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LONGEVITY RISK: ITS IMPACT ON PENSION PLANS AND THE MITIGATION STRATEGIES

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ABSTRACT

Longevity Risk, the risk that pension scheme members live longer than expected, has emerged as a critical concern for institutions, individuals, policymakers and pension scheme stakeholders in the U.K. As life expectancy continues to rise due to medical advancements and improved standards of living, pension providers face the growing challenge of ensuring that retirees receive benefits for potentially longer-than-anticipated durations. This report explores the various impact of longevity risk on both defined benefit (DB) and defined contribution (DC) pension schemes, with a focus on the financial, actuarial and sustainability implications.

For DB schemes, extended lifespans can significantly increase liabilities, straining sponsor funding requirements and leading to funding any deficits. In DC schemes, longevity risk is largely transferred to the individual, raising concerns about the adequacy of retirement income and the risk of outliving the retirement savings. The report further examines the pattern of possible future liabilities based on the U.K. mortality tables and improvement projections.

To address these challenges, we have outlined some mitigation strategies that can be put in place. These include acceptance of the reality of longevity risk rather than undermining or ignoring its existence, Buy-ins, Buy-outs, Longevity swaps and diversification of investment portfolio – particularly in the emerging longevity bond market.

This report essentially underscores the need for pension scheme sponsors, government and individuals to be proactive towards acknowledging and managing longevity risk, as the sustainability of pension promises – and therefore financial security in retirement – depends on how this risk is addressed in this new era.

Keywords: Longevity risk, Defined Benefit Scheme (DB), Defined Contribution Scheme (DC), United Kingdom (U.K.)

RESUMO

O Risco de Longevidade, o risco de que os participantes de planos de pensão vivam mais do que o esperado, tornou-se uma preocupação crítica para instituições, indivíduos, decisores políticos e partes interessadas em planos de pensão no Reino Unido. À medida que a expectativa de vida continua a aumentar devido aos avanços médicos e à melhoria nas condições de vida, os prestadores de pensão enfrentam o desafio crescente de garantir que os reformados recebam benefícios por períodos possivelmente mais longos do que o antecipado. Este relatório explora os diversos impactos do risco de longevidade tanto em planos de benefício definido (BD) quanto em planos de contribuição definida (CD), com foco nas implicações financeiras, atuariais e de sustentabilidade.

Para os planos BD, o aumento da longevidade pode aumentar significativamente as responsabilidades, pressionando os requisitos de financiamento dos patrocinadores e levando à necessidade de cobrir défices. Nos planos CD, o risco de longevidade é, em grande parte, transferido para o indivíduo, levantando preocupações sobre a adequação do rendimento na reforma e o risco de esgotar as poupanças antes do fim da vida. O relatório analisa ainda o padrão de possíveis obrigações futuras com base nas tábuas de mortalidade do Reino Unido e nas projeções de melhoria.

Para enfrentar esses desafios, delineámos algumas estratégias de mitigação que podem ser implementadas. Estas incluem a aceitação da realidade do risco de longevidade, em vez de o subestimar ou ignorar, bem como a utilização de instrumentos como *buy-ins*, *buy-outs*, *longevity swaps* e a diversificação da carteira de investimentos — particularmente no emergente mercado de obrigações de longevidade.

Este relatório sublinha essencialmente a necessidade de os patrocinadores de planos de pensão, o governo e os indivíduos adotarem uma postura proativa na aceitação e gestão do risco de longevidade, uma vez que a sustentabilidade das promessas de pensão — e portanto, a segurança financeira na reforma — depende da forma como esse risco é encarado nesta nova era.

Palavras-chave: Risco de longevidade, Plano de Benefício Definido (BD), Plano de Contribuição Definida (CD), Reino Unido (RU).

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GLOSSARY

Abbreviation	Meaning
CAS	Career Average Salary
CMI	Continuous Mortality Investigation
DB	Defined Benefit
DC	Defined Contribution
FAS	Final Average Salary
FB	Flat Benefit
NRA	Normal Retirement Age
ONS	Office of National Statistics
PPVM	Pension Present Value Multiplier
PSAL	Past Service Actuarial Liabilities
PVFB	Present Value of Future Benefit
TPR	The Pensions Regulator
U.K.	United Kingdom
WTW	Willis Towers Watson

1. INTRODUCTION

Pension planning has always been a point of focus for every individual in a population when they step into the working-class group of the society or country at large. There is the general expectation and the need to plan for after-working-life span (generally age 65). This plan tends to begin immediately upon being gainfully employed.

The working-class group are the ones who would later fall into the retired group when they reach the statutory age of retirement and would hope to sustain their lifestyles. The process of transitioning from working-class to retired group is a part of what is known as aging. Aging is a critical factor in pension planning and has a major impact on the extent to which a person will continue to receive pension after retirement.

U.K.'s aging population has posed significant challenges to pension providers as the aging population is rapidly growing. This is caused by a reduction in birth rate and increase in life expectancy. In 1951, the baby-boom era when U.K. experienced high birth rates, the population had reached 43.8 million and the birth rate per woman grew from 2.0 (1946) to 2.6 (1948). The percentage of the age-over-65 compared to the working-class population was 16.5%. Furthermore, there was another momentous increase as the population was up to 48.5 million and life expectancy at birth rose from 66 to 71 years (for men) and 71 to 77 years (for women) between 1951 and 1981. During this time, the age-over-65 compared to the working-class increased to 23.2% (Office for Budget Responsibility; 2014).

In today's view, the baby-boom generation would be aged between 72 and 78. The implications are the following:

- There are more age-over-65 population than the recent working-class population.
- Fewer working-class groups support the pension fund system in paying for the retired group.
- Life expectancy is increasing due to improvement in health, development of cure for terminal diseases and advanced technologies, as well as preventives health care measures. Although in recent years, there has been a slowdown.
- Age-over-65 population is living longer than expected.
- Pension providers are having to continue to pay pension longer than expected.

There is a challenge for the young working-class who opt for a contributory pension scheme, where both the employee and the employer contribute a percentage of the salary into a retirement savings account. The adequacy of retirement funds – especially for those who live long – depends heavily on the investment performance during their working years.

Another challenge exists where the employer runs a scheme that guarantees a specific benefit upon retirement for employees so that they can sustain themselves after retirement. This benefit is converted to pension, and it will be funded by the employer until the death of the retired members. As retirees enjoy the gift and the privilege of long life, employers face increased financial pressure to keep the scheme funds sustainable, especially amid both local and global economics policies, changes and uncertainties.

Therefore, the starting point to the magnitude of longevity risk is the cost of aging. One of which is the increase in liabilities because of funding longer retirements periods. As liabilities increase, funding ratio to liabilities will reduce and pension providers will be concerned with meeting their obligations in ensuring that sufficient funds are available in the pension fund account.

Pension planning in upcoming years will pose additional requirements for the pension providers considering the projections and development surrounding aging population and life expectancy. This report further explores the impact of longevity risk on pension schemes and the strategies that can support the mitigation of this risk.

In Chapter 2, we will begin the discussion on longevity risk. From an overview to the existing perspectives on life expectancy and how longevity risk is being sidelined in the calculation of pensions.

Moreso, chapter 3 will focus on the different types of Pension Schemes, and the method of calculation, as well as the regulatory framework in calculating and providing pension. We will delve into the impact of longevity risk on the types of Pension Schemes in chapter 4 using the available data at WTW. This is where we will examine the existing Mortality tables in the U.K. which are being used at WTW alongside some scenarios, while chapter 5 will investigate the possible mitigation strategies. We will conclude our longevity risk discussion in chapter 6.

2. LONGEVITY RISK

2.1 Overview

2.1.1 Shift in demographic concept

The aging population cannot be separated from this discussion on longevity risk. However, there is the need to recognise that the demographic records are developing into a ‘longevity concept’ rather than just the widely known ‘aging concept’. The focus, when categorising the demography of a society, is now inclusive of how long people are living which has become a game-changer. This paradigm-shift of viewing the population of a country is helping the governments, as well as institutions, in planning for retirement of the working population and those who have retired, to not only consider the age structure of the population but also the benefits/challenges that come with the population living longer than expected.

2.1.2 Costs and benefits of longevity

Longevity in simple terms represents an extension beyond the expected duration of life. People, generally, love to live longer for various reasons such as having a stronger family relationship; contributing positively to their communities; leaving a greater legacy; having the opportunity to discover and fulfil their purpose; having the opportunity to travel the world; having the opportunity to experience different cultures and broaden their perspectives.

However, with people living longer, there are the downsides that they experience. The downside mostly relates to health but not limited to it. Some of the downsides are related to high health costs which may require more medical interventions and treatments; the risk of age-related diseases; experiencing cognitive breakdown in the form of memory loss; feeling socially isolated where friends and family move away or pass away; experiencing mental health issues; outliving their financial resources and becoming a financial burden to family members including children who are within the working age population; becoming a burden to caregivers as they may feel overwhelmed; decline in hearing and loss of vision; experiencing reduced mobility; increase in the risk dental/oral health issues and putting strain on the social security system or pension system.

Obviously, one can deduce that the cost of living longer than expected outweighs the benefits. This will usually be the experience, especially if people do not plan towards the point of transition from one age structure to another and living longer than desired or than expected.

2.1.3 Longevity risk as a financial risk

“Longevity risk refers to the potential financial risk that arises from individuals living longer than expected.” (Finance Strategists; 2023)

This risk is a financial risk because the underlying concept behind longevity relates to a population who has reached the normal retirement age, who would rely on their pension system and/or retirement savings for sustenance for the rest of their lives until death. It poses financial strain or burden on the existing pension system if they continue to live beyond the expected remaining life after retirement. Thus, longevity risk is a financial risk that burdens not only individuals but also government and pension providers, as well as the insurance firms.

2.1.4 Uncertainties associated with longevity risk

Improvements in medical technology and healthcare can lead to declines in mortality rates, thereby resulting in the large increase in longevity. Longevity risk considered at the pensionable age carries some levels of uncertainties. We would classify these uncertainties into three categories (CRO Forum; 2010):

- i. **Mortality Trend Risk**: This refers to the potential risk associated with changes in mortality rates over time. That is, it is the risk of wrongly estimating the future trends in mortality. Changes in mortality rates can affect the sustainability of social security and pension systems, potentially leading to funding shortfalls or increased burden on the young working-class population.
- ii. **Mortality Level Risk**: This implies the potential risk associated with the level of mortality rates at a given point in time or over a specific period. It relates to the misestimation of the current level of mortality rates rather than changes in mortality rates over time. Mortality level risk can influence population dynamics, including population growth, age structure, and dependency ratios. All this directly affects life expectancy numbers that support governments and institutions in Pension planning.
- iii. **Volatility Risk**: This describes the risk associated with fluctuations in mortality rates. In the context of our discussion, it is the risk of people dying earlier or even later than expected. This type of risk can have significant implications for individuals, organizations, and governments that are exposed to longevity risk.

2.1.5 Historical glimpse of U.K. longevity development

The U.K. continually monitors the development of its population knowing how important it aids planning and development of the country, as well as ensuring that the old aged or retired population are adequately catered for as they would rely on their pensions or retirement savings for survival until death. This approach has led to recognising the rate of births, the rate of deaths, and the expected number of years people born at certain periods are projected to live. These are used for building tables like mortality, morbidity, and annuities tables, which are then used as factors for estimating the pension liabilities (pension schemes), insurance contract liabilities (life and health insurance).

At this moment, the generations of those who were born during the U.K. baby-boom historical record, are in retirement. In 2016, the baby-boom generation of post-World War II showed survival to age 70. This increased the population of people in their 70's from 4 million to 5 million as of 2016. Furthermore, it was recorded that 78% of 820,719 babies born in 1946 (post-World War II) turned 70 years old in 2016. (ONS 2018)

Undoubtedly, one can suggest that, with the prevalent improvements in medical technologies and preventive health measures, there is the likelihood of the baby-boom generation surviving for a few more years. The statistics available support this logical presumption.

In 2018, the Office of National Statistics (ONS) reported that based on the mortality pattern in 2016, men and women, who were aged 70, were expected to live for another 15.3 years and

17.3 years respectively. Also adding that this increase in the life expectancy was connected to reduction in smoking and circulatory disease of people in their 70's.

To further substantiate the logical presumption, a report on U.K. National population projections (2022-based), released by ONS on 28 January 2025, suggested that death rates will increase between mid-2022 and mid-2032 due to the baby boom generation reaching older ages. This time interval falls within the horizon of the expected number of years that baby boomers, who were aged 70 in 2016, are to live before dying, as mentioned earlier.

Furthermore, it was determined, by the ONS, that the life expectancy at birth from 2020 to 2022 for males and females were 78.6 years and 82.6 years respectively. This represents a decrease when compared with record of 2017 to 2019 life expectancy at birth. Males were expected to live 79.3 years while females were expected to live for 83 years. For the pensionable age category (age 65), their life expectancy in 2020 to 2022 was estimated to 18.3 years and 20.8 years for male and females in that order.

This decline can be attributed to the abrupt outbreak of pandemic (COVID-19) in late 2019 but became widespread in 2020. The outbreak claimed many lives, particularly amongst those over 65, thereby increasing the mortality rate. Hence, life expectancy projection, being underpinned by mortality rate, declined amid medical discoveries of diseases including COVID-19. The subsequent cures of such diseases are likely to once again increase the life expectancy. Figures 1 and 2 below graphically depict the life expectancy trend of the past 30 years in the U.K. .

Figure 1: Life expectancy at birth for males and females, U.K., between 1980 to 1982 and 2020 to 2022

**Life expectancy at birth for males and females, UK, between 1980 to 1982
and 2020 to 2022**

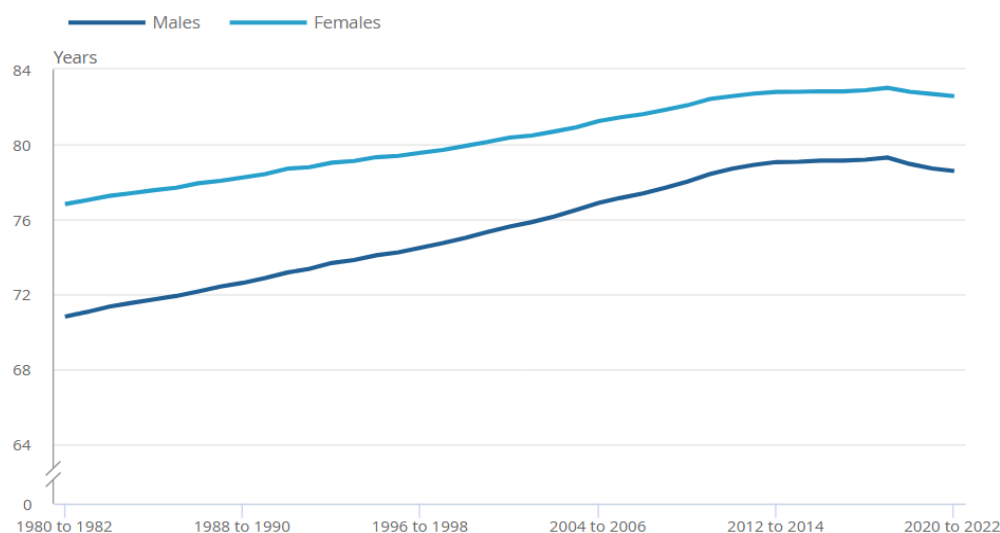
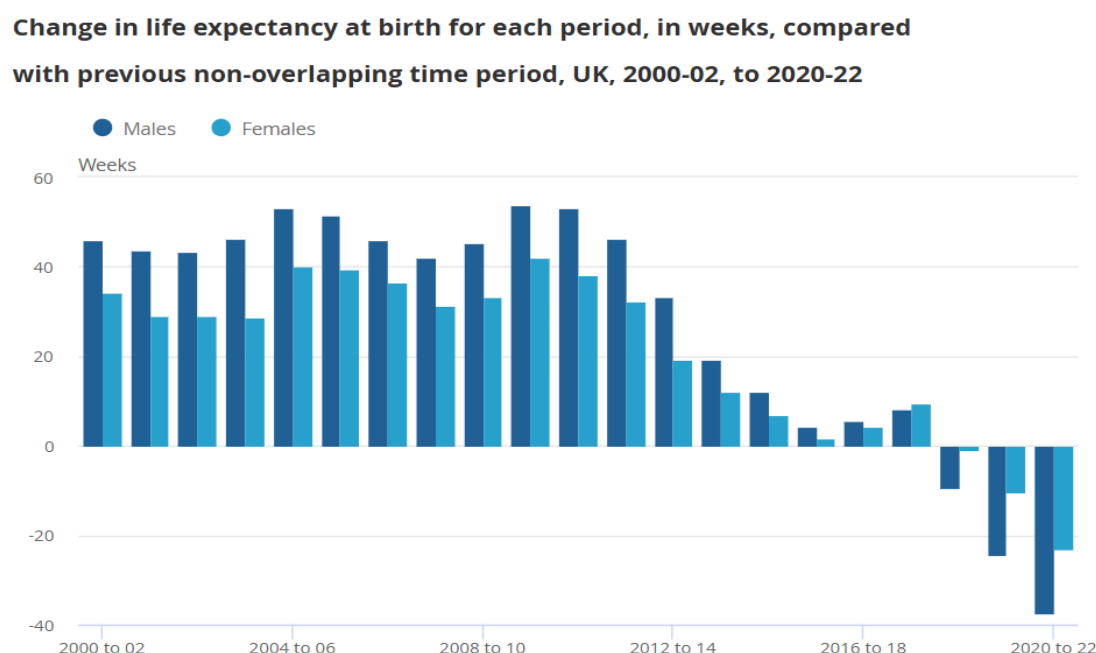


Figure 2: Change in life expectancy at birth for each period, in weeks, compared with previous non-overlapping period, U.K., 2000-02, to 2020-22



Source: National life tables - life expectancy in the UK: 2020 to 2022 from the Office for National Statistics

Figure 2 gives a clearer view of the 2020 to 2022 life expectancy decline at birth. However, based on the fact mortality rates change from year to year, the children born in 2020-2022 are likely to live longer than the expected lifespan. For example, if future mortality rates decrease, and another projection is carried out, then we would expect an increase the life expectancy of the those born in 2020-2022.

In summary, the growing population alongside the baby-boom generation at retirement and unparalleled life expectancy increase are conditions that would continue to enhance longevity risk. The significant impact of longevity risk will remain a prominent point of consideration for individuals, governments and institutions in the light of financial obligations within their purviews. In this case, pension obligations and the likelihood of paying beyond the estimated lifespan of the retired population.

2.2 Perspectives on Life Expectancy: Limit vs No Limit

Life expectancy refers to the number of years that a child at birth is expected to live or any individual at age (x) is expected to live. This can be either period life expectancy or cohort life expectancy.

Period life expectancy relates to the average number of years a person is expected to live based on the mortality rates of a specific year or period. It assumes that the mortality rates of the specific year or period will remain constant over the person's lifetime. That is, it does not consider the changes in mortality rate over time which result in the underestimation or overestimation of mortality rate.

Meanwhile Cohort life expectancy is the average number of years a person is expected to live, based on the mortality rates experienced by their birth cohort. This type of life expectancy provides more accurate estimation because it factors in the change in mortality rate over time.

We will briefly look into some debates around early 21st century by some scholars on whether there is limit to life expectancy and not.

In 2005, the New England Journal of Medicine published a report that opined that life expectancy has limit. The underlying factor that the authors of the report considered in their analysis to establish their position was the obesity rate in the United States. They stated that:

“Unless effective population-level interventions to reduce obesity are developed, the steady rise in life expectancy observed in the modern era may soon come to an end and the youth of today may, on average, live less healthy and possibly even shorter lives than their parents.”

In: S. J Olshansky & Douglas J. Passaro (2005).

Twenty years ago, they disbelieved the assumption that the emergence of technology in its potential state could substantiate either developing or revising life expectancy forecast and even if the technology that will improve the life of people came into existence, with tendencies of having further increases in life expectancy, it will have to be widespread for it to have significant influence on the aging structure.

In contrast to the above opinion that life expectancy has limit, Jim Oeppen & James W.Vaupel argued that purported ‘limit’, (also representing the position of the officials saddled with projecting life expectancy to facilitate retirement planning) to life expectancy was no longer authentic because the trends in various countries for life expectancy says otherwise. They established the facts of advances in medical care, nutrition, sanitation etc. led to reduction in the death rates of young-aged population and consequently imply that mortality improvements lead to an increase in life expectancy (Science’s Compass; 2002).

Notwithstanding the opinions of the parties as to whether life expectancy has limit or not, there still exists a common element that increase in life expectancy was a possibility when certain conditions are set in place. Hence, longevity risk was also a possibility.

Fast forward to recent times, we can acknowledge that there may be no longer further assertions or controversies as to limits to life expectancy or not. It is no longer news that we now live in an era where sophisticated technologies are prevalent and unequivocally promote the improvement of lives leading to people living longer than expected.

In a report by the ONS (February 2025), it was projected that males and females born in 2023 are expected to live on average, to age 86.7 and 90.0 years respectively. This has considered future improvement in mortality. Meanwhile, for those within the age 65 category, 19.8 years and 22.5 years are the respective expected number of years that males and females are to live. Not only that, by 2047, the projected years in 2023 are expected to increase further. That is, in 2047, males and females at birth will have a life expectancy of 89.3 and 92.2 years respectively while those in age 65 will live for an additional 21.8 years (males) and 24.4 years (females).

The above shows that life expectancy will continue to be on the rise in the presence of all favorable conditions even in future years. Hence, there seems to be no limit to life expectancy

particularly in these times and seasons where technology is rapidly growing to create a better and improved life for people, thereby resulting in a longer life. However, we will not dismiss the certainty of death for all humans. This certainty of death naturally places a limit to life expectancy though the timing is uncertain. This is why there is an arbitrary limit, for instance, 120 years which is mostly used when building life mortality tables.

2.3 Under-estimation of longevity risk

We have been able to establish that when considering longevity risk, we are looking at the scenario of people or a population group who at retirement (which is called pensionable age), have the likelihood of living longer than expected. Since longevity risk has become the talk in town especially in the life & health insurance space, not excluding the corridor of retirement benefits providers, we expect it to be factored into their liabilities calculations as an absolute. However, its futuristic impact is still undermined. A report by International Monetary Fund (IMF) says that:

“Typical assumptions for pension liability valuations in some countries suggest that longevity assumptions may not adequately account for future developments in longevity.” (IMF; 2012).

Not accounting for the future increase in longevity risk even when using the actual longevity data in the calculation of pension liabilities would only lead to underestimation of pension liabilities. It could be said that pension providers undermine future increase in longevity risk to avoid recording exorbitant pension liabilities in their books because doing so would require that they raise more funds or inject more capital to match the financial obligations that will be reflected in the books. This also means that they would not want to appear to the public and all stakeholders as insolvent.

Nonetheless, they still would have to pay for the underestimation because the pensioners could continue to live beyond the expected age the pension providers might have pre-planned for. Both ways, longevity risk will still be stirring right to their faces waiting to be fully embraced.

Longevity risk is a force that has been enthroned by the continued improvement in mortality rate after a person reaches the retirement age. Its rule spreads across various types of pension schemes and the stakeholders of the pension schemes are, without doubt, impacted by it.

We will now delve into the impact of longevity risk on pension schemes and steps to mitigate it in subsequent chapters.

3. PENSION SCHEME

3.1 Overview

A pension scheme, being a retirement plan, is structured to provide financial security and stability after individuals stop earning from being active members of any employer because they have attained normal retirement age or choose to retire early upon reaching the minimum age for early retirement or retired after the normal retirement age but not exceeding maximum age based on the stipulations in the benefit scheme of the employer. In this chapter, we will take a detailed look into the various types of Pension Schemes that a person can opt for. Pension Schemes can be sponsored by employers, individuals, as well as the state.

3.1.1 Highlights of U.K. Pension Scheme History

- i. The Chatham Chest: Established in 1590, it was a groundbreaking pension scheme for injured Royal Navy seamen. It provided financial support based on the severity of the injury. The scheme was funded through a 5% monthly deduction from seamen's wages. While pensions were typically lifelong, they could be terminated or reduced if the recipient's health improved, and they became capable of working again (Pension Archive; 2024).
- ii. Scheme for Royal Navy Officers: This was a state superannuation scheme that was established in 1672. It was introduced for retired naval officers and was believed to be the first occupational pension scheme in the world, as it provided lifetime pensions due to old age upon retirement. The scheme had no fixed retirement age and a benefit of 100% of salary and allowance was payable to officers who were incapacitated to carry out their duties due to age if, and only if, they had completed a minimum of 15 years of service (Pension Archive; 2024).
- iii. The Civil Service: Government civil servants were among the first workers to receive pension benefits, starting with an official in the London port in 1684. The practice spread to other departments, such as Customs and Excise, in the early 18th century. Pensions were used to retain staff and promote integrity within the civil service.

The Superannuation Fund was established in 1712 to provide lower-ranking officers with a pension of one-third of their final salary after 7 years of service and reputable behaviour, contingent on regular yearly contributions. By 1810, the pension system had been extended across the entire civil service, offering financial support to staff who could no longer continue working (Pension Archive; 2024).

- iv. Early Occupational Pension Scheme: Occupation pension schemes emerged in the 17th and 18th centuries, initially for select government employees. Private firms began adopting this practice in the 19th century, starting with middle-class workers in clerical and administrative roles.

The Bank of England and East India Company, both government-associated private firms, established company pensions in the late 17th century. The Bank of England granted its first pension in 1739, with subsequent grants awarded discretionarily. The Chartered Gas Light and Coke Company's 1841 Superannuation Fund was one of the

earliest private occupational pension schemes. Railway companies, such as Reuters (1882), WH Smith (1894), and Colmans (1899), soon followed suit.

The trend continued to spread, with the National Pension Fund for Nurses established in 1887, marking the expansion of pension schemes across various professions (Pension Archive; 2024).

- v. State Pension Scheme: Germany offered the first State Pension in the world in the late 19th Century. However, the British government set up two committees in the 1890s to examine such an equivalent scheme for the U.K. The first committee, in 1896, was the Rothschild Committee on Old Age Pensions and the second committee, in 1899, was the Select Committee on the Aged Deserving Poor. By 1908, U.K. State Pension was introduced.

The Pension Act of 1908 allowed the Government to provide 5 sterling to those over 70 who passed what was known as the 'Means Test'. This amount was paid not by pensioners' contribution but directly from Government revenue. By 1919, there was an increase in the rate to 10 sterling. Subsequently, more Pension Acts were introduced. Some of which are:

- a. Contributory Pension Act of 1925 – It was a contributory state scheme to provide pension for manual workers and those who earned up to £250 a year from age 65 above.
- b. Old age and Widow's Pension Act of 1940 – It widened the benefits for women, as their pensionable age was reduced to 60 specifically for insured women who were unmarried and the wives of insured male pensioners.
- c. National Insurance Act of 1959 – This Act created graduated pension which is a top-up state pension scheme based on earnings. This was meant to supplement the basic state pension (Pension Archive; 2024).

The above has given some glimpses in to historical development of pension scheme in the U.K. The further discussion will be focused on occupational pension schemes.

3.2 Occupational Pension Schemes

An occupational pension scheme is a type of retirement plan provided by an employer to help employees save for retirement. The employer sets up and contributes to the scheme, which provides a pension or other benefits to employees upon retirement. Occupational pension schemes can be either Defined Benefit (DB) or Defined Contribution (DC) schemes. This gives employees the opportunity to secure their financial future after retirement.

3.2.1 Defined Benefit Scheme

A DB scheme is a Pension Scheme where the employer promises to pay a specific benefit amount to the employee upon retirement, based on a formula that typically considers factors such as salary and years of service. This plan provides a guaranteed income for the rest of the life of an individual after retirement, irrespective of how long the individual lives.

This, therefore, places the employer in a position where they would have to put the risk of longevity into an adequate perspective before and after the employee reaches retirement age. Particularly after the employee retires so there is adequate provision in funding the future benefits.

For instance, if an employer states in the benefit plan that an employee would, upon retirement, be entitled to 65% of their average salary for the last 4 years of service which will then be multiplied by the number of years of their pensionable service. This grants employees a sense of security after they retire. Now, the employer will work towards fulfilling their obligation to the employees in the form of contributions which will fund the plan. The contributions are based on actuarial calculations for the purpose of adequate provision for the future liability of the employer.

Defined benefits are usually calculated using a formula based on service and salary at/or near retirement. The following are the methods used in calculating the benefits:

- i. **Final Average Salary (FAS)**: In this method, the benefit is calculated based on the average of employees' salary in the final years of employment usually between 3 to 5 years. Mathematically, it is written as:

$$\text{Benefit} = \text{Final Average Salary} \times \text{Years of Service} \times \text{Accrual Rate} \quad (1)$$

where Accrual Rate refers to the rate at which the pension benefits grow for each year of service.

3.2.1.1 A hypothetical illustration of using Final Average Salary Method for calculating Defined Benefits

Assuming the following randomly generated data represent XYZ Limited Company ("The Participating Employer") details of retired employees with 5 years final average salary. It should be noted that the information used here as well as subsequent hypothetical illustration only mimics what a real data looks like. Hence, there is compliance with WTW global data privacy policy.

Table 1: FAS Illustrative Data

S/N	Employee ID	5 years FAS	Years of Service (YoS)
1	R1135	£115,000.00	16
2	R1116	£85,000.00	25
3	R1172	£60,000.00	26
4	R1154	£92,000.00	27
5	R1144	£75,000.00	14
6	R1131	£90,000.00	9
7	R1111	£105,000.00	12
8	R1107	£95,000.00	23
9	R1110	£110,000.00	29
10	R1141	£120,000.00	5
11	R1147	£100,000.00	4
12	R1119	£210,000.00	8
13	R1133	£130,000.00	28

14	R1156	£125,000.00	6
15	R1118	£115,000.00	9
16	R1132	£95,000.00	23
17	R1121	£85,000.00	8
18	R1126	£130,000.00	22
19	R1115	£100,000.00	16
20	R1123	£105,000.00	1
21	R1117	£112,000.00	7
22	R1124	£80,000.00	22
23	R1101	£155,000.00	18
24	R1103	£110,000.00	7
25	R1120	£125,000.00	17
26	R1125	£95,000.00	11
27	R1102	£180,000.00	12
28	R1127	£95,000.00	8
29	R1128	£145,000.00	21
30	R1130	£85,000.00	5

Also, assuming that, in the benefit plan, the following are the accrual rates for members based on their years of service.

Table 2: Accrual Rate

Years of service	Accrual Rate
1	1/150th
2	1/150th
3	2/150th
4	3/150th
5	4/150th
6	5/150th
7	6/150th
8	7/80th
9	8/150th
10	9/150th
11	10/150th
12	11/150th
13	12/150th
14	13/150th
15	14/150th
16	15/150th
17	16/150th
18-above	17/150th

The table below shows the estimated pension liability of **£4,418,150** using the FAS method.

Table 3: FAS Method

S/N	Employee ID	5 Years FAS	Years of Service (YoS)	Accrual Rate (AR)	Pension Benefit = $FAS \times YoS \times AR$
1	R1135	£115,000.00	16	0.10	£184,000.00
2	R1116	£85,000.00	25	0.11	£233,750.00
3	R1172	£60,000.00	26	0.11	£171,600.00

4	R1154	£92,000.00	27	0.11	£273,240.00
5	R1144	£75,000.00	14	0.09	£94,500.00
6	R1131	£90,000.00	9	0.05	£40,500.00
7	R1111	£105,000.00	12	0.07	£88,200.00
8	R1107	£95,000.00	23	0.11	£240,350.00
9	R1110	£110,000.00	29	0.11	£350,900.00
10	R1141	£120,000.00	5	0.03	£18,000.00
11	R1147	£100,000.00	4	0.02	£8,000.00
12	R1119	£210,000.00	8	0.05	£84,000.00
13	R1133	£130,000.00	28	0.11	£400,400.00
14	R1156	£125,000.00	6	0.03	£22,500.00
15	R1118	£115,000.00	9	0.05	£51,750.00
16	R1132	£95,000.00	23	0.11	£240,350.00
17	R1121	£85,000.00	8	0.05	£34,000.00
18	R1126	£130,000.00	22	0.11	£314,600.00
19	R1115	£100,000.00	16	0.10	£160,000.00
20	R1123	£105,000.00	1	0.01	£1,050.00
21	R1117	£112,000.00	7	0.04	£31,360.00
22	R1124	£80,000.00	22	0.11	£193,600.00
23	R1101	£155,000.00	18	0.11	£306,900.00
24	R1103	£110,000.00	7	0.04	£30,800.00
25	R1120	£125,000.00	17	0.11	£233,750.00
26	R1125	£95,000.00	11	0.07	£73,150.00
27	R1102	£180,000.00	12	0.07	£151,200.00
28	R1127	£95,000.00	8	0.05	£38,000.00
29	R1128	£145,000.00	21	0.11	£334,950.00
30	R1130	£85,000.00	5	0.03	£12,750.00
					£4,418,150.00

- ii. Career Average Salary (CAS): This method considers the average salary of an employee for the entire period of their career (not only the final years of employment). It can be calculated as:

$$\text{Benefit} = \text{Career Average Salary} \times \text{Years of Service} \times \text{Accrual Rate} \quad (2)$$

3.2.1.2 A hypothetical illustration of using CAS Method for calculating Defined Benefits

Table 4: CAS Illustrative Data

S/N	Employee ID	CAS	Years of Service (YoS)
1	R1135	£110,000.00	16
2	R1116	£80,000.00	25
3	R1172	£58,000.00	26
4	R1154	£85,000.00	27
5	R1144	£70,000.00	14
6	R1131	£82,000.00	9
7	R1111	£95,000.00	12
8	R1107	£88,000.00	23
9	R1110	£105,000.00	29
10	R1141	£118,000.00	5
11	R1147	£98,000.00	4
12	R1119	£210,000.00	8

13	R1133	£130,000.00	28
14	R1156	£120,000.00	6
15	R1118	£110,000.00	9
16	R1132	£88,000.00	23
17	R1121	£80,000.00	8
18	R1126	£120,000.00	22
19	R1115	£95,000.00	16
20	R1123	£102,000.00	1
21	R1117	£108,000.00	7
22	R1124	£75,000.00	22
23	R1101	£150,000.00	18
24	R1103	£102,000.00	7
25	R1120	£120,000.00	17
26	R1125	£92,000.00	11
27	R1102	£175,000.00	12
28	R1127	£87,000.00	8
29	R1128	£140,000.00	21
30	R1130	£82,000.00	5

The table below shows the total estimated pension liability of **£4,205,960** using the CAS method.

Table 5: CAS Method

S/N	Employee ID	CAS	Years of Service (YoS)	Accrual Rate (AR)	Pension Benefit = $CAS \times YoS \times AR$
1	R1135	£110,000.00	16	0.10	£176,000.00
2	R1116	£80,000.00	25	0.11	£220,000.00
3	R1172	£58,000.00	26	0.11	£165,880.00
4	R1154	£85,000.00	27	0.11	£252,450.00
5	R1144	£70,000.00	14	0.09	£88,200.00
6	R1131	£82,000.00	9	0.05	£36,900.00
7	R1111	£95,000.00	12	0.07	£79,800.00
8	R1107	£88,000.00	23	0.11	£222,640.00
9	R1110	£105,000.00	29	0.11	£334,950.00
10	R1141	£118,000.00	5	0.03	£17,700.00
11	R1147	£98,000.00	4	0.02	£7,840.00
12	R1119	£210,000.00	8	0.05	£84,000.00
13	R1133	£130,000.00	28	0.11	£400,400.00
14	R1156	£120,000.00	6	0.03	£21,600.00
15	R1118	£110,000.00	9	0.05	£49,500.00
16	R1132	£88,000.00	23	0.11	£222,640.00
17	R1121	£80,000.00	8	0.05	£32,000.00
18	R1126	£120,000.00	22	0.11	£290,400.00
19	R1115	£95,000.00	16	0.10	£152,000.00
20	R1123	£102,000.00	1	0.01	£1,020.00
21	R1117	£108,000.00	7	0.04	£30,240.00
22	R1124	£75,000.00	22	0.11	£181,500.00
23	R1101	£150,000.00	18	0.11	£297,000.00

24	R1103	£102,000.00	7	0.04	£28,560.00
25	R1120	£120,000.00	17	0.11	£224,400.00
26	R1125	£92,000.00	11	0.07	£70,840.00
27	R1102	£175,000.00	12	0.07	£147,000.00
28	R1127	£87,000.00	8	0.05	£34,800.00
29	R1128	£140,000.00	21	0.11	£323,400.00
30	R1130	£82,000.00	5	0.03	£12,300.00
					£4,205,960.00

Although the FAS method and CAS are similar, the difference is in how average salary is calculated. Also, the estimated pension is lower for CAS compared to FAS. Employers who adopt CAS consider it be more stable and easier for their long-term planning as opposed to FAS where late career promotions can sharply increase the benefits of their employees.

- iii. **Flat Benefit (FB):** This is where the employer stipulates a fixed amount in the benefit plan regardless of the employees' years of service or changes in salary due to promotions. It is a simple approach for an employer with a small plan.

$$\text{Benefit} = \text{Fixed amount} \times \text{Years of Service} \quad (3)$$

3.2.1.3 A hypothetical illustration of using FB Method for calculating Defined Benefits

The data below was randomly generated assuming the employer, XYYZ LIMITED COMPANY, stipulated a fixed amount of £6,000 as benefit per year of service in the benefit plan. Then total estimated pension benefit will be £2,634,000 under the Flat Benefit method.

Table 6: Flat Benefit Method

S/N	Employee ID	FB	Years of Service (YoS)	Annual Benefit = <i>FB × YoS</i>
1	R1135	£6,000.00	16	£96,000.00
2	R1116	£6,000.00	25	£150,000.00
3	R1172	£6,000.00	26	£156,000.00
4	R1154	£6,000.00	27	£162,000.00
5	R1144	£6,000.00	14	£84,000.00
6	R1131	£6,000.00	9	£54,000.00
7	R1111	£6,000.00	12	£72,000.00
8	R1107	£6,000.00	23	£138,000.00
9	R1110	£6,000.00	29	£174,000.00
10	R1141	£6,000.00	5	£30,000.00
11	R1147	£6,000.00	4	£24,000.00
12	R1119	£6,000.00	8	£48,000.00
13	R1133	£6,000.00	28	£168,000.00
14	R1156	£6,000.00	6	£36,000.00
15	R1118	£6,000.00	9	£54,000.00
16	R1132	£6,000.00	23	£138,000.00
17	R1121	£6,000.00	8	£48,000.00
18	R1126	£6,000.00	22	£132,000.00
19	R1115	£6,000.00	16	£96,000.00
20	R1123	£6,000.00	1	£6,000.00
21	R1117	£6,000.00	7	£42,000.00
22	R1124	£6,000.00	22	£132,000.00

23	R1101	£6,000.00	18	£108,000.00
24	R1103	£6,000.00	7	£42,000.00
25	R1120	£6,000.00	17	£102,000.00
26	R1125	£6,000.00	11	£66,000.00
27	R1102	£6,000.00	12	£72,000.00
28	R1127	£6,000.00	8	£48,000.00
29	R1128	£6,000.00	21	£126,000.00
30	R1130	£6,000.00	5	£30,000.00
				£2,634,000.00

- iv. **Unit Benefit:** This is where pension benefits are calculated according to the number of units accumulated by an employee over his career period. Each unit is a representation of a certain number of benefits however, it is not frequently used even though it is beneficial when the employer wants to reward the long service of the employees. It is calculated as:

$$\text{Pension Benefit} = \text{Benefit per unit} \times \text{number of unit earned} \quad (4)$$

where *Benefit per unit* is a fixed amount based on a percentage of the salary.

- v. **Hybrid Plan:** An example is cash balance plan. It is a combination of the elements in DB plan and DC Plan. In this approach, the employer would credit a hypothetical account for each employee which will be based on a percentage of their salary. This hypothetical account grows with interest being credited to it. The benefit amount that will be paid is usually based on the amount accumulated in the hypothetical account. This can then be paid as a lump sum, as a lifetime annuity or a mix of both.

3.2.2 Defined Contribution Scheme

A DC plan differs from defined benefit in a way that an individual account is opened for each employee, and both the employee and the employer contribute a specific amount of money to the account. This also aims to provide financial security for individuals upon retirement.

The benefit that the employee will be entitled to at retirement depends on the amount of contributions made and the performance of investment vehicles where the contributions might have been invested. Unlike DB, DC does not guarantee a specific benefit at retirement. In this type of retirement plan, the employees bear the risks that the investment is exposed to, as well as longevity. Therefore, supporting the risk if after retirement they live longer, and the pension is unable to sustain them for the 'extra' years of living.

There are countries that adopt the defined contribution with regulations clearly defining what is mandatory, as well as what proportion employees and employers are to contribute to ensure that employees have retirements savings to fall back onto when they attain retirement age.

Appendix 1 gives examples of the contributions employers and employees make into the individual account for pension purposes in some countries. Occupational pension schemes have provided options for countries to consider whichever they deem suitable for them to adopt (although some adopt both defined benefit and defined contribution schemes).

3.3 Summary of U.K. Pension schemes guidelines

The U.K. pension system has a comprehensive regulatory framework with the aim of ensuring fairness, security and sustainability in pension arrangements. This has resulted in the establishment of guidelines to ensure sufficient contributions and funding for pensions. Actuarial valuations of pension funds are conducted to evaluate whether the funds are adequate to fulfil the employer's pension obligations to retired members. If the funds are found to be insufficient, the employer is required to contribute additional funds to the scheme (in the case of a defined benefit). In cases where the employer becomes insolvent, the Pension Protection Fund (PPF) guarantees compensation to members of underfunded DB schemes (TPR web page).

Meanwhile, for DC schemes, employers are to contribute a minimum of 3% of qualifying earnings and employees must contribute 5% (TPR web page). However, there are some flexibilities to this as both employers and employees are allowed to contribute higher amounts.

In the next section, we will examine how longevity risk impacts the occupation pension schemes: DB and DC Schemes.

4. LONGEVITY RISK IMPACT ON PENSION SCHEMES

4.1 Impact on Defined Benefit Scheme

Following the previous chapter's discussion on occupational pension schemes, for individuals who are under the defined benefit plan of a company, longevity risk will be borne by the employer. The employer is the pension provider having guaranteed that, at retirement, the employees who are under the scheme would be entitled to a certain amount, usually a percentage of their salary (either final years' average or entire career average) applied to pensionable service years.

This arrangement has made the employer obligated in ensuring that the promise made is fulfilled to the employees. Considering that employer is regulated, then escape from fulfilling that promise would be impossible because the regulatory body would demand to know the status of their pension fund, in whether it is sufficient or not. In addition, the regulatory body would also assess the financial condition of the employer, if it will become insolvent or not. If the pension fund available at the time of assessment is not sufficient to meet the financial liabilities owed to the pensioners, it is necessary for the employer to provide additional funds into the pension fund so that the fund can match the estimated liabilities. This means that the employer must 'cough out' additional funds that are not within the envisaged contribution plan towards the pension fund. This alone can undoubtedly put a strain on the employer and a schedule of contributions is usually established.

Now, if the pensioners, who have claims on the pension fund, are enjoying their old age by engaging in activities that constantly improve their overall health, then, the most expected thing is that they would continue to be alive and to claim benefits from the pension fund. The 'sad' reality for the employer would be that the longer the already existing pensioners are alive, they are obliged to keep contributing to the pension fund and where there are new entrants into the pensioner status, then more funds would be required of the employer. Even though the pensioners may be expected not to live beyond a particular period after retirement, when the pensioners defy the odds, then the pension provider (the employer) has no alternative than to accept the 'sad' reality (also, in the face of unfavourable economic circumstances).

Thus, the burden of longevity risk under a defined benefit plan rests on the shoulders of the employer.

4.2 Impact on Defined Contribution Scheme

In this type of plan, there is no guaranteed amount the employer is obligated to when the employees retire. This is a plan where whatever amount has been contributed into the employees' retirement savings account (and invested), that is what becomes the employee's benefit for the whole period of their service years when they are admitted into the pensioner status.

Here, the implication is that if the amount contributed until retirement is low, the employee would bear the risk of insufficient funds for sustenance at retirement. In addition, if the pensioner (former employee) is alive beyond the expected duration of years after retirement,

the burden that comes with longevity risk will rest on his shoulders. This means that the employer contribution towards the pension fund will cease at the retirement of the employees.

Meanwhile, in the case of a Hybrid Plan where the amount in the hypothetical account can be paid either as a lump sum or an annuity, the employer will bear the longevity risk of a pensioner if and only if the account balance is paid as annuity. This means the employer will continue to make payments until the pensioner dies. If the pensioner survives past their life expectancy, the annuity payment will not cease, and the employer is obligated to pay.

However, where a lump sum is opted for by the employee at retirement, then we can say that the employer is free from the longevity risk, as the employee (the pensioner) would be financially responsible for the risk of living longer than expected.

4.3 U.K. Mortality Assumption Table

The U.K. mortality tables serve as tools that are used by various professionals or specialists such as demographers, policymakers and actuaries. They are used to assess and project mortality rates across various segments of the population. The insightful information they provide about life expectancy, mortality rates, as well as the probability of death at various ages become vital for the users of the information. This information helps with pension planning, insurance underwriting and reserving. It also promotes policies relating to public health to support people living a healthy life.

The U.K. mortality tables development is dated back to the 17th century and the first vital table was introduced by John Graunt in 1662 and it was called Life Table (Natural and Political Observations mentioned in a following index and made upon the Bill of mortality; 1662). More refined and developed versions of the table came to effect in the 19th century. One of the earliest most comprehensive mortality table was the “A1967-70” table. This was created based on the data or information available from 1967 to 1970.

A typical mortality table can be identified when structures like the following are present:

- **$age(x)$** – Age as the start of the interval
- **l_x** – represents the number of in people surviving to age x
- **q_x** – represents the probability that a person age x will die before attaining age $x+1$
- **p_x** – represents the probability that a person age x will survive to age $x+1$
- **T_x** – represents the total number of person-years lived by the cohort above age x
- **e_x** – represents the expected number of years of remaining for an individual at age x (life expectancy)

Over the years, the mortality tables have consistently been improved and, of course, through the information that was gathered because experiences for each year were not the same. Various occurrences and unexpected events would always impact society, thereby determining the information that would be available at every point in time. People may be affected by the outbreak of a new kind of diseases or have their life and health deteriorate in the bid to keep up with ‘trending’ lifestyles which, in turn, jeopardise their health, increasing sickness rates

and for those who do not recover, they add to death rates. Hence, a continuous update to the already collected information used in developing mortality tables will be required.

A division of the Institute and Faculty of Actuaries, U.K. known as Continuous Mortality Investigation (CMI) is a trusted and independent provider of the mortality and sickness rate tables used by life insurers and pension schemes' actuaries. They produce mortality projections that aid the calculation of liabilities, so that organisations can make adequate provision for their financial obligations, both to policyholders (insurance) or to pensioners (pension schemes). The projection model is referred to as CMI Mortality Projection Model (CMI Model).

In recent years, the CMI has produced updated mortality tables to capture evolving trends and the latest data. For example, the CMI_2021 table incorporates mortality data through 2021 and includes adjustments to account for the effects of the COVID-19 pandemic.

The CMI produces a standard table and an improvement table (model). The standard table is used as the starting point in calculating life expectancy or liabilities in actuarial models. Hence, it is considered as baseline mortality rates, as it captures the mortality for a specific population (pensioners, annuitants, normal health category etc.) over a defined period. Examples of the tables are S3PMA, S3PFA, S2PA, S2NMA, S4PML etc. and designed for a specific group: males, females, pensioners, annuitants etc. Further adjustments can be made using rating factors or scaling to better reflect the characteristics or experience of a specific scheme or industry.

The improvement table is used to project future mortality rates when combined with the standard table. This means that future changes in mortality are projected to observe how mortality improves over time (people living longer). It focuses on trends in mortality and not the current mortality levels. Example of the tables are CMI_2019, CMI_2020, CMI_2021.

In the next sub-section below, we will examine sample scenarios and focus mainly on two statuses that exist in a Defined Benefit Scheme. We would also use the combination of CMI standard and improvement tables to ascertain the future liability pattern and that the pattern will be congruent with this report discussion that increasing life expectancy poses a longevity risk. This should not be sidelined by individuals, by organizations neither by the government in planning for retirement.

4.4 Sample Scenarios

In this sub-section, we will examine the active status (employee who is in active service with the employer) and the retired status (employee who has retired from active status) of the DB scheme only. The objective is to assess how the actuarial liabilities of a male and a female reflect the mortality improvement projection given that the subject of this report is the fact that longevity is now on the higher side of expectations in retirement planning. We will compare the results of two recent CMI improvement projections on actuarial liabilities.

A. Active Status (Male and Female)

Let us consider the following pension scheme description, the basic information, valuation date and the assumptions.

Table 7: Active Status Sample Information

Valuation Date	31/12/2021
Pension Scheme Description	
Normal Retirement Age (NRA)	65
Benefit at NRA	$Service \ Salary \times \frac{1}{60}$
Form of Payment	Single Life Annuity
Assumptions	
Interest Rate	3.00%
Pay Increase	4.00%
Pension Increase in Payment	2.00%
Withdrawal Rates	Age 16-25: 10% Age 26-30: 7% Age 31-39: 5% Age 40-49: 3% Age 50-64: 1%
Disability	1% for all ages
Retirement	100%
CMI Combination of Standard and Improvements Table	S4NMA_L^CMI.2020.M1.25%; S4NMA_L^CMI.2020.F1.25%.
	S4NMA_L^CMI.2023.M1.25%; S4NMA_L^CMI.2023.F1.25%.
Basic Information	
Status	Active
Gender	Male and Female
Date of Birth	13/04/1978
Hire Date	01/01/1999
Monthly Salary at Val Date	£ 3,000
Salaries per year	12

The focus from the above information is the CMI combination of standard and improvements table. The standard tables, which represent 2017 mortality table, from the syntax are:

- S4NMA_L (SAPS series 4 Normal Health Male – Light)
- S4NFA_L (SAPS series 4 Normal Health Female – Light).

The improvement tables we will compare in this analysis are 2020 and 2023 table and the syntax are:

- CMI.2020.M1.25% (CMI 2020 Improvements for Males with a 1.25% Long-Term Rate)
- CMI.2020.F1.25% (CMI 2020 Improvements for Females with a 1.25% Long-Term Rate)
- CMI.2023.M1.25% (CMI 2023 Improvements for Males with a 1.25% Long-Term Rate)
- CMI.2023.F1.25% (CMI 2023 Improvements for Females with a 1.25% Long-Term Rate)

All other information only mimics what is likely when preparing to calculate the actuarial liabilities using client information. We have not considered exact client information and assumptions because of the WTW's global data privacy policy with respect to client data when interns are performing their Master's Final Work analysis.

For proper comparison, we have held the basic information to be the same for both male and female, while WTW software was used to extract mortality tables based on the above syntaxes.

The probability survival from $age(x)$ to $age(x + t)$ is represented as ${}_tp_x$ and was calculated based on decrements given above. That is, the mortality (q_d), withdrawal (q_w), disability (q_i) and retirement (q_r). This was calculated using the formula below the sample extraction is shown below:

$${}_tp_x = (1 - q_d) \times (1 - q_w) \times (1 - q_i) \times (1 - q_r) \times {}_{t-1}p_x \quad (5)$$

where ${}_0p_x = 1$

Table 8: Sample of a Multiple Decrement Table (Male - Current age 44)

Year	t	Mortality (q_d)	Withdrawal (q_w)	Disability (q_i)	Retirement (q_r)	${}_tp_x$
31/12/2021	0	0.11%	3.00%	1.00%	0%	100%
31/12/2022	1	0.12%	3.00%	1.00%	0%	96%
31/12/2023	2	0.13%	3.00%	1.00%	0%	92%
31/12/2024	3	0.13%	3.00%	1.00%	0%	88%
31/12/2025	4	0.14%	3.00%	1.00%	0%	85%
31/12/2026	5	0.15%	3.00%	1.00%	0%	81%
31/12/2027	6	0.16%	1.00%	1.00%	0%	78%
31/12/2028	7	0.17%	1.00%	1.00%	0%	76%
31/12/2029	8	0.18%	1.00%	1.00%	0%	74%
31/12/2030	9	0.19%	1.00%	1.00%	0%	73%
31/12/2031	10	0.20%	1.00%	1.00%	0%	71%
31/12/2032	11	0.21%	1.00%	1.00%	0%	70%
31/12/2033	12	0.22%	1.00%	1.00%	0%	68%
31/12/2034	13	0.24%	1.00%	1.00%	0%	67%
31/12/2035	14	0.25%	1.00%	1.00%	0%	65%
31/12/2036	15	0.27%	1.00%	1.00%	0%	64%
31/12/2037	16	0.29%	1.00%	1.00%	0%	62%
31/12/2038	17	0.32%	1.00%	1.00%	0%	61%
31/12/2039	18	0.34%	1.00%	1.00%	0%	60%
31/12/2040	19	0.38%	1.00%	1.00%	0%	58%
31/12/2041	20	0.42%	1.00%	1.00%	0%	57%
31/12/2042	21	0.46%	0.00%	1.00%	100%	55%

The pensionable service was computed using the formula below:

$$\text{Pensionable Service Years} = \frac{\text{Valuation Date} - \text{Hire Date}}{365.25} \quad (6)$$

The calculation captures leap years between both dates.

As previously explained in chapter 3, accrued benefit calculation was done using the formula below:

$$\text{Accrued Benefit at initial valuation date} = \text{Annual Salary} \times \text{Years of Service to date} \times \text{Accrual Rate} \quad (7)$$

where Annual salary = monthly salary at valuation date $\times$ 12

This annual salary is the annual salary at initial valuation date.

Given the assumption that salary increased at the rate of 4% per annum in subsequent years (after the initial valuation date), accrued benefit was calculated as:

$$\begin{aligned} \text{Accrued Benefit at future valuation date} = \\ \text{Annual Salary at previous valuation date} \times (1 + \text{pay increase rate}) \times \\ \text{Years of Service to date} \times \text{Accrual Rate} \end{aligned} \quad (8)$$

All the above are classified as pre-retirement calculations. Now, when the active members (both male and female) attain the assumed normal retirement age of 65, they would then begin to receive their regular pension, bearing in mind that we are using separate CMI mortality assumptions for them. Hence, the annual expected benefit to the member was calculated using the formula below:

$$\begin{aligned} \text{Annual Expected Benefit} = \text{Accrued Benefit at age 65} \times \\ \text{Retirement decrement } (q_{65}) \times \text{Survival probability at age 65 } (p_{65}) \times \\ \text{Discount factor at age 65} \end{aligned} \quad (9)$$

$$\text{where Discount Factor at age } (x) = \frac{1}{(1 + \text{Interest Rate})^t} \quad (10)$$

Furthermore, we will calculate the Pension Present Value Multiplier (PPVM) that will be applied to the annual pension payable to determine the present value of the future benefits.

This was done using:

$$\text{PPVM} = \text{Annuity at retirement} \times \text{Pension increase rate} \quad (11)$$

$$\begin{aligned} \text{where Annuity at retirement} = \text{Survival probability at retirement} \times \\ \text{Discount factor at retirement.} \end{aligned} \quad (12)$$

Note that 'annuity at retirement' represents one unit of pension.

Therefore, Pension Present Value Multiplier (PPVM) can be re-written as

$$\begin{aligned} \text{PPVM} = \text{Survival probability at retirement} \times \\ \text{Discount factor at retirement} \times \text{Pension increase rate} \end{aligned} \quad (13)$$

At post-retirement, the probability of survival used in estimating the PPVM only considers the mortality rate at each age after retirement.

$${}_t p_x = (1 - q_d) \times {}_{t-1} p_x \quad (14)$$

where the probability of survival at age 65 (for post-retirement calculations) equals one.

Then, the present value of future benefits is calculated by applying the annuity factor to the annual pension payable.

$$\text{Present Value of Future Benefit} = \text{PPVM} \times \text{Annual Expected Benefit} \quad (15)$$

Finally, we calculated the past service actuarial liabilities that will be required by an employer to make provisions for. This helps to ensure that pension funds are adequate to pay pensioners. In this sample analysis, it has been calculated as:

$$\text{Past Service Actuarial Liabilities (PSAL)} = \frac{\text{Years of Service at Valuation Date}}{\text{Years of Service at Retirement Age}} \times \text{Present of Value of the Future Benefit} \quad (16)$$

We should also note that the figures in the tables have been rounded for the purpose of this report but not in the calculation process. See Appendix 2 and Appendix 3 for the annual expected benefit sample table and post-retirement calculation sample for male active status who is currently age 44.

Having provided an overview of the methods used in this sample analysis, we will now provide the actuarial liabilities results for both male and female active members based on the CMI 2020 and CMI 2023 mortality improvements tables following the syntaxes.

We can recall that Standard mortality table base year is 2017 (that is, 2017 Mortality table for a group of Normal Health people). Now, when the CMI projections (2020 and 2023) were applied to the standard table, we have the projected mortality rates for all ages from 2018 to 2150. This led to having the mortality rates to be used for the comparison of CMI 2020 and CMI 2023 from 2017 – 2150. However, we have capped the years to be from 2017 to 2055 (See Appendix 5 for sample).

The combination of the Standard table and CMI tables to generate the ‘new’ mortality table from 2017 to 2055 for all ages was done using the WTW Toolkit. WTW Toolkit is a suite of digital tools and software solutions developed by WTW to support processes and promote efficiency.

The mortality rate for each age beginning from the base year 2017 was selected and applied to the calculation process. The calculation process was an iterative process as the mortality rate became the changing factor (which resulted to changes in survival probability) towards generating the liabilities.

We have used the year 2017 - 2055 to categorise the summation of the past service actuarial liabilities in line with the years in the ‘new’ mortality table that has been used in the process.

Table 9: Active Status PSAL Projection (2017 – 2055)

ACTIVE STATUS									
Male					Female				
Year	Based on CMI 2020		Based on CMI 2023		Year	Based on CMI 2020		Based on CMI 2023	
	PSAL	PSAL Percentage Change	PSAL	PSAL Percentage Change		PSAL	PSAL Percentage Change	PSAL	PSAL Percentage Change
2017	188,829.58		188,829.58		2017	200,144.97		200,144.97	
2018	189,295.27	0.25%	189,098.89	0.14%	2018	200,606.17	0.23%	200,461.96	0.16%
2019	189,758.37	0.24%	189,319.77	0.12%	2019	201,094.68	0.24%	200,772.23	0.15%
2020	190,202.22	0.23%	189,477.41	0.08%	2020	201,578.53	0.24%	201,044.41	0.14%
2021	190,631.09	0.23%	189,583.23	0.06%	2021	202,062.40	0.24%	201,285.48	0.12%
2022	191,054.12	0.22%	189,648.75	0.03%	2022	202,554.15	0.24%	201,502.38	0.11%
2023	191,478.73	0.22%	189,685.69	0.02%	2023	203,057.77	0.25%	201,702.17	0.10%
2024	191,909.31	0.22%	189,709.64	0.01%	2024	203,573.61	0.25%	201,896.51	0.10%
2025	192,345.67	0.23%	189,741.06	0.02%	2025	204,097.83	0.26%	202,101.47	0.10%
2026	192,786.48	0.23%	189,796.82	0.03%	2026	204,627.00	0.26%	202,329.45	0.11%
2027	193,232.23	0.23%	189,887.89	0.05%	2027	205,161.12	0.26%	202,587.69	0.13%
2028	193,682.81	0.23%	190,017.50	0.07%	2028	205,700.23	0.26%	202,876.47	0.14%

2029	194,137.68	0.23%	190,185.54	0.09%	2029	206,244.27	0.26%	203,194.32	0.16%
2030	194,596.09	0.24%	190,392.57	0.11%	2030	206,792.92	0.27%	203,542.18	0.17%
2031	195,057.51	0.24%	190,637.53	0.13%	2031	207,345.88	0.27%	203,919.76	0.19%
2032	195,521.78	0.24%	190,918.30	0.15%	2032	207,903.00	0.27%	204,325.80	0.20%
2033	195,989.13	0.24%	191,232.19	0.16%	2033	208,464.01	0.27%	204,758.31	0.21%
2034	196,460.05	0.24%	191,576.64	0.18%	2034	209,028.61	0.27%	205,215.04	0.22%
2035	196,935.27	0.24%	191,949.49	0.19%	2035	209,596.43	0.27%	205,693.85	0.23%
2036	197,415.55	0.24%	192,348.62	0.21%	2036	210,167.09	0.27%	206,192.45	0.24%
2037	197,901.67	0.25%	192,771.97	0.22%	2037	210,740.13	0.27%	206,708.50	0.25%
2038	198,394.30	0.25%	193,217.43	0.23%	2038	211,315.07	0.27%	207,239.65	0.26%
2039	198,894.03	0.25%	193,682.83	0.24%	2039	211,891.39	0.27%	207,783.53	0.26%
2040	199,401.27	0.26%	194,165.94	0.25%	2040	212,468.52	0.27%	208,337.81	0.27%
2041	199,916.33	0.26%	194,664.48	0.26%	2041	213,046.22	0.27%	208,900.19	0.27%
2042	200,439.36	0.26%	195,176.14	0.26%	2042	213,624.55	0.27%	209,468.41	0.27%
2043	200,970.34	0.26%	195,698.59	0.27%	2043	214,203.46	0.27%	210,040.26	0.27%
2044	201,509.16	0.27%	196,230.40	0.27%	2044	214,782.85	0.27%	210,614.37	0.27%
2045	202,055.67	0.27%	196,771.03	0.28%	2045	215,362.55	0.27%	211,190.24	0.27%
2046	202,609.68	0.27%	197,319.97	0.28%	2046	215,942.36	0.27%	211,767.38	0.27%
2047	203,171.03	0.28%	197,876.74	0.28%	2047	216,522.10	0.27%	212,345.38	0.27%
2048	203,739.53	0.28%	198,440.93	0.29%	2048	217,101.56	0.27%	212,923.90	0.27%
2049	204,314.94	0.28%	199,012.17	0.29%	2049	217,680.59	0.27%	213,502.68	0.27%
2050	204,896.97	0.28%	199,590.15	0.29%	2050	218,259.05	0.27%	214,081.59	0.27%
2051	205,485.20	0.29%	200,174.55	0.29%	2051	218,836.84	0.26%	214,660.54	0.27%
2052	206,079.13	0.29%	200,765.00	0.29%	2052	219,413.84	0.26%	215,239.54	0.27%
2053	206,678.06	0.29%	201,361.03	0.30%	2053	219,989.97	0.26%	215,818.59	0.27%
2054	207,281.18	0.29%	201,962.13	0.30%	2054	220,565.12	0.26%	216,397.70	0.27%
2055	207,887.53	0.29%	202,567.65	0.30%	2055	221,139.14	0.26%	216,976.86	0.27%

Figure 3: Active Male PSAL Percentage Change (CMI 2020)

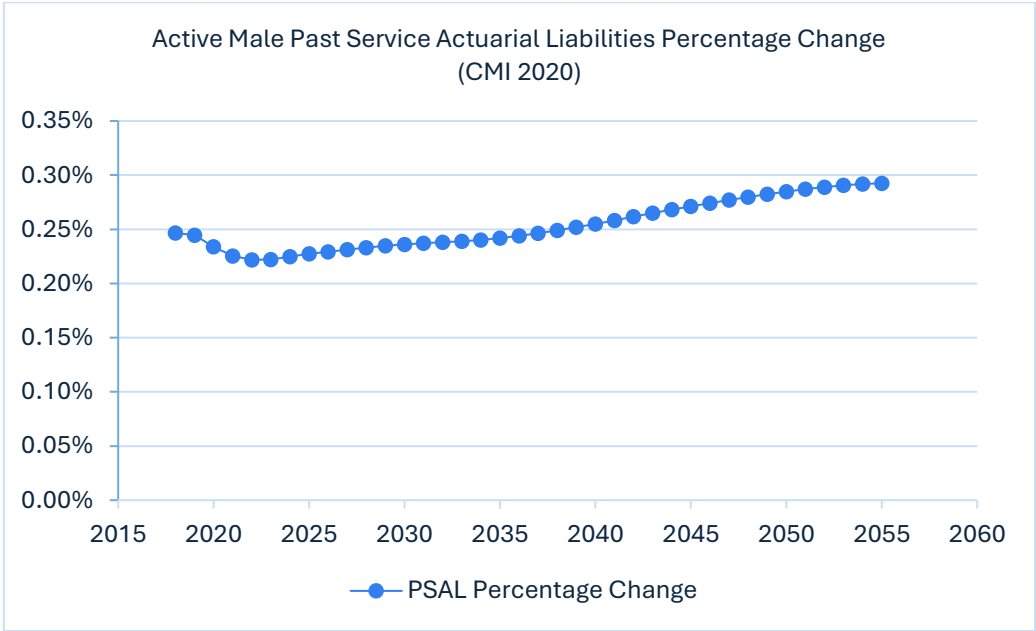


Figure 4: Active Female PSAL Percentage Change (CMI 2020)

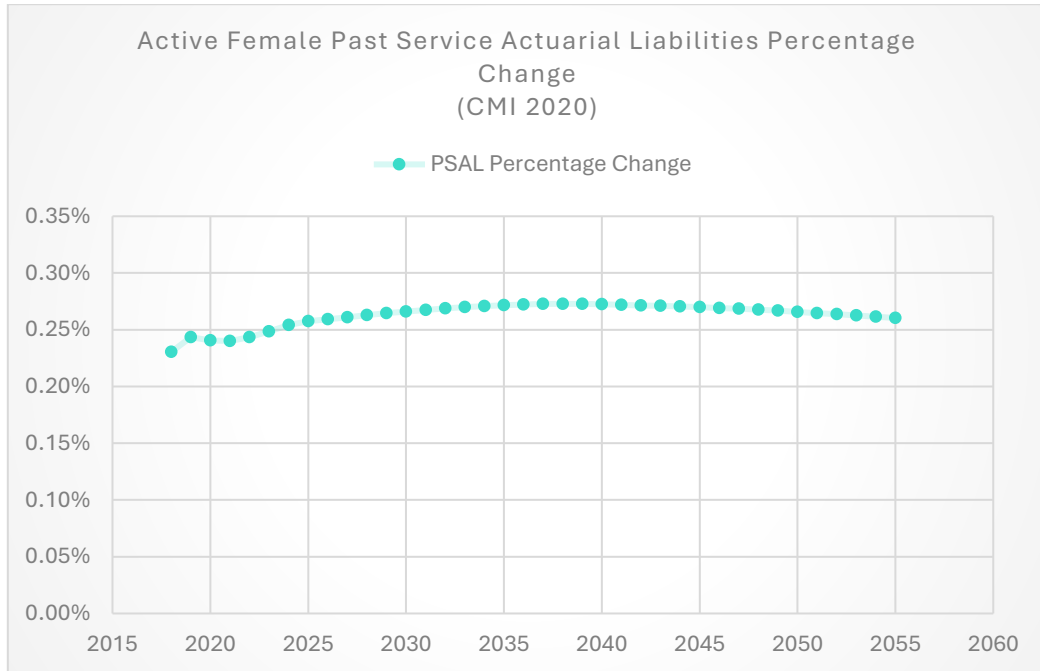


Figure 5: Active Male PSAL Percentage Change (CMI 2023)

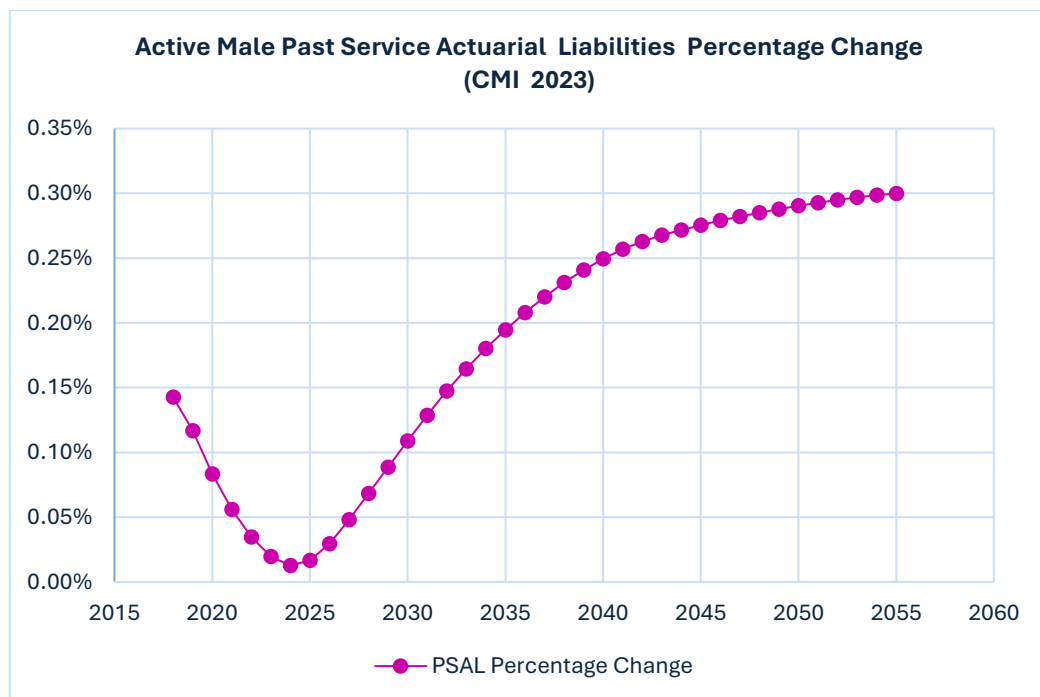
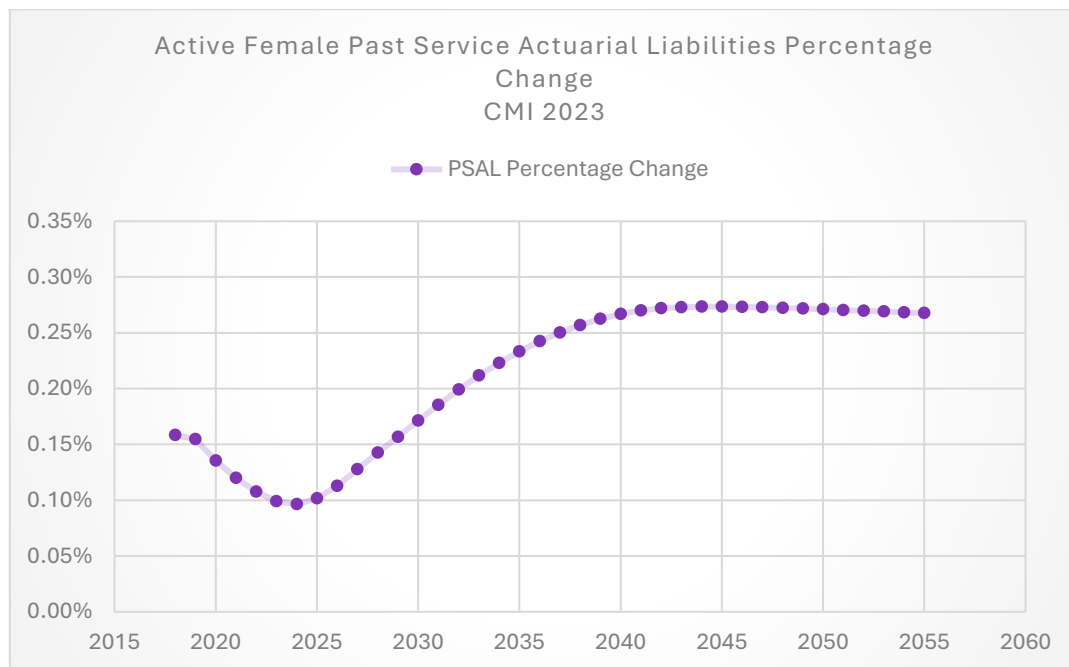


Figure 6: Active Female PSAL Percentage Change (CMI 2023)



A comparison of the CMI 2020 and CMI 2023 improvement projections for both genders yields the following insights:

- Liabilities projected under CMI 2020 are higher than those under CMI 2023.
- Both projections indicate a modest slowdown in the growth of liabilities between 2019 and 2023.
- Figure 3 (Male – CMI 2020) does not fully reflect the impact of COVID-19, as the projection was made during the peak of the pandemic.
- Conversely, Figure 5 (Male – CMI 2023) offers a more comprehensive view of the pandemic’s impact, with the projection conducted during a period of post-pandemic normalization. This likely allowed for inclusion of the full mortality effects of COVID-19.
- As previously discussed, life expectancy declined during the pandemic, reducing projected liabilities for that period. This contributes to the lower liabilities seen under CMI 2023 compared to CMI 2020.
- Figure 4 (Female – CMI 2020) shows a sharp increase in liabilities beginning in 2022 after a subdued rise between 2019 and 2021. However, from 2040 onwards, the growth rate is projected to decline significantly.

- In contrast, Figure 6 (Female – CMI 2023) displays a consistent slowdown in liability growth from 2019 to 2024, followed by a shift to gradual increase in 2025, with stabilization projected from 2041.

The overall conclusion from this analysis is that future liabilities are projected to increase; however, the rate of this increase will be influenced by actual future mortality trends. Once active members retire, the liabilities owed to them are expected to continue rising—provided that favourable health and economic conditions persist, supporting the increased longevity.

B. Retired Status (Male and Female)

Let us consider the following Pension Scheme description, the basic information, valuation date and the assumptions.

Table 10: Pensioner Status Sample Information

Valuation Date	31/12/2021
Pension Scheme Description	
NRA	65
Benefit at NRA	$Service \times Salary \times \frac{1}{60}$
Form of Payment	Single Life Annuity
Assumptions	
Interest Rate	3.00%
Pay Increase	4.00%
Pension Increase in Payment	2.00%
CMI Combination of Standard and Improvements Table	S4PMA_L^CMI.2020.M1.25%; S4PMA_L^CMI.2020.F1.25%.
	S4PMA_L^CMI.2023.M1.25%; S4PMA_L^CMI.2023.F1.25%.
Basic Information	
Status	Pensioner
Gender	Male and Female
Date of Birth	15/12/1952
Hire Date	01/12/1980
Date of Retirement	15/12/2017
Current Pension in Payment	£ 26,800

The focus from the above information is the CMI combination of standard and improvements table. The standard tables, which represent 2017 mortality table, from the syntax are:

- S4PMA_L (SAPS series 4 All Pensioner Male – Light)
- S4PFA_L (SAPS series 4 All Pensioner Female – Light).

For the avoidance of repetition, the following are consistent with post-retirement description, including method of calculation (unless stated otherwise) under the Active status scenario:

- CMI Improvement Table (2020 and 2023)
- Survival probability
- Discount Rate
- Pension Present Value Multiplier (PPVM)

- Present Value of Future Benefit (PVFB).

For pensioner status, the PVFB is the same for the Past Service Actuarial Liability unlike the active status, where we prorate the PVFB by service year at valuation date and at retirement. In addition, we have been given the pension amount that the pensioner is receiving.

Finally, the limitations to this analysis stated under the active status remain the same. We should also note that the figures in the tables have been rounded for the purpose of this report but not in the calculation process. See Appendix 4 for the Sample Male Pensioner calculation.

Following the overview of the methodologies applied in this sample analysis, we now present the actuarial liability results for male and female pensioners, based on mortality improvement rates from the CMI 2020 and CMI 2023 tables, using the specified syntaxes. The same process described under active status (p.24) applies here. We have used the year 2017 - 2055 to categorise the summation of the past service actuarial liabilities in line with the years in the 'new' mortality table that has been used in the process.

Table 11: Pensioner Status PSAL Projection (2017 – 2055)

PENSIONER STATUS									
Male					Female				
Year	Based on CMI 2020		Based on CMI 2023		Year	Based on CMI 2020		Based on CMI 2023	
	PSAL	PSAL Percentage Change	PSAL	PSAL Percentage Change		PSAL	PSAL Percentage Change	PSAL	PSAL Percentage Change
2017	457,605.33		457,605.33		2017	482,533.82		482,533.82	
2018	458,933.22	0.29%	458,413.94	0.18%	2018	483,784.35	0.26%	483,378.33	0.18%
2019	460,223.40	0.28%	459,073.49	0.14%	2019	485,091.63	0.27%	484,189.69	0.17%
2020	461,429.66	0.26%	459,542.97	0.10%	2020	486,372.75	0.26%	484,886.31	0.14%
2021	462,561.85	0.25%	459,847.84	0.07%	2021	487,638.49	0.26%	485,483.56	0.12%
2022	463,646.82	0.23%	460,016.72	0.04%	2022	488,909.81	0.26%	485,998.56	0.11%
2023	464,709.48	0.23%	460,080.71	0.01%	2023	490,198.78	0.26%	486,450.24	0.09%
2024	465,767.21	0.23%	460,084.59	0.00%	2024	491,508.69	0.27%	486,872.40	0.09%
2025	466,824.09	0.23%	460,088.42	0.00%	2025	492,831.70	0.27%	487,312.44	0.09%
2026	467,879.94	0.23%	460,141.63	0.01%	2026	494,161.40	0.27%	487,808.08	0.10%
2027	468,938.31	0.23%	460,275.46	0.03%	2027	495,501.08	0.27%	488,382.14	0.12%
2028	469,999.54	0.23%	460,497.58	0.05%	2028	496,853.56	0.27%	489,036.99	0.13%
2029	471,061.40	0.23%	460,805.08	0.07%	2029	498,220.51	0.28%	489,769.43	0.15%
2030	472,120.34	0.22%	461,196.60	0.08%	2030	499,602.21	0.28%	490,582.55	0.17%
2031	473,172.50	0.22%	461,666.27	0.10%	2031	500,997.66	0.28%	491,475.58	0.18%
2032	474,214.84	0.22%	462,205.93	0.12%	2032	502,404.92	0.28%	492,444.70	0.20%
2033	475,245.90	0.22%	462,807.39	0.13%	2033	503,821.50	0.28%	493,484.10	0.21%
2034	476,266.23	0.21%	463,463.68	0.14%	2034	505,244.73	0.28%	494,586.86	0.22%
2035	477,278.49	0.21%	464,169.68	0.15%	2035	506,672.09	0.28%	495,745.60	0.23%
2036	478,287.35	0.21%	464,922.28	0.16%	2036	508,101.46	0.28%	496,953.03	0.24%
2037	479,299.07	0.21%	465,720.07	0.17%	2037	509,531.22	0.28%	498,202.19	0.25%
2038	480,321.03	0.21%	466,563.07	0.18%	2038	510,960.29	0.28%	499,486.66	0.26%
2039	481,361.04	0.22%	467,452.27	0.19%	2039	512,387.99	0.28%	500,800.69	0.26%
2040	482,427.09	0.22%	468,389.13	0.20%	2040	513,814.20	0.28%	502,139.16	0.27%
2041	483,526.30	0.23%	469,375.09	0.21%	2041	515,239.80	0.28%	503,497.46	0.27%
2042	484,664.18	0.24%	470,411.07	0.22%	2042	516,666.47	0.28%	504,871.38	0.27%
2043	485,843.95	0.24%	471,496.87	0.23%	2043	518,095.54	0.28%	506,257.13	0.27%
2044	487,066.36	0.25%	472,632.92	0.24%	2044	519,527.83	0.28%	507,652.98	0.28%
2045	488,329.84	0.26%	473,819.92	0.25%	2045	520,963.70	0.28%	509,059.04	0.28%
2046	489,630.92	0.27%	475,056.46	0.26%	2046	522,403.01	0.28%	510,474.99	0.28%
2047	490,964.99	0.27%	476,339.34	0.27%	2047	523,845.24	0.28%	511,900.07	0.28%

2048	492,327.25	0.28%	477,663.91	0.28%	2048	525,289.64	0.28%	513,333.18	0.28%
2049	493,713.84	0.28%	479,024.64	0.28%	2049	526,735.47	0.28%	514,772.96	0.28%
2050	495,122.82	0.29%	480,415.76	0.29%	2050	528,182.19	0.27%	516,217.92	0.28%
2051	496,552.90	0.29%	481,831.88	0.29%	2051	529,629.43	0.27%	517,666.72	0.28%
2052	498,002.39	0.29%	483,268.90	0.30%	2052	531,076.84	0.27%	519,118.41	0.28%
2053	499,469.18	0.29%	484,724.60	0.30%	2053	532,524.07	0.27%	520,572.75	0.28%
2054	500,950.71	0.30%	486,197.35	0.30%	2054	533,970.71	0.27%	522,029.72	0.28%
2055	502,444.08	0.30%	487,685.28	0.31%	2055	535,416.31	0.27%	523,489.21	0.28%

Figure 7: Male Pensioner PSAL Percentage Change (CMI 2020)

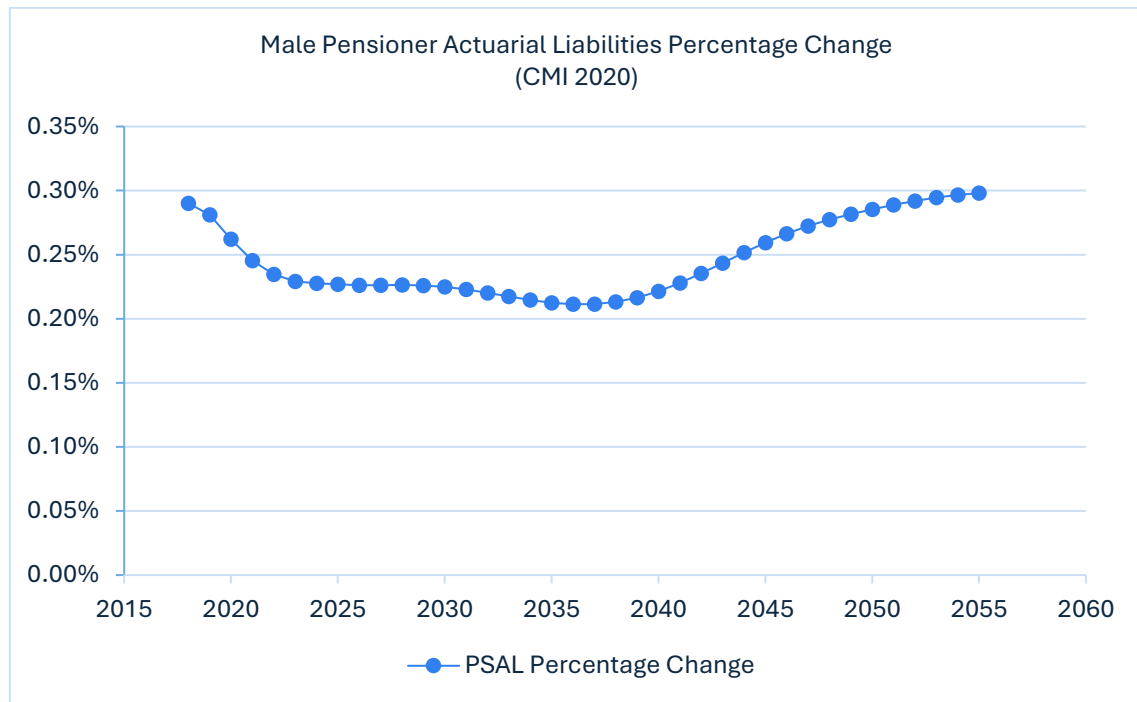


Figure 8: Female Pensioner PSAL Percentage Change (CMI 2020)

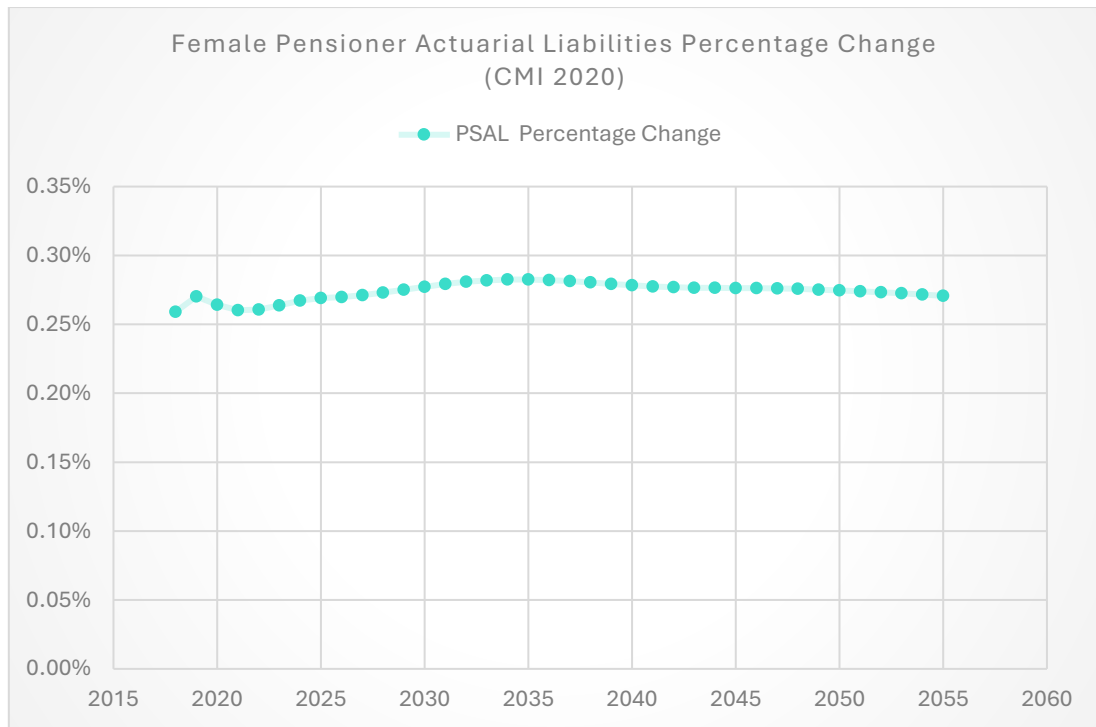


Figure 9: Male Pensioner PSAL Percentage Change (CMI 2023)

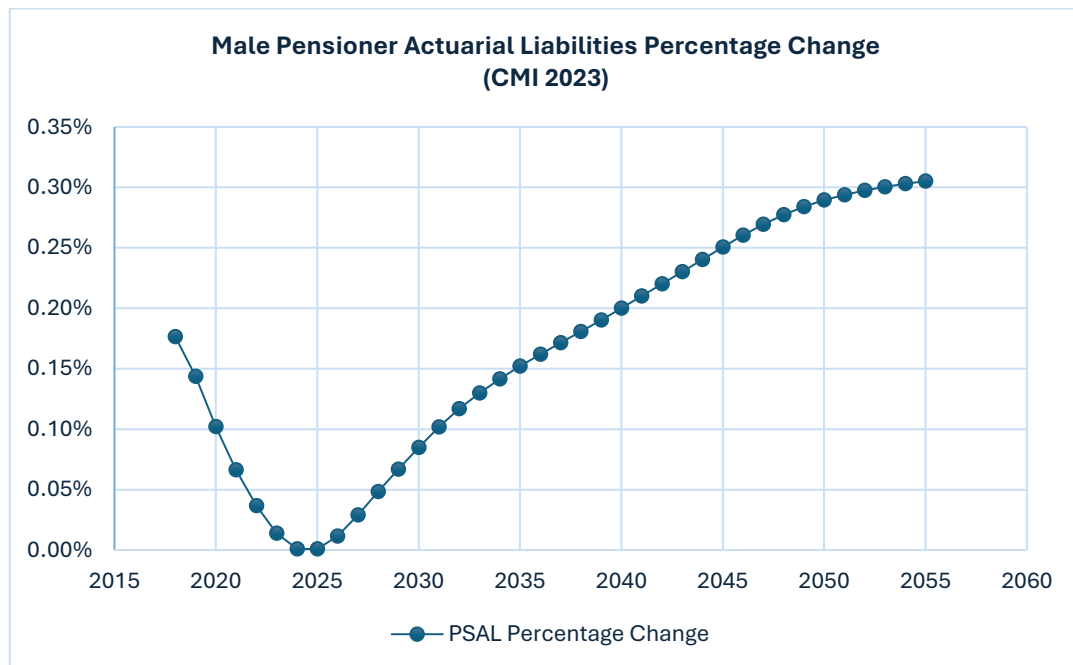
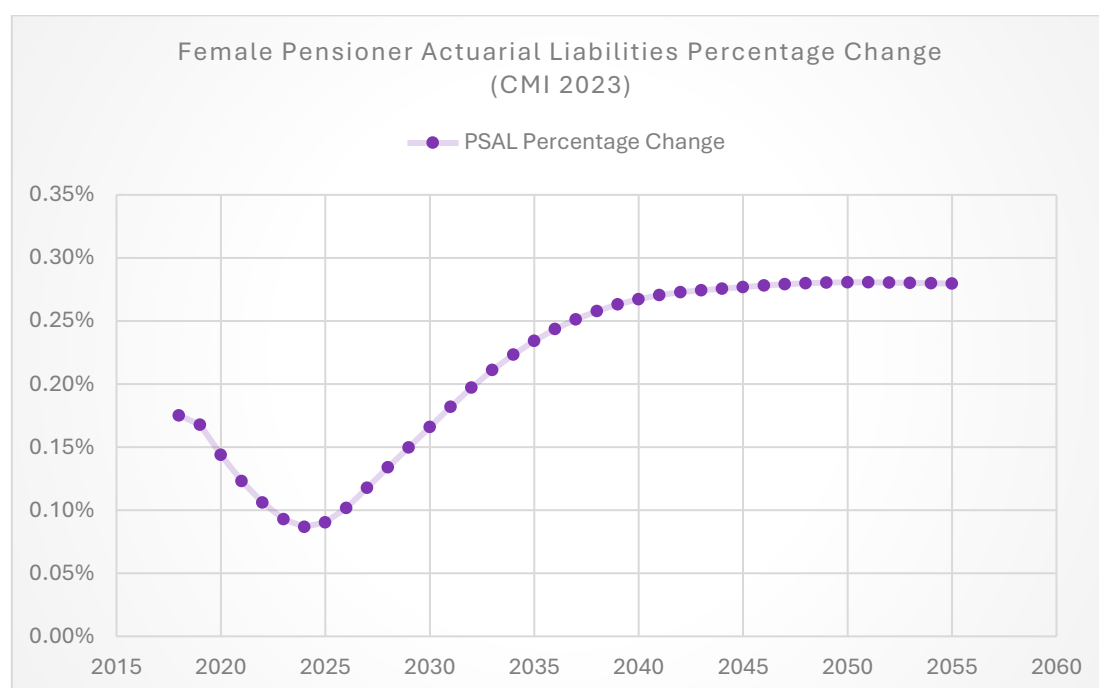


Figure 10: Female Pensioner PSAL Percentage Change (CMI 2023)



In this case of pensioner scenario, a comparison of the CMI 2020 and CMI 2023 improvement projections for both genders yield the following insights:

- Liabilities projected under CMI 2020 are higher than those under CMI 2023.
- Both projections indicate a modest slowdown in the growth of liabilities between 2019 and 2023.
- Figure 7 (Male Pensioner – CMI 2020) does not fully reflect the impact of COVID-19, as the projection was made during the peak of the pandemic. This is the same case for the Active Male.
- Conversely, Figure 9 (Male Pensioner – CMI 2023) offers a more comprehensive view of the pandemic's impact, with the projection conducted during a period of post-pandemic normalization. This likely allowed for inclusion of the full mortality effects of COVID-19. While from 2025, we see a consistent upward trajectory in the growth of the liabilities.
- As previously discussed, life expectancy declined during the pandemic, reducing projected liabilities for that period. This contributes to the lower liabilities seen under CMI 2023 compared to CMI 2020.
- Unlike the active male projection under CMI 2020 where there was further steady upward liabilities growth even till 2055, the male pensioner liabilities growth declined between 2034 and 2039.
- This validates our previous discussion that the male population aged 65 in 2020 to 2022 have a life expectancy of 18.3. Hence, the decline in pensioner liabilities growth falls within the purported estimation in terms of year bracket.

- Figure 8 (Female Pensioner – CMI 2020) shows a swift increase in liabilities beginning in 2022 after a subdued rise between 2019 and 2021. However, from 2036 onwards, the growth rate is projected to decline significantly.
- In contrast, Figure 10 (Female – CMI 2023) displays a consistent slowdown in liability growth from 2019 to 2024, followed by a shift to gradual increase in 2025, with stabilization projected from 2041.
- In addition, both active female and female pensioner projection under CMI 2020 show reflect decline in liabilities growth from 2039 and 2035 respectively.
- The female pensioner projection affirms our previous discussion that female population aged 65 in 2020 to 2022 have a life expectancy of 20.8. Hence, the decline in pensioner liabilities growth falls within the projected life expectancy.

The conclusion from this analysis is that future liabilities are projected to increase; however, the rate of this increase will be influenced by actual future mortality trends. In the case where pensioners live longer than expected, the liabilities owed to them are expected to continue rising.

5. THE MITIGATION STRATEGIES

5.1 Overview

The outcomes of the analysis in the previous chapter were not only indicative of what the future trend of actuarial liabilities can look like but also reinforce how the privilege of a long life beyond the expected ‘window’ can put significant weight on pension providers, even as there are new entrants into the pensioners’ group. Thus, there is the need to adopt strategies that will aid mitigating against longevity risk. This is crucial because there are many future uncertainties that can be faced by pension providers which can impede their ability to continue to provide adequate funds for pensioners, who may live a long life. In the next sub-section, we will consider some strategies that can be employed in mitigating against longevity risk.

5.2 Mitigation Strategies

- i. Acceptance and Early Integration: When a risk is identified and it is poised to have significant impact, the best practice is to admit/accept the existence of such risk. This also applies to the focus of the report, longevity risk. Individuals, organisations and government should not wait until the effect of longevity risk begins to have negative impact on their finances before embracing this risk. Accepting that longevity risk is here to stay in today’s world, is the starting point of mitigating against it. This will help to consider how they can integrate it into their calculation/preparations to ensure that adequate funds are available to continue to cater for members after retirement. Ignoring, denying or even delaying early integration of longevity risk in pension planning may lead to unfavourable financial conditions, not for the pensioners, but also for the providers (IMF 2012).
- ii. Buy In and Buy Out: These are strategies that are adopted in a defined benefit scheme. They are used as de-risking strategies. That is, they are used to reduce the financial risk present in a pension scheme. As we have seen earlier that longevity risk is also considered a financial risk, then these strategies help organisations to reduce long term liabilities that may rise due to longevity risk as well.

Buy In is simply when the pension scheme is used to purchase an insurance policy. It is expected that the insurance policy will provide fund or income for the set of pensioners included in the buy in which are part of the pension scheme. Therefore, the insurance policy held will become an asset of the pension fund. As pensions are paid from the pension fund, the insurer reimburses the pension scheme. Here, the Trustee in charge of the pension scheme makes the pay out to the pensioners (Insight Investment 2020).

Meanwhile, **Buy Out** is where the obligation of an organisation towards ensuring that sufficient fund is available for the pension scheme is fully transferred to the insurer. Here, the insurer pays the members of the pension scheme directly. Therefore, the organisation (the employer) will no longer be the sponsor of the scheme and the Trustee’s role will not be required anymore. Usually, Buy Out occurs when the scheme is winding up or full de-risking is the main objective of the employer (Insight Investment 2020).

- iii. Longevity Swaps: This is a new development in the actuarial space in recent years which is used for the purpose of managing the risk of people living longer than expected.

Longevity swap is a tool used for hedging longevity risk and is a risk transfer mechanism in which a pension scheme or insurer exchanges the uncertain cost of future pension payments, due to people living longer, for a predictable fixed payment (Chief Investment Officer 2022).

Bringing into focus the analysis on the previous chapter where we saw that in future years, the actuarial liabilities will experience an upward and stable growth based on CMI 2023. In light of longevity swaps, instead of the sponsor of the scheme paying the year-on-year increases in the actuarial liabilities, a predictable fixed amount will be exchanged for it. This will make the reason for using a long-term rate (longevity effect) applied to standard mortality for predicting future liabilities become defeated.

- iv. Diversification of Investment Portfolio: Investment strategy adopted for the purpose of ensuring funds are sufficient in a pension scheme is another area to consider when the goal is to minimise the effect of longevity risk. That is, to reduce to the barest minimum the financial burden that comes with members of the scheme living longer. The Trustee of the pension may need to change or diversify their current investment portfolio to include assets that deliver sustained and long-term consistent cashflow. Whilst there are traditional long-term assets such as long-term government bonds or gilts, indexed-linked bonds such as the longevity-linked bond can be a much better consideration.

Longevity-linked Bond is an emerging asset with the objective to directly hedge against longevity risk. This form of asset links the bond payouts to the actual survival outcome and not just interest rate or inflation parameters. The full development of this asset will be pivotal, especially in the era that we are in today. This will assist in matching up the liabilities due to people living longer (Epochs & Echoes 2024).

For instance, a bond pays £ 15,000,000 as a base coupon every year and is adjusted for survival index, then in the case where the 90% of the population survives, the coupon payable will be £ 13,500,000.

Now, if the survival index is higher assuming 105%, this implies that there is better survival than expected, so then the coupon payable will be £15,750,000. Thus, we can conclude that the value will match pension liabilities that increase the number of people living longer increases.

6. CONCLUSION

Longevity Risk presents a profound and evolving challenge to the financial sustainability and design of pension schemes. As improvement in the healthcare, lifestyle, public health policy and the emergence of sophisticated technology in the medical space continue to drive increases in life expectancy, both DB and DC pension arrangements will have to adapt to manage the resultant financial burdens or pressures.

Now that longevity risk has brought a paradigm shift to the way view demographics, people tend to no longer consider aging structure as the only way to describe the demography of a country but also have included the extent of the length of life of population. This is due to the uprising perception about longevity being a very important risk to consider.

In addition, longevity risk is also extending its tentacles to the point of being viewed or described as a financial risk. This is true and worthy of acceptance as it poses enormous financial challenge after retirement. Not adequately preparing for retirement with the possibility of living longer than expected, will make the existence of longevity risk to be grievous with different costs attaching to it.

We can see from the analysis in this report that improvements of mortality in the future can and will increase the growth rate of liabilities that pension providers are obligated to. Comparing the liabilities graphs for CMI 2020 and CMI 2023, we can deduce that mortality data gathered in the middle of any diseases outbreak for projection will mostly likely not provide a clear picture of the impact of such outbreak on liabilities.

In addition, if future mortality rates are low, then there will be no doubt that employers' liabilities obligation will not continue to move in the upward trajectory but may also become significantly high in-between the future years. Therefore, proactiveness to embedding various mitigation strategies that they deem fit based on the peculiarities of their schemes will be of great value in properly managing the effects and impact of longevity on pension schemes.

One of the mitigation strategies that will worth exploring in future projects is the longevity linked bond. The longevity bond market is an emerging market and will require stakeholders such as policy makers, experts (financial, legal, risk, actuarial, economists etc.), institutions, government, as well as regulatory authorities, to collaborate and participate with a sense of urgency in developing the market. This should be done with full consideration for related challenges and taking measures to tackle them *a priori*. The complete and concrete establishment of the longevity bond market will not only be beneficial to pension providers and pensioners but can also impact a nation's economy positively.

In conclusion, we consider it interesting to explore longevity risk from the aspect of what future liabilities will look like for pensioner providers in the case of DB schemes, instead of focusing on the future mortality pattern model development. The analysis in chapter 4 could potentially have been more extensive if real client data was available, including assumptions. Due to project scope, the scenarios were limited to two statuses out of three (active, deferred and pensioner) and the CMI comparison was limited to 2020 and 2023. Additional mitigation strategies and more details of their implications could be further explored outside the scope of this report.

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APPENDICES

Appendix 1: Some Countries with Defined Contribution Plan

Some Countries with Defined Contribution Plan				
Country	Employer Contribution	Employee Contribution	Policies	Reference
Austria	12.55%	10.25%	Pay As You Go (PAYG) + Occupational pensions.	https://www.pensionfundsonline.co.uk/content/country-profiles/austria
Australia	11.50%	Voluntary	Superannuation Guarantee, rising to 12%.	https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2023/12/pensions-at-a-glance-2023_4757bf20/PaG2023-country-profiles.pdf
Botswana	5% (min)	5% (min)	Occupational schemes under Retirement Funds Act.	https://www.nbfira.org.bw/wp-content/uploads/2024/10/retirement-funds-act-2022.pdf
Chile*	Future 6%	10%	Individual Capitalization Accounts.	https://www.spensiones.cl/portal/institucional/594/articles-3523_chapter4.pdf
Denmark	2/3	1/3	Mandatory Occupational Schemes.	https://www.iopsweb.org/resources/44962212.pdf
Ghana	13%	5.50%	Tier 1 and 2 System under National Pension Regulatory Act (NPRA).	https://nprra.gov.gh/assets/documents/3RD-EDITION-ISSUE-2-v2.pdf
Ireland	10.75%	4%	Public and Occupational Pensions.	https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2023/12/pensions-at-a-glance-2023_4757bf20/PaG2023-country-profiles.pdf
Kenya	15%	Year 1: 2%. Year 2: 5%. Year 3 above: 7.5%.	Public Service Superannuation Scheme (PSSS).	https://publicservice.go.ke/wp-content/uploads/2024/03/Public-Service-Superannuation-Scheme-Act-of-2012.pdf
Malawi	10%	5%	Regulated under Pension Act 2010.	https://www.iopsweb.org/resources/Malawi-IOPSWebsite-Country-Profile-2022.pdf
Mexico	5.15%	1.13%	Managed by private Administrator of Retirement Funds (AFOREs).	https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2023/12/pensions-at-a-glance-2023_4757bf20/PaG2023-country-profiles.pdf
Norway	2% (min)	Voluntary	Mandatory occupational pension.	https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2023/12/pensions-at-a-glance-2023_4757bf20/PaG2023-country-profiles.pdf
Nigeria	10%	8%	Contributory Pension Scheme (CPS) under 2014 Act.	https://www.pencom.gov.ng/wp-content/uploads/2018/01/PRA_2014.pdf
Rwanda	5%	3%	Ejo Heza Voluntary Savings supported by Government.	https://social.un.org/ageing-working-group/documents/elevanth/Inputs%20MS/Rwanda%20-%20Substantive%20and%20Normative.pdf

Slovak Republic	9%	4%	Mandatory Second Pillar.	https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2023/12/pensions-at-a-glance-2023_4757bf20/PaG2023-country-profiles.pdf
South Korea	4.50%	4.50%	National Pension System (NPS).	https://www.pensionfundsonline.co.uk/content/country-profiles/south-korea
Tanzania	10%	10%	National Social Security Fund (NSSF) for Private and Non-Government workers.	https://www.issa.int/sites/default/files/documents/2024-07/United%20Republic%20of%20Tanzania_0.pdf
Uganda	10%	5%	National Social Security Fund (NSSF) mandatory for formal sector.	https://www.iopsweb.org/resources/Uganda-IOPS-Country-Profile.pdf
Zambia	5%	5%	National Pension Scheme Authority (NAPSA).	https://www.iopsweb.org/resources/44875869.pdf

** Currently, employers do not contribute towards the Pension Scheme but there is a proposed change in the pension system for employers to contribute 6% in the future. This is expected to be introduced gradually over time.*

Appendix 2: Annual Expected Benefit Calculation at Retirement Sample for Active Status (Male – Current age 44)

Year	t	Pensionable Service	Pensionable Salary (£)	Accrual Rate	Accrued Benefit (A) (£)	Retirement (q _r) (B)	t _p x (C)	Discount Factor (v) (D)	Expected Benefit (E) = (A) * (B) * (C) * (D) (£)
31/12/2021	0	23	36,000	1/60	13,800	0.00%	1.00	1.00	-
31/12/2022	1	24	37,440	1/60	14,976	0.00%	0.96	0.97	-
31/12/2023	2	25	38,938	1/60	16,224	0.00%	0.92	0.94	-
31/12/2024	3	26	40,495	1/60	17,548	0.00%	0.88	0.92	-
31/12/2025	4	27	42,115	1/60	18,952	0.00%	0.85	0.89	-
31/12/2026	5	28	43,800	1/60	20,440	0.00%	0.81	0.86	-
31/12/2027	6	29	45,551	1/60	22,017	0.00%	0.78	0.84	-
31/12/2028	7	30	47,374	1/60	23,687	0.00%	0.76	0.81	-
31/12/2029	8	31	49,268	1/60	25,455	0.00%	0.74	0.79	-
31/12/2030	9	32	51,239	1/60	27,328	0.00%	0.73	0.77	-
31/12/2031	10	33	53,289	1/60	29,309	0.00%	0.71	0.74	-
31/12/2032	11	34	55,420	1/60	31,405	0.00%	0.70	0.72	-
31/12/2033	12	35	57,637	1/60	33,622	0.00%	0.68	0.70	-
31/12/2034	13	36	59,943	1/60	35,966	0.00%	0.67	0.68	-
31/12/2035	14	37	62,340	1/60	38,443	0.00%	0.65	0.66	-
31/12/2036	15	38	64,834	1/60	41,062	0.00%	0.64	0.64	-
31/12/2037	16	39	67,427	1/60	43,828	0.00%	0.62	0.62	-
31/12/2038	17	40	70,124	1/60	46,750	0.00%	0.61	0.61	-
31/12/2039	18	41	72,929	1/60	49,835	0.00%	0.60	0.59	-
31/12/2040	19	42	75,847	1/60	53,093	0.00%	0.58	0.57	-
31/12/2041	20	43	78,880	1/60	56,531	0.00%	0.57	0.55	-
31/12/2042	21	44	82,036	1/60	60,159	100.00%	0.55	0.54	17,912.53

Appendix 3: Post – Retirement Calculation Sample for Active Status (Male – Current age 44)

Year	Age in Retirement	Annual Expected Benefit (£)	iP_x (A)	Pension Increase (B)	Discount Factor (C)	Pension Present Value Multiplier $D = A * B * C$	Present Value of Future Benefit (£)	Past Service Actuarial Liabilities (£)
31/12/2042	65	17,912.53	1.00	1.00	1.00	1.00	17,912.53	9,363.37
31/12/2043	66	17,912.53	1.00	1.02	0.97	0.99	17,657.02	9,229.81
31/12/2044	67	17,912.53	0.99	1.04	0.94	0.97	17,396.06	9,093.40
31/12/2045	68	17,912.53	0.98	1.06	0.92	0.96	17,128.51	8,953.54
31/12/2046	69	17,912.53	0.98	1.08	0.89	0.94	16,853.04	8,809.54
31/12/2047	70	17,912.53	0.97	1.10	0.86	0.92	16,568.19	8,660.65
31/12/2048	71	17,912.53	0.96	1.13	0.84	0.91	16,272.30	8,505.97
31/12/2049	72	17,912.53	0.95	1.15	0.81	0.89	15,963.47	8,344.54
31/12/2050	73	17,912.53	0.94	1.17	0.79	0.87	15,639.62	8,175.26
31/12/2051	74	17,912.53	0.93	1.20	0.77	0.85	15,298.41	7,996.89
31/12/2052	75	17,912.53	0.92	1.22	0.74	0.83	14,937.25	7,808.11
31/12/2053	76	17,912.53	0.90	1.24	0.72	0.81	14,553.36	7,607.44
31/12/2054	77	17,912.53	0.89	1.27	0.70	0.79	14,143.72	7,393.31
31/12/2055	78	17,912.53	0.87	1.29	0.68	0.77	13,705.17	7,164.07
31/12/2056	79	17,912.53	0.85	1.32	0.66	0.74	13,234.46	6,918.01
31/12/2057	80	17,912.53	0.82	1.35	0.64	0.71	12,728.40	6,653.48
31/12/2058	81	17,912.53	0.80	1.37	0.62	0.68	12,183.98	6,368.90
31/12/2059	82	17,912.53	0.76	1.40	0.61	0.65	11,598.64	6,062.93
31/12/2060	83	17,912.53	0.73	1.43	0.59	0.61	10,970.54	5,734.60
31/12/2061	84	17,912.53	0.69	1.46	0.57	0.57	10,298.88	5,383.51
31/12/2062	85	17,912.53	0.65	1.49	0.55	0.54	9,584.37	5,010.01
31/12/2063	86	17,912.53	0.61	1.52	0.54	0.49	8,829.62	4,615.49
31/12/2064	87	17,912.53	0.56	1.55	0.52	0.45	8,039.61	4,202.52
31/12/2065	88	17,912.53	0.50	1.58	0.51	0.40	7,222.02	3,775.14
31/12/2066	89	17,912.53	0.45	1.61	0.49	0.36	6,387.51	3,338.93
31/12/2067	90	17,912.53	0.40	1.64	0.48	0.31	5,549.67	2,900.97
31/12/2068	91	17,912.53	0.34	1.67	0.46	0.26	4,724.88	2,469.82
31/12/2069	92	17,912.53	0.29	1.71	0.45	0.22	3,932.08	2,055.40
31/12/2070	93	17,912.53	0.23	1.74	0.44	0.18	3,190.31	1,667.66
31/12/2071	94	17,912.53	0.19	1.78	0.42	0.14	2,516.66	1,315.53
31/12/2072	95	17,912.53	0.14	1.81	0.41	0.11	1,924.62	1,006.05
31/12/2073	96	17,912.53	0.11	1.85	0.40	0.08	1,422.88	743.78
31/12/2074	97	17,912.53	0.08	1.88	0.39	0.06	1,014.68	530.40
31/12/2075	98	17,912.53	0.05	1.92	0.38	0.04	696.70	364.18
31/12/2076	99	17,912.53	0.04	1.96	0.37	0.03	459.97	240.44
31/12/2077	100	17,912.53	0.02	2.00	0.36	0.02	291.81	152.53
31/12/2078	101	17,912.53	0.01	2.04	0.35	0.01	177.90	92.99
31/12/2079	102	17,912.53	0.01	2.08	0.33	0.01	104.34	54.54
31/12/2080	103	17,912.53	0.00	2.12	0.33	0.00	59.00	30.84
31/12/2081	104	17,912.53	0.00	2.16	0.32	0.00	32.27	16.87
31/12/2082	105	17,912.53	0.00	2.21	0.31	0.00	17.16	8.97
31/12/2083	106	17,912.53	0.00	2.25	0.30	0.00	8.90	4.65
31/12/2084	107	17,912.53	0.00	2.30	0.29	0.00	4.50	2.35
31/12/2085	108	17,912.53	0.00	2.34	0.28	0.00	2.22	1.16
31/12/2086	109	17,912.53	0.00	2.39	0.27	0.00	1.07	0.56
31/12/2087	110	17,912.53	0.00	2.44	0.26	0.00	0.50	0.26
31/12/2088	111	17,912.53	0.00	2.49	0.26	0.00	0.23	0.12
31/12/2089	112	17,912.53	0.00	2.54	0.25	0.00	0.10	0.05
31/12/2090	113	17,912.53	0.00	2.59	0.24	0.00	0.05	0.02
31/12/2091	114	17,912.53	0.00	2.64	0.23	0.00	0.02	0.01
31/12/2092	115	17,912.53	0.00	2.69	0.23	0.00	0.01	0.00
31/12/2093	116	17,912.53	0.00	2.75	0.22	0.00	0.00	0.00

31/12/2094	117	17,912.53	0.00	2.80	0.22	0.00	0.00	0.00
31/12/2095	118	17,912.53	0.00	2.86	0.21	0.00	0.00	0.00
31/12/2096	119	17,912.53	0.00	2.91	0.20	0.00	0.00	0.00
31/12/2097	120	17,912.53	0.00	2.97	0.20	0.00	0.00	0.00
						20.17	361,239.20	188,829.58

Appendix 4: Pensioner Calculation Sample (Male)

Year	Age in Retirement	Pension (£)	Mortality Rate (q _d)	iP _x (A)	Discount Factor (B)	Pension Increase (C)	Pension Present Value Multiplier D = A*B*C	PVFB=PSAL (£)
31/12/2021	69	26,800.00	0.80%	100.00%	1.00	1.00	1.00	26,800.00
31/12/2022	70	26,800.00	0.91%	99.20%	0.97	1.02	0.98	26,326.18
31/12/2023	71	26,800.00	1.03%	98.30%	0.94	1.04	0.96	25,834.11
31/12/2024	72	26,800.00	1.16%	97.29%	0.92	1.06	0.94	25,320.87
31/12/2025	73	26,800.00	1.32%	96.15%	0.89	1.08	0.92	24,783.23
31/12/2026	74	26,800.00	1.51%	94.88%	0.86	1.10	0.90	24,217.61
31/12/2027	75	26,800.00	1.73%	93.45%	0.84	1.13	0.88	23,620.13
31/12/2028	76	26,800.00	1.98%	91.83%	0.81	1.15	0.86	22,986.57
31/12/2029	77	26,800.00	2.28%	90.01%	0.79	1.17	0.83	22,312.47
31/12/2030	78	26,800.00	2.62%	87.97%	0.77	1.20	0.81	21,593.16
31/12/2031	79	26,800.00	3.01%	85.66%	0.74	1.22	0.78	20,823.93
31/12/2032	80	26,800.00	3.48%	83.08%	0.72	1.24	0.75	20,000.19
31/12/2033	81	26,800.00	4.01%	80.19%	0.70	1.27	0.71	19,117.72
31/12/2034	82	26,800.00	4.63%	76.98%	0.68	1.29	0.68	18,172.99
31/12/2035	83	26,800.00	5.34%	73.42%	0.66	1.32	0.64	17,163.61
31/12/2036	84	26,800.00	6.17%	69.49%	0.64	1.35	0.60	16,088.86
31/12/2037	85	26,800.00	7.11%	65.21%	0.62	1.37	0.56	14,950.21
31/12/2038	86	26,800.00	8.20%	60.57%	0.61	1.40	0.51	13,752.05
31/12/2039	87	26,800.00	9.43%	55.61%	0.59	1.43	0.47	12,502.30
31/12/2040	88	26,800.00	10.84%	50.36%	0.57	1.46	0.42	11,212.93
31/12/2041	89	26,800.00	12.43%	44.90%	0.55	1.49	0.37	9,900.40
31/12/2042	90	26,800.00	14.21%	39.32%	0.54	1.52	0.32	8,585.52
31/12/2043	91	26,800.00	16.16%	33.73%	0.52	1.55	0.27	7,294.12
31/12/2044	92	26,800.00	18.28%	28.28%	0.51	1.58	0.23	6,056.19
31/12/2045	93	26,800.00	20.58%	23.11%	0.49	1.61	0.18	4,901.07
31/12/2046	94	26,800.00	23.04%	18.36%	0.48	1.64	0.14	3,854.86
31/12/2047	95	26,800.00	25.62%	14.13%	0.46	1.67	0.11	2,937.92
31/12/2048	96	26,800.00	28.24%	10.51%	0.45	1.71	0.08	2,164.15
31/12/2049	97	26,800.00	30.89%	7.54%	0.44	1.74	0.06	1,538.00
31/12/2050	98	26,800.00	33.53%	5.21%	0.42	1.78	0.04	1,052.62
31/12/2051	99	26,800.00	36.12%	3.46%	0.41	1.81	0.03	692.88
31/12/2052	100	26,800.00	38.60%	2.21%	0.40	1.85	0.02	438.33
31/12/2053	101	26,800.00	40.91%	1.36%	0.39	1.88	0.01	266.54
31/12/2054	102	26,800.00	43.02%	0.80%	0.38	1.92	0.01	155.96
31/12/2055	103	26,800.00	44.87%	0.46%	0.37	1.96	0.00	88.00
31/12/2056	104	26,800.00	46.40%	0.25%	0.36	2.00	0.00	48.05
31/12/2057	105	26,800.00	47.70%	0.14%	0.35	2.04	0.00	25.50
31/12/2058	106	26,800.00	48.98%	0.07%	0.33	2.08	0.00	13.21
31/12/2059	107	26,800.00	50.22%	0.04%	0.33	2.12	0.00	6.67
31/12/2060	108	26,800.00	51.43%	0.02%	0.32	2.16	0.00	3.29
31/12/2061	109	26,800.00	52.60%	0.01%	0.31	2.21	0.00	1.58
31/12/2062	110	26,800.00	53.74%	0.00%	0.30	2.25	0.00	0.74
31/12/2063	111	26,800.00	54.85%	0.00%	0.29	2.30	0.00	0.34
31/12/2064	112	26,800.00	55.92%	0.00%	0.28	2.34	0.00	0.15
31/12/2065	113	26,800.00	56.97%	0.00%	0.27	2.39	0.00	0.07
31/12/2066	114	26,800.00	57.99%	0.00%	0.26	2.44	0.00	0.03

31/12/2067	115	26,800.00	58.99%	0.00%	0.26	2.49	0.00	0.01
31/12/2068	116	26,800.00	59.95%	0.00%	0.25	2.54	0.00	0.00
31/12/2069	117	26,800.00	60.90%	0.00%	0.24	2.59	0.00	0.00
31/12/2070	118	26,800.00	61.82%	0.00%	0.23	2.64	0.00	0.00
31/12/2071	119	26,800.00	62.71%	0.00%	0.23	2.69	0.00	0.00
31/12/2072	120	26,800.00	0.00%	0.00%	0.22	2.75	0.00	0.00
							17.07	457,605.33

Appendix 5: Sample of Mortality Projection for Active Status (Male – CMI 2020)

Age	2017 (Base Year)	2025	2055
44	0.001149	0.000975	0.000627
45	0.00121	0.00104	0.00066
46	0.001275	0.001114	0.000698
47	0.001344	0.001196	0.000741
48	0.001416	0.001286	0.00079
49	0.001493	0.001384	0.000846
50	0.001576	0.00149	0.000908
51	0.001664	0.001602	0.000979
52	0.001758	0.00172	0.001056
53	0.00186	0.001841	0.00114
54	0.001971	0.001967	0.001232
55	0.002093	0.002096	0.001332
56	0.002226	0.002228	0.00144
57	0.002374	0.002367	0.001557
58	0.002538	0.002514	0.001685
59	0.002723	0.002673	0.001827
60	0.002929	0.002848	0.001984
61	0.003167	0.003051	0.002164
62	0.003446	0.003295	0.002376
63	0.003773	0.003589	0.002625
64	0.004154	0.003945	0.002919
65	0.0046	0.004374	0.003266