The authors find that for a typical person aged 65, life expectancy increased by 0.7 years between 1992 and 2005. Disability-free life expectancy increased by 1.6 years, and disabled life expectancy fell by 0.9 years. Overall, this evidence suggests that while the prevalence of diseases is indeed increasing among the elderly, the impact of such diseases on the individual has been reduced, being both less lethal and less disabling, and the period of life where ill health becomes disabling has been compressed toward the end of life. Consistent with this, the U.S. labor force participation rate of people 65 years and older has continued to increase since 1985. While many other contributing factors likely exist, this phenomenon suggests that the elderly are able to remain productive participants of the workforce. However, open questions remain about whether this trend of compression has continued beyond 2005, whether compression of morbidity is occurring in other countries, and what are the reasons that explain the apparent variations between countries.

5.3. Living Arrangements for the Elderly

How will population ageing affect household structure and living arrangements, and how do these trends differ between high- and low-income countries, by gender, and between urban and rural areas? Understanding these living arrangements is important from a policy perspective, as they are important determinants of the well-being and social and financial position of the elderly and the social support networks available to them.

5.3.1. Developed Countries

We first review the evidence from developed countries. Using U.S. Census data, Ruggles (2007) reports that intergenerational co-residence has declined dramatically since the mid-nineteenth century. Almost 70 percent of persons aged 65 or older resided with their adult children in the mid-1850s, but by the end of the twentieth century, fewer than 15 percent did so. These changes are attributable to several factors, including the establishment of the Social Security program, the decline of agricultural inheritance, and the rising income of the older generation (Engelhardt et al., 2005; Ruggles, 2007). Other frequently cited reasons for the decline of the joint family household include urbanization, industrialization, and demographic changes, although the data do not necessarily support these views (Costa, 1997; Ruggles, 2007).

Other high-income countries generally mirror the U.S. trends: a declining proportion of elderly persons live with their children, and older people spend substantially fewer years living in old-age co-residence. In Europe, more and more elderly choose to live independently for as long as possible, even after the death of a spouse. Co-residence is significantly less common among divorced men than among divorced women. A low-income situation in a family, among either children or older persons, increases the probability that parents and adult children will co-reside (de Jong Gierveld et al., 2001). Overall, the literature suggests that privacy is a normal

good for the elderly in developed countries and that increased living independence is desired (Costa, 1997, 1999; de Jong Gierveld et al., 2001; Engelhardt et al., 2005; Ruggles, 2007).

Even as joint households are diminishing, children remain an important source of support for older people who live alone, providing care, social companionship, and housekeeping assistance. This informal, private-sector support still prevails across more developed countries, despite the availability of institutional care and other social services. Surveys in developed countries demonstrate that adult children tend to be more supportive, either through time or money, of parents living alone than of parents who are still together (Jong Gierveld et al., 2001). At the same time, the idea of institutionalization as a "last resort" appears to be fading, and an increasing number of older persons have opted for residential care (Oldman and Quilgars, 1999). A notable trend in both the United States and Europe is the rise of unmarried cohabitation following divorce or bereavement. According to U.S. Census figures, co-habitation figures for people over 65 have tripled in the past decade, jumping from 193,000 in 2000 to 575,000 in 2010. Similarly, in Europe, cohabitation among the elderly is becoming increasingly common and accepted (de Jong Gierveld, 2004).

As discussed in Section 5.1, the rise of population ageing also brings the growing prevalence of NCDs, some of which, such as dementia, require time-intensive care. In the United States, unpaid caregivers, many of whom live in the same household and are typically family members, still provide most of the care of such debilitating disease. Caring for a person with Alzheimer's or another dementia can often be very difficult, and the impacts on the caregiver range from lost earnings to emotional stress. Many people with dementia also receive paid services at home or in other settings such as adult day centers and assisted living facilities over the course of their illness (Alzheimer's Foundation, 2010). At the same time, given the high average cost of these paid services, most households cannot afford them on a long-term basis unless they have Medicaid coverage or private long-term care insurance. Hence, the necessity of family caregiving of dementia patients may lead to an increase in intergenerational co-residence.

5.3.2. Developing Countries

The experience of ageing is substantially different in developing countries. Few developing countries offer formal pension plans for residents, especially those in rural areas, and few people are able to accumulate sufficient assets or savings to support themselves in old age. According to national surveys, less than 11 percent of the elderly have a pension of any sort in India (Uppal and Sarma, 2007). Further, saving is difficult or impossible for many because earnings are low. Hence, the elderly in developing countries typically rely on extended family for support in their old age (Hashimoto et al., 1992).

At the same time, the factors that led to the devolution of the joint household in developed countries beginning a century ago are now affecting the developing world at a much

faster rate. These changes, including the rise of nonagricultural employment, reductions in fertility, rural to urban migration, and changing societal mores, all have profound implications for the support and care of the elderly. For example, rising off-farm employment and increased mobility among working-age children implies that their elderly parents often live alone. The decline in fertility has left the elderly with fewer children to provide support, and, as migration fragments families, the elderly will have to work more and longer. In India, where old-age income support is limited, labor force participation remains close to 40 percent among the elderly and is even higher among the rural elderly (Uppal and Sarma, 2007). Similarly, in China a large proportion of the elderly continue to work in the formal labor force, and those who have withdrawn from the formal sector contribute to the informal sector through activities such as caring for their grandchildren and doing household chores (Pang et al., 2004).

The family remains the dominant social institution for the support and care of the elderly in most of the developing world. In China, multigeneration family households are still one of the main living arrangements for the elderly, especially in rural areas (Pang et al., 2004). However, the trends may be changing. Data from the China Household Income Project and Census show that an increasing number of elderly persons, especially those in urban areas, are more likely to live with their spouses than in intergenerational joint households with their children (Meng and Luo, 2008). A recent RAND study uses the data from the China Health and Retirement Longitudinal Study (CHARLS) to show that while many Chinese elderly live alone or only with a spouse, most have a child living nearby to guarantee care when needed (Lei et al., 2011). In addition to the tremendous fertility decline (in part due to the family-planning policies that began in the early 1970s), scholars have attributed the declining joint household in urban China to an increased availability of pensions and the housing reform beginning in the 1990s, which increased housing availability and enabled elders to live alone (Meng and Luo, 2008; Palmer and Deng, 2008; Zeng and Wang, 2003).

Similar trends in living arrangements have been observed in other developing countries. In India, while co-residence in a joint household remains predominate, the share of older Indians living with only a spouse or alone has doubled since the early 1990s, and the share of older Indians living with their children declined by about 7 percentage points during the same period (Kumar et al., 2011). Living patterns in Latin America are similar to those in Asia, although the regional average for co-residence with adult children is substantially higher in Asia. Another notable difference in Latin America is that the gender ratio of co-resident children is near 1.0, whereas most countries in Asia and Africa exhibit son preference (Bongaarts and Zimmer, 2001). In African countries, the HIV/AIDS epidemic has affected family structure and living arrangements of the elderly. Many older people have lost the support of their children and are forced to care for young grandchildren. Using the Demographic and Health Surveys, Kautz et al. (2010) find that an increase in annual AIDS mortality of one death per 1,000 people was

associated with a 1.5 percent increase in the proportion of older individuals living alone and a 0.4 percent increase in the number of older individuals living in missing generation households.

Not yet clear is whether the elderly in developing countries prefer to live independently or with family, or whether these preferences will shift over time. As previously mentioned, most prior studies of the effects of income on living arrangements in the developed world concur that individuals do have preferences over living arrangements and that because additional income increases the incidence of independent living, this is the preferred living state (e.g., see Costa, 1998). Surveys focusing on the elderly will play increasingly important roles in understanding the living arrangements and well-being of the elderly.

Institutionalization is still a somewhat new concept, and data on institutional care in developing countries are scarce. In China, where such facilities have traditionally been very limited, only an estimated two percent of the elderly are in institutional care (Gu et al., 2007), although institutional care is now expanding rapidly (Feng et al, 2012). A 2006 survey of 101 privately run care homes in Bueno Aires, Argentina, demonstrates that close to 40 percent of nursing homes are unregulated. Conditions even in the regulated homes are concerning, with most residents claiming a poor quality of life (Redondo and Lloyd-Sherlock, 2010). As population ageing continues at a rapid pace, policymakers clearly need to pay increasing attention to the institutional care industry as it inevitably expands.

Other challenges are particular to the developing world. First, higher female life expectancy becomes a problem in developing countries where literacy and financial independence for women are low (Chen and Volpe, 1998). Second, although fertility in rural areas tends to be higher than in urban areas, ageing problems will be more serious in rural areas because of continuing rural to urban migration of mostly young people. In China, the rural-urban exodus has been deemed the largest flow of internal migration in history (Zhang and Song, 2003). A large share of the elderly lives in rural areas, where necessary institutional support and services are more difficult to obtain. Policymakers should thus pay special attention to elderly widows and those in rural areas. The topic of who cares for the elderly will also be of increasing importance to policymakers in the developing world, as the prevalence of NCDs such as dementia that require time-intensive care continues to grow and the potential pool of family caregivers diminishes due to changing social norms, migration, conflict, and HIV/AIDS.

6. Open Research Questions

We end with a collection of open research questions that have emerged throughout the chapter. Two demographic forces—fertility decline and increased life expectancy—drive population ageing. While the demographic components of population ageing are well established, the reasons for the changes in them that have led to populating ageing remain actively debated. Numerous questions on the topic of fertility remain open. First, more research on the causal

effect of the increasing returns to education on fertility behavior, in particular the rise of women in higher education and female wages, would be welcome. Much room exists for research to be conducted on how alternative policies such as expanding paternal leave benefits or flexible work schedules may affect fertility. Whether private organizations or the state should undertake these policies is also a relevant question. And even though the decline of child mortality has been frequently hailed as a reason for the fall in fertility, the causal relationship between the two factors is surprisingly poorly documented. Similarly, old-age support from children is a frequently cited motivation for having children, but the empirical evidence for the hypothesis is lacking. Better understanding the demand for children will both provide more insight on where fertility is heading and help shape policy.

A consensus does not exist on the future of fertility and longevity. While some scholars predict that fertility will stabilize at replacement rate, other scholars remain doubtful given that TFR has fallen far below replacement in many countries. Whether we will see an end to the rise in longevity is another subject of debate. The difficulty in predicting fertility and longevity is reflected in population projections, which tend to overestimate populations at very young ages and underestimate populations at very old ages. While economists have generally left the task of population forecasting to demographers, the new era of machine learning presents exciting opportunities for economists to use big data to analyze and forecast population dynamics, such as fertility trends and migration patterns.

The shift to NCDs, including dementia, suggest that health and pension policies need to be tailored to factor in the long-lasting, costly nature of these diseases. At the same time, certain risk factors causing NCDs are preventable and manageable, including smoking and obesity, and more systematic research on innovative strategies to modify such behaviors is welcome. Relatedly, more investigation on whether a compression or expansion of morbidity occurs at old age, which will help shed light on the economic productivity and health care costs of the growing elderly population, is needed.

Where do the elderly live and who cares for them? Are they happy and economically secure? How do living arrangements and sources of financial support compare across countries? To understand the well-being, economic security, and preferences of the elderly, data on the elderly are needed. The lack of such data presents a stumbling block for researchers and policymakers, especially in developing countries. An exciting development in this arena is the growing Health and Retirement Survey family, which comprises harmonized longitudinal panel surveys that focus on the elderly population. Of particular note are the Longitudinal Ageing Study in India (LASI), which is in pilot stage, and the Chinese Health and Retirement Longitudinal Survey (CHARLS), which began in 2011. These two surveys will provide a more complete picture of the rapidly growing elderly population in the two most populous countries in the world. Related surveys include the Japanese Study of Ageing and Retirement (JSTAR), the

English Longitudinal Study of Ageing (ELSA), and the impending Health and Ageing in Africa: Longitudinal Studies of INDEPTH communities (HAALSI). These efforts will enable researchers to gain a more complete picture of the dynamic character of the ageing process and the health, social support, and economic security of the growing elderly population.

7. Concluding Remarks

While population ageing certainly poses new challenges, doomsday scenarios about irreparable economic strain are likely overstated. The demographic shift of population ageing has the potential to inspire behavioral adjustments and technological and institutional innovations to considerably offset its possible negative results. Mitigating the negative consequences of population ageing will involve some combination of increased labor supply from women, immigrants, and older people; investment in education and training at all ages; increased rates of savings during the working years; slower growth of benefits; and faster growth of tax contributions to finance government transfers to older people. Some of these policy shifts have already began to take place: many EU countries have opted to raise the retirement age over the next few decades and have enacted partial privatizations of their pension systems in recent years. Governments and private organizations alike have adopted other strategies to encourage savings, such as pension (or 401K) auto-enrollment. Several developing countries are considering adopting or expanding pension and health programs for the elderly (Kinsella and Velkoff, 2001). China established a contributory pension system in 1997, which covered more than 280 million urban workers and 460 million rural workers by the end of 2012 (Pozen, 2013). However, challenges abound in designing and implementing pension systems in developing countries, including poor financial literacy and public budget constraints (Bloom and McKinnon, 2013). Even in developing countries that have implemented pension programs, such as several countries in Latin America, low participation rates remain a problem (Auerbach et al., 2005).

The exact mix of interventions should be tailored to country contexts and will determine the distribution of costs between current and future cohorts of the elderly. Importantly, the sooner these policy and institutional reforms are considered and implemented, the smoother the transition to a grayer population will be. Although demographic change has historically posed significant challenges and will continue to do so, demography is not destiny. The adaptations that human society and individuals can make in the face of such changes are equally impactful and key to transforming challenges of an ageing population into opportunities for change and growth.

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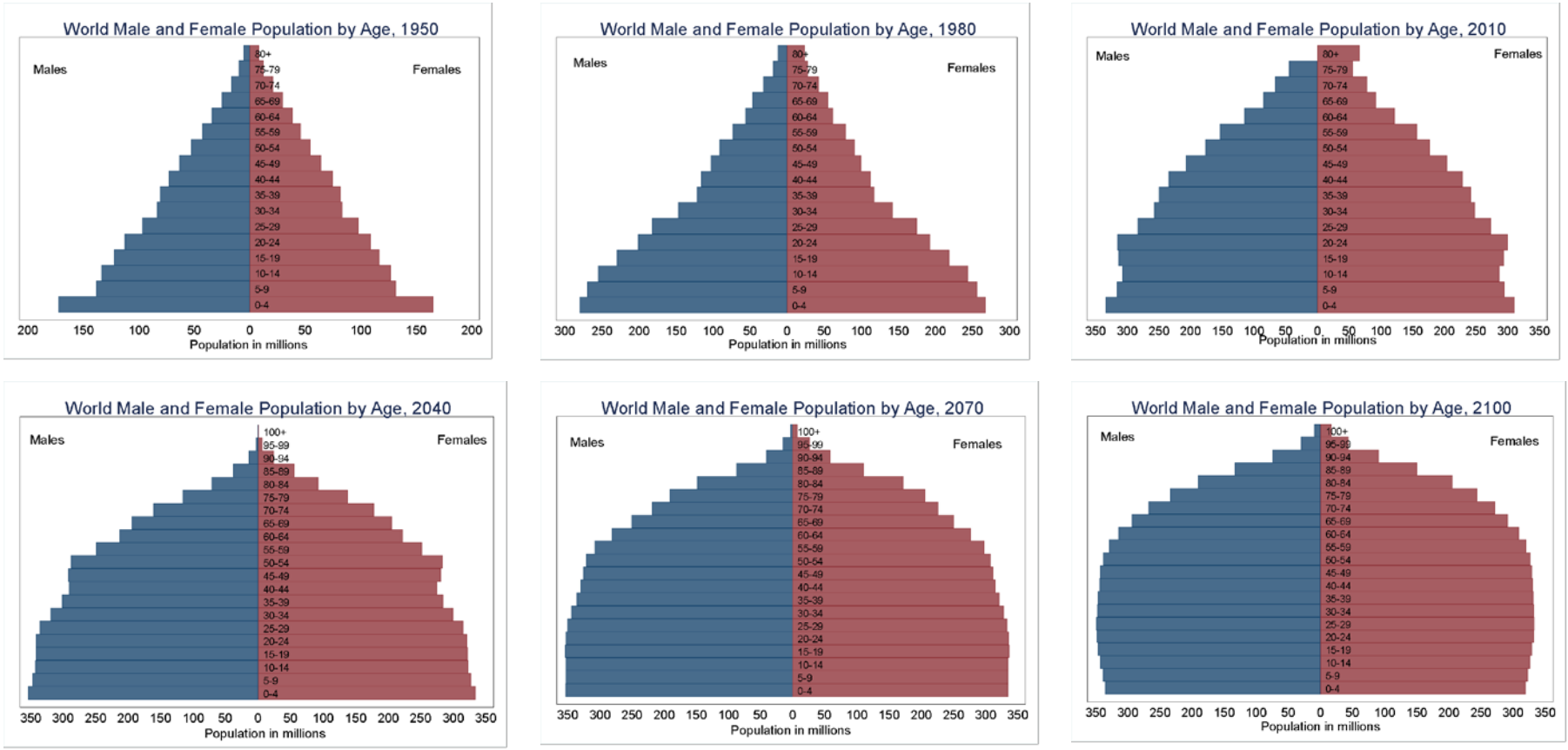
Figure 1: World population by age group, 1950–2100



Source: UN, World Population Prospects, 2015

Figure 2: Population share of those aged 60 and over, by level of development, 1950–2100

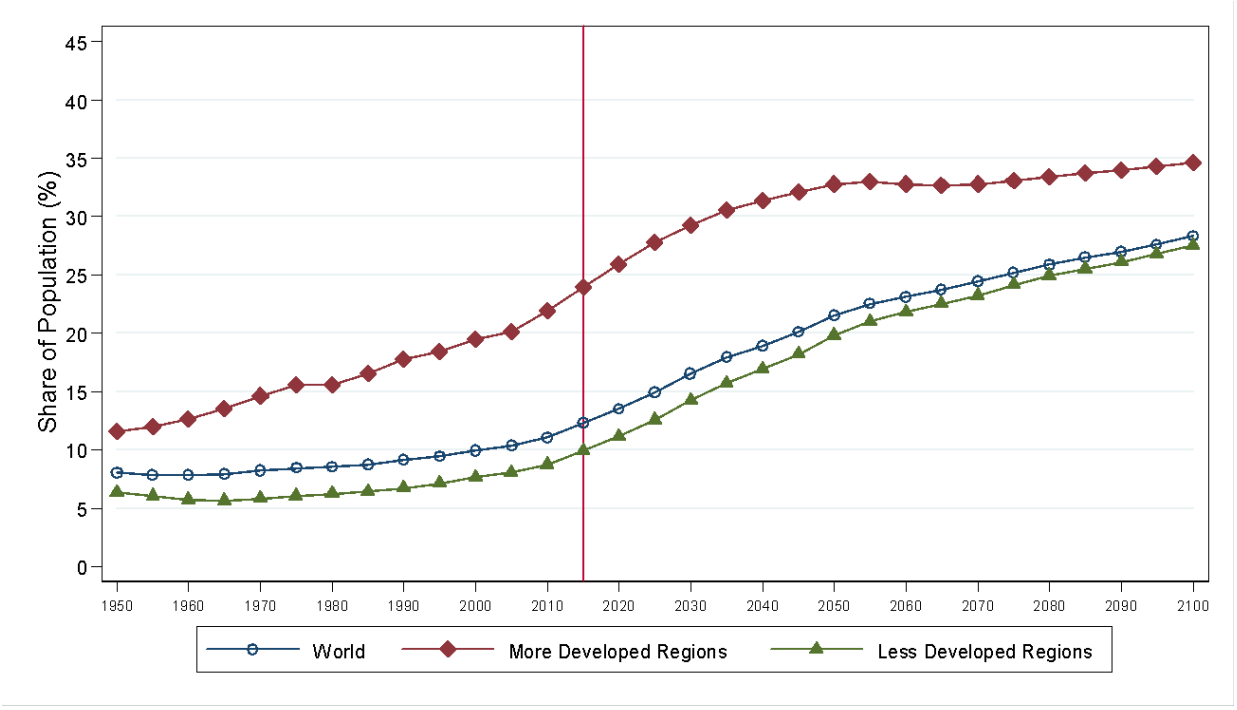


Figure 3: Population share of those aged 60 and over, and those aged 80 and over in China, India, Brazil, and Nigeria, 1950–2100

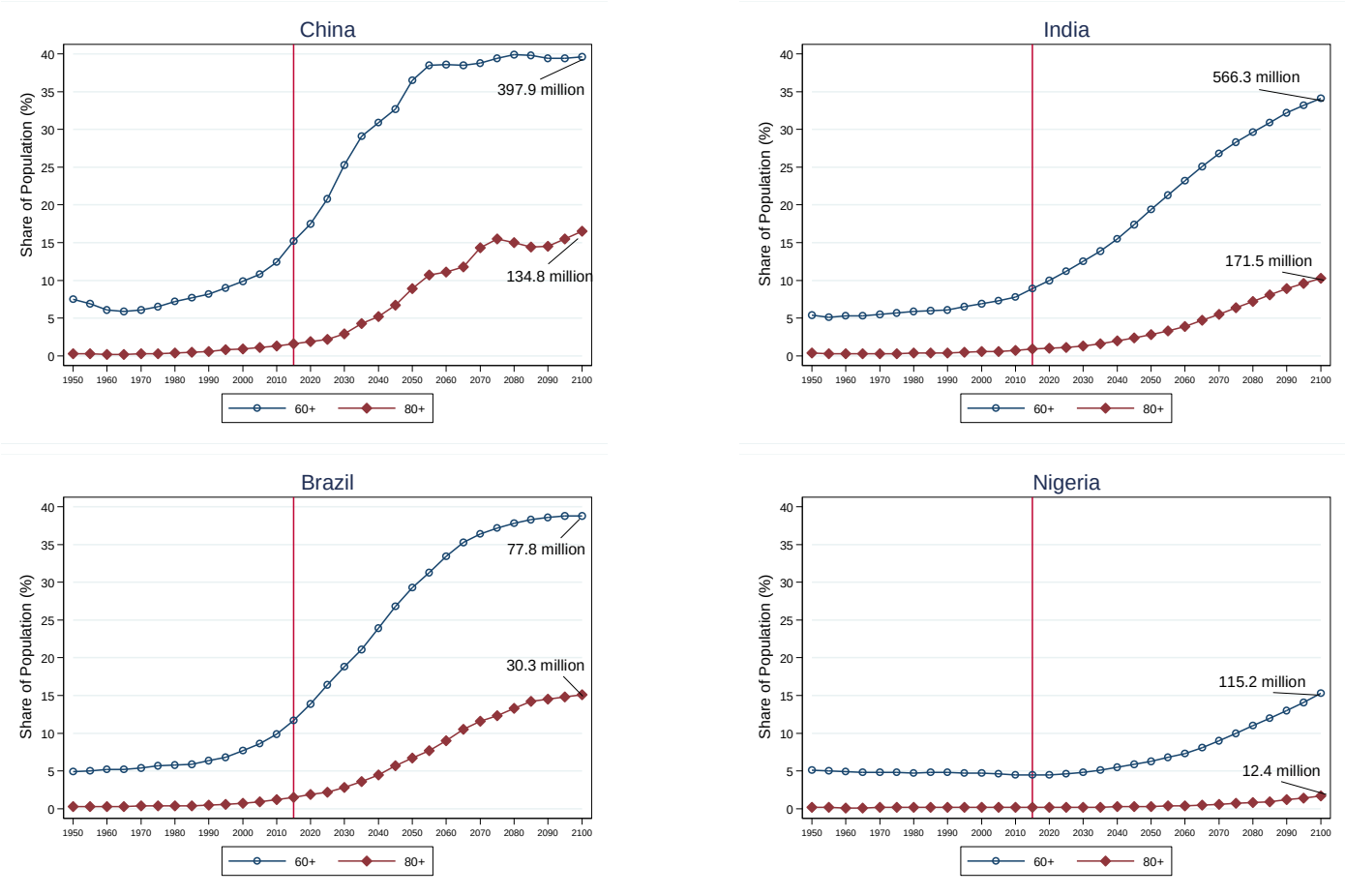


Figure 4: Old-age dependency ratio (in percent), by level of development, 1950–2100

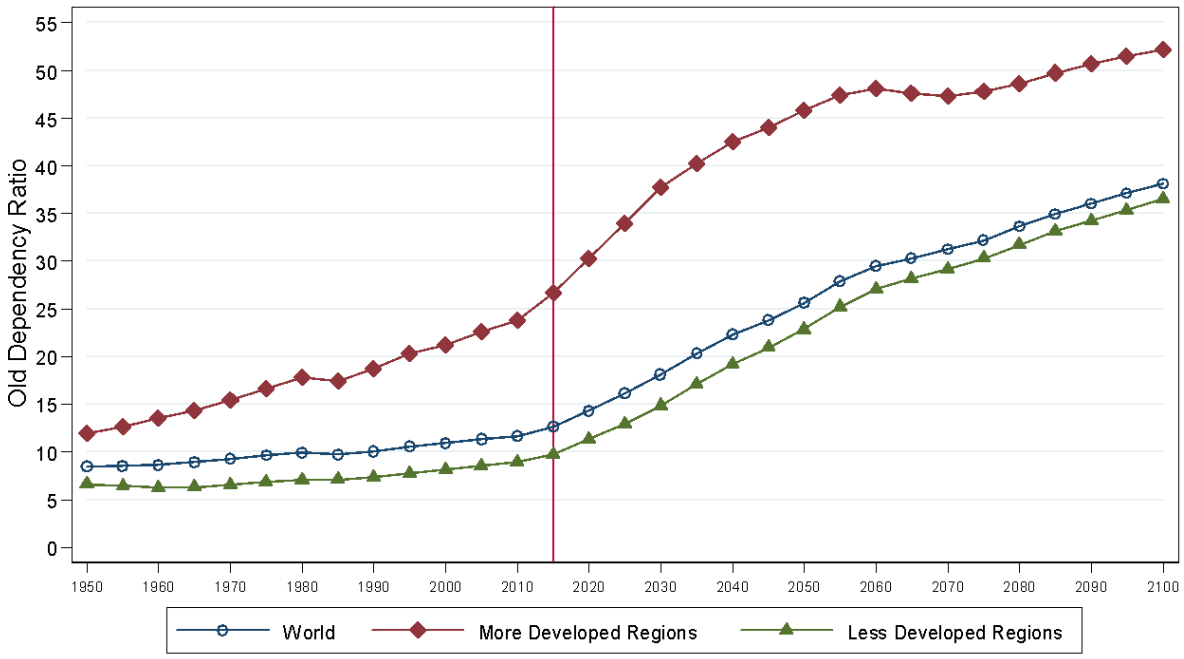


Figure 5: Change in M/F ratio, 60+ population, by level of development, 1950–2100

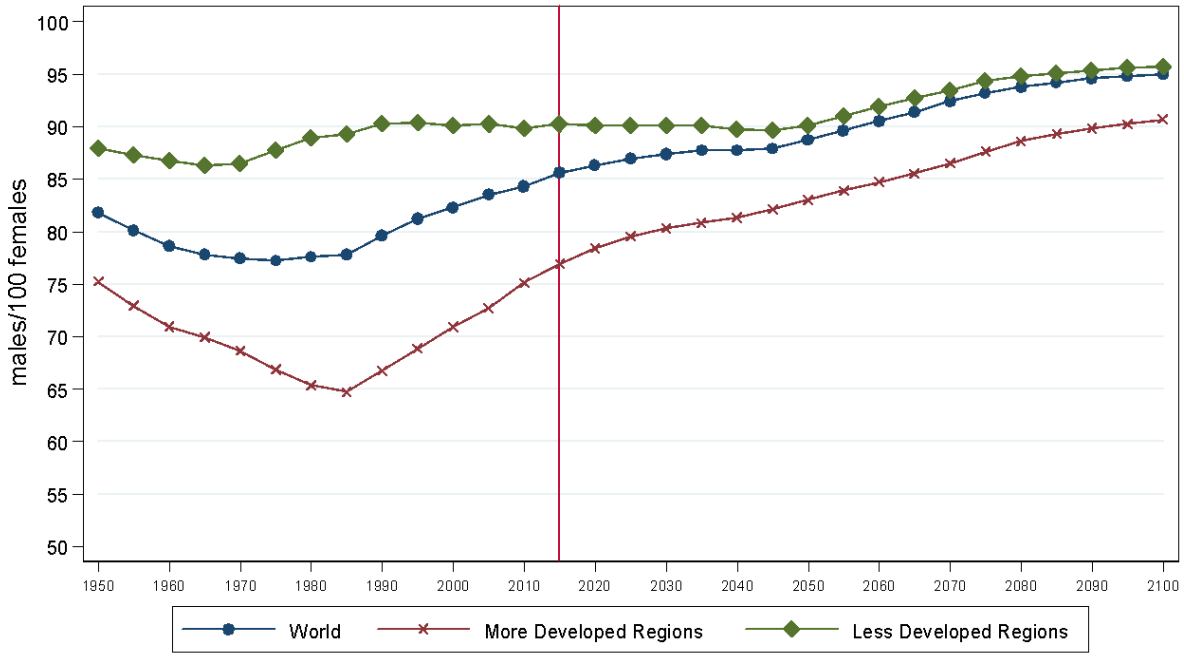


Figure 6: Total fertility rate, by level of development, 1950–2100

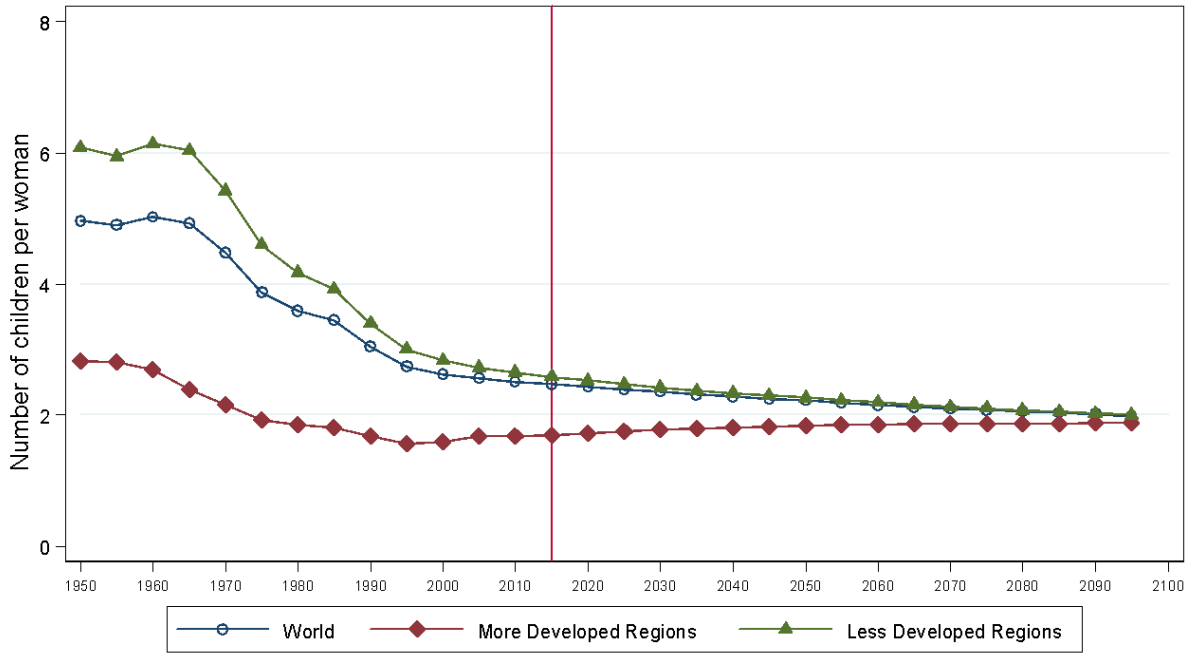


Figure 7: Life expectancy, by level of development, 1950–2100

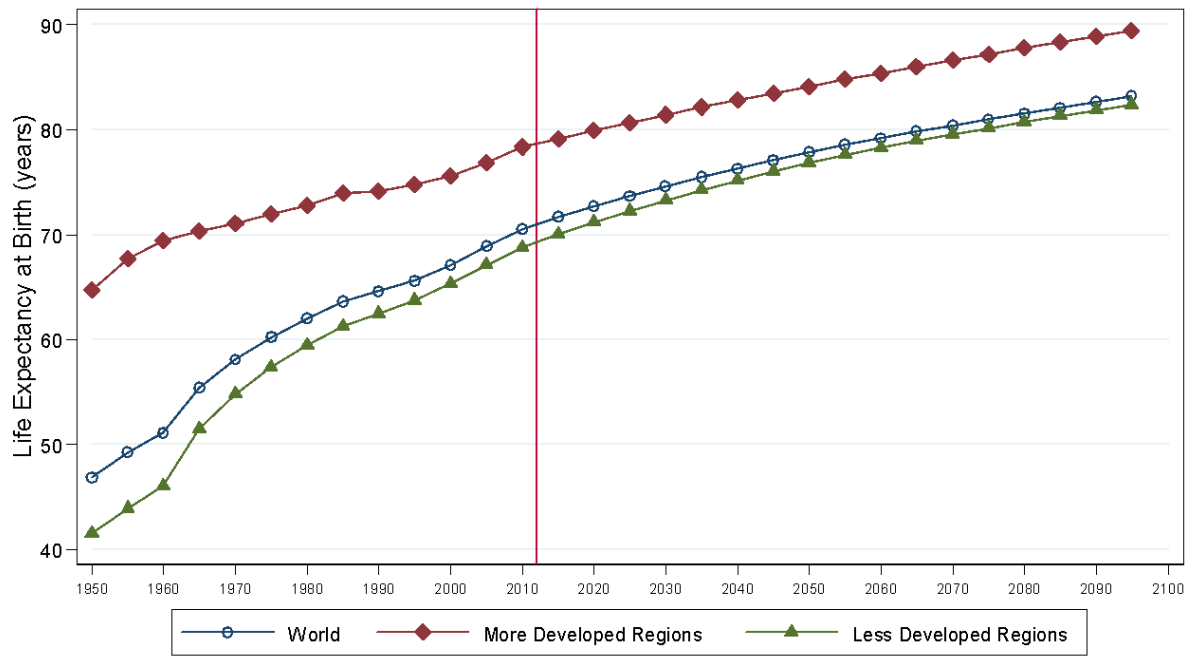


Table 1: Change in UN forecast of 2050 elderly population, 1994–2010

	Forecast Year	Total (population, billions)	60+	80+	60+ share (%)	80+ share
World	**1994**	9.83	1.97	0.33	20.04	3.36
	1996	9.37	1.94	0.32	20.70	3.42
	1998	8.91	1.97	0.37	22.11	4.15
	2000	9.32	1.96	0.38	21.03	4.08
	2002	8.92	1.91	0.38	21.41	4.26
	2004	9.08	1.97	0.39	21.70	4.30
	2006	9.19	2.01	0.4	21.87	4.35
	2008	9.15	2	0.4	21.86	4.37
	2010	9.30	2.03	0.4	21.83	4.30
	2012	9.55	2.02	0.39	21.15	4.08
	% change 94–00	-5.2	-0.5	15.2	4.94	21.45
	% change 00–06	-1.4	2.6	5.3	4.00	6.75
	% change 06–12	3.9	0.5	-2.5	-3.29	-6.18
	% change 94–12	-2.8	2.5	18.2	5.54	21.65
Less Developed Regions	**1994**	8.63	1.61	0.24	18.66	2.78
	1996	8.20	1.58	0.23	19.27	2.80
	1998	7.75	1.59	0.27	20.52	3.48
	2000	8.14	1.57	0.27	19.29	3.32
	2002	7.70	1.51	0.26	19.61	3.38
	2004	7.84	1.57	0.28	20.03	3.57
	2006	7.95	1.6	0.28	20.13	3.52
	2008	7.88	1.6	0.27	20.30	3.43
	2010	7.99	1.63	0.28	20.40	3.50
	2012	8.25	1.6	0.27	19.39	3.27
	% change 94–00	-5.7	-2.5	12.5	3.39	19.27
	% change 00–06	-2.3	1.9	3.7	4.35	6.18
	% change 06–12	3.8	0	-3.6	-3.64	-7.08
	% change 94–12	-4.4	-0.6	12.5	3.96	17.68
More Developed Regions	**1994**	1.21	0.36	0.09	29.75	7.44
	1996	1.16	0.36	0.09	31.03	7.76
	1998	1.16	0.38	0.1	32.76	8.62
	2000	1.18	0.4	0.11	33.90	9.32
	2002	1.22	0.39	0.11	31.97	9.02
	2004	1.24	0.4	0.12	32.26	9.68
	2006	1.25	0.41	0.12	32.80	9.60
	2008	1.28	0.42	0.12	32.81	9.38
	2010	1.31	0.42	0.12	32.06	9.16
	2012	1.30	0.42	0.12	32.31	9.23
	% change 94–00	-2.5	11.1	22.2	13.94	25.33
	% change 00–06	5.9	2.5	9.1	-3.24	2.98
	% change 06–12	4	2.4	0	-1.50	-3.85
	% change 94–12	7.4	16.7	33.3	8.59	24.10