CHAPTER 4

THE FINANCIAL IMPACT OF LONGEVITY RISK

Summary

As populations age in the decades ahead, the elderly will consume a growing share of resources. It is recognized that this will strain public and private balance sheets, and governments and private pension providers have been preparing for the financial consequences of aging. However, these preparations are based on baseline population forecasts that in the past have consistently underestimated how long people live.

Unexpected longevity beyond those baseline forecasts, while clearly beneficial for individuals and society as a whole, is a financial risk for governments and defined-benefit pension providers, who will have to pay out more in social security benefits and pensions than expected. It may also be a financial risk to individuals, who could run out of retirement resources themselves. These risks build slowly over time, but if not addressed soon could have large negative effects on already weakened private and public sector balance sheets, making them more vulnerable to other shocks and potentially affecting financial stability.

Few governments or pension providers adequately recognize longevity risk. Where they do, they find it is large. This chapter shows that if individuals live three years longer than expected—in line with underestimations in the past—the already large costs of aging could increase by another 50 percent, representing an additional cost of 50 percent of 2010 GDP in advanced economies and 25 percent of 2010 GDP in emerging economies. In an example, the chapter shows that for private pension plans in the United States, such an increase in longevity could add some 9 percent to their pension liabilities. Because the stock of pension liabilities is large, corporate pension sponsors would have to make many multiples of typical annual pension contributions to match these extra liabilities.

Addressing longevity risk requires a three-pronged approach. First, governments should acknowledge the significant longevity risk they face through defined-benefit plans for their employees and through old-age social security schemes. Second, risk should be appropriately shared between individuals, pension plan sponsors, and the government. An essential reform measure would allow retirement ages to increase along with expected longevity. This could be mandated by government, but individuals could also be encouraged to delay retirement voluntarily. Better education about longevity and its financial impact would help make the consequences clearer. Allowing flexibility for pension providers is also important: where it is not feasible to increase contributions or retirement ages, benefits may have to decrease. Risk transfers in capital markets from pension plans to those that are better able to manage the risk are a third approach. The chapter highlights a number of instruments in this growing market, and potential measures to improve its functioning.

Better recognition and mitigation of longevity risk should be undertaken now. Measures will take years to bear fruit and effectively addressing this issue will become more difficult if remedial action is delayed. Attention to population aging and the additional risk of longevity is part of the set of reforms needed to rebuild confidence in the viability of private and public sector balance sheets.

The economic and fiscal effects of an aging society have been extensively studied and are generally recognized by policymakers, but the financial consequences associated with the risk that people live longer than expected—longevity risk—has received less attention.[1] Unanticipated increases in the average human life span can result from misjudging the continuing upward trend in life expectancy, introducing small forecasting errors that compound over time to become potentially significant. This has happened in the past. There is also risk of a sudden large increase in longevity as a result of, for example, an unanticipated medical breakthrough. Although longevity advancements increase the productive life span and welfare of millions of individuals, they also represent potential costs when they reach retirement.

More attention to this issue is warranted now from the financial viewpoint; since longevity risk exposure is large, it adds to the already massive costs of aging populations expected in the decades ahead, fiscal balance sheets of many of the affected countries are weak, and effective mitigation measures will take years to bear fruit. The large costs of aging are being recognized, including a belated catch-up to the currently *expected* increases in average human life spans. The costs of longevity risk—*unexpected* increases in life spans—are not well appreciated, but are of similar magnitude. This chapter presents estimates that suggest that if everyone lives three years longer than now expected—the average underestimation of longevity in the past—the present discounted value of the additional living expenses of everyone during those additional years of life amounts to between 25 and 50 percent of 2010 GDP. On a global scale, that increase amounts to tens of trillions of U.S. dollars, boosting the already recognized costs of aging substantially.

Threats to financial stability from longevity risk derive from at least two major sources. One is the threats to fiscal sustainability as a result of large longevity exposures of governments, which, if realized, could push up debt-to-GDP ratios more than 50 percentage points in some countries. A second factor is possible threats to the solvency of private financial and corporate institutions exposed to longevity risk; for example, corporate pension plans in the United States could see their liabilities rise by some 9 percent, a shortfall that would require many multiples of typical yearly contributions to address.

Longevity risk threatens to undermine fiscal sustainability in the coming years and decades, complicating the longer-term consolidation efforts in response to the current fiscal difficulties.[2] Much of the risk borne by governments (that is, current and future taxpayers) is through public pension plans, social security schemes, and the threat that private pension plans and individuals will have insufficient resources to provide for unexpectedly lengthy retirements. Most private pension systems in the advanced economies are currently underfunded and longevity risk alongside low interest rates further threatens their financial health.

A three-pronged approach should be taken to address longevity risk, with measures implemented as soon as feasible to avoid a need for much larger adjustments later. Measures to be taken include: (i) acknowledging government exposure to longevity risk and implementing measures to ensure that it does not threaten medium- and long-term fiscal sustainability; (ii) risk sharing between governments, private pension providers, and individuals, partly through increased individual financial buffers for retirement, pension system reform, and sustainable old-age safety nets; and (iii) transferring longevity risk in capital markets to those that can better bear it. An important part of reform will be to link retirement ages to advances in longevity. If undertaken now, these mitigation measures can be implemented in a gradual and sustainable way. Delays would increase risks to financial and fiscal stability, potentially requiring much larger and disruptive measures in the future.

Note: This chapter was written by S. Erik Oppers (team leader), Ken Chikada, Frank Eich, Patrick Imam, John Kiff, Michael Kisser, Mauricio Soto, and Tao Sun. Research support was provided by Yoon Sook Kim.

[1]See, for example, IMF (2011a).

[2]See IMF (2012).

Box 4.1. The Evolution of Life Expectancy in the Twentieth and Twenty-First Centuries

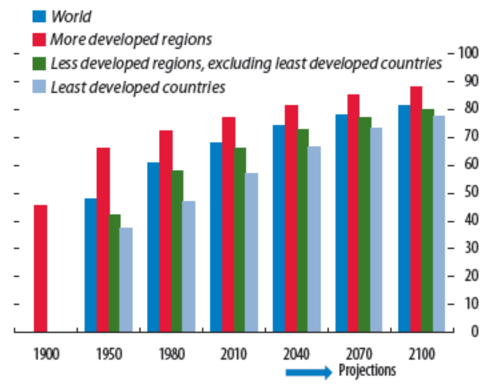
Most gains in life expectancy at birth are attributable to improvements in infant mortality, but they have also occurred in life expectancy at older ages, the variable most important for longevity risk.

Life expectancy at birth has increased greatly in the past 100 years. In the 1750s, estimated life expectancy at birth was below 40 years in northern and western Europe. Life expectancy at birth rose steadily after that and has seen a near linear increase since about 1900, reaching about 80 years by 2010 in the best performing areas (the Nordic countries, New Zealand, and Japan). More generally, life expectancy at birth has been increasing in all regions of the world, rising from a global average of 48 years in 1950 to 60 years in 1980 and close to 70 years by 2010. The increases over the past decades have been particularly marked in countries classified by the United Nations as less developed and least developed (see Figure 4.1.1).

The large increase in life expectancy at birth is mainly attributable to a decline in infant mortality rates. In the period 1950–70, more than 70 percent of the increase in life expectancy at birth in Canada and the United States was due to improvements in mortality at ages below 65 years. In the other advanced economies about 85 percent of the increase was due to improvement at younger ages.

What matters for longevity risk, however, are developments in life expectancy at older ages, which has also improved significantly over the past 100 years. Life expectancy at age 60 in advanced economies in Europe, for example, rose from 15 years in 1910 to 24 years in 2010, and is expected to improve further. This raises the question of how far life expectancy can be extended and whether there is a maximum life span for humans (Siegel, 2005).

Figure 4.1.1. Life Expectancy at Birth
(In years)



Sources: Kinsella and He (2009); United Nations (2011); and IMF staff estimates.
Note: The regional groupings reflect the UN classification.

These effects can be visualized in so-called life curves, which track (and project) the proportion of a population that remains alive at various ages (see Figure 4.1.2, in which the year labels represent the year of birth). If people died evenly across age groups, the curve would be closer to a downward-sloping diagonal line. With a high rate of infant mortality, the curve drops steeply near age zero, as in the curve for 1851.

If all people died at the same age, the curve would be a rectangle, with 100 percent of the population being alive before that age, and 0 percent

Note: Prepared by Frank Eich, John Kiff, and Mauricio Soto.

The chapter proceeds as follows. After defining and quantifying longevity risk, the chapter investigates its impact, who is exposed to it, and how it affects their liabilities, including in the current low-interest-rate environment. The chapter then describes the market for longevity risk transfer, identifying impediments, and looks forward with measures that could promote its development. It concludes with potential policy implications.

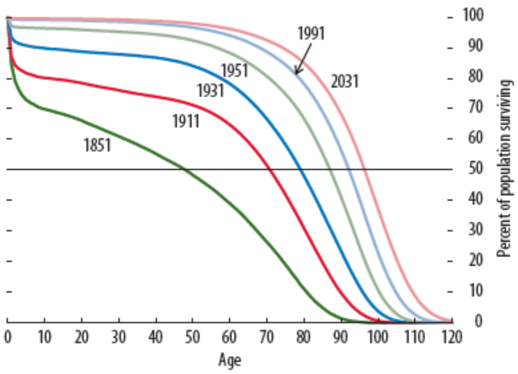
Longevity Risk

Longevity risk is the risk that actual life spans of individuals or of whole populations will exceed expectations.[3] As described in Box 4.1, people have been

[3]This chapter focuses on *aggregate* longevity risk, the risk that people on average live longer than expected. Individuals face an individual or "idiosyncratic" longevity risk that may cause them to outlive their financial resources, sometimes referred to as "retirement ruin" (Milevsky, 2006).

Box 4.1 *(continued)*

Figure 4.1.2. Life Curves for the United Kingdom, by Year of Birth, 1851–2031



Source: Office of National Statistics.
Note: Proportion of persons born in a given year surviving to successive ages. For example, of people born in 1851, 50 percent survived to about age 47.

after that age. Developments in longevity that have made the life curve more rectangular over time have been dubbed the "rectangularization" of the life curve.

Using various methodologies detailed in Box 4.2, most current forecasts assume that increases in life expectancy, including those at older ages, will slow down in the future. As noted in the main text, that assumption is arguable. Nonetheless, the United Nations projects that by 2050 life expectancy at age 60 will increase to an average of 26 years in advanced economies and about 22 years in developing economies—an improvement of about 1 month per year. These expected increases are slightly below the increases experienced in the past for the United States and Canada but substantially below those in the rest of the world (see Table 4.1.1).

Table 4.1.1. Longevity Trends, 1970–2050
(In years)

	Observed			Projected	
	1970–2010	Increase per year	Standard deviation	2010–50	Increase per year
Change in life expectancy at birth					
United States and Canada	8.2	0.20	0.14	4.3	0.11
Advanced Europe	8.6	0.21	0.13	4.7	0.12
Emerging Europe	1.1	0.03	0.36	6.8	0.17
Australia and New Zealand	10.8	0.27	0.27	4.9	0.12
Japan	10.8	0.27	0.23	4.6	0.11
Change in life expectancy at age 60					
United States and Canada	4.9	0.12	0.11	3.1	0.08
Advanced Europe	5.7	0.14	0.13	3.7	0.09
Emerging Europe	0.6	0.02	0.18	3.8	0.09
Australia and New Zealand	7.2	0.18	0.23	3.7	0.09
Japan	7.7	0.19	0.19	3.7	0.09

Sources: Human Mortality Database as of December 13, 2011; and IMF staff estimates.

living longer lives for at least a century now, and this has obvious benefits. But governments, private companies, and individuals all potentially face financial risks if people on average live longer than expected. In particular, defined-benefit pension plans, insurance companies that offer life annuities, and governments that sponsor old-age social security systems would have to pay benefits longer than anticipated, increasing the present discounted value of their liabilities.

The main source of longevity risk is therefore the discrepancy between expected and actual life spans, which has been large and one-sided: forecasters, regardless of the techniques they use, have consistently underestimated how long people will live (Box 4.2). These forecast errors have been systematic over time and across populations. A study by the U.K. Office for National Statistics (Shaw, 2007) has evaluated the forecast errors made in

Box 4.2. Forecasting Longevity

Longevity forecasts can be made using various methods. Forecasting models can be broadly categorized into (i) methods that attempt to understand and use the underlying drivers of mortality and (ii) extrapolative methods, which use only historical trends to forecast future developments.

So-called process-based methods and econometric models seek an understanding of the underlying factors driving death rates. These methods use biomedical assumptions to forecast death rates from various causes, leading to longevity rates of "cohorts" (people in a particular demographic section of the population born in a particular year or period). Econometric methods principally model longevity as a function of general economic, environmental, and epidemiological factors. A difficulty with both approaches is that they require a model for the relationship between underlying factors and longevity. Also, if they are used to make forecasts of longevity, forecasts need to be available for any underlying factors used in the model.[1]

Extrapolative approaches do not attempt to identify the drivers of death rates but use only information contained in historical data to forecast future mortality rates. Such models could assume that historical trends continue into the future, either exactly or in some "smoothed" form, or could try to derive a more sophisticated model from historical trends (possibly disaggregated by cohort) that could then be used for a forecast. Methods can be deterministic—meaning that they directly calculate future changes from past trends—or stochastic, meaning that they apply random changes from a probability distribution derived from past developments to generate future changes.

When Lee and Carter (1992) showed that their extrapolative model explained 93 percent of the variation in mortality data in the United States, it became the standard model for the longevity forecast literature and the preferred forecasting methodology for the U.S. Census Bureau and the Social Security Administration. Employing time-series analysis, the model estimates an underlying "mortality index" using variations in mortality data across different age groups over time. The index can then be used to forecast future longevity.[2]

A drawback with the extrapolative approach, including that of Lee and Carter, is that it looks only at the past and does not use available information (or assumptions) about possible future developments that affect longevity, such as medical breakthroughs or changes in behavior. Although the Lee-Carter model has been successfully applied to Canada, France, Japan, Sweden, and the United States, it has not been as successful in some other countries. For example, it has trouble explaining developments in the United Kingdom because of cohort effects that depend on the year in which a group of individuals was born. Forecasters in the United Kingdom now generally use another extrapolative method (Currie, Durban, and Eilers, 2004). Other studies have explicitly included cohort effects.[3]

Note: Prepared by John Kiff and Michael Kisser.

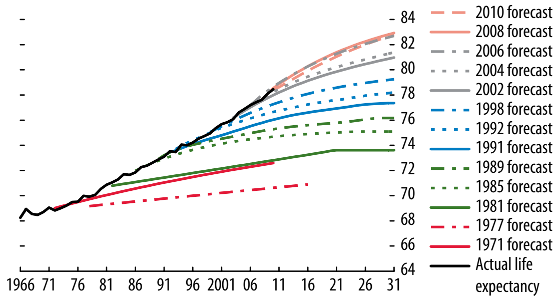
[1]For a detailed discussion of these issues, see for example Continuous Mortality Investigation (2004).

[2]Specifically, the model assumes that $\ln[m(x, t)] = a(x, t) + b(x)k(t) + \varepsilon(x, t)$ where $m(x, t)$ denotes the death rate at age x and time t. The death rate is a direct function of the individual's age through $a(x)$. It also depends on $k(t)$, which represents falling mortality rates (that is, improvements in longevity) over time. How much mortality falls at a given point in time also depends on the individual's age, through $b(x)$. ε is a random term.

[3]A detailed comparison of different stochastic mortality models can be found in Cairns and others (2009).

the United Kingdom over the past decades (Figure 4.1). It showed that future estimates of longevity were consistently too low in each successive forecast, and errors were generally large. In fact, underestimation is widespread across countries: 20-year forecasts of longevity made in recent decades in Australia, Canada, Japan, New Zealand, and the United States have been too low by an average of 3 years (Bongaarts and Bulatao, 2000). The systematic errors appear to arise from the assumption that currently observed rates of longevity improvement would slow down in the future. In reality,

Figure 4.1. United Kingdom: Projected Life Expectancy at Birth, for Males, 1966–2031
(In years)



Source: Office of National Statistics.

they have not slowed down, partly because medical advances, such as better treatments for cancer and HIV-AIDS, have continued to raise life expectancy (Box 4.3).

Life expectancy at birth is most often used to discuss longevity, although the measure most relevant for longevity risk is life expectancy at pensionable age. The latter has increased less in the past, but the rectangularization of the life curve (see Box 4.1) implies that more of the increases in life expectancy in the future will be due to increases at older ages. Still, higher longevity at younger ages is clearly *not* a risk. Longer healthy and productive lives (before retirement) add to incomes, retirement savings, and tax revenues. This matters particularly in countries with currently low life expectancy, where longer life spans generally are economically beneficial.

Appropriate longevity assumptions should use the most recent longevity data and allow for future increases in longevity. Even when pension providers use updated data, they do not always allow for reasonable further future increases in longevity from its current level. In fact, longevity at age 60 in the advanced economies has increased in every decade over the past half century by an average of one to two years (see Table 4.1.1 in Box 4.1). Typical assumptions for pension liability valuations in some countries suggest that longevity assumptions may not adequately account for future developments in longevity. Although valuations typically incorporate some future increases that exceed current life expectancy tables, those increases are still much smaller in a number of countries than those that have occurred in the past (Table 4.1). This is partly because regulatory frameworks—while mandating the use of the most recent actual longevity data—often do not require that *future* expected improvements in longevity are included in calculations of pension liabilities.

The substantial costs of aging already faced by society provide a useful starting point to assess the magnitude of longevity risk. The most common measure of aging is the old-age dependency ratio—the ratio of the population 65 and older to the population 15 to 64. Over the period 2010–50 old-age dependency ratios are expected to increase from 24 to 48 percent in advanced economies and from 13 to 33 percent in emerging economies. These numbers are subject to considerable uncertainty, not only regarding longevity, but also with respect to developments in fertility. United Nations populations

Table 4.1. Pension Estimates and Population Estimates of Male Life Expectancy at Age 65 in Selected Advanced Economies
(In years)

Country	(1) Typical Assumption for Pension Liability Valuation[1]	(2) Population Life Expectancy[2]	Difference: (1)–(2)	(3) Observed Improvements since 1990[3]
Australia	19.9	18.7	1.2	3.5
Austria	20.8	17.0	3.8	3.4
Canada	19.4	18.2	1.2	2.6
Germany	19.0	16.9	2.1	3.3
Ireland	21.0	16.7	4.3	3.8
Japan	18.8	18.6	0.2	2.7
United Kingdom	21.2	17.2	4.0	3.9
United States	18.4	17.5	0.9	2.4

Sources: Sithole, Haberman, and Verrall (forthcoming); Human Mortality Database as of February 22, 2012.

[1]Takes into account some future improvement in longevity.

[2]Does not take into account future improvement in longevity.

[3]Difference beween the latest population life expectancy at age 65 and that in 1990 (taken from the Human Mortality Database).

Box 4.3. An Example of a Longevity Shock

The advent of antiretroviral drugs for people with HIV infection in the mid-1990s created a positive longevity shock for patients but undid the financial expectations of existing investors in viatical settlements.

The AIDS epidemic emerged in the early 1980s and drove down the life expectancy of patients infected with HIV. During the early years of the epidemic, patients with HIV whose infection had progressed to AIDS were considered terminally ill, with a life expectancy measured in months.

Often without other sources of income, patients with AIDS turned to the value embedded in their life insurance policies for financial resources in a transaction known as a viatical settlement. If their life insurance policies permitted it, terminally ill patients could obtain a significant proportion of the face value of their policy as an immediate cash payment by selling the policy to a third party. The size of the cash payment depended principally on the life expectancy of the policy owner.

A number of viatical settlement companies emerged during the 1980s. Although settlement terms varied widely, some sense of the financial provisions can be gleaned from government regulations that were introduced in the 1990s to protect those selling their life insurance. For example, in the United States, Virginia regulations stipulate minimum payout percentages to be received by the seller that range from 80 percent of face value for those with a life expectancy of less than 6 months to 60 percent of face value for those with a life expectancy of up to 24 months. For 25 months or more, the payout could be less, as only the cash surrender value was required (Virginia Registrar of Regulations, 2003).

In the mid-1990s, HAART (highly active antiretroviral therapy) drugs became available and sharply improved the outlook for those infected with HIV. Whereas the median survival time after infection with HIV without treatment is about 11 years, the survival time at age 20 with treatment is estimated to be close to 50 years.[1] For those patients who progress to AIDS, the improvement in life expectancy with treatment is even more dramatic. The median survival time after diagnosis with AIDS without treatment is 6 to 19 months (Zwahlen and Egger, 2006). With treatment, many individuals recover from AIDS to a state of latent HIV infection, with survival rates similar to other HIV-infected individuals.

The introduction of these life-saving anti-HIV medications led to a large positive longevity shock for those living with HIV. Viatical settlements disappeared quickly as life expectancies rose. Investors in viatical settlements saw a significant realization of longevity risk, with associated losses, as they were required to continue to pay premiums for much longer than expected and were faced with delayed payouts. Data on such losses are not available, but a crude estimate can be made from the minimum percentage payouts in the Virginia regulations: if life expectancy rose from less than 6 months (80 percent payout) to more than 24 months (60 percent payout or less), the loss to investors could be 20 percent or more.

Note: Prepared by S. Erik Oppers.

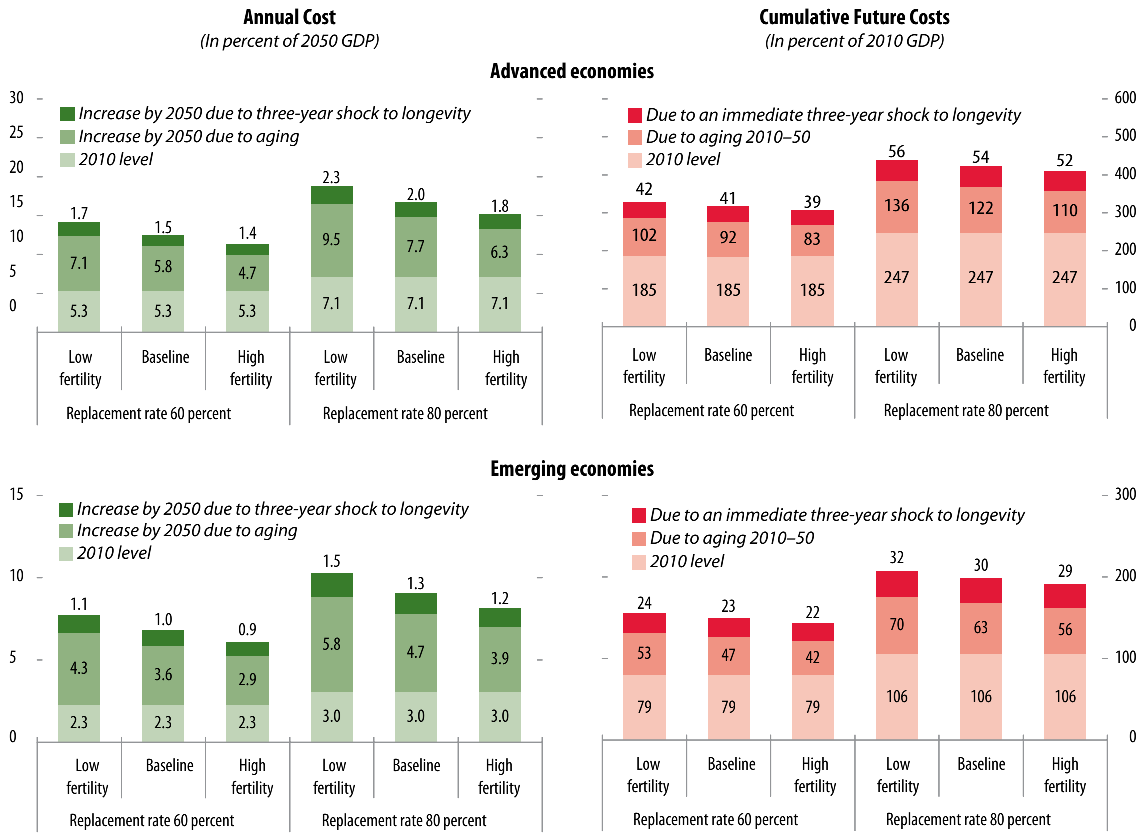
[1]UNAIDS Reference Group for Estimates, Modeling and Projections (2006); and Antiretroviral Therapy Cohort Collaboration (2008).

forecasts therefore have a baseline, and low and high fertility variants.[4] A way to measure the associated financial burden of an aging society is to estimate the cost of providing all individuals aged 65 and older with an average income necessary to keep their standard of living at its preretirement level. That income, measured as a percentage of the average preretirement income, is called the "replacement rate." A reasonable replacement rate may differ across countries, but the literature generally puts it in the range of 60 to 80 percent.[5]

[4]The United Nations projects that life expectancy at age 65 will increase by two years over the period 2010–50.

[5]The 60 to 80 percent range for replacement rates reflects the fact that retirees often need lower gross incomes to maintain their preretirement standards of living: retirees do not pay payroll taxes and pensions generally have preferential income tax treatment. In addition, retirees do not need to save for retirement and do not incur work-related expenses such as transportation. On the other hand, medical expenses may be higher. Several studies suggest that the actual replacement rates are within this range for the advanced economies (OECD, 2009, 2011; Borella and Fornero, 2009; Palmer, 2008; and Disney and Johnson, 2001).

Figure 4.2. Increases in Costs of Maintaining Retirement Living Standards due to Aging and to Longevity Shock



Sources: United Nations; and IMF staff estimates.

Note: The left panels correspond to spending levels in 2050—a flow measure—expressed as share of 2050 GDP. The right panels represent the present discounted value of all future spending—a stock measure—expressed as a share of 2010 GDP. This calculation uses a discount rate of 1 percent, which is equivalent to assuming a differential between the interest rate and rate of growth of 1 percentage point. The replacement rate is the percentage of preretirement income needed to maintain standard of living during retirement.

Under the demographic trends expected by the United Nations, and with a 60 percent replacement rate, the aggregate expenses of the elderly will roughly double over the period 2010–50. In the baseline population forecast and with a 60 percent replacement rate, the annual cost rises from 5.3 percent to 11.1 percent of GDP in advanced economies and from 2.3 percent to 5.9 percent of GDP in emerging economies (Figure 4.2). Taken over the full period, the cumulative cost of this increase because of aging in this scenario is about 100 percent of 2010 GDP for the advanced economies and about half that amount in emerging economies. The numbers reflect pension costs only and do not account for likely increases in health and long-term care costs, which will further increase the burden of aging. Much of the costs of aging will need to be funded through existing retirement systems, and various reforms have been put in motion to deal with these cost pressures (see IMF, 2011a).

A longevity shock of three years would add nearly half to these cumulative costs of aging by 2050. A three-year shock approximates the average underestimation of longevity in the past.[6] Using the same calculation as in the previous paragraph, in the

[6]Bongaarts and Bulatao (2000) found underestimations of life expectancy at birth, not life expectancy at pensionable age. However, other evidence supports at least a three-year underestimation for life expectancy at older ages as well: in the Netherlands, for example, life expectancy at 65 rose from 14 years in 1971 to 18 years in 2010. In the United States, life expectancy at 63 rose from 15 years in 1971 to 19 years in 2007.

baseline aging scenario the additional cost of providing all individuals of age 65 with a 60 to 80 percent replacement rate for those additional three years adds about 1.5 to 2.0 percentage points of GDP to the *annual* cost of aging in advanced economies in 2050, and 1.0 to 1.3 percentage points of GDP in emerging economies. These annual increments imply a cumulative cost of about 50 percent of 2010 GDP for the advanced economies and about 25 percent of 2010 GDP for the emerging markets—in each case adding nearly half to the cost of aging.[7]

There is uncertainty around these estimates, but the effects are of similar magnitude in different aging scenarios. In the U.N. high fertility variant (which leads to slower aging of the population as a whole), the cumulative effect of a longevity shock in advanced economies is still in the range of 39 to 52 percent of GDP, depending on the replacement rate. For emerging economies, the range is between 22 and 29 percent.

The Impact of Longevity Risk

Although longevity risk develops and reveals itself slowly over time, if left unaddressed it can affect financial stability by building up significant vulnerabilities in public and private balance sheets. On a macroeconomic level, the effects of a longevity shock on the economy and markets are similar to the effects of aging—they propagate through the size and composition of the labor force, public finances, corporate balance sheets, private saving and investment, and potential growth (Box 4.4). While the effects of longevity risk perhaps act too slowly to cause sharp movements in asset prices, if unaddressed they add to balance sheet vulnerabilities, affecting fiscal sustainability and the solvency of private financial and corporate institutions. This in turn makes institutions and markets more prone to the negative effects of other shocks.

The Effect of Longevity Risk on Fiscal Sustainability

Governments in particular bear a significant amount of longevity risk. Their longevity exposure is threefold: (i) through public pension plans, (ii) through social security schemes, and (iii) as the "holder of last resort" of longevity risk of individuals and financial institutions. An unexpected increase in longevity would increase spending in public schemes, which typically provide benefits for life. If individuals run out of resources in retirement they will need to depend on social security schemes to provide minimum standards of living. There may also be an expectation that governments will step in if financial institutions or corporations face solvency threats from longevity exposure. In addition, private pensions in some countries are backed by guarantee funds (including in Japan, Sweden, the United Kingdom, and the United States), but these may be underfunded (as in the United States), representing an additional contingent liability for the government.

The longevity risk faced by governments adds strain to public balance sheets, which have already seriously deteriorated under the stress of the financial crisis (see Chapter 2). To the extent that governments are not acknowledging longevity risk (and few in fact do), fiscal balance sheets become more vulnerable. If not adequately addressed soon, it could potentially further threaten fiscal sustainability.

The framework that was used earlier to calculate the overall potential cost of longevity risk can be used country by country to estimate its effect on fiscal sustainability. Table 4.2 summarizes the impact of aging and a longevity shock on the fiscal position for a number of advanced and emerging market economies.

[7]The large addition to the cost of aging because of the longevity shock can be seen intuitively as follows. The total cost of aging is the result of two factors: first, lower fertility rates (two-thirds of the effect) and, second, an increase in life expectancy at the age of retirement (one-third of the effect). Longevity at the age of retirement, the second factor, increases by nearly two years in the U.N. baseline, so that an additional shock of three years should have an impact of (3 years/2 years) × 1/3 which equals ½. Because changes in fertility take a long time to work themselves through the age structure, they are unlikely to have a large impact on the financial implications of aging over the next few decades. For example, if fertility rates were to immediately increase by 0.5 children per woman across all regions, the old-age dependency ratio in 2030 would remain virtually unchanged. In contrast, an increase in life expectancy at age 60 of one year would increase old-age dependency ratios substantially. Migration can alter the demographic structure quickly. Immigration of young adults and children from "younger" nations could offset to some extent the aging of populations in advanced economies.

Box 4.4. The Impact of Aging on the Macro Economy and on Financial Stability

This box summarizes the literature on the impact of aging on the macro economy and on financial stability.

The Macro Economy

The macroeconomic effects of aging can be summarized with the help of the national accounts identity and the Cobb-Douglas production function.

Note: Prepared by Patrick Imam and Tao Sun.

The national account framework shows the relation between aggregate production, income, domestic demand, and the external accounts through the following equations:

$$GDP = (C_{\text{private}} + I_{\text{private}}) + (C_{\text{public}} + I_{\text{public}}) + X - M \quad (1)$$

$$GNDI = C_{\text{private}} + C_{\text{public}} + S_{\text{private}} + S_{\text{public}} \quad (2)$$

4.4.1. Impact of Aging on the Macro Economy

<table>
<tr><th>Framework</th><th>Variable</th><th>Impact</th><th>Channels</th></tr>
<tr><td rowspan="5">National account framework</td><td>Consumption</td><td>Changing consumption pattern toward nontradables</td><td>• Different consumption patterns for the elderly (see Eghbal, 2007, for a case study of Italy) tend to shift demand toward services and lead to an increase in the price of nontradables compared with tradables, causing an increase in the real exchange rate.</td></tr>
<tr><td>Investment</td><td>Reducing investment return</td><td>• If the aging population is also declining, this may lead additionally to falling rates of return on public investment. If governments do not plan for a declining population, existing public capital (e.g., schools, public infrastructure) may become underutilized to the extent that their use differs among generations.</td></tr>
<tr><td>Savings</td><td>Reducing private and public saving</td><td>• According to the life-cycle hypothesis, older people will tend to liquidate existing savings.
• Assuming no migration or fertility rise, with fewer active individuals, governments pay out more in health care and pension benefits and collect less tax revenue, leading to deteriorating fiscal conditions.
• Rising fiscal deficits (negative public saving) could put the fiscal outlook on an unsustainable trajectory.</td></tr>
<tr><td>Current account</td><td>Reducing current account balance</td><td>• The net effect of falling private and public saving on the current account depends on the relative changes in saving and investment. It is expected that the effect will apply to both current account surplus and deficit countries (see Lee and Mason, 2010).
• The shrinking current account balance in some major countries, such as China and Japan, may contribute to the adjustment of global imbalances to the benefit of global financial stability.</td></tr>
<tr><td rowspan="2">GDP</td><td rowspan="2">Reducing growth rates</td><td>• Skirbekk (2004) finds that skills that are key inputs to innovation—problem solving, learning, and speed—tend to degenerate with age, leading to a population that is less creative and entrepreneurial, thereby reducing growth rates.
• Empirically, the IMF (2004) finds that per capita GDP growth is positively correlated with changes in the relative size of the working age population and negatively correlated with changes in the share of the elderly.</td></tr>
<tr><td rowspan="4">Cobb–Douglas production function</td><td>• Empirical evidence from OECD countries shows that the complementary role of young and old workers means an optimum mix that exists may be damaged by having too many old workers (Feyrer, 2007).</td></tr>
<tr><td>Capital</td><td>Reducing real interest rates</td><td>• Aging is likely to translate into a gradual rise in the ratio of capital to labor and some concomitant decline in longer-term real interest rates (Visco, 2005). The flattened yield curve would reduce the effectiveness of monetary policy transmission and could impact institutions such as banks or pension funds that rely on a steep curve for their business model. This effect may be counterbalanced by decreasing saving, which may drive up interest rates.</td></tr>
<tr><td>Labor</td><td>Affecting labor supply and returns</td><td>• An aging population will tend to shrink the labor force, which could lead to a lack of both unskilled and skilled workers. Countervailing factors, however, such as working longer (by raising the pension eligibility age for instance) or encouraging migration, could counteract the shrinking labor supply effect.
• The higher capital-to-labor ratio would tend to lower expected returns on investment. Similarly, the same countervailing factors, such as working longer and immigration, may help buffer the decline in returns on investment.</td></tr>
<tr><td>Productivity</td><td>Reducing productivity growth</td><td>• The elderly demand more services than the rest of the population (van Groezen, Meijdam, and Verbon, 2005), which tends to shift consumption toward services and away from durables. Given generally lower productivity growth in the service sector, this will tend to reduce productivity growth in the overall economy.</td></tr>
</table>

Box 4.4 *(continued)*

where:

GDP = gross domestic product
C = consumption expenditures
I = gross domestic investment
X = exports of goods and services
M = imports of goods and services
$GNDI$ = gross national disposable income
S = gross national savings
$(S – I) = CA$ = current account balance

The impact of aging on each of the components of the national income identity is summarized in Table 4.4.1.

The effect of aging on GDP can be further investigated by considering the Cobb-Douglas production function, which describes the relationship of the aggregate output of the economy to the use of inputs, as follows:

$$Q = AL^{\alpha}K^{\beta} \quad (3)$$

where:

Q = total production (the value of all goods produced in a year)
L = labor input
K = capital input
A = total factor productivity

Exponents α and β are the output elasticities of labor and capital, respectively, which are viewed as constants determined by available technology at a point in time.

Thus, changes in GDP as a result of aging can be explained by changes in the labor supply, in the capital stock, and in productivity, as summarized in Table 4.4.1.

Financial Stability

The impact of aging on financial stability occurs largely through changes in the allocation of assets and liabilities among individuals and institutions. These effects are summarized in Table 4.4.2.

Table 4.4.2. Impact of Aging on Financial Stability

Balance Sheet Items	Impact	Channels
Assets	Reallocation of saving from riskier to safe assets may lead to potential mispricing of risk	• The rising demand for safe assets by the elderly (including through their pension funds) may lead to safe asset shortages and an overpricing of safe assets. At the same time, since risky assets such as equities are increasingly shunned, there is a possibility of an underpricing of riskier assets (Caballero, 2006). • These effects may be counterbalanced by defined-benefit funds with funding gaps in the current low-interest-rate environment, which may invest in risky assets to enhance expected returns. Underpricing may also be mitigated by international investors' buying the cheaper risky assets.
	Running down assets may result in negative wealth effects	• Evidence is increasingly emerging that asset prices fall with advancing population aging (Poterba, 2004). For instance, an aging population, by requiring less housing, puts downward pressure on house prices (Takáts, 2010). The same principle applies to equity prices, although because equities are internationally tradable, they are somewhat less susceptible to supply/demand changes driven by aging (Brooks, 2006). • Negative wealth effects could have deflationary consequences (as suggested by Japan's experience), which could lead to a negative price spiral that further depresses economic activity.
Liabilities	Changing borrowing habits may alter banks' business model	• The business model of banks is closely related to the life-cycle behavior of consumers. In their early years, consumers are net borrowers from banks, to pay for education and housing. Over their life time, consumers pay back their debt to banks. Therefore, in a consumer's later years, banks will increasingly be used for payment/transaction purposes, and less for maturity transformation. With fewer young borrowers, traditional lending activities would decline, and banks would have to enter new activities and act more like nonbanks. If not well managed (including through supervision), this transition could pose risks to financial stability. • With saving increasingly being channeled to capital markets via pension funds, the similarity of investment approaches may lead to herding, which, combined with procyclicality in the markets, could raise volatility and threaten financial stability.
	Individuals, governments, and pension providers face longevity risk	• Aging societies face heightened longevity risk—the risk of living longer than expected. Currently, there is a lack of instruments to hedge this risk. Those exposed—defined-benefit pension plan sponsors (i.e., corporations and governments), social security systems (i.e., governments), and individuals themselves—could face financial difficulties in the event of a realization of this risk. In the case of corporations, such difficulties could lead to potentially large changes in stock prices. Extreme longevity risk is likely to be borne by the sovereign, and a realization of this risk can lead to a substantial deterioration of the fiscal accounts and possible debt sustainability issues.

Table 4.2. Longevity Risk and Fiscal Challenges in Selected Countries
(In percent of 2010 nominal GDP)

Country	(1) Household Total Financial Assets (2010)[1]	(2) Present Discounted Values of Needed Retirement Income	(3) General Government Gross Debt (2010)	(4) Gap: (1) – (2)	(5) Increase in Present Discounted Values Given Three-Year Increase in Longevity
United States	339	272 to 363	94	67 to –24	40 to 53
Japan	309	499 to 665	220	–190 to –356	65 to 87
United Kingdom	296	293 to 391	76	3 to –95	44 to 59
Canada	268	295 to 393	84	–27 to –125	42 to 56
Italy	234	242 to 322	119	–8 to –88	34 to 45
France	197	295 to 393	82	–97 to –196	40 to 54
Australia	190	263 to 350	21	–73 to –161	36 to 49
Germany	189	375 to 500	84	–186 to –311	55 to 74
Korea	186	267 to 357	33	–81 to –170	39 to 52
China	178	197 to 263	34	–19 to –85	34 to 45
Spain	165	277 to 370	60	–112 to –205	39 to 52
Hungary	108	190 to 254	80	–82 to –146	34 to 45
Czech Republic	89	216 to 289	39	–127 to –200	36 to 48
Poland	88	160 to 213	55	–72 to –125	27 to 35
Lithuania	80	189 to 252	39	–109 to –172	34 to 45

Sources: National flow of funds accounts; national accounts; IMF (2011c); and IMF staff estimates.

Note: Range of values in columns (2), (4), and (5) cover, at the low end, a replacement rate of 60 percent of preretirement income and, at the high end, an 80 percent replacement rate for retirees aged 65 or older to maintain preretirement standard of living during the 2010–50 period.

[1]For China, 2009.

- In many countries, the private sector does not appear to have sufficient financial assets to deal with aging-related costs, let alone with longevity risk. In most countries, the estimated present discounted value of required retirement income under current U.N. longevity assumptions for 2010–50 [Table 4.2, column (2)] exceeds household total financial assets [column (1)].[8] Gaps vary among countries, partly because of differing aging trends; they may also reflect individuals counting to varying degrees on income from social security schemes and on net housing wealth (which are excluded from the table because of data limitations).
- In Japan and Germany, for instance, the gaps between financial assets and potential liabilities are equivalent to between about 2 and 3½ times their respective GDPs in 2010, assuming again a range of replacement rates of 60 to 80 percent of the average wage. Although some of the gaps in the table would be covered by social security, housing equity, and further asset accumulation by households, it is unlikely that current household wealth is sufficient to provide for the necessary retirement income in many countries.
- The potential effects of longevity risk on government liabilities are substantial in many countries. With the private sector ill-prepared for even the expected effects of aging, it is not unreasonable to suppose that the financial burden of an unexpected increase in longevity will ultimately fall on the public sector. Implied increases in potential public liabilities from a three-year extension of average lifetimes are generally between one-third and one-half of 2010 GDP, with larger effects in Germany (two-thirds of 2010 GDP) and Japan (three-fourths of 2010 GDP) [Table 4.2, column (5)].
- The contingent liabilities from longevity risk could add to already-stretched debt-to-GDP ratios in a number of countries. For instance, if the risk of an extra three years of longevity were indeed to fall on the government, debt-to-GDP ratios could rise to about 150 percent in Germany and the United States and to 300 percent in Japan [Table 4.2, sum of columns (3) and (5)].

[8]Column (1) of Table 4.2 includes the claims on defined-benefit pension plans, balances of defined-contribution plans, claims on insurance reserves, and other financial assets. In a defined-contribution plan, an employee contributes a set amount to a retirement plan. These amounts, often complemented by employer's contributions, are then invested. The amount available at retirement depends only on contributions and cumulated rates of return; there is no promise of a particular payment upon retirement.

The Effect of Longevity Risk on Private Institutions

The rising awareness of longevity risk is starting to affect the corporate sponsors of retirement plans. For corporations that offer defined-benefit schemes, unexpected increases in longevity assumptions (sometimes forced by improved accounting rules) hurt firms' profits, affect their balance sheet, and—ultimately—their stock price.[9] Institutional investors and credit rating agencies are increasingly scrutinizing longevity risks in defined-benefit schemes, and forcing companies to increase reserves. In addition, merger and acquisition activities are increasingly complicated by risks in defined-benefit schemes, including longevity risk (Pensions Institute, 2005).

Longevity risk is also affecting financial institutions. For life insurance companies, longevity risk may lead to losses on their existing annuity contracts, potentially leading to regulatory increases in reserves for such contracts. For insurance companies with important annuity business (as is the case for many in France, Japan, and the United Kingdom) large and continuous longevity increases have a potentially substantial financial impact. Without the benefits of diversified business lines, stand-alone annuity providers, such as those in the United Kingdom, run even greater risks of insolvency. For pension funds, longevity risk can add significantly to underfunding (see example below). To the extent that insurance companies and pension funds are interconnected with other financial institutions (including, importantly, banks), the financial consequences of a longevity shock could propagate through the financial system. Longevity risk may also have an upside, however, depending on the specific exposure of financial institutions. For example, to the extent that life insurance companies have written more life policies than annuities, they benefit when their policyholders live longer, since that leads to longer premium payments and delayed payouts. This is why life insurance companies are a "natural buyer" of longevity risk (see "Longevity Risk in the Low-Interest-Rate Environment" below).

[9]Recent acknowledgment of unrealized losses of banks has caused large declines in their share prices. A similar event could occur for corporations with pension liabilities.

An Example: The Impact of Longevity Risk on U.S. Defined-Benefit Plans

This example uses detailed data from the U.S. Department of Labor (DOL) to estimate the longevity risk faced by defined-benefit pension plans in the United States.[10] Actuarial and financial information on large U.S. pension funds are contained in filings of the DOL's Form 5500 between 1995 and 2007 (the most current year available). Important statistics from this form for evaluating longevity risk are total liabilities, number of plan participants, and the actuarial assumptions used.

The Form 5500 data suggest that the use of outdated mortality tables has been a common practice (Table 4.3).[11] Until recently, a majority of plans used the Group Annuity Mortality table of 1983, and many still did by the end of the sample period, implying a lag of almost a quarter-century in their mortality assumptions. Throughout the sample, only a few plans used the latest available table.[12] This exposes many pension providers to substantial longevity risk. Indeed, a study by Dushi, Friedberg, and Webb (2010) compared the present value of pension liabilities as reported by the plan sponsor (using its own longevity assumptions) with the liabilities that result from using longevity forecasts by the Lee-Carter model.[13] The study argued that the use of outdated mortality tables is causing pension liabilities to be understated by some 12 percent for a typical male participant in a defined-benefit pension plan.[14]

[10]For a complete treatment of this example, see Kisser and others (forthcoming).

[11]Actuaries typically use mortality statistics to compute liabilities. Mortality is of course the complement of longevity, and therefore conceptually equivalent.

[12]For some pension funds, information on the underlying mortality table is not available as the corresponding tables are classified as "other" with no further information given. Anecdotal evidence suggests that some funds may have switched to another recently proposed table (the RP-2000 mortality table), but this evidence cannot be used in the analysis. Nonetheless, assuming that plans that do not report a mortality table use the most recent one changes the results of the analysis only marginally.

[13]For a description of the Lee-Carter model, see Box 4.2.

[14]Similarly, Antolin (2007) computes the impact on a hypothetical pension plan of an unexpected improvement in life expectancy and finds that the present value of pension liabilities increases between 8.2 percent and 10.4 percent.

Table 4.3. Mortality Tables Used by Reporting Pension Plans
(In percent)

Year	1951 GAM	1971 IAM	1984 UP	1983 IAM	1983 GAM	1994 UP	2007 Mortality Table	Other	Hybrid	None
1995	1	0	7	1	48	6	0	3	22	0
1996	0	0	6	0	57	1	0	6	19	0
1997	0	0	4	0	62	1	0	6	17	0
1998	0	0	4	0	66	1	0	6	15	0
1999	0	0	3	0	67	1	0	7	14	3
2000	0	0	3	0	68	2	0	7	13	2
2001	0	0	2	0	69	2	0	8	12	2
2002	0	0	2	0	69	2	0	10	11	3
2003	0	0	2	0	66	3	0	13	11	3
2004	0	0	1	0	63	3	0	17	10	3
2005	0	0	1	0	49	3	0	31	10	3
2006	0	0	1	0	28	3	0	55	8	3
2007	0	0	1	0	16	2	12	57	6	4

Sources: U.S. Department of Labor; and IMF staff estimates.

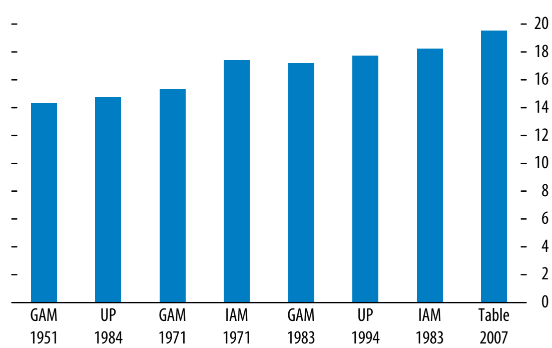
Note: GAM = Group Annuity Mortality table; IAM = Individual Annuity Mortality table; UP = Unisex Pension table. “Other” includes undefined mortality tables. “Hybrid” means that the standard mortality tables have been modified by the pension fund. “None” means that no mortality table has been used.

Each mortality table implies different life expectancies of retirees, and the impact of longevity increases can be inferred across funds and from instances when plans shift to the use of an updated table. The difference in implied life expectancy of 63-year-old males (the average retirement age in the sample) between the most dated and the most current mortality table is 5.2 years (Figure 4.3). For the substantial fraction of plans previously employing the 1983 Group Annuity Mortality table, a switch to the 2007 table (as required since 2008) implies an increase in longevity of 2.1 years.

Because the Form 5500 data show which table is used each year by each plan, the increase in the longevity assumptions is known when a plan switches to an updated table. Hence, controlling for other changes over time, a regression method can be used to disentangle increases in liabilities due to differences in discount rates, benefit payments, and the number of plan participants (Annex 4.1). The results imply that U.S. pension funds face a longevity risk that would see their total liabilities increase by about 3 percent for each additional year that their retirees live beyond the age of 63, implying a 9 percent increase for a three-year longevity shock.

The estimated shock is considerable, since it affects a large stock of liabilities; multiples of sponsors’ typical yearly contributions would be necessary to increase assets commensurately. For example, a longevity adjustment in the Nether-

Figure 4.3. Life Expectancy at Age 63, by Year of Mortality Table
(In years)



Sources: For GAM 1951, SOA (1983); for UP 1984, Jackson and Fellers (1976); for GAM 1971, Greenlee and Keh (1971); for IAM 1971, Cherry (1971); for GAM 1983, SOA (1983); for UP 1994, SOA (1995); for IAM 1983, SOA (1981); for Table 2007, *Federal Register* (2007).

Note: GAM = Group Annuity Mortality table; IAM = Individual Annuity Mortality table; UP = Unisex Pension table.

lands in 2010 led to an increase in liabilities of the pension sector of about 7 percent (or 8 percent of GDP). This increase in liabilities could not be matched by an increase in assets through employer and employee contributions; other measures to cover the shortfall are now being considered, including foregoing indexation of pensions and possible lowering of nominal pensions—measures allowable under Dutch law, but not typically available in most countries (Box 4.5).

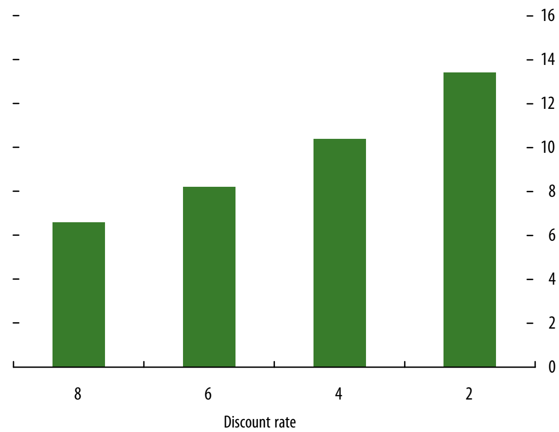
Longevity Risk in the Low-Interest-Rate Environment

Pension plans, providers of annuities, and other providers of retirement income face larger increases in liabilities because currently low interest rates exacerbate the financial impact of longevity risk. Longevity risk pertains to events in the future, so its financial consequences must be discounted. The lower the discount rate, the higher the present discounted value of the cost of longevity risk events.[15] A stress test framework for defined-benefit pension plans developed by Impavido (2011) indicates how the impact of longevity risk is dependent on interest rates.

The magnitude of the effects of longevity changes on pension liabilities differs depending on the age structure of a pension plan, on the actuarial assumptions used, and on how shocks are applied. Therefore, the calculations in this section should be viewed as an illustrative example that is based on the following specific assumptions:[16]

- To simulate longevity shocks, "extension factors" are applied to all age-specific mortality rates in the original mortality table in Impavido (2011), so that average life expectancy would be increased by three years.
- Retirement benefits in the model are single-life inflation-indexed annuities, based on a final-salary formula with an accrual rate of 1 percent.[17] The exercise assumes an inflation rate of 1 percent, annual real salary increases for active employees of 1 percent, and an annual inflation correction for retirees receiving an annuity.
- The calculations assume that all pension plan members enter the plan at age 20 and retire at age 60.

Figure 4.4. Increase in Actuarial Liabilities from Three-Year Increase in Longevity, by Discount Rate
(In percent)



Source: IMF staff estimates.
Note: Actuarial liabilities are projected benefit obligations of a model pension plan.

The calculations confirm that lower discount rates have significant effects on the size of longevity risk (Figure 4.4). With a discount rate of 6 percent, a three-year extension in average life expectancy increases liabilities by 8 percent in this example; with a discount rate of 2 percent, the same three-year shock increases liabilities by almost 14 percent.

Low interest rates therefore affect pension plans in two ways: by increasing their liabilities and by exposing them to higher longevity risk. In some countries liabilities of defined-benefit pension plans already exceed assets (leaving their funding ratios below 1), partly because of declining or low discount rates, which increase the present discounted value of liabilities.[18] The same discount effect applies to longevity risk, exacerbating the underfunding problem. In a sample of advanced economies, a three-

[15]For accounting purposes, the discount rate used in calculating pension liabilities is typically the yield on long-term high-quality domestic corporate bonds; for prudential regulation purposes, it is often the long-term government bond yield, which is currently around historical lows.

[16]For more information on technical details and assumptions, see Impavido (2011).

[17]Single-life refers to an annuity that does not include survivor benefits.

[18]See IMF (2011b) for the possible effects of protracted low interest rates on pension plans.

Box 4.5. Pension Reform in the Netherlands: Proactively Dealing with Longevity Risk

A recent agreement on pension reform in the Netherlands explicitly factors in longevity risk. The flexibility permitted by this agreement is exemplary, providing potential guidance to other countries facing similar longevity issues.

The Netherlands has a mandatory pension scheme for all employees based on the premise of full prefunding. Dutch pension funds have accumulated a large pool of assets, amounting to about 130 percent of GDP (OECD, 2011). Still, liabilities exceed assets, with the funding ratio falling below 100 percent recently. Several developments have contributed to this fall, including declines in asset prices since the start of the financial crisis, falling interest rates, and increases in life expectancy.

Longevity risk has contributed to the decline in funding ratios. In 2005, a new Financial Assessment Framework was introduced, later codified in the new Pension Act of 2007, mandating that pension funds not only use the latest mortality tables to calculate liabilities (which had been the practice), but also take into account the latest forecasts of future increases in longevity (which had previously not been included). This change had the effect of increasing aggregate liabilities of Dutch pension funds by some 5 to 6 percent. An update of future longevity assumptions in 2010 further increased liabilities by 7 percent, or €50 billion (8 percent of 2011 GDP; Stichting van de Arbeid, 2011). These large longevity shocks led to significant declines in funding ratios.

These developments prompted a discussion on pension reform in the Dutch Labor Foundation, a consultative body consisting of trade unions and employers' associations. In 2010, a Pension Accord was reached, recommending the following elements for reform:

- *Contribution stabilization.* The Accord recognized that a maximum limit had been reached on contribution rates by employers and employees. Contribution adjustments could no longer be part of the mechanism used to absorb changes in life expectancy or financial market shocks.
- *Marked-to-market assets and liabilities.* While the assets of Dutch pension funds have traditionally been marked-to-market, the liabilities had been discounted at the risk-free interest rate. A discussion is now ongoing about replacing this with the expected long-term return, allowing future liabilities to be discounted at a market-based rate. More realistic valuations will allow better management of the risks.
- *No unconditional nominal commitments.* Future pension benefits are explicitly conditional on the investment performance of the pension fund. Financial market shocks will be offset by reductions in benefits (for pensioners) or accrual rates (for active participants) aimed at returning the funding ratio to 100 percent over a 10-year period.
- *Adjustments for changes in longevity.* Pensions will be adjusted to relate the number of expected benefit years to the number of accrual (working) years, thus linking the effective retirement age to expected developments in longevity. In practice, the retirement age for private pensions will rise with that for the public old-age pension, to 66 in 2020, with further adjustments every 5 years in line with projected longevity.

The reform elements from the Pension Accord have been transmitted to the government as recommendations, to be codified and implemented in the period ahead. It is expected that these reforms will result in a pension system that is more robust to financial market and longevity shocks.

Note: Prepared by S. Erik Oppers.

year longevity shock could further reduce funding ratios by between 6 and 10 percent (Table 4.4). Moreover, low interest rates also lower the return on the fixed-income assets in the portfolio, making it more difficult for plans to earn their way out of the underfunding problems.

Mitigating Longevity Risk

Like any other risk faced by economic agents—such as interest rate or exchange rate risk—longevity risk should be recognized and addressed. On a global scale, *reducing* longevity risk would require reversing

Table 4.4. Corporate Pension Funding Ratios and Discount Rate Assumptions for Selected Countries
(In percent)

	Funding Ratio			Discount Rate	
	2006	2010	With Three-Year Longevity Shock[1]	2006	2010
Japan	70	62	55	2.0	1.5
United Kingdom	87	95	88	5.1	5.4
Netherlands	89	97	90	4.6	5.1
United States	89	85	79	5.8	5.4
Ireland	90	95	89	4.7	5.2
Canada	92	91	84	5.1	5.2
Switzerland	99	87	77	2.7	2.6

Sources: Towers Watson (2011); Watson Wyatt (2007); and IMF staff estimates.

Note: The funding ratios in this table are ratios of the current market value of plan assets to the plans' projected benefit obligations, which are based on a survey of accounting assumptions for corporate defined-benefit plans. Regulatory calculation requirements may differ from accounting assumptions, and funding ratios in this table may therefore differ from ones reported by regulators.

[1]Calculations assume projected benefit obligations increase by parameters derived from the model used in Figure 4.4. The discount rate for this calculation was 2 percent for Japan and Switzerland, and 6 percent for the others. Possible effects of a longevity shock on the plans' assets are not taken into account.

the current bias toward underestimating longevity. Given the uncertainties inherent in forecasting, however, it is likely that longevity risk will remain. To effectively deal with longevity risk, three types of approaches are required: (i) addressing government longevity exposure; (ii) risk sharing between governments, pension providers, and individuals (including across generations), coupled with an improved ability of individuals to self-insure against their individual longevity risk and attention to the sustainability of the old-age safety net; and (iii) market-based transfer of longevity risk to those that are better able to bear it.

One of the most effective offsets to longevity risk is individuals' human capital, their labor or entrepreneurial income. By linking the retirement age to expected future developments in longevity, longer working lives can offset longer life spans, essentially keeping the number of years in retirement (and thus financial retirement needs) fairly constant. Increases in the retirement age can be mandated by the government for its own retirement or old-age payments, reducing the liabilities of the government (and of private pension providers if they use the government retirement age as a benchmark). People have also been working longer spontaneously—without government intervention—as individuals choose to work longer in response to living longer healthy lives and when they realize they might live longer than previously expected. Additional years spent working can increase financial buffers of individuals, helping further to offset their individual longevity risk. The extra labor income would also generate additional tax revenue, offsetting some of the public sector's costs.

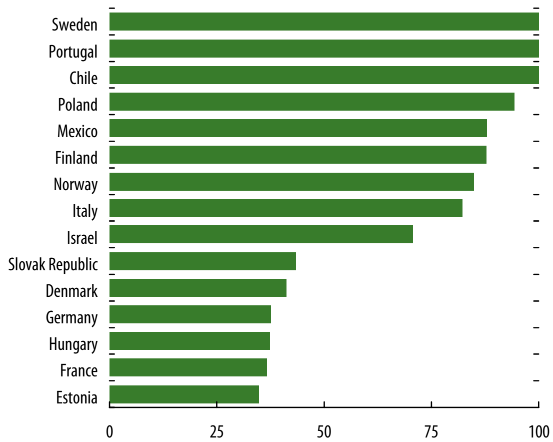
Addressing the Longevity Exposure of the Public Sector

Addressing the substantial longevity risk of the public sector will first require measuring the extent of its exposure. As in the case of the private sector, determining future contingent liabilities demands realistic estimates of future life spans for individuals covered by public pension plans and old-age social security schemes. In addition, it would be important to assess the extent of the contingent liability that governments hold because of possible insufficient retirement resources in the private sector.

The longevity risk could be partly quantified with a variety of longevity scenarios, possibly derived from the range of assumptions that are typically used in population forecasts. Such an analysis could effectively "stress test" the public finances regarding their exposure to longevity risk and their resilience to various shocks and outcomes. The exercise would be akin to the stress tests used by private financial institutions to determine their exposure and resilience to various types of financial and macroeconomic risks that affect their liquidity and solvency.

Mitigation of the identified risk would likely require a combination of policies. These could include

Figure 4.5. Index of Share of Pension Entitlements Linked to Life Expectancy in Selected Countries
(In percent)



Source: OECD (2011).
Note: Index includes links to life expectancy through defined-contribution plans.

risk sharing with individuals (see the section below) by adjusting the terms of pension plans and social security schemes (including reducing benefits, increasing contributions rates, and raising the statutory retirement age), and reducing debt in anticipation of potential longevity pressures. The main considerations for these adjustments are the sustainability of the public debt, the ability of public schemes to alleviate old-age poverty, the consequences for intergenerational equity, and transfers across income groups. Finally, like private holders of longevity risk, governments could also use the possibility of selling the risk in the capital markets (see the section on "Market-Based Transfer of Longevity Risk" below).

Only a few governments so far have taken steps to limit their exposure to longevity risk (Figure 4.5). Some countries have adjusted pension formulas to relate improvements in life expectancy to benefits (Finland, Germany, Japan, and Portugal) or to the retirement age (Denmark, France, and Italy), transferring some of the longevity risk to individuals. Some governments have instituted defined-contribution plans (Chile and Sweden). Governments could also consider increasing contribution rates to social security schemes.[19] Although such transfers could be an effective way to share the burden of aging and longevity risk, any measures need to be carefully designed to avoid overwhelming the retirement resources of individuals, in which case the risk would return to the government as the holder of last resort.

Risk Sharing across Sectors

Longevity risk is too large to be managed by any one sector of society. The solution therefore demands better risk sharing between the private business sector, the public sector, and the household sector (individuals). Much of the risk is now borne by pension providers and governments. Risk sharing could be promoted by having pension plans share longevity burdens with retirees through raising the retirement age, and increasing financial buffers for individuals to allow "self-insurance" against longevity risk.

More flexibility in the design of retirement income schemes would allow more effective burden sharing between pension providers and retirees, increasing the system's resilience to longevity shocks. Providers of pension income are already taking measures to shift some longevity risk to individuals, but national regulations differ as to the flexibility that plan sponsors have in this respect. Private and public pension providers should optimally have a variety of ways to cope with financial shortfalls as a result of unexpected increases in longevity and share the associated financial burden, including increasing the retirement age, increasing pension premiums, and reducing pensions, measures that are currently being discussed in the Netherlands.[20] Where flexibility is lacking (such as in the United Kingdom), plan sponsors are closing down defined-benefit plans and

[19]This is an option for countries that still have room for raising payroll contribution rates. In countries where the tax wedge—income and payroll taxes as a share of labor earnings—is already near or above 50 percent of total labor costs, raising contribution rates could have adverse labor market effects. Another option is to equalize the taxation of pensions and other forms of income—many advanced economies tax pensions at a lower rate, even though there is little justification for taxing pensions differently than other forms of income. Where increasing revenues is desirable, alternative revenue sources such as consumption taxes could also be considered, particularly to finance the redistributive components of pension systems.

[20]For annuities, rather than adjusting the pensionable age, Richter and Weber (2009) and Denuit, Haberman, and Renshaw (2011) discuss contracts that link payouts to longevity.

switching to defined-contribution schemes. Insurance companies are also taking longevity risk into account by charging higher premiums for annuities.

As pension providers shed aggregate longevity risk, individuals are increasingly exposed to their own individual longevity risk; to cope, individuals should delay their retirement and increase their financial buffers. Effective burden sharing requires increasing individual financial buffers for retirement, for example by mandating additional retirement savings or encouraging saving through tax policy. In order for these buffers to be available for retirement, financial stability and prudent investment strategies (with appropriate shares of "safe" assets—see Chapter 3) are key to avoid a situation where turmoil in financial markets would deplete buffers intended for retirement (as occurred recently in some countries that rely heavily on defined-contribution schemes, including the United States).

These buffers could then be used for self-insurance of households against longevity shocks without recourse to government resources, resulting in better burden sharing between households and the public sector. For instance, to avoid running out of resources before the end of life, households could be required to use a minimum portion of their retirement savings to buy an annuity contract, which guarantees a specific recurring payment until death. However, this annuitization should be well designed and well regulated to ensure consumers fully understand these contracts and to avoid the undue concentration of this risk among annuity sellers.

Few households purchase annuities, partly because annuities are not priced at actuarially fair levels for general populations (Dushi and Webb, 2006). Unattractive pricing is partly due to administrative costs and profit margins. In addition, those who expect to live longer than average are more apt to purchase annuity contracts—a form of adverse selection. Annuity companies take this selection bias into account in their pricing, which makes these products unattractive for the general public. To get around this problem, some governments have made annuitization compulsory—for example, the United Kingdom until recently, and Singapore in 2013 (Fong, Mitchell, and Koh, 2011). As an alternative, Piggott, Valdez, and Detzel (2005) have proposed that groups of retirees pool and self-annuitize to reduce adverse selection costs. Another option for elderly homeowners is to increase retirement income by consuming their home equity via reverse mortgages.[21]

Better education about retirement finances and about the concept of longevity risk are important if individuals are to increase their financial buffers for retirement and self-insure against longevity risk. Retirement finance is a complex subject, and although it is related to decisions about medical care and housing, it is often considered in isolation instead of holistically. Most households are probably unaware of the magnitude of the individual (idiosyncratic) longevity risk to which they are exposed, which make it less likely that they will be willing or able to self-insure against longevity risk. Improved education on these issues should therefore be part of a comprehensive plan of governments to address longevity risk.

Market-Based Transfer of Longevity Risk

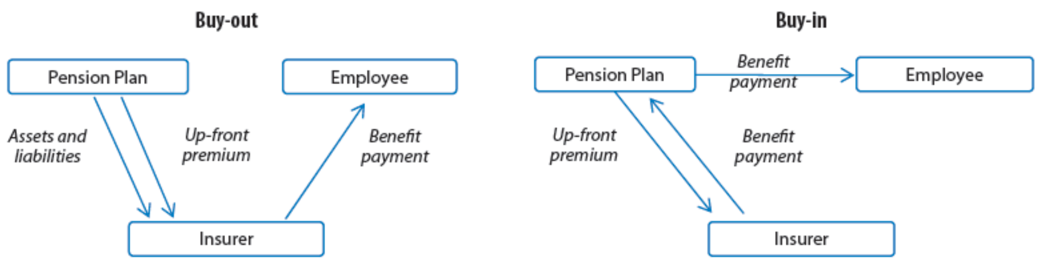
Further sharing of longevity risk could be achieved through market-based transfer of longevity risk to those better able to cope with its adverse financial consequences. In such a market, the "supply" of longevity risk would meet "demand" for that risk. That is, the risk would be transferred from those who hold it, including individuals, governments, and private providers of retirement income, to (re-)insurers, capital market participants, and private companies that might benefit from unexpected increases in longevity (providers of long-term care and health care, for example).[22] In theory, the price of longevity risk would adjust to a level at which the risk would be optimally spread through market transactions.[23]

[21]In a reverse mortgage the lender advances payments to the borrower. The loan continues to accrue interest and is settled using the proceeds from selling the property when the borrower dies.

[22]Reinsurers purchase (for a premium payment) blocks of insurance contracts from insurance companies looking to manage their risk exposures. Subject to any agreed-to conditions, the reinsurer then becomes responsible for paying any claims on the underlying insurance policies.

[23]Risk transfer would be beneficial to financial stability even for aggregate longevity risk. The benefit does not result from diversification—the aggregate risk cannot be diversified away—but from shifting the risk to those that are better able to handle its financial consequences.

Figure 4.6. Structure of Pension Buy-Out and Buy-In Transactions



Simply designed, over-the-counter (OTC) bilateral contracts and longevity bonds are the two principal instruments through which longevity risk can be transferred. The bilateral solutions include pension buy-outs and buy-ins, swaps, and other derivative contracts.[24]

Bilateral Contracts

Buy-ins and buy-outs are simple transactions accomplishing risk transfer, but each has different implications for the sponsor. In a buy-out transaction all of the pension fund's assets and liabilities are transferred to an insurer for an up-front premium (Figure 4.6). The pension liabilities and their offsetting assets are removed from the pension fund sponsor's balance sheet and the insurer takes over full responsibility for making payments to pensioners. In a buy-in, the sponsor pays an up-front premium to the insurer, who then makes periodic payments to the pension fund sponsor equal to those made by the sponsor to its members. This "insurance policy" is held as an asset by the pension plan; the premium is the cost of the insurance policy that guarantees payments even if retirees live longer than expected.

In another type of bilateral transaction, the longevity swap, the pension fund obtains a similar protection from higher-than-expected pension payouts. The plan sponsor makes periodic fixed "premium" payments to the swap counterparty, which in turn makes periodic payments that are based on the difference between the actual and expected benefit payments (Figure 4.7). The sponsor maintains full responsibility for making benefit payments to its employees. An advantage of buy-ins and swaps is that they can be used to hedge the longevity risk associated with specific subsets of the underlying population. An advantage of swaps is that longevity risk can be isolated, whereas buy-in and buy-out transactions typically also transfer the investment risk of the assets. Longevity swaps can also be combined with other types of derivative contracts, such as inflation, interest rate, and total return swaps, to create so-called "synthetic" buy-ins that transfer all of the risks.

Longevity Bonds

The payout on a longevity bond would depend on an index that tracks the longevity experience of a given population (Figure 4.8). The periodic payment (or coupon) on a longevity bond would be proportional to the number of survivors in the population. Therefore, the issuer of the bond (an investment bank or insurance company) pays more to the owner of the bond (the pension fund sponsor) when longevity is higher. The owner of the bond could thus use the periodic payments from the bond to offset any higher-than-expected payments to retirees. Because investors can offset some of their longevity risk with this bond, the interest rate they demand for holding it may be lower than for regular bonds. One disadvantage is that, unlike a swap, the owner of the bond

[24]Longevity risk can also be transferred to capital markets via "life settlement" securitizations. A life settlement occurs when the owner of a life insurance policy sells the policy for an amount below the face value of the policy (i.e., the amount paid when the policyholder dies). The purchaser becomes responsible for making premium payments in return for collecting death benefits. Although life settlement volumes have been growing recently, they have not reached the point at which securitization becomes viable on a large scale. Life settlements are akin to viatical settlements (see Box 4.3).

Figure 4.7. Structure of Longevity Swap Transactions

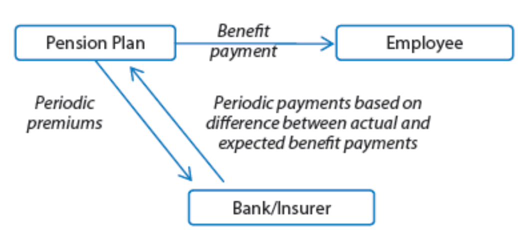


Figure 4.8. Structure of Longevity Bond Transaction

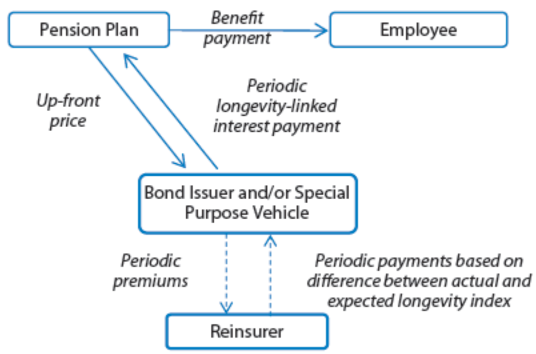
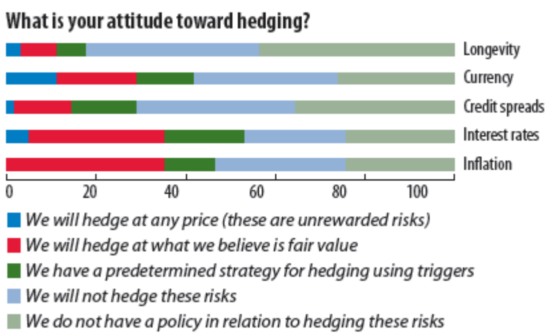
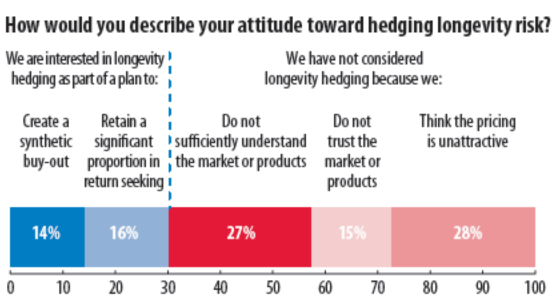


Figure 4.9. Attitudes of Pension Plan Sponsors toward Hedging Pension Risk, by Type of Risk
(In percent of respondents)



Source: Aon Hewitt (2011).

Figure 4.10. Attitudes of Potential Sellers of Longevity Risk toward Hedging
(In percent of respondents)



Source: Aon Hewitt (2011).

must make a large up-front payment to the issuer, resulting in counterparty risk exposure to the issuer. To date, there has been no successful longevity bond issuance, although there have been several false starts.

Challenges for the Risk Transfer Market

The use of capital market-based longevity risk management solutions has been growing, but their use remains small, with the notable exception of the swap, buy-in, and buy-out markets in the United Kingdom and the Netherlands (Box 4.6). Explanations for the slow growth include challenges on the sell and buy sides, as well as market infrastructure issues affecting both sides of the transaction.

For those that are "selling" (that is, trying to reduce) their longevity risk, a major reason for a limited market for longevity risk transfer is that only a few pension plan sponsors recognize longevity risk at all, and fewer still have plans to address it. Longevity risk is seen as less important to hedge than other financial risks (Figure 4.9). It is also considered to be dominated by the higher volatility of asset valuations and liability discount rates, which may mask the slower-moving effects of increases in life expectancy. In addition, many plan sponsors would have to first recognize and remedy existing underfunding before transferring their longevity risk, making risk transfer an "expensive" exercise. Also hindering the transfer market is a degree of moral hazard, in which pension providers may expect a government bailout if a significant longevity event threatens their financial viability.

Lack of familiarity with the market for longevity risk is another impediment. That lack of familiarity was shown in a recent survey (Aon Hewitt, 2011), which suggested that potential sellers of longevity risk (i) lacked an understanding of the market, (ii) lacked trust in longevity products, and (iii) considered pricing to be unattractive (Figure 4.10).

Another concern for sellers of longevity risk is basis risk. In this context, basis risk exists because the payout in a risk transfer deal is typically linked to an index that is based on the longevity experience of a sample population, whereas actual payouts depend on the actual pool of retirees of the pension provider.[25]

[25]Basis risk can be large, caused by differences in life expectancy at age 65 depending on gender, employment history, income, and geographic location. For example, for a higher-income female in

Box 4.6. Recent Activity in the Dutch and U.K. Buy-Out, Buy-In, and Longevity Swap Markets

This box provides an overview of recent activity in the longevity risk transfer market in the Netherlands and the United Kingdom.

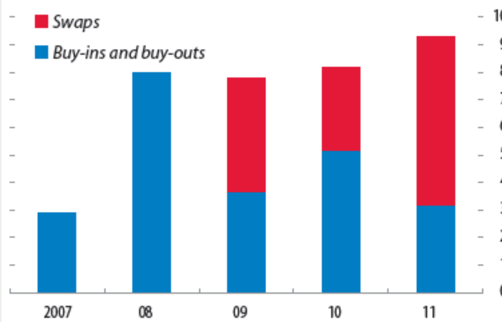
Transactions by defined-benefit pension funds in the United Kingdom to transfer their longevity risk averaged about £8 billion per year in the period 2008–10 and rose to about £9 billion in 2011 (see Figure 4.6.1). About half have been longevity swaps, with investment banks increasing their activity in this market starting in 2008 as buyers or intermediaries. Almost all of the largest transactions (greater than £1 billion) are swaps, with buy-outs being used primarily for smaller funds (less than £500 million). There have been a number of small transactions in the Netherlands over the last few years, and a €12 billion longevity swap between Aegon and Deutsche Bank in early 2012 (Steinglass and Wilson, 2012).

The different risk-transfer solutions are associated with particular types of counterparties (see Figure 4.6.2). U.K. insurers regulated by the Financial Services Authority are associated with all of the buy-in and buy-out activity, whereas almost all of the longevity swap transactions have been made by investment banks. In turn, insurers and banks have passed some of this risk to reinsurers via swap contracts. So far, none of the risk has been passed on to capital markets, although some longevity bond transactions may be in the works.

Despite numerous buy-out, buy-in and swap transactions (see Table 4.6.1 for the largest), to date no longevity bonds have been issued. The European Investment Bank tried to issue a longevity bond in 2004, but it was cancelled due to lack of interest on both the buy and sell sides (Biffis and Blake, 2009). The World Bank's attempt in 2010 also did not succeed (Zelenko, 2011). The experience with longevity bonds contrasts with the much more active market for "mortality" bonds, which transfer medium-term (three- to five-year) risk associated with catastrophic mortality events such as pandemics.

Note: Prepared by John Kiff.

Figure 4.6.1. U.K. Longevity Risk Transfers, by Type of Transfer
(In billions of pounds sterling)



Sources: Hymans Robertson; and IMF staff estimates.

Figure 4.6.2. Structure of Longevity Transfers by U.K. Defined-Benefit Pension Plans, by Type of Counterparty

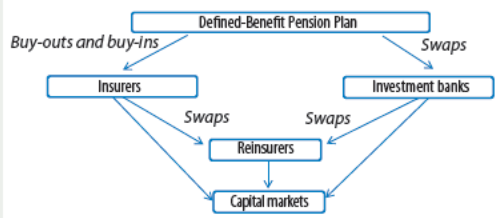


Table 4.6.1. Largest Longevity Risk Transfers by U.K. Pension Plans

Pension Plan	Provider	Deal Type	Value (In billions of pounds sterling)	Date
Rolls Royce	Deutsche Bank	Swap	3.0	November 2011
RSA Insurance	Rothesay Life[1]	Swap	1.9	July 2009
ITV	Credit Suisse	Swap	1.7	August 2011
British Airways	Rothesay Life[1]	Buy-in[2]	1.3	June 2010
British Airways	Rothesay Life[1]	Swap	1.3	December 2011
Babcock	Credit Suisse	Swap	1.2	July 2010
Thorne	Pension Corporation	Buy-out	1.1	December 2008
Turner & Newall	Legal & General	Buy-in	1.1	October 2011
Cable & Wireless	Prudential (U.K.)	Buy-in	1.0	September 2008
Pilkington	Legal & General	Swap	1.0	January 2012

Source: Hymans Robertson.
[1]An insurance subsidiary of Goldman Sachs.
[2]Synthetic buy-In (longevity swap plus asset swap).

The small size of the longevity risk market is due in part to a dearth of buyers of longevity risk relative to its potential sellers. Since global longevity risk is large and many individuals and institutions (including governments) are already exposed, there are few natural buyers for this risk.

Reinsurers and insurers exposed to life insurance risk are one class of natural buyers, as the acquisition of longevity risk may provide a partial hedge for their insurance exposure. This is because the two risks largely offset each other—life annuity liabilities increase when annuitants live longer, whereas life insurance liabilities decrease.[26] However, reinsurer capacity to take on longevity risk may already be approaching the limit (which market participants estimate at approximately $15 billion per year), so a broader investment base is needed to match the large potential seller volume. Other natural buyers might include those companies that would benefit from having people living longer, including firms in the health care, home-care, and pharmaceutical industries.[27] As this risk gets transferred to capital market participants outside the regulated perimeter, supervisors need to remain vigilant to ensure that final recipients understand the risks they take on and can manage them appropriately.

A relatively untapped pool of potential buyers of longevity risk consists of asset managers, sovereign wealth funds, and hedge funds. Asset managers and sovereign wealth funds may be encouraged by the fact that longevity risk is likely to be largely uncorrelated to the other risk factors in their portfolio.[28] However, hedge funds may be put off by the long duration of the contracts, which may make them inappropriate for most hedge fund's investment styles. A solution to the duration problem could be the Deutsche Börse's longevity swaps based on their XPect® family of longevity indices.[29] These swaps settle based on changes in expected life curves over shorter time periods.

Buyers of longevity risk may be discouraged by the illiquidity of instruments and by asymmetric information. Sellers of longevity risk would tend to seek customized hedge contracts to maximize the effectiveness of risk transfer, whereas many buyers of this risk would likely look for standardized instruments to maximize liquidity. This fundamental difference in perspective complicates the development of an active market. More standardized products would improve liquidity for buyers, but would also increase basis risk for sellers, because standardization will likely increase the demographic differences between the actual pool of retirees and the reference pool on which payments are based. In addition, the asymmetry of information in risk transfer deals disadvantages buyers, which can lead to mispricing in markets. For example, a pension fund may know more than risk buyers about the health of its retirees. Therefore, only those pension funds with the longest-living populations may want to hedge the risk.

Both buyers and sellers of longevity risk face counterparty risk. Longevity deals tend to be long-term contracts in which the counterparty may fail to honor its financial commitments over time. Such counterparty risk is usually addressed with collateralization, which can involve significant costs because it requires that the proceeds be invested in high-quality liquid securities that may be in short supply (see Chapter 3). This consideration favors derivative contracts, such as longevity swaps, which require the collateralization of only the net payments, which is

the southeast of England life expectancy at 65 is approximately 22 years, whereas for a low-income male living in the north it is just under 13 years (Byrne and Harrison, 2005). Recent research has proposed index-based hedge methodologies to reduce such basis risk to acceptably low levels (Coughlan and others, 2011; and Li and Hardy, 2011).

[26]Cox and Lin (2007) and Dowd and others (2006) discuss the role that derivative contracts (mortality/survivor swaps) can play in such hedging. Mortality risk can be used in part to hedge longevity risk, but the risk reduction may be lower than expected because mortality risk contracts are short term in nature (typically one- to five-year maturity) with a large exceptional element (e.g., pandemic risk), while longevity risk is a longer-term risk (typically 20- to 80-year horizon) and reflects largely unanticipated changes in trend.

[27]There are fewer prospects for swapping risk between countries with different demographics. Developing and advanced economies have different levels of longevity, but they probably do not want to buy each other's longevity *risk*. What matters in trading longevity risk across countries is not the difference in longevity levels per se, but the degree to which they are correlated. It is likely that the correlations across countries are increasing, making such an investment unattractive.

[28]However, the value of instruments for transferring longevity risk is correlated with interest rate levels via their role in the present value discounting of future payouts, so the lack-of-correlation rationale may be weaker than expected.

[29]The monthly XPect® indices are based on data from Germany, the Netherlands, and the United Kingdom. They track a number of male and female cohorts defined by birth dates (1900–19, 1920–39, 1940–59, 1960–79, and 1980–99).

the difference between what each swap participant owes the other.[30]

Finally, both sides of the market are also affected by a lack of reliable and sufficiently detailed information about longevity developments. Life tables are not updated frequently and are only available for relatively aggregated groups in the population. Sophisticated longevity risk management and transfer would benefit from much more disaggregated demographic data (including, for example, by postal code and cause of death), which can reduce basis risk; indexes of such data would facilitate the design and trading of longevity risk transfer instruments. Index-based transactions may also lessen the problem of asymmetric information.

The Role of Government

Government may be able to facilitate the private sector in developing an efficient market for the transfer of longevity risk. A thriving market in longevity risk would transfer this risk to those that can better bear it, promoting financial stability, a clear public good. The government can promote this market through a number of measures, including:

- *Providing more detailed longevity data.* The lack of detailed longevity and related demographic data is a major constraint facing the longevity risk market. Governments are best placed to provide such data, perhaps through national statistics offices or government actuaries.[31] Essential data would include longevity information that is disaggregated by geographic area, as well as by gender, socioeconomic status, cause of death, and occupation. The government could also usefully track the emergence and evolution of new diseases, especially those afflicting the elderly (such as Alzheimer's disease), medical advances (such as new diagnostics and treatments, and genetic advances), and lifestyle changes (such as smoking and obesity rates).
- *Enhancing regulation and supervision.* Governments could provide tighter regulation to promote the recognition and mitigation of longevity risk, including through stricter funding requirements and enhanced accounting transparency for pension funds and insurance companies. Indeed, pension regulations requiring the mitigation of financial risks could be expanded to include longevity risk.
- *Improving the education of market participants.* Surveys suggest that market participants are generally unaware of longevity risk. There is a role for government to promote awareness of the importance of addressing longevity risk similarly to other financial risks. Pension supervisors are well placed to take on this task. In addition, in some countries, households are provided with periodic estimates of their pension resources to sensitize them to potential shortfalls.

Some market participants have suggested that there is also a role for the government in jumpstarting the market for longevity bonds, but it is not clear what market failure governments could correct. Government-issued bonds would provide benchmarks and liquidity to the market, and some say that once the market is established, the government could reduce its issuance and let the private sector take over (Blake, Boardman, and Cairns, 2010). However, unless tied to rising retirement ages, issuance of longevity bonds would expose governments to additional longevity risk. It is not clear that the advantages of jumpstarting the market outweigh the costs, although estimates of net gains are difficult to measure. Some liken the issuance of longevity bonds to that of inflation-indexed bonds that helped that market thrive.

Conclusions and Policy Considerations

Longevity risk is large and affects all of society. If everyone in 2050 lived just three years longer than now expected—in line with the average underestimation of longevity in the past—society would need extra resources equal to 1 to 2 percent of GDP per

[30]Biffis and others (2011) show that the cost of collateral to secure longevity swaps can be quite reasonable, especially when counterparty default risk and collateral rules are symmetric.

[31]The private sector also has a role in providing better data. The Life and Longevity Markets Association is a nonprofit group of several investment banks, insurers, and reinsurers interested in facilitating the structuring of longevity risk transfer deals. It is pushing for the development of a more standardized and liquid index-based longevity risk market. The group is setting up standardized term sheets and pricing methodologies for swap transactions and pushing for the production of detailed and frequently updated life tables. Efforts of individual companies (including Credit Suisse in 2006, Goldman Sachs in 2007, and JP Morgan in 2007) to develop indexes have been met with skepticism by market participants, who doubt the independence of their calculations.

year. If this longevity shock occurred today and society wanted to save to pay for these extra resources for the next 40 years (that is, fully fund these additional "pension liabilities"), advanced economies would have to set aside about 50 percent of 2010 GDP, and emerging economies would need about 25 percent of 2010 GDP—a sum totaling tens of trillions of dollars. As such, longevity risk potentially adds one-half to the vast costs of aging up to the year 2050—and aging costs themselves are not fully recognized in most long-term fiscal plans.

Private pension providers and governments are particularly exposed to longevity risk and this risk is greatly increased in the current low-interest-rate environment. In line with other estimates in the literature, the analysis in this chapter finds that the liabilities of U.S. pension plans would rise by 9 percent for a three-year increase in longevity. Governments may be even more exposed: many not only sponsor defined-benefit pension plans for their employees, but maintain extensive old-age social security systems covering most of the population. In addition, the government is likely liable for the "tail" of longevity risk: in the case of a longevity shock affecting the entire population, the private sector would likely be overwhelmed by the financial consequences. In that case, the losses are likely to be assumed by the government in some way, including through pension fund guarantee schemes that take on the pension liabilities of failing institutions and social security schemes that aim to prevent old age poverty.

Longevity risk is generally not well recognized, although this is slowly improving. Until recently, few pension plans or governments explicitly recognized the existence of longevity risk, and even fewer prepare for or mitigate it. Even if updated mortality tables were used, adequate provisions for future mortality improvements were often not being applied. Regulations tend not to emphasize longevity risk and supervisors may themselves not be fully aware of the extent of longevity risk faced by pension providers. Few governments have assessed the longevity risk present in public pension plans and social security systems. In the past few years, more pension plans and insurers have started to pay attention to longevity risk, especially in the United Kingdom and the Netherlands, and the market for risk transfer has developed some activity, although representing just a fraction of the existing risk.

Longevity risk affects financial stability by threatening fiscal sustainability and weakening private sector balance sheets, adding to existing vulnerabilities in the current environment. Although longevity risk is a slow-burning issue, it increases the vulnerability of the public and private sectors to various other shocks. The risk is therefore perhaps not immediate, but the longer these vulnerabilities are allowed to build up, the more likely it is that there will be large adjustments in the future.

Policy Recommendations

- Governments should acknowledge the existence of longevity risk in their balance sheets as contingent liabilities and ensure that it does not threaten the sustainability of the public finances. A credible and realistic plan to deal with longevity risk can help restore confidence in the long-term sustainability of the public finances. A first-best policy would be to link the eligibility age for public pensions to actual developments in longevity (thereby responding to longevity risk events as they materialize and holding constant the duration of retirement), preferably through automatic or formula-based periodic adjustments to avoid recurring public debate about the issue. In countries where higher taxation is unlikely to affect labor supply much, this policy could be complemented by increases in contribution rates. Reducing benefits, though perhaps most difficult politically, is a third way of coping with the issue.
- Given the magnitude of longevity risk, risk sharing between businesses, the government, and individuals will help alleviate pressures on any one sector. The government could promote risk sharing in several ways. It could increase the ability of pension providers to share shortfalls with plan participants. The government could promote increased financial buffers for individuals, for example by promoting retirement products that take account of possible future increases in longevity. Individuals could then share the burden of longevity risk by self-insuring against longevity risk to some extent. This would require better education on retirement finance

and improved awareness by individuals of longevity risk. Because individuals would turn to public resources if they run out of retirement resources, the government is a natural provider of such education and of regular updates on estimated personal retirement resources.

- Although the private sector will further develop market-based transfer mechanisms for longevity risk if it recognizes the benefits of doing so, the government has a potential role in supporting this market. Measures could include provision of better longevity data, better regulation and supervision, and education to promote awareness of longevity risk. Those governments that are able to limit their own longevity risk could consider issuing a limited quantity of longevity bonds to jumpstart the market.
- Full recognition and effective mitigation of longevity risk requires improvements in data availability and transparency. Public or private development of longevity indexes and more diverse population-specific mortality tables would facilitate assessment of longevity risk and its transfer. The credibility of these data would be enhanced if they were compiled by government statistical offices or independent industry associations acting at arm's length from the market.
- Regulation and supervision of institutions exposed to longevity risk should be improved. Insurance companies and defined-benefit pension plans should have to deal with longevity risk just as they must manage other financial risks, such as interest rate risk and inflation risk. Doing so would require at least an annual assessment using the most up-to-date mortality tables, conservative assumptions for future mortality improvements, and the use of appropriate discounting factors, all enforced by appropriately strengthened accounting rules. Recognition of underfunding by pension plans and their sponsors is key; they need realistic plans to achieve full funding over a reasonable period, because longevity risk can be transferred more easily once a plan is fully funded.

In sum, better recognition and mitigation of longevity risk should be undertaken now, including through risk sharing between individuals, pension providers, and the public sector, and through the development of a liquid longevity risk transfer market. Longevity risk is already on the doorstep and effectively addressing it will become more difficult the longer remedial action is delayed. Much of the apprehension surrounding fiscal sustainability relates to the apparent inability to address structural fiscal issues in the affected countries. Attention to population aging—and, *a fortiori,* the additional risk of longevity—is part of the set of reforms needed to rebuild confidence in the viability of sovereign balance sheets.

Annex 4.1. The Impact of Longevity Risk on U.S. Defined-Benefit Plans

This annex describes an empirical measure of the impact of longevity risk on defined-benefit pension plan liabilities. The analysis uses actuarial and financial data from U.S. corporate pension funds, which plan sponsors are required to submit annually to the U.S. Department of Labor on the department's Form 5500. The data used here cover the period 1995–2007.[32] As of 2007, the total amount of U.S. defined-benefit pension liabilities equaled approximately $2.2 trillion and covered more than 42 million plan participants.

When computing the present value of future pension obligations, corporations have to make and report several actuarial assumptions, including the discount rate they apply and the mortality tables underlying the computations of the expected length of future payout streams. The data show that there is a substantial level of variation in the use of mortality tables across funds and over time. This variation can be used in a regression analysis to estimate the impact of an additional year of life expectancy on the present value of pension liabilities.

Regression Specification

The regression specification is based on the idea that defined-benefit pensions can be modeled as an annuity; that is, a specified regular payment for the remainder of life. Following de Witt (1671) it is known that the present value of a pension liability (L) is given by

$$L = pb \sum_{i=1}^{T} \frac{(1 - s_i)}{(1 + r)^i} \qquad (4.1)$$

where p is the number of plan participants, T is the assumed maximum life span, s_i denotes the survival probability over i periods, b is the promised amount of periodical payouts, and r denotes the discount rate.[33] Due to data limitations, we will proxy for the valuation equation by using

$$L \approx pb \left[\frac{(1 - (1 + r)^{-n}}{r} \right] \qquad (4.2)$$

where n is the expected number of future payouts.[34] Rearranging terms and taking the logarithm, it follows that

$$\log(L) \approx \log(p) + \log(b) - \log(r) + \log[(1 + r)^n - 1] - n\log(1 + r) \qquad (4.3)$$

Linearizing the two last terms of equation (4.3), we obtain

$$\log(L) = \alpha + \beta_1 \log(p) + \beta_2 \log(b) + \beta_3 \log(r) + \beta_4 n + \beta_5 \log(r)n + e \qquad (4.4)$$

which can be estimated in a panel regression, accounting for plan-specific effects. The main interest is in the coefficient β_4, which is the effect of one additional year of life expectancy on the present value of pension liabilities.

Results

The impact of longevity assumptions on pension liabilities is estimated using the simple pension valuation model of equation (4.4) with the Form 5500 data and focusing on only those participants who are already receiving the "annuity," namely, retired plan participants. Table 4.5 summarizes the results.

Note: Prepared by Michael Kisser.

[32]The required level of detail differs depending on whether a plan is classified as small or large and on the type of plan (welfare plans, pension plans, common trusts, and so on). A plan is generally classified as large if it has more than 100 participants. The starting point for the coverage period was determined by the fact that information regarding the underlying mortality tables used in actuarial computations became available in 1995. The final year of the period, 2007, is the most recent for which Form 5500 data have been published.

[33]In reality, the promised periodic payment, b, would differ across employees. However, using the average payment across employees leads to a similar valuation.

[34]Note that the life expectancy is equal to the sum of the individual survival probabilities. The valuations presented in equations (4.1) and (4.2) will be exactly equal to each other when the discount rate, r, equals zero. If we assume that r is low (as in the current macroeconomic environment) then the approximation is reasonable.

Table 4.5. The Impact of Longevity Risk on Pension Liabilities

	Coefficient
log (discount rate)	–0.945***
log (participants)	0.914***
log (benefit)	0.519***
Longevity	0.03***
Observations	89552
R-squared	0.742

Source: IMF staff calculations.

Note: The initial estimation of equation (4.4) included the interaction term between longevity and log(discount rate), as specified. However, the high correlation between longevity, log(discount rate), and the interaction term rendered all three variables statistically insignificant in this specification. Subsequently, the interaction term was excluded; these results are reported in the table. *** $p < 0.001$.

The regression explains 74 percent of the variation in (the logarithm of) pension liabilities and shows that an additional year of life expectancy at age 63 increases pension liabilities by approximately 3 percent.[35]

[35]A substantial number of pension plans do not specify the actuarial table used, which potentially biases the results. However, if all those plans are assumed to use the latest table (the strongest assumption possible), the results of the regression are substantially the same.

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