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Working Party on Private Pensions

Mortality assumptions and longevity risk

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MORTALITY ASSUMPTIONS AND LONGEVITY RISK

TABLE OF CONTENTS

MORTALITY ASSUMPTIONS AND LONGEVITY RISK ................................................................. 3

I. Introduction: Longevity risk ......................................................................................... 4
II. How do pension funds, annuity providers and the regulatory framework account for future improvements in mortality and life expectancy? ................................................................. 5
   Regulatory Requirements .......................................................................................... 7
   Market Practice ....................................................................................................... 7
   Accounting for future improvements in mortality ..................................................... 8
III. Are assumptions used by pension funds and annuity providers in line with future expectations regarding improvement in mortality and life expectancy? ............................................... 8
   Methodology .......................................................................................................... 9
   Mortality projection models ..................................................................................... 9
   Basis of the Calculations and Comparison .............................................................. 10
   Interpretation of Results ....................................................................................... 11
   Assessment of results ............................................................................................. 12
   Overview of population life expectancy ................................................................ 12
   Results for pension funds and annuity providers ................................................... 14
IV. How to manage longevity risk ................................................................................ 17
   The importance of using mortality tables which adequately reflect current and future expectations of mortality .......................................................... 18
   Assessing the potential impact of unexpected improvements in life expectancy ...... 20
   The potential role that regulation can play in encouraging the management of longevity risk .......................................................... 22
   The need for financial instruments to enable pension funds and annuity providers to mitigate longevity risk .......................................................... 23
V. Concluding Remarks ................................................................................................. 27

Tables

Table 1. Regulatory mortality tables incorporating future improvements in mortality and life expectancy 6
Table 2. Evolution of the gender gap ........................................................................... 14
Table 3. Classification of countries by longevity risk ................................................... 15
Table 4. Financial impact of unexpected improvements in life expectancy at the 95% level of confidence as a percentage of pension liabilities ......................................................... 21

Figures

Figure 1. Illustration of mortality adjustment and projections ...................................... 11
Figure 2. Male population life expectancy at age 65 ................................................... 13
Figure 3. Female population life expectancy at age 65 ............................................. 13
Figure 4. Expected annuity payments using different mortality assumptions ............ 18
MORTALITY ASSUMPTIONS AND LONGEVITY RISK

1. This report presents the results of the OECD project on mortality assumptions and longevity risk. The project first aims to assess how pension funds and annuity providers (i.e. insurance companies) account and provision for future improvements in mortality and life expectancy. It then examines whether the mortality assumptions used by pension funds and annuity providers are insufficient and would then expose them to longevity risk. In that case, it would expose them to a potential shortfall in the funds which are reserved in order to meet future pension and annuity payments. As the report will show, the mortality assumptions used by entities often do not account sufficiently for expected mortality improvements, exposing them to additional longevity risk. The report then discusses the different options to manage the longevity risk coming from potential increases in life expectancy beyond current expectations. The report concludes with a set of recommendations to address the problems posed by longevity risk and manage the uncertainty surrounding future improvements in mortality and life expectancy.

2. The analysis looks first at the mortality tables typically used by pension funds and annuity providers to provision to meet future expected pension and annuity payments. These can be specific tables required by the regulatory framework or those most commonly used by the industry. The study then assesses whether these standard mortality tables include future improvements in mortality and life expectancy and looks at how those future improvements are included.

3. The project then examines the extent to which the assumptions included in the standard mortality tables expose pension funds and annuity providers to longevity risk. Longevity risk is the risk that future mortality and life expectancy outcomes prove to be different than assumed and reflected in provisions. Inaccurate or unreasonable assumptions can result in serious challenges for pension funds and annuity providers to keep pension and payment promises. The study assesses whether the assumptions for future improvements in mortality and life expectancy embedded in the standard mortality tables used are sufficient to account for the expected increase in longevity of pensioners and annuitants by benchmarking the assumed evolution in mortality with that which is predicted by four well-known models for projecting future mortality. The results shows that pension funds and annuity providers are indeed exposed to longevity risk and that the degree of exposure can in some cases be quite large.

4. The report then discusses the different approaches to manage and mitigate the potential impact of longevity risk. Based on these discussions a set of policy recommendations is put forth to highlight best practices in accounting and provisioning for future improvements in mortality and life expectancy as well as encouraging the management of longevity risk.


2. The study assesses sixteen countries: Brazil, Canada, Chile, China, France, Germany, Israel, Korea, Japan, Mexico, the Netherlands, Peru, Spain, Switzerland, the United States and the United Kingdom.

3. This discussion draws from previous documents discussed at the CMF (DAF/CMF(2012)4) and WPPP (DAF/AS/PEN/WD(2012)2).

4. The Joint Forum recently published a paper in December 2013 which also addresses the issues surrounding the management of longevity risk, and puts forth recommendations regarding the development of the longevity market. The recommendations offered by this document are not incompatible or contradictory. Indeed, the recommendations included here often elaborate in more detail on the issues raised by the Joint Forum paper.
I. Introduction: Longevity risk

5. Longevity risk is the risk that people live longer than expected or provisioned for. While longer lives are generally positive, living longer can also have significant financial implications, enough to qualify longevity as a major risk. At the individual level, this risk is generally taken to mean outliving one’s retirement savings. But pension plan sponsors, pension funds and annuity providers are all exposed to longevity risk as well, as they are in the business of funding individuals’ retirement and often promise to make payments for the lifetime of the individual. In other words, they accept and insure the longevity risk of the individual.

6. Plan sponsors, pension funds and annuity providers with liabilities contingent on longevity need to set aside reserves or funds in order to meet their future payment obligations. The amount necessary is driven by two main factors: the return on the assets accumulated and how long the payments will be made. Analogous to a discount rate being assumed to account for the expected accumulation of assets, mortality rates must also be assumed to determine how long payments are expected to be made, as payments are usually paid until the death of the individual. If the individual lives longer than expected, more payments will have to be made than may have been provisioned for, which could leave the pension fund or annuity provider with insufficient funds to do so.

7. The uncertainty about mortality rates, and the potential shortfall in pension or annuity provisions from underestimating life expectancy, stem largely from the uncertainty as to how mortality will evolve and the future improvements in mortality rates. Globally, life expectancy at birth has more than doubled over the last two centuries. For the countries examined in this paper, life expectancy for individuals aged 65 has increased by an average of nearly two months per year over the last decade. Each additional year of life expectancy not provisioned for can be expected to add around 3-5% to current liabilities. Thus the improvements in mortality cannot be ignored when establishing the mortality assumptions which determine how long pension and annuity payments are expected to be made.

8. Nonetheless, mortality assumptions used to value pension and annuity liabilities are not always given the due attention they deserve. Regulation does not consistently acknowledge the need to account for improvements in mortality, and though in practice pension sponsors and annuity providers often do provision for these improvements, this is not always the case and assumptions can sometimes be out of date and not reflective of recent mortality experience. Policy must ensure that mortality assumptions adequately reflect the mortality of the population for which they are used and encourage active assessment and monitoring of longevity assumptions by pension funds and annuity providers in order to avoid the unexpected increases in future payments related to underestimating longevity.

9. Awareness of the continuing improvement in mortality has been increasing, however, and with this increased awareness has come the need to manage and mitigate the exposure to the underlying longevity risk. The regulatory framework must support the effective management of longevity risk, as otherwise the sustainability of pension funds and annuity providers will be threatened and the income received and relied upon by pensioners and annuitants will be put at risk. In order to do so, mechanisms to hedge and mitigate the longevity risk from unexpected increases in life expectancy could be helpful, and regulation needs to enable the effectiveness of these mechanisms.

10. The analysis herein shows a potential shortfall of provisions for future annuity and pension payments in several of the countries examined, based on the expected evolution and improvement in

5. Mortality and life expectancy are two sides of the same coin. Decreasing mortality rates directly imply that people are living longer on average, and therefore that life expectancy is increasing.

6. Based on the analysis in Section 3.
mortality and life expectancy. The magnitude of this potential shortfall confirms the need for regular monitoring of mortality experience and updating of mortality assumptions accordingly. While countries failing to account for increasing longevity in their regulatory and market tables are also those who face the most significant potential shortfall in liabilities, even countries where improvements are assumed but not sufficiently reflective of recent experience could find that they, too, are exposed to a moderate to significant shortfall in reserves for pension or annuity liabilities.

Issues for discussion:

- Delegates are invited to verify the accuracy of the details of regulation and market practice provided for each country.

- Delegates are invited to ensure the appropriateness of the methodology used here for the quantification of longevity risk as applied to mortality assumptions for their respective jurisdiction. Additional information such as updated mortality experience to improve accuracy would be greatly appreciated.

- Do delegates object to the recommendations regarding managing longevity risk contained in this report?

- Could delegates identify any specific barriers or impediments in the existing regulatory framework to implement this report’s recommendations?

II. How do pension funds, annuity providers and the regulatory framework account for future improvements in mortality and life expectancy?

11. This section examines the mortality tables commonly used by pension funds and annuity providers to provision for future improvements in mortality and life expectancy. It looks at whether these standard tables include future improvements in mortality and life expectancy and how those improvements are incorporated. The regulatory framework can require specific mortality tables to be used. These tables specify minimum mortality assumptions and may or may not account for future improvements in mortality and life expectancy. However when minimum tables are required, pension funds and annuity providers are also typically allowed to use mortality tables that are more conservative than those required so as to account and provision for larger future improvements in mortality and life expectancy if deemed to be appropriate. Where the regulatory framework does not establish specific mortality tables, pension funds and annuity providers may use their own tables or the tables most commonly used by the industry.

12. The extent to which mortality assumptions are regulated varies widely from one country to the next and is not necessarily consistent for pension funds and annuity providers within the same country. Table 1 shows a) whether the regulation requires minimum mortality assumptions -- whether or not a specified minimum level of mortality is mandated regardless of whether this requirements includes mortality improvement --, and b) whether the regulation requires accounting for future improvements in mortality in valuing pension and annuity liabilities, though the exact assumptions to be used do not necessarily need to be specified. The analysis also considers whether the common market practice is to account for the future improvement of mortality in the valuation of liabilities, even if regulation does not require it.

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7. Annex 1 provides a detailed description of the standard mortality tables used in each country.
13. The common market practice in some countries goes above and beyond the minimum mortality assumptions technically required by law, while in other countries market practice follows the minimum requirement rather closely. Where specific tables are not mandated by regulation, industry bodies often play a role in setting the standard which pension funds and annuity providers are expected to abide by in practice.

Table 1. Mortality Tables and Improvements Required by Regulation and Used in Practice

<table>
<thead>
<tr>
<th>Country</th>
<th>Annuity providers</th>
<th>Pension plans</th>
<th>Mortality Improvements Required by Regulation</th>
<th>Mortality Improvements Used in Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Canada</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chile</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>China</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>France</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Germany</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes&lt;sup&gt;9&lt;/sup&gt;/No&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Yes</td>
</tr>
<tr>
<td>Israel</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Japan</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Korea</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mexico</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Netherlands</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Peru</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Some&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spain</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Switzerland</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes Some&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>United States</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: OECD

14. Six of the sixteen countries assessed require a minimum level of mortality for both pension funds and annuities, and seven do not have a minimum requirement for either. Four additional countries have a minimum requirement for only one or the other.

15. The majority of countries do not require that both pension funds and annuity providers account for future mortality improvement. Seven of the sixteen countries have no requirement for annuity providers or pension funds, and two additional countries have no requirement for one or the other. Seven countries have requirements to account for mortality improvements for both annuity providers and pension funds.

16. Despite the lack of a legal requirement to provision for improvements in mortality, the majority of countries do so in practice, though annuity providers do so more often than pension funds. Annuity providers in thirteen of the sixteen countries examined use mortality improvement assumptions in practice, whereas pension funds in only eleven of the countries tend to do so.

<sup>8</sup> For non-regulated Pensionskassen and insurance oriented Pensionsfonds.

<sup>9</sup> For regulated Pensionskassen and non-insurance oriented Pensionsfonds.
Regulatory Requirements

17. Behind these results there are variations in the extent to which requirements are specified and the freedom given to pension funds and annuity providers to set their own assumptions.

18. There are no specific regulatory minimum requirements for mortality assumptions for either annuity providers or corporate pension plans in Korea, Spain and Switzerland. Annuity providers in Japan and Brazil and pension plans in Mexico are not subject to any minimum mortality requirements either. While there are no minimum requirements for mortality itself, some countries do have stipulations regarding the experience on which assumptions are based, with Spain and Switzerland requiring that the assumptions be based on more recent experience and Korea having credibility requirements for the experience used for assumption setting based on the number of observations.

19. Requirements in China and Peru as well as for pension plans in Brazil and Japan and annuity providers in the US stipulate a minimum level of mortality or life expectancy for valuing liabilities, though taking into account future mortality improvements is not required. The minimum level to be used for US annuity providers is determined at a state level, and while some types and generations of products are required to account for future improvements the majority are not.

20. Specific tables accounting for future improvements in mortality are required as a regulatory minimum for valuing liabilities in Chile, France and Israel as well as for annuity providers, Pensionskassen and Pensionsfonds in Germany, annuity providers in Mexico and pension plans in the United States.

21. Canada requires that standards set by the Canadian Institute of Actuaries (CIA) be followed, and as the CIA standard suggests the basis for mortality improvements, the effective regulation is that mortality improvements are included for valuation. Similarly the Netherlands and the UK require that future changes in mortality be taken into account, though the level is not specified.

22. For annuity providers, premiums are set based on provider discretion in all countries, except France where as of 1 January 2007, the generational tables TGH/TGF05 are a minimum requirement for pricing annuities.

Market Practice

23. The extent to which practice deviates from the requirements above and how mortality improvements are taken into account, if at all, also varies.

24. No provision for mortality improvement is typically taken into account for Brazil, China or Peru, or for Japanese pension funds, and the regulatory minimum in these countries tends to be relied upon, though sometimes more conservative assumptions are used in practice. For example Brazilian pension funds and annuity providers often tend to use the more recent US table (US Annuity 2000 tables), though future improvements in mortality are usually still not accounted for. Additionally, some evidence indicates that annuity providers and pension funds in Peru do take improvements into account up through the valuation date, and may be taking future improvements into account as well. Pension funds in Japan are allowed to include up to a 10% margin for males and 15% for females for funding purposes, though many do not do this in practice.

25. No minimum tables are required for corporate pension plans in Mexico, and in practice they typically rely on an older table from 1997, which accounts for improvements up to a certain date.

26. The minimum regulatory tables incorporating future mortality improvements are normally relied upon in Chile, France and Israel as well as for annuity providers in Mexico and pensions funds in the US.
While not specifically required as a minimum, standard assumptions developed by industry bodies tend to be relied upon for Canada, Korea, the Netherlands, Spain, Switzerland and the UK. This is also true for annuity providers in Japan and the US. All of these standard tables account for future improvements in mortality, though for pension plans in Switzerland this has only recently been the case as historically the tables used have not incorporated improvements. Many of the larger funds in Switzerland, however, develop their own tables internally and do not necessarily rely on the standard tables, and the new standard tables being developed are generational tables (e.g. the BVG2010 and VZ2010 tables). For the UK the magnitude of mortality improvement is not specified by the industry, rather a common modelling methodology has been developed to project future mortality improvements. While the tables in Korea do not explicitly account for mortality improvements, the margins are significant and thus effectively cover the risk of decreasing future mortality.

Accounting for future improvements in mortality

Tables developed by the Institute of Actuaries in Japan for annuitants are static, though they contain a margin which is meant to account for future decreases in mortality. Korea also issues standard tables which seem to have significant margins covering the increasing life expectancy. Pension plans in Mexico typically use a static table which has been improved to 2011 for males and 2013 for females.

Pension funds in the US and Canada have the option of applying static tables projected to some future date in order to account for the improvement in mortality, though in practice fully generational tables are used as well. Annuity providers in both countries tend to use fully generational tables.

Fully generational tables tend to be used by both pension funds and annuity providers in Chile, France, Germany, Israel, the Netherlands, Spain, Switzerland and the UK as well as for annuity providers in Mexico. While specific tables tend to be used in the majority of these countries, tables developed in the UK are rather flexible. Initial mortality assumptions there are often based on base mortality tables developed by the Continuous Mortality Investigation (CMI) which is supported by the British actuarial profession. However to project mortality beyond this point, the CMI has developed a model where users can specify a long term future rate of improvement, which can be set at a higher rate depending on the purpose of the calculations.

Cohort-based generational tables where future improvements are projected based on generations rather than age only have been developed in France, Israel, Switzerland and the UK.

Tables developed in Germany, Israel, the Netherlands, Switzerland, the UK and more recently the US project improvements which vary by age across time, that is having a higher short-term improvement assumption reflecting recent improvements gradually reverting to a lower long-term trend. The recently proposed pensioners’ mortality table in Canada also takes into account short term vs. long term trends.

III. Are assumptions used by pension funds and annuity providers in line with future expectations regarding improvement in mortality and life expectancy?

This section assesses whether pension funds and annuity providers may be exposed to longevity risk. The following analysis examines therefore whether the assumptions used by pension funds and annuity providers regarding future improvements in mortality and life expectancy expose them to an expected shortfall in provisions. If assumptions incorporated in the standard mortality tables used are insufficient, pension funds and annuity providers will be required to make higher payments than provisioned for.
Methodology

35. The study assesses whether pension funds and annuity providers are exposed to longevity risk, an expected shortfall in provisions, by comparing the life expectancy and annuity values given by the standard mortality tables used with the life expectancy and annuity values suggested by alternative mortality projection models.\textsuperscript{10} If the mortality assumptions being used for the valuation of liabilities are significantly different from improvements which have been experienced and the future expectations based on this experience, entities are likely exposed to additional longevity risk which will result in current provisions underestimating future liabilities.

36. The analysis uses historical population data for each country to calibrate four alternative models to project mortality into the future. The mortality improvements implied by each of these models are then applied to the standard mortality tables, replacing any improvement assumptions embedded in the standard mortality tables.

37. The potential shortfall in provisions or reserves to cover the expected longevity of pensioners and annuitants is quantified by comparing the resulting annuity values. A smaller annuity value based on the standard table as compared to the value implied by the models indicates a potential inadequacy of mortality assumptions.

Mortality projection models

38. The four mortality projection models which have been used to assess the adequacy of mortality assumptions are the Lee-Carter (LC), Cairns-Blake-Dowd (CBD), P-spline (PS) and CMI models.\textsuperscript{11}

39. The first two models listed are stochastic models, while the second two are deterministic. Stochastic models allow for assessment of longevity risk at a given confidence level, whereas deterministic models provide only a best estimate view of future longevity, therefore depending on the purpose of the projections one type or the other may be preferable.

40. In general, the stochastic models presented here are relatively easy to understand and implement compared to the deterministic models, for which the underlying modelling is quite complex in terms of the procedures used to calibrate the parameters of the models. Beyond this, each model presents shortcomings which must be considered when interpreting the results of the projections.

41. The Lee-Carter model is the simplest model, and its projections maintain the pattern of improvements by age which was experienced over the historical period used for the calibration of the model. This can pose a problem, however, as in many developed countries the pattern of improvements across ages has been changing over time. Decreases in infant mortality have been followed by decreasing mortality for adults coming from improvements in healthcare and the development of vaccines and antibiotics, and more recently medical advances in fields such as cardiology have impacted the mortality at older ages. As this acceleration of mortality improvement at the older ages has only occurred more recently, the Lee-Carter model tends not to capture this shift of improvements to the older ages, potentially underestimating the increase in life expectancy at these ages. In addition, the stochastic projections tend to result in rather narrow confidence levels making risk assessment at more extreme percentiles problematic.

42. Compared to the Lee-Carter model, the Cairns-Blake-Dowd model allows for a more complex correlation structure for improvements across different ages, which is arguably more realistic than a scenario

\textsuperscript{10} Annex 2 describes actuarial concepts and measures relating to longevity.

\textsuperscript{11} Annex 3 provided technical details on each of these models.
of perfect correlation. The model was developed with the aim to provide reasonable mortality projections for older ages, which is the focus of the analysis presented in this paper. However this model still tends to demonstrate a poorer fit compared to the other models.

43. The P-spline model is very good at smoothing out the noise in raw historical data, however future projections can be rather unstable as they are very sensitive to the most recent years of input experience.

44. While the underlying modelling of the CMI model is extremely complex, the projected scenario is influenced by a long term improvement assumption determined by the user, resulting in scenarios that both reflect recent experience in the short term but converge to a long term scenario judged to be plausible by the user.

Basis of the Calculations and Comparison

45. The projection models have been calibrated to the mortality of the overall population for each respective country, therefore the direct output of the projection models is the future mortality for the overall population. However, the standard mortality tables used by pension funds and annuity providers typically intend to represent the mortality for subgroups of the total population.

46. Pensioners and annuitants are subsets of the overall population who often have lower expected mortality (higher life expectancy) than the population in general. Pensioners, and even more so annuitants, tend to have a higher average income level (and/or have higher educational attainment levels) than the population as a whole. This has been shown to be positively correlated with longevity and life expectancy, and the mortality assumptions applied to these subpopulations reflect these differences (Deaton, 2003). Indeed, the mortality tables used for pensioners and annuitants are typically established based on the mortality experience of these subsets. However the extent to which the mortality of these two populations differs depends largely on the structure and coverage of the pension system itself, as if the coverage rate is quite high the pensioner population will be largely similar to the overall population.

47. The life expectancy and annuity rates obtained from the standard mortality tables are therefore not directly comparable in most cases to the outputs of the models which give the life expectancy for the entire population. To the extent that the life expectancy given by the standard tables is lower than that predicted by the models it is possible to conclude that the standard tables likely do not account sufficiently for longevity, as we expect the inverse relationship, that is, for pensioners and annuitants to have a higher life expectancy. However, it is not possible to quantify the amount of longevity risk from this result.

48. In order to quantify the potential shortfall in provisions that pension funds and annuity providers may be facing, the population mortality coming from the models is adjusted proportionally to match the level of the pensioner/annuitant mortality based on the most recent mortality experience available for these populations (typically the experience on which the standard table was based). In this way, it is possible to compute a life expectancy predicted by the model which is comparable to that which is assumed in the standard mortality tables.

49. This approach is demonstrated in the figure below. The mortality rates for the general population output by the model are represented by the solid line. These mortality rates are adjusted downward – using the ratio of actual insured mortality rates to actual population mortality rates - to the level of the pensioner mortality, point A in Figure 1. The rates of mortality improvement for the general population and the pensioner/annuitant population are assumed to be the same, so the difference in the mortality given by the standard table and that predicted by the model is then driven only by the differences in the assumed and

12. For details of how this is done see Annex 3.
modelled mortality improvements. The resulting shortfall is therefore coming from the gap between the two dashed lines.

**Figure 1. Illustration of mortality adjustment and projections**

50. The actual quantification of the shortfall in this exercise relies on the computation of the annuity values based on these two sets of mortality rates. The annuity value represents the premium an individual would have to pay to receive one unit of currency per annum. It also represents the present value of the expected payments which the pension fund or annuity provider owes to the individual, and therefore can be seen as the amount that needs to be held in reserve in order to meet future payment obligations. The current funding and reserve requirements of pension funds and annuity providers are based on the regulatory and industry mortality tables.

51. Therefore, the ratio of the annuity value based on the mortality model outputs over the annuity value based on the mortality tables used by pension funds and annuity providers measures the potential shortfall in provisions to which they may be exposed.

*Interpretation of Results*

52. The results of each projection model cannot be accepted blindly, and must be placed into the context of the recent evolution in mortality to assess the appropriateness of the model outputs and judge whether or not the shortcomings of each model summarized above render the results more or less plausible.

53. For example, if mortality improvements have accelerated rapidly in the past decade compared to previous decades, the improvements projected by the stochastic models will likely be low compared to recent experience, as projections will reflect more the average improvement over the entire historical period used. By contrast, in this same scenario, the P-spline model could project these recent high improvements indefinitely into the future, as it is quite sensitive to the most recent data. Therefore, when considering the

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13. Annuity values are calculated with a discount rate of 4.5%.
results one must form an expectation of plausible future scenarios in order to aid interpretation. The analysis which led to conclusions presented here has therefore attempted to use both quantitative and qualitative reasoning.

54. The historical data available used in the calibrations also vary by country. When available, data from the Human Mortality Database (HMD) were used from 1960. However a more limited number of historical years was available for Brazil, Chile, China, Israel, Korea and Mexico. Therefore the results for these countries reflect the shorter observation period of historical experience. Brazil, China, Korea and Mexico are not included in the HMD therefore these results are also subject to slight methodological differences.  

Assessment of results

Overview of population life expectancy

55. The information presented in this section focuses on the evolution of the life expectancy for the general population of each country in order to provide insights into the impact that mortality improvements have had on life expectancy historically and the impact future mortality improvements are expected to have on life expectancy.

56. Figures 2 and 3 below show the evolution in population life expectancy at age 65 for males and females for the countries assessed, demonstrating the increase in period life expectancy from 2000 to 2010 as well as the average additional life expectancy taking into account future mortality improvements as predicted by the projection models (i.e. cohort life expectancy for 2010).

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14. For details please see Annex 4 Data Sources.

15. All calculations were made as at 2010, with the exception of the UK and the VZ2010 table in Switzerland for which calculations were as at 2012. Annex 5 provides the results of the assessment of longevity risk for each country.

16. Period life expectancy makes no allowance for changes in mortality beyond the year in question, whereas cohort life expectancy is calculated taking into account future improvements in mortality and uses probabilities of death which follow a given group of the population. The cohort life expectancy shown here is the average given by the four projection models.
Figure 2. Male population life expectancy at age 65

Figure 3. Female population life expectancy at age 65

Source: Historical data from HMD where available, future improvements are average OECD calculations; * period life expectancy 2010 estimated based on the average annual increase of the last five years of available data

The countries experiencing the highest increase in life expectancy from 2000 to 2010 for both genders have been Israel, Korea, the Netherlands and the United Kingdom. Canada also makes the top five for males and China for females.
The difference between the period life expectancy and the cohort life expectancy of 2010 shows the impact that future improvements are expected to have on life expectancy. On average, the projected mortality improvements add 2 years of life expectancy for males and 2.5 years for females. Chile, China, Japan, Korea and the UK are expected overall to have the highest increase in life expectancy for both genders. Of these countries, Chile, China and Korea have relatively low life expectancies compared to that in other countries, and the high improvements projected by the models likely reflect the fact that life expectancy in these countries is catching up with the other countries, particularly for Korea for whom projected improvements have the largest impact on life expectancy. Once life expectancy is more in line with the other countries, we can likely expect that the mortality improvement beyond that point will also align with average levels, thus the analysis presented here may overstate somewhat the longevity risk in these countries.

Brazil and Mexico also have relatively low life expectancies, although as mortality improvements in these countries have not been as high relative to other countries, the projected improvement in life expectancy is also relatively low. Nevertheless, as with the countries just mentioned, there is room for life expectancy for these countries to catch up with the others, and therefore a good chance that the longevity risk as assessed here could be understated and that mortality improvement could accelerate in the near future.

Table 2 shows the gap in period life expectancy at age 65 for males and females in 2010. The number of years females can expect to live longer than males ranges from 2 years in Mexico and China to 5 years in Japan. However, the difference has been shrinking in most countries, with the exception of Brazil, China, Japan and Korea where females have continued to experience increasing life expectancy at a higher rate than males.

<table>
<thead>
<tr>
<th>Country</th>
<th>Gender Gap 2010</th>
<th>Change from 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>1.9</td>
<td>(0.0)</td>
</tr>
<tr>
<td>China</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Israel</td>
<td>2.2</td>
<td>(0.0)</td>
</tr>
<tr>
<td>United States</td>
<td>2.6</td>
<td>(0.4)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.6</td>
<td>(0.6)</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Chile</td>
<td>2.9</td>
<td>(0.4)</td>
</tr>
<tr>
<td>Canada</td>
<td>3.0</td>
<td>(0.5)</td>
</tr>
<tr>
<td>Germany</td>
<td>3.2</td>
<td>(0.6)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>3.2</td>
<td>(0.5)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.3</td>
<td>(0.6)</td>
</tr>
<tr>
<td>Spain</td>
<td>3.9</td>
<td>(0.1)</td>
</tr>
<tr>
<td>France</td>
<td>4.2</td>
<td>(0.4)</td>
</tr>
<tr>
<td>Korea</td>
<td>4.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Japan</td>
<td>5.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: OECD Calculations

Results for pension funds and annuity providers

The following analysis is based on the projections of the population mortality adjusted to the mortality level of the pensioners and annuitants by using the initial level of mortality established by the standard mortality tables and applying the mortality improvements given by the projection models.

Overall, pension plans face more longevity risk than annuity providers, who more often tend to include assumptions for future mortality improvement and whose tables tend to be more up to date. Five tables used for pension funds lead to a potential shortfall in provisioning for longevity risk of over 5%, whereas only two tables used by annuity providers lead to such results. In countries where different tables
are used for pension funds and annuity providers, pension funds are exposed to more longevity risk than the annuity providers in all cases except the UK, where both pension funds and annuity providers seem to sufficiently account for the future improvement in mortality, and Mexico, where projected mortality improvements tend to be relatively low. Of the tables for which little to no longevity risk was assessed, four are used by annuity providers whereas only two tables used by pension funds met the criteria (the US RP-2014 table was not yet officially released at the time of publication).

The table below classifies the mortality tables used for pension plans and annuity providers in each country by the percentage of additional reserves which would be required based on the results of the projection models compared to the table.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Potential Shortfall</th>
<th>Pension Plans</th>
<th>Annuity Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant</td>
<td>5-10%</td>
<td>Japan (EPI2005), US (RP2000-ScaleAA)</td>
<td>Chile (RV2009), Spain (PERM/F C 2000), US (GAM94-ScaleAA)</td>
</tr>
<tr>
<td>Moderate</td>
<td>2-5%</td>
<td>Canada (UPS94-ScaleAA), Chile (RV2009), Spain (PERM/F C 2000)</td>
<td>Chile (RV2009), Spain (PERM/F C 2000), US (GAM94-ScaleAA)</td>
</tr>
<tr>
<td>Monitor</td>
<td>&lt;2%; specific issues to address</td>
<td>France (TGH/F 2005), Israel, Mexico (EMSSA 1997), Spain (PERM/F P 2000), Switzerland (BVG 2010, VZ 2010), US (RP2000-ScaleBB)</td>
<td>Canada (GAM94-CIA), France (TGH/F 2005), Israel, Mexico (EMSSA 2009), Japan (SMT 2007), Spain (PERMF/P 2000)</td>
</tr>
<tr>
<td>OK</td>
<td>little to no expected shortfall</td>
<td>Netherlands (AG-Prognosetael 2010), UK (PCMA/PCFA 2000-CMI), US (RP2014)</td>
<td>Germany (DAV 2004 R), Netherlands (AG-Prognosetael 2010), Switzerland (ERM/F 2000), UK (SAPS1-CMI)</td>
</tr>
</tbody>
</table>

Source: OECD Calculations

17 The tables used by German pension funds (Heubeck 2005 G) were not available so could not be assessed.

18 The results shown in the table list the country and the name of the standard mortality table used in the following format: Country (Standard Mortality Table Name)

19 The quantification here is based on the present value of whole life annuities discounted at 4.5%. However, one needs to bear in mind that the discount rate used to value liabilities differs across countries. For the sake of the comparability and in order to isolate the impact of changes in mortality, the analysis herein assumes a common discount rate of 4.5%. Nevertheless it should be kept in mind that the valuation of liabilities is highly sensitive to changes in discount rates, and the underlying longevity risk is exacerbated in scenarios of low interest rates. In this context, we could expect that if the current scenario of low interest rates remains (IMF World Economic Outlook, Spring 2014, Chapter 3) the potential shortfall shown here would be underestimated.

20 The expected shortfall could not be reasonably assessed for Korea, though given the high level of life expectancy assumed by the standard table, 6th EMT, would be classified as having little to no expected shortfall.
64. None of the tables classified as having greater than a 10% shortfall in provisions take future mortality improvement into account. However the extent to which the EVK2000 table in Switzerland is used in practice is minimal, with only 8% of pension funds relying on this table in 2012 and an increasing number of funds moving towards the more recent generational tables BVG 2010 and VZ 2010. Furthermore many of the larger pension funds in Switzerland develop their own mortality tables based on internal experience.

65. For the tables classified as having a significant shortfall, all are required by regulation. While Japanese regulation permits occupational pension plans to take into account the future mortality improvements to the extent that the Employees' Pension Insurance Scheme does so in its actuarial valuation, in practice no pension plans take them into account and the assessment for the EPI2005 table here therefore does not consider improvements. Although the US does take improvements into account, the assumptions are lower than the level that recent experience implies, resulting in a larger discrepancy between the results using the models and those coming from the tables.

66. The assumptions used in Chile also incorporate mortality improvements, though these assumptions do not seem to reflect the most recent experience\(^{21}\), resulting in a moderate shortfall. The tables used by Canadian pension funds and US annuity providers fall in this category as well, and both rely on the Scale AA mortality improvements. The table used by Spain for policies issued prior to 2000 is also classified at this level, whereas the more prudent table developed concurrently for policies issued later than 2000 has lower risk, though slightly more potential risk for males than females.

67. Besides these latter tables for Spain, the regulatory tables used in France and Israel also show little potential risk of an expected shortfall, though the assumptions should be closely monitored as the assumptions for females at high ages in France may be insufficient in light of recent experience, and recent improvements in Israel have been quite high even compared to the relatively prudent assumptions used. The newer generational tables used by pension funds in Switzerland (BVG 2010, VZ 2010) and the US (Scale BB) are a significant improvement compared to the older tables used, though as neither of these newer assumptions are required it is not clear how widely these tables have been adopted for use. The assumptions used by Canadian annuity providers based on the more recently issued minimum improvement basis also demonstrate rather low potential shortfall, particularly given the practice of applying an additional load to the baseline mortality. The assumptions used by Japanese annuity providers seem also to be sufficient on average, though attention should be paid to the demographic distribution of the populations for which these tables are used, as over-provisioning for longevity improvements for ages over 65 tends to compensate for the under-provisioning for younger ages. While the tables used in Mexico also seem to sufficiently provision for expected mortality improvements for now, recent improvements in mortality have been slowing and Mexico currently has rather low life expectancy compared to other OECD countries. Therefore the potential for longevity to accelerate in Mexico and life expectancy to catch up to other OECD countries exists, and mortality experience should be closely monitored for changing patterns to ensure that the tables remain adequate.

68. Tables used by pension funds in the Netherlands and the UK seem to sufficiently account for future improvements in mortality. Both of these tables were developed by actuarial associations in the respective countries, and while commonly used in practice, neither table is legally required. This also holds true for the tables used by annuity providers in these two countries, as well as in Germany, though in Germany the tables are required by regulation. The recent RP2014 table for pensioners in the US also seems to result in little to no expected shortfall of provisions, and this table is expected to replace the older RP2000.

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\(^{21}\)Chile is planning to update their mortality table in 2016, at which point they plan to set mortality improvement assumptions to be more in line with observed historical experience and the results presented here.
69. **Brazil** and **Canada**, the two countries using tables based on experience outside of their own country, have both recently developed mortality tables based on their own populations. While no mortality improvement assumptions have been incorporated into the new tables for **Brazil**, this update does significantly reduce the potential longevity risk to a moderate level. The potential shortfall in provisions also reduces for Canadian pensioners under the new CPM table being proposed.

70. Several countries (Canada, Israel, UK and US) have also developed specific mortality tables for pensioners or annuitants based on socioeconomic factors such as income and employment type. The results of these tables clearly show that liabilities increase relative to the total pensioner or annuitant population for those with higher income levels and white collar employment. However, in all cases income matters more than the type of employment and the impact for males is much more significant than for females. These results highlight the fact that attention should be paid to the demographic characteristics of the population for which standard mortality assumptions are being used, and should be adjusted accordingly if the population tends to be of a higher socioeconomic level.

**IV. How to manage longevity risk**

71. This section discusses how pension funds and annuity providers can manage longevity risk and how the regulatory framework can support this effort. Previous sections showed that if the assumptions on mortality improvements embedded in the mortality tables used, pension funds and annuity providers may be exposed to longevity risk. This exposure could result in higher liabilities than they have provisioned for, increasing the likelihood that they will not be able to make their future pension payments. This should be a concern for regulators, who should aim to ensure pension funds and annuity providers will be able to meet future payment obligations to retirees.

72. The analysis above addressed the first step in managing longevity risk, which is to ensure that mortality assumptions used account for the expected improvements in mortality and life expectancy. In this regard pension funds and annuity providers need to use adequate mortality tables which not only account for future improvements in mortality, but are based on relevant mortality experience, which is used to regularly update the tables. Tables should be regularly updated.

73. The second step is to use financial instruments to mitigate excess longevity risk. Once pension funds and annuity providers have caught up to current expectations about future mortality improvements, they then need to address and recognize the potential financial impact of unexpected increases in longevity beyond the current expectations and determine if and how to mitigate this risk. The financial impact of these unexpected or unaccounted for improvements in mortality can also be quite significant, and pension funds or annuity providers must then decide how much of this risk they are willing or able to bear. The risk beyond their capacity must be transferred or mitigated in some manner.

74. Therefore, the regulation needs to ensure that longevity risk is recognized and provide a framework that encourages and facilitates the active management of the risk. This should be done based on two main objectives. The first objective is to ensure that pension plans and annuity providers have addressed the costs

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22. There are different approaches to address the impact of longevity risk that may be country specific. Consequently, discussions about managing longevity risk need to keep in mind the different country contexts. One example could be the existence of pension protection funds that can be drawn to offset the future impact of longevity risk in the event that it materialises. The approaches presented in this section focus on addressing the management of longevity risk directly to prevent it from materialising.

23. Mitigating or hedging a risk is the act or method of reducing the risk of financial loss of an investment. In what follows, the text refers to hedging longevity risk as mitigating the longevity risk to which pension funds and annuity providers are exposed.
of aligning with the current expectations of life expectancy by using mortality assumptions which are based on relevant and recent mortality data and account for the future expected trend in mortality. Secondly, incentives for the management of this risk also need to be put in place, with regulation encouraging and facilitating the measurement and mitigation of longevity risk. The latter objective, however, is not possible unless the first objective is met. Longevity risk will not be able to be accurately measured or appropriately managed unless the mortality assumptions they are using are in line with reasonable expectations. The mortality assumptions used must therefore be the first focus of policymakers.

The importance of using mortality tables which adequately reflect current and future expectations of mortality

75. The importance of starting with reasonable mortality assumptions can be illustrated with a simple example. Imagine a pension fund that has up-to-date mortality assumptions that account for the expected improvement in mortality and wants to assess the financial impact of overestimating its mortality assumptions by 25%. This overestimation would mean a realized life expectancy higher than provisioned for and an increase in the amount of future pension payments made. The expected pension payments and the increase in these payments due to an overestimation in mortality are shown for Scenario 1 in the figure below, which clearly demonstrates the significant financial impact this longevity risk could have.

![Figure 4. Expected annuity payments using different mortality assumptions](image)

76. Now imagine that the pension fund’s starting mortality assumptions fail to include mortality improvements. As demonstrated in the previous section of the document, not accounting for future improvements has a significant impact on the present value of expected payments and can increase these liabilities by over 10%. However, Scenario 2 shows that not only are the expected future pension payments underestimated, but the estimated financial impact of overestimating these assumptions by 25% is unrealistic compared to the actual financial impact shown by the difference between the two lines in Scenario 1.

77. The use of unreasonable mortality assumptions therefore not only increases the probability that future payments are not properly reserved for, but also that the fund is underestimating its exposure to longevity risk and will not take appropriate actions to manage this risk. The fund in Scenario 2 is not likely to deem its exposure to longevity risk significant enough to consider mitigation, when in reality its actual exposure to longevity risk is much greater than the fund in Scenario 1. Furthermore, even if it did want to hedge its risk, any solution to do so with a third party is likely to be more expensive than the pension fund
is willing or able to pay, as the price to hedge the longevity would be based on the assumptions accounting for mortality improvements in Scenario 1.

78. This example clearly illustrates the importance of setting reasonable mortality assumptions both to avoid a significant shortfall in provisions for future pension payments but also for the ability to make appropriate decisions regarding the management of the risk. The regulatory framework therefore needs to set the standards for assumption setting in order to subsequently further its goals of the recognition of longevity risk and the active management of it.

79. In order to accomplish this goal, there should be clear guidelines regarding the data used as the basis for mortality assumptions. Moreover, assumptions in mortality tables should include expected mortality improvements.

80. As a starting point, assumptions should be based on mortality data of the country in which they are used. Figure 2 and 3 demonstrated that life expectancy and the evolution of mortality can vary significantly from one country to the next. Mortality assumptions for pensioners and annuitants based on one country’s population cannot be assumed to accurately reflect the mortality in another country. This difference stems not only from the social and economic environment in a given country, but also the structure of the pension system itself, which would be reflected in the magnitude of the differences in mortality for the subpopulations of pensioners and annuitants compared to the general population. This is because the proportion of the population covered by private pensions and whether or not the system is mandatory is related to the level of anti-selection experienced, in other words the extent to which individuals with lower mortality and higher life expectancy choose to insure their own longevity. This anti-selection will be larger where private pensions represent a small proportion of retirement income and where this type of longevity protection is voluntary, as the individuals most likely to elect this type of coverage tend to be of a higher socio-economic status than the general population. Income and socio-economic status are correlated with having a higher life expectancy, resulting in a gap between the mortality of the general population and that of the pensioners and annuitants.

81. With that said, ideally the initial mortality assumptions should be based not only on the mortality experience of the country in question, but also of the subpopulation of pensioners and annuitants themselves, where available.

82. Expected improvements in mortality must also be taken into account. The highest assessed shortfall in provisions is for tables which do not account for these improvements. Figures 2 and 3 showed that future mortality improvements are expected to add at least two years to life expectancy on average, with each additional year of life expectancy not provisioned for translating to an expected shortfall in reserves of 3-5%.  

83. Finally, mortality tables should also be regularly updated and based on the most recent experience to ensure that assumptions accurately represent the current mortality level and monitor whether or not experience has been in line with expectations. Encouraging frequent review will also help to avoid significant one-off increases in liabilities driven by the update of assumptions as these changes in expectations could be implemented more gradually.

84. To facilitate the establishment of mortality assumptions, policymakers should also ensure that accurate and timely mortality data are publicly available. National statistical institutes should regularly publish population estimations and death statistics so that the mortality of the general population may be assessed. This data should be as granular as possible – by individual age and gender at a minimum – in order

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24 Based on the analysis in Section 3
to provide a benchmark or basis for mortality assumptions. Data including socio-economic indicators could also be quite useful to assess the general differences in mortality within the same country. Having readily available data allows for academic studies regarding mortality patterns and trends which could lead to a better understanding overall of the potential future evolution of mortality and its drivers. The data and studies can furthermore be used to inform the setting of mortality assumptions by providing a credible basis for model inputs and measuring mortality improvements. The data should be released in a timely manner, as a significant time-lag results in more uncertainty around the current assumptions.

85. To go even further, cooperation with industry bodies to organize the collection of mortality data from pension plans and insurance companies could allow for the assessment of the mortality for these specific populations. This could lead to the development of more appropriate mortality assumptions for these sub-populations, particularly for smaller plans or portfolios which do not have sufficient experience of their own on which to base assumptions. However this initiative can be costly to organize in the private sector, and as there is a clear benefit that this type of data is made available, the organization of the data collection in the public sector may be more effective.

Assessing the potential impact of unexpected improvements in life expectancy

86. The risk of having insufficiently provisioned for future improvements in mortality and life expectancy stems from having unreasonable starting mortality assumptions and from the uncertainty surrounding future improvements. The previous discussion highlighted the importance of establishing reasonable mortality assumptions.

87. Once adequate mortality assumptions have been established which reasonably reflect recent mortality experience and the expectations regarding its future improvement, the remaining longevity risk coming from the unexpected increases in life expectancy can be assessed. While the central mortality assumptions can reasonably be determined using deterministic models, stochastic models are typically more useful for the assessment of the additional longevity risk as they are capable of providing probability distributions around the expected value of future improvements in mortality. Such distributions allow pension funds and annuity providers to quantify the likelihood that their current provisions could be insufficient and what the financial impact of that shortfall could be.

88. Two stochastic models, the Lee-Carter (LC) model and the Cairn-Blake-Dowd (CBD) model, were implemented in Section 2 for the quantification of the potential shortfall in provisions due inadequate mortality assumptions. These two models can also be used here to demonstrate the potential impact of the additional longevity risk to which pension funds and annuity providers are exposed coming from unexpected improvements in future mortality.

89. The table below shows the financial impact of unexpected improvements in life expectancy at the 95% confidence level as a percentage of liabilities for each age and gender for several countries. This means that there should be only a 5% chance that future mortality experience will result in a financial loss greater than the figures given in the table. Therefore, if a pension fund or annuity provider wants to be 95% sure to be able to meet its future payment obligations, it should have this additional amount of funds, or capital, available to cover the excess longevity risk.

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>LC Model</th>
<th>CBD Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>Male</td>
<td>2.1%</td>
<td>3.0%</td>
</tr>
<tr>
<td>75</td>
<td>Male</td>
<td>1.4%</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

The first row in table 5 indicates that the provider of the annuity promise for an individual age 55 retiring at 65, when the annuity payments start, will have a shortfall in provisions of 2.1% with the LC model and a shortfall in provisions of 3.0% with the CBD model, for a male. The third row indicates the shortfall in provision for an annuity that began paying at age 65 evaluated for an individual aged 75, which is 1.4% with the LC model and 2.6% with the CBD model.
Table 4. Financial impact of unexpected improvements in life expectancy at the 95% level of confidence as a percentage of pension liabilities

<table>
<thead>
<tr>
<th>Country</th>
<th>Age</th>
<th>Male LC</th>
<th>Male CBD</th>
<th>Female LC</th>
<th>Female CBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>55</td>
<td>2.1%</td>
<td>3.0%</td>
<td>2.1%</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>1.4%</td>
<td>2.2%</td>
<td>1.6%</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>1.4%</td>
<td>2.6%</td>
<td>1.9%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Chile</td>
<td>55</td>
<td>6.0%</td>
<td>7.3%</td>
<td>4.8%</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>4.7%</td>
<td>5.2%</td>
<td>4.1%</td>
<td>4.7%</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>6.1%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>6.2%</td>
</tr>
<tr>
<td>France</td>
<td>55</td>
<td>4.7%</td>
<td>6.1%</td>
<td>3.6%</td>
<td>4.4%</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>3.3%</td>
<td>4.3%</td>
<td>3.1%</td>
<td>3.7%</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>3.4%</td>
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<td>4.7%</td>
</tr>
<tr>
<td>Germany</td>
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<td>3.9%</td>
</tr>
<tr>
<td></td>
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<td>Japan</td>
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<td>3.6%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Netherlands</td>
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<td>6.1%</td>
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</tr>
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<tr>
<td></td>
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<td>4.1%</td>
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<tr>
<td>Spain</td>
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</tr>
<tr>
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<tr>
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<tr>
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<tr>
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<td>4.7%</td>
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Source: OECD Calculations

Notes: 1. The table shows the percentage increase in liabilities that can be expected at the 95% confidence level. These calculations are based on 1,000 simulations of future mortality using the two stochastic mortality projection models (LC and CBD), evaluated at ages 65 and assuming a discount rate of 4.5% to calculate the annuity value based on those stochastic projections of mortality.

The first row in table 5 indicates that the provider of the annuity promise for an individual age 55 retiring at 65, when the annuity payments start, will have a shortfall in provisions of 2.1% with the LC model and a shortfall in provisions of 3.0% with the CBD model, for a male. The third row indicates the shortfall in provision for an annuity that began paying at age 65 evaluated for an individual aged 75, which is 1.4% with the LC model and 2.6% with the CBD model.

The results of this risk assessment are quite dependent on the model being used. We can observe that the Cairns-Blake-Dowd model generally results in a larger estimation of longevity risk than the Lee-Carter model. This is driven by the tendency of the Lee-Carter model to produce narrower confidence intervals, and has been mentioned as a disadvantage for the use of this model for risk assessment (see annex 2 in DAF/AS/PEN/WD(2014)7/ADD1). Nevertheless, considering the results of the two models here provides a reference for the potential magnitude of the longevity risk coming from unexpected improvements in life expectancy.

91. Assessing longevity risk using probability distributions from stochastic models provides a way to quantify the risk at a given confidence level. The results from this type of analysis can provide a basis for
the pension fund or annuity provider to make a decision regarding its ability to retain the risk or the need to mitigate the risk. This will ultimately be affected by capital constraints – i.e. are there sufficient assets to meet future payment obligations if longevity experience turns out to be at the 95\textsuperscript{th} percentile of what we expect today – or internal risk appetite limits, for example the decision of management to limit the possible losses from changes in longevity experience to a certain amount.

\textbf{The potential role that regulation can play in encouraging the management of longevity risk}

92. Policymakers can ensure that the regulatory framework provides incentives not only to assess and evaluate the risk, but also facilitates the availability and effectiveness of instruments to hedge the excess risk. Incentives for the management of longevity risk can be addressed through capital and funding requirements as well as through accounting standards. Unless these regulatory standards consistently recognize the existence of longevity risk, pension funds and annuity providers will have little incentive to do anything about the risk to which they are exposed.

93. As such, \textit{capital and funding requirements should be based on the risks faced in order to account for the specific exposure to longevity risk}.

94. Risk-based requirements aim to reflect the underlying risk profile of the concerned entity and would therefore compel it to measure the longevity risk to which it is exposed. Changes to this exposure should have a direct impact on the capital required to support the pension or annuity liabilities. This then provides an incentive to mitigate excess risk in order to achieve a target level of capitalization or funding, or at least not fall below any minimum limits imposed.

95. It is clearly imperative, then, that the reduction in risk from any instrument used to hedge longevity risk be reflected in the capital requirements. Otherwise the entity will not have an incentive to reduce its risk, even if internal risk measures consider the risk reduction prudent or necessary.

96. As an example of failing to reflect the reduction of risk in requirements, take the calculation of capital requirements which is based on a simple formula of a percentage of reserves. As the purchase of a longevity swap would not necessarily impact the value of reserves, it would also not impact the capital requirement. The reduction in risk achieved would therefore not be recognized by regulation and the entity will not have the incentive to use the instrument to manage their longevity risk. Indeed, the entity would be penalized for purchasing such an instrument in the short-term compared to another entity which has not hedged its longevity risk.

97. The full potential impact of longevity risk needs to be reflected in capital and funding requirements so that these requirements are reactive to risk mitigating measures which decrease the risk of insolvency. Risk-based requirements for which an explicit charge is imposed for longevity risk would force pension sponsors and annuity providers to address the risk and actively assess their exposure to it.

98. In addition to capital and funding requirements, however, \textit{accounting standards should ensure the appropriate valuation of longevity hedging instruments}. If longevity hedges are not appropriately reflected in the balance sheet, pension funds and annuity providers will not have an incentive to use these instruments to hedge their longevity risk.

99. For example, in some countries where the prudence principle is applied, insurance companies would not be allowed to value longevity instruments at a higher value than the purchase price. Thus, if mortality improves at a higher rate than expected and the pension fund can expect a positive return from a longevity swap, they would not be allowed to recognize this increase in the value of their assets to offset the resulting increase in liabilities. Moreover, for participating policies where annuitants are entitled to a certain
part of the annuity provider’s unrealized gains, the increase in fair value of the longevity swap could only be partly used to offset the increase in liabilities as a portion of the gains would be paid to the policyholders.

100. If longevity hedging instruments cannot be used to offset the increase in liabilities due to decreasing mortality rates, providers will not have an incentive to purchase these hedges as no benefit from the hedge will be realized.

*The need for financial instruments to enable pension funds and annuity providers to mitigate longevity risk*

101. Once incentives are in place for the management and mitigation of longevity risk, the regulatory framework must also address the availability of solutions to do so. With the trend towards risk based requirements and the increased emphasis on enterprise risk management, the capacity for the (re)insurance industry to absorb the increasing demand for longevity protection is limited. These capacity constraints therefore need to be addressed in order to ensure a supply of longevity protection sufficient to meet the demand.

102. Capital markets have the potential to offer some additional capacity for longevity risk as investors look for new ways to diversify their portfolios or business; however the misalignment of incentives between these investors and the annuity providers and pension plans needs to be overcome. Index-based instruments offer a promising solution to the constraints of capital markets investors in supplying longevity protection, and the further development of these instruments could be encouraged by additional standardization and transparency in the market. On the demand side, the measurement of the residual basis risk from using index-based longevity instruments to hedge their risk remains a challenge for pension funds and annuity providers, particularly for the risk relating to socio-economic differences. This poses a problem not only for assessing the residual longevity exposure which is retained, but also in determining the appropriate level of risk reduction which should be reflected through the capital and funding requirements. This measurement then needs to be facilitated and clear rules communicated as to the level of capital or funding relief which can be realized from index-based longevity hedges.

103. There are several capital market solutions or financial arrangements that allow pension funds and annuity providers to either transfer or hedge longevity risk. For pension plans or annuity providers looking to reduce their exposure to longevity risk, the traditional solution has been to transfer the risk to insurance or reinsurance entities. Several different types of structures for this arrangement are possible. The first type is referred to as a bulk annuity, where both investment and longevity risk are transferred to the third party, and can be done either as a buy-out or buy-in structure. The second type is via a longevity swap, a hedge which transfers only the longevity risk to the third party.

104. This type of transaction tends to be bespoke, that is the longevity risk is fully transferred to the third party as payments are based on the actual realized mortality of the underlying individuals being hedged. In exchange for a fixed premium from the pension fund or annuity provider, the payments from the counterparty will match the pension or annuity payments owed to the individual, even if she lives longer than expected. Buy-outs and buy-ins have historically been the most popular method of transferring the risk, although longevity swaps have been rapidly gaining in popularity.

105. Insurers and reinsurers are capable of taking on longevity risk for bespoke transactions because this type of risk forms a core part of their business and expertise. However, they will be limited in their capacity to absorb longevity risk. While exposure to longevity risk can be partially offset by the exposure to

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26. Annex 6 provides descriptions and examples of different mechanisms and instruments to transfer and hedge (mitigate) longevity risk.
mortality risk coming from life insurance products sold by insurers, the life insurance and annuity portfolios often cover different population groups so this arrangement is not a perfect hedge and there is residual longevity exposure. Furthermore, given the recent trends in regulation towards risk-based approaches to measuring capital requirements, insurers will be forced to limit the amount of longevity exposure on their books and will be subject to capacity constraints, as discussed above.

106. With the limited capacity of the insurance market to absorb longevity risk, another solution will have to be found. Given the increased demand for longevity protection from both individuals, who are increasingly bearing their own longevity risk with the shift to defined contribution plans, and pension plans which are also looking to mitigate their longevity risk, society will find itself in a situation where demand for protection exceeds the supply.

107. Capital markets have the potential to provide the additional capacity for longevity risk and offer some relief from the concentration in the supply of longevity protection. One of the main incentives for capital markets investors to invest in longevity risk is that longevity is largely uncorrelated with typical market risks, and therefore could offer a diversifying investment opportunity.

108. However, while a small number of longevity swap transactions to hedge longevity risk have already been conducted in the capital markets, the development of this market as a solution has been slow. The largest factor preventing longevity risk from being passed on to the capital markets is the misalignment of incentives between the interests of the party looking to hedge the longevity risk and those of the investor.

109. Pension funds and insurance companies want to be guaranteed that they are fully protected against longevity risk and therefore have a preference for bespoke transactions based on the actual mortality of the underlying population being hedged, which is why these types of transactions have been by far the most popular.

110. However, bespoke transactions pose several problems for the capital markets investor. First of all is the lack of transparency of such a transaction, where the insurer or pension fund possesses asymmetrical information regarding the mortality experience of the population being hedged. Secondly, a bespoke transaction can be extremely time-consuming to implement as the investor must assess the specific longevity characteristics of the portfolio or fund in order to price the transaction. Finally the long-term nature of longevity risk would expose the investor to a very long-tailed investment with a duration upwards of fifty years. These characteristics are not conducive to the creation of an attractive investment vehicle, for which cash flows would need to be based on an easily understood and independent measure, be transacted in a timely manner and reflect a duration more in line with the preferred investment strategy of the investor.

111. Index based longevity hedges could address the above shortcomings and provide a potentially attractive investment for capital markets investors. Rather than payments being based on the actual underlying mortality of the plan or portfolio being hedged as in a bespoke transaction, an index-based transaction is based on the mortality of an independent mortality index, such as the mortality of the general population of the country. This structure would address the concerns of capital markets investors as cash flows would be based on an independent longevity index with clearly defined indicators, providing full transparency for the investor with respect to the calculation of payments. As cash flows would not be based on the mortality of the portfolio itself, the counterparty does not need to have any information about the portfolio and a transaction could be executed more quickly. Finally there can be more flexibility around the design of the structure of the transaction so the duration of the instrument could be defined for a shorter time horizon and the tail risk limited.

112. Nevertheless, as opposed to a bespoke transaction, with an index-based hedge the pension fund or annuity provider would have to accept to be exposed to some remaining residual and tail risk, primarily that
coming from basis risk. Basis risk exists as the mortality on which the index is based is not guaranteed to evolve in the same way as the mortality of the portfolio or fund being hedged, so there can be some discrepancy between the cash flows the hedger receives from the investors and the payments to be made to the pensioners.

113. The main sources of basis risk stem from the structural risk coming from the structure of the instrument itself, sampling risk due to the natural volatility in mortality experience, and the demographic risk reflecting the inherent underlying differences in dynamics of mortality of the index and hedged populations. This latter risk is typically driven primarily by geographic and socio-economic differences, which were previously demonstrated to have a significant impact on life expectancy.

114. Structural risk can be reduced with careful analysis and matching of the age and gender profile of the portfolio with the one the hedge references. More granular the hedge references enable a better match to be achieved. This risk would further be reduced with the emergence of a more liquid market as the hedge could be adapted to the evolving demographic profile over time.

115. The risk stemming from underlying volatility, also referred to as idiosyncratic risk, can be mitigated by pooling underlying portfolios. This implies that basis risk in general is likely to be much larger for small pension schemes or portfolios as the mortality experience is subject to more volatility than large ones, making indexed based solutions less effective for a small group of lives where this idiosyncratic risk, or individual differences, are not sufficiently diversified as with a large pool of lives. Index-based transactions would be much more effective in transferring the systemic longevity risk, which comes from the overall shifts in longevity trends and cannot be diversified away by pooling risks. One solution to the challenge smaller plans and portfolios face in mitigating their longevity risk would be for an insurer or reinsurer act as an intermediary to the capital markets by providing bespoke hedges with these small plans to acquire and pool the risks, subsequently transferring the systemic longevity risk of this pool to the capital markets.

116. Demographic basis risk remains the most challenging component to mitigate and quantify, primarily due to the lack of data on which to assess such differences. As discussed previously in the document, there is some evidence that insurers and pensioners not only experience lower mortality than the general population but also experience higher improvements, these differences driven primarily by differences in socio-economic profiles. Thus if a longevity swap is indexed to the evolution in the population of the general mortality, the floating payments received may not be sufficient to cover the higher increase in longevity for the pensioners or annuitants being hedged. This component presents one of the largest obstacles to the demand for index-based longevity protection.

117. The development of capital market solutions for hedging longevity risk seems to be the most promising way forward in order to ensure the continued capacity for pension funds and annuity providers to mitigate the risk. However, this misalignment of incentives between those needing to hedge longevity risk and the capital markets investors who can provide additional capacity will need to be overcome. This will involve addressing the risk constraints of the capital markets investors through the use of index-based instruments, as well as facilitating the recognition and assessment of the residual basis risk for those using these instruments to hedge their risk.

118. As policymakers have an interest in the continued availability of longevity risk protection and solutions to mitigate the risk, the additional capacity the capital markets can offer must be acknowledged and the development of this market facilitated. This involves addressing the misalignment of incentives on both sides of the market. The transparency and standardization of longevity hedge instruments should be facilitated to address the constraints of capital markets investors in supplying longevity protection. For pension funds and annuity providers seeking to mitigate their longevity risk, the measurement of the

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residual basis risk retained needs to be facilitated and the recognition of it clear and consistent for capital and funding requirements.\textsuperscript{27}

119. More transparency and standardization in the pricing of longevity instruments would aid potential investors in becoming comfortable with investing in longevity risk and promote the development of index-based instruments. The issuance of index-based longevity bonds has often been discussed as a solution to kick-start the purchase of longevity risk by the capital markets by providing this standardization and transparency. A longevity bond would allow prices to become publicly available as a reference point for other transactions, establishing a riskless term structure which the private sector could use as a basis to issue index-based longevity derivatives. This term structure could also be used by regulators as a check for the appropriateness of the level of capital which the (re)insurers are holding to cover longevity risk.

120. There are several arguments for government issuance of a longevity bond. Compared to solutions offered by the private sector, such a bond would provide a longevity hedge with little to no counterparty risk which could increase the capital relief (re)insurance companies could potentially receive from such a hedge. The government would also be better positioned to offer a hedge in line with the long duration of longevity risk, which capital markets investors have been so far reluctant to do. The government is also arguably in a better position to support the systemic longevity risk. Benefits for the government itself could include the reduction of its cost of borrowing compared to traditional government bonds since it would be receiving a risk premium for taking on the longevity risk. However, the longevity bond market is likely to remain fairly illiquid and the coupons would have to include a certain level of illiquidity premium, therefore it is not certain that the cost of borrowing could be reduced in reality (Brown and Orszag, 2006).

121. Nevertheless this solution would have to be very carefully assessed as many governments already hold significant longevity risk on their balance sheet from public pensions and health programs. While the government could hedge some of its exposure to increases in systemic longevity through adjustments to the state pension, governments are currently proving that these types of adjustments – such as increasing retirement age or decreasing pension levels – are very slow to implement. However if insurance companies are not able to insure the longevity risk of individuals, it is possible that more elderly would fall into poverty and their longevity risk would have to be covered by the government anyway through the safety nets which are in place.

122. The current lack of demand for these bonds and the extent to which these instruments are effective in hedging longevity risk must also be considered, as attempts thus far to issue a longevity bond have not succeeded. Reasons for the lack of interest by pension funds and annuity providers are the significant upfront capital required and the basis risk involved, the latter of which seems to be the main reason for the failure. The bond structure is meant to provide longevity risk protection to several entities seeking to hedge their pension funds and annuity portfolios, therefore the reference index on which the coupons is based has to be more generic than the reference population which could be used for an index-based swap. As such, a longevity hedge using longevity bonds would expose the pension fund or annuity provider to arguably more structural basis risk than a longevity swap, where the reference index can be tailored more specifically to the population being hedged.

123. However there is some evidence that the private markets are beginning to develop products and structures to hedge longevity risk without direct government intervention. A handful of index-based longevity swaps have already succeeded in being transacted. Progressively innovative structures have aimed

\textsuperscript{27.} The misalignment of incentives leads those demanding hedging instruments to prefer bespoke products, while the supply side of the market prefers indexed products. In order to address the problem, regulators need to ensure that data on mortality by different socio-economic characteristics are available to facilitate the assessment of basis risk by pension funds and annuity providers.
to resolve the tension between the interests of the hedging party and the investor and create standardized instruments which can be easily customized to provide attractive investments which offer effective longevity hedges which minimize basis risk for the subscriber.

124. This evolution in the structures being used to hedge longevity risk indicate a strong potential for index-based instruments to be used more widely to achieve an effective reduction in longevity risk for pension funds and annuity providers while attracting a wide investor base in the capital markets. Perhaps, then, all that is needed is an additional nudge towards the more rapid development of the market by taking smaller steps to facilitate the standardization and transparency of these instruments.

125. A regular and reliable publication of a longevity index could further the standardization and transparency. This index could provide a basis for the calculation of future swap payments as well as provide a price reference from which market participants could decide how much they are willing to pay for a given transaction. Such an index should include both metrics relating to current mortality as well as mortality projections which reflect the most up-to-date expectations of future mortality improvement and life expectancy. The methodology and data used to develop the index should be clear and transparent so that the market understands the basis of the calculations and will be confident in the reliability of the index going forward. As governments have access to all necessary data needed to publish such indices on an ongoing basis, perhaps national statistical institutes could be in charge of publishing annual indices for their respective countries.

126. Finally, to further the aim of transparency, regulation could consider bringing in standardized swaps traded on the capital markets into exchanges so as to limit the opaqueness of these over-the-counter (OTC) transactions and keep tabs on the accumulation of longevity risk in the capital markets.

V. Concluding Remarks

116. Mortality assumptions have a significant influence on the liability value for pension funds and annuities and realistic assumptions are necessary in order to sufficiently provision for future payment obligations in both cases. The improvement in mortality and life expectancy is a phenomenon observed in all countries addressed in this study and cannot be ignored when setting mortality assumptions for the future. Pension funds and annuity providers must actively assess and monitor mortality experience, keeping assumptions up-to-date and recognizing the risk to which they are exposed.

117. This analysis has shown that failure to account for future improvements in mortality can result in an expected shortfall of provisions of well over 10% of the pension and annuity liabilities. Likewise, the use of assumptions which are not reflective of recent improvements in mortality can expose the pension plan or annuity provider to the need for a significant increase in reserves. Countries which seem to be the least exposed to an expected shortfall in provisions tend to be those where the industry experts actively participate in defining acceptable standards and driving the analysis of mortality experience and assumption setting, regardless of what regulation is in place.

118. Along with the recognition of the expected increase in life expectancy and the assessment and management of longevity risk, however, comes the need to mitigate the risk when necessary, and options to do so have to be available. With the limited capacity for insurers and reinsurers to accept this risk, capital market solutions seem to be a promising option for hedging the risk for pension plans and annuity providers. However several issues need to be addressed to encourage both the supply and demand of index based longevity hedging instruments which could be traded on the capital markets. Investors have a need for standardization and transparency with respect to the pricing of the instruments, and additional benchmarks may be necessary to facilitate this. Regulatory frameworks should encourage pension funds and annuity providers to make use of longevity hedging instruments and facilitate their effectiveness in doing so.
Demand for protection against longevity risk will only increase as individuals are expected to live longer, and the sustainability of pension funds and annuities providing this protection for individuals has to be ensured. Sufficient provisioning for longevity is essential to guarantee that future payments will be met, and the ability for providers to manage and mitigate this risk will allow continued protection to be offered in the future.

The main recommendations for policymakers are:

1. The regulatory framework should ensure that pension funds and annuity providers use appropriate mortality tables to account and provision for expected future improvements by establishing clear guidelines for the development of mortality tables used for reserving for annuity and pension liabilities.
   - Mortality tables should include the expected future improvements in mortality.
   - Mortality tables should be regularly updated to accurately reflect the most recent experience and avoid significant increases in reserves.
   - Mortality tables should be based on the mortality experience of the relevant population.

2. Governments should facilitate the measurement of mortality for the purposes of assumption setting and the evaluation of basis risk.
   - Accurate and timely mortality data should be publicly available.
   - Mortality data by a socio-economic indicator should be made publically available.

3. The regulatory framework should provide incentives for the management and mitigation of longevity risk.
   - Capital and funding requirements should be based on the risks faced in order to account for the specific exposure to longevity risk and allow institutions using instruments to hedge longevity risk to adjust their requirements accordingly. These recommendations elaborate in more detail existing recommendations relating to managing longevity risk, such as those of the Joint Forum Paper. For example, the secretariat recommendation suggesting specifically that future improvements should be accounted for, that tables are regularly updated, and that the relevant experience be used as a basis for setting assumptions develops in more detail the Joint Forum recommendation 4 “Review longevity risk rules and regulations … pertaining to the measurement, management and disclosure of longevity risk”. Additionally, the Secretariat’s recommendations saying that policymakers should facilitate the measurement of mortality for the purposes of assumption setting by ensuring that accurate and granular mortality data is publically available – a recommendation completely in line with Recommendation 8 of the Joint Forum to “Collect adequate data” goes further than the recommendation 2 of the Joint Forum. Moreover, the final recommendation in this paper, policy makers could encourage the development of the longevity transfer market, goes hand and hand with Recommendation 3 of the Joint Forum to “Assess relevant policies…with regard to where longevity risk should reside” and simply takes a position that longevity risk should be more broadly shared across society in order to ensure the continued capacity of pension funds and annuity providers to manage and insure longevity risk.
requirements could be based on results from stochastic models which provide probability distributions.

- Accounting standards should ensure the appropriate valuation of longevity hedging instruments.

4. Governments should encourage the development of a market for instruments to hedge longevity in order to ensure the capacity for pension plans and annuity providers to continue to provide longevity protection to individuals. Index-based products in particular have the most potential to address the misalignment of incentives between the hedging party and the capital markets investor. Governments could encourage this development by facilitating transparency and standardization of longevity hedges.

- A reliable longevity index could be developed to provide price reference and encourage liquidity and standardization.

- Over-the-counter standardized transactions could be brought into exchanges.

- The issuance of longevity indexed bond could be considered, though with care. While it may be helpful in kick-starting the market for longevity hedging instruments by providing standardization, a benchmark for pricing and liquidity, it would also significantly increase the exposure of the government to longevity risk, to which many governments already have significant exposure on their balance sheets.