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The Impact of COVID-19 on the Liabilities of Defined Benefit Pension Plans in the UK

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Abstract

From 2020 to 2023, the world was affected by a pandemic, Covid-19, which caused a significant number of deaths, including in the UK. The current situation is no longer consider as a pandemic, although the virus continues to cause some deaths. However, the number of deaths is lower than at the beginning of the pandemic. The mortality during the pandemic had a significant impact on the Liabilities of DB Schemes in the UK due to its unexpected level. As a result, the actuaries had to make more considerate decisions regarding on the application of mortality assumptions, given the uncertainty of the future. It is not clear whether the mortality rates will rise again or decline in line with pre-pandemic levels.

This report uses the CMI model, which is applied by the majority of UK pension schemes. The CMI model is a mortality projection model that uses mortality data from England and Wales. In this report, the models are used between 2019 and 2023 to understand the behaviour of Liabilities in DB Schemes in the pre and during Covid-19 periods. Consequently, the weights of the data, the Long-Term rate and the Initial Addition rate for each CMI model is modified.

This work compares the impact of the pandemic on Liability by sex. Three distinct populations have been created, each containing the same data, apart from the sex variable. The first population assume that all members are males; the second population assume that all members are females; and the third population assume the actual sex provided by WTW. The impact on Liability compared to 2019 is more pronounced for males than for females. The lowest Liability for males is observed when the CMI_2021 is used at full weight, with an impact of -6.37%. For females it is observed when the CMI_2022 is used at full weight, with an impact of -5.21%. The biggest Liability is observed when the CMI_2021 is used with a LTR of 1.50% and an A of 1%, resulting in an increase of 3.17% for males and 3.04% for females. The impacts observed in the third population are within the range of impacts observed in the other two populations, as expected.

Keywords: CMI, Covid-19, UK Pension Schemes, Mortality Rate, Mortality Impact

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I would like to thanks to my parents and my sister for their support and for their belief in me.

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1. Introduction

This project was developed when I was working at Willis Towers Watson (WTW) in the United Kingdom (UK) pensions schemes department. This department works with Defined Benefit (DB) schemes in the UK. In the course of developing this paper, I have gained a deeper understanding of the concepts and models associated with UK pension schemes, thereby enhancing my knowledge in this area.

This work is a continuation of Shadri Butcher's internship work, "The impact of Covid-19 on mortality assumptions when valuing UK Defined Benefit Pension Schemes" (Butcher, 2021). The main objective is to determine the impact of the mortality models used in UK, developed by the Continuous Mortality Institute (CMI) during and in the period subsequent to the Covid-19 pandemic on the Liabilities.

The Covid-19 pandemic lasted from March 2020 to May 2023. However, the disease persists in the world and continues to cause deaths (World Health Organization, 2024). Nevertheless, the number of deaths is not as high as it was in the past. The impact of the pandemic on DB pension schemes was significant, particularly in terms of mortality rates, which led to a reduction in Liabilities, *ceteris paribus*. The actuaries were not expecting to observe a significant increase in the mortality rates since the pandemic was not predicted to happen. Consequently, when the Liability from a valuation prior to the pandemic is compared to the current Liability, it is expected a reduction in the overall Liability due to the increase in the mortality.

During the pandemic, the actuaries had to make a more considered choice when selecting mortality assumptions due to the inherent uncertainty regarding the future trajectory of expected deaths (Caine S., 2023). The question is whether the mortality rates will fall and stabilise at pre-pandemic levels, or whether they will remain elevated for a prolonged period compared with pre-pandemic levels (Caine S., 2023). The selected mortality rate table will have an impact on the expected benefit payable to the members until the final payment is made, thereby also affecting the funding level of the scheme.

This project presents an analysis of the CMI models between 2019 and 2023, with the objective of evaluating the impact of the mortality on the Liabilities during this period. This analysis allows for the conclusion of the tendency of the deaths until 2023.

The paper is structured into five chapters, with Chapter 1 serving as an introduction.

Chapter 2 presents an overview of the fundamental principles of the UK pension funds, the British National Insurance System, and the UK's Private Pension Schemes including Defined Benefit (DB), Defined Contribution (DC) and Hybrids schemes.

Chapter 3 provides an explanation of the methodology employed in calculating Liabilities, the assumptions used in the calculation of Liabilities and the CMI models for the period 2019 to 2023.

Chapter 4 presents a study case in which the application of different CMI models between 2019 and 2023 will be demonstrated. This will enable an examination of the impact of different CMI models on the Liability, with the same assumptions and data. The data set is a dummy data set provided by the WTW. This dummy data set was used

to create three distinct populations, each with the same data, except for the sex variable. In the first population, the sex was assumed to be male, in the second population, the sex was assumed to be female, and in the third population, the sex was assumed to be the actual sex. The calculations of the Liabilities were performed in the WTW's internal software.

Chapter 5 will present the conclusions of the case study.

2. Pension Funds in UK

A pension fund is defined as an investment fund financed by contributions from members of a pension scheme, which in many cases are also made by their employers. Upon reaching the retirement age, the member is entitled to receive the benefit in the form of a lump sum and/or a monthly payment, in accordance with the rules of the pension fund (Dickson et. al., 2019).

In the UK, two distinct types of pension schemes exist: public and private. The private scheme is financed by a company, and the public scheme is provided by the National Insurance (NI) and aims to guarantee a minimum level benefit for all individuals in the UK upon reaching the State Pension Age (SPA). Currently, the SPA could vary between 67 and 68 for both sexes depending on the date of birth (UK Government, 2024e).

There are different types of members, and the associated benefits are determined on this basis. They can be described as follows:

- Active: This status is applied to members who are still in service and accruing pensionable service, i.e., the members currently working in the company.
- Deferred: This status is applied to members who have stopped to accrue service to the fund but have not yet retired, i.e., the member is now working for a different employer.
- Retiree: This status is applied to members who have retired and are receiving the pension to which they are entitled from the fund.
- Dependant: This status is applied to the widow(er)/child that had a legal partner/parent who were entitled to the pension and have died. In such cases, part of the pension is paid to the surviving partner and/or children.

The following sections will provide an overview of the public and private schemes.

2.1 Public Scheme

In the British NI system, the NI contributions made by the employer and the employee will fund the savings that the member will receive at retirement. The contributions paid are correlated with the salary received by the individual during their working life.

In the Public Scheme, it is necessary to have accrued a minimum number of qualifying years in order to be eligible to receive the full amount of State Pension. A qualifying year is defined as a year in which an individual has been employed for the entirety of the year and has made the required National Insurance contributions in that year. Individuals between the ages 16 and SPA are eligible to contribute to the National Insurance.

The increase rate per annum of the State Pension has undergone fluctuations over time. However, since April 2011, the increase rate of the State Pension has been constrained to a maximum of either fixed 2.5%, the increase rate in earnings, or the Consumer Prices Index (CPI). This is referred to as the “Triple Lock” (PPI, 2023).

The British National Insurance System is divided by three types: the Basic State Pension, the Additional State Pension and new State Pension.

2.1.1 Basic State Pension and Additional State Pension

The Basic State Pension (BSP) is applicable only to individuals who have retired prior to 5 April 2016. The eligibility criteria for each sex are distinct, and different obligations must be met to receive the full BSP amount, which is £169.50 per week in 2024 (UK Government, 2024d). In order to qualify for the BSP, a male must have accrued at least 30 qualifying years if born between 1945 and 1951, or at least 44 qualifying years if born before 1945. While a female must have accrued at least 30 qualifying years if born between 1950 and 1953, or at least 39 qualifying years if born before 1950 (UK Government, 2024c). If the requisite number of qualifying years is not met, the individual will receive a benefit that is less than the full BSP amount.

The Additional State Pension was a benefit that was only available until 5 April 2016. It was an extra pension amount that a person could receive upon reaching the SPA, if they had made contributions to the National Insurance (PPI, 2023). This pension was created to provide a benefit that would be more in line with the earnings of the individual during working life (PPI, 2023). Contracting-out was an option for this type of pension, allowing individuals to pay reduced National Insurance contributions (PPI, 2023). Three distinct timeframes were identified for this type of scheme (PPI, 2023): the Graduated Retirement Benefit (GRB) was implemented between 1961 and 1975; The State Earnings Related Pension Scheme (SERPS) was implemented between 1978 and 2002. To be eligible, an individual must not have been self-employed or contract-out; In 2002, the SERPS was replaced by the State Second Pension (S2P), which remained in effect until April 2016. To be eligible, an individual must have been employed or have received any benefits, such as disability benefits, benefits for those caring for others, or child benefit (UK Government, 2024a).

2.1.2 New State Pension

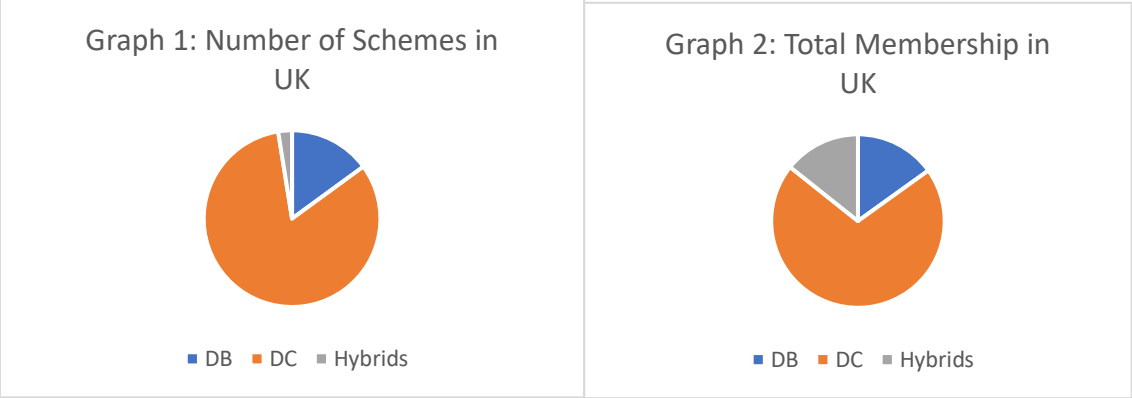
The new State Pension (nSP) is a replacement for the BSP and it is applicable only to individuals who have retired on or after 6 April 2016. The individual will receive the greater of the nSP and BSP, if they had contributed before 6 April 2016 (PPI, 2023). As with the BSP, there are specific eligibility criteria that must be met in order to receive this State Pension. The males must have a date of birth on or after 6 April 1951, while the females must have a date of birth on or after 6 April 1953 (UK Government, 2024b). In terms of qualifying years, the individuals must have accrued a minimum of 10 years of National Insurance contributions; to receive the full nSP, they must have accrued 35 qualifying years (PPI, 2023).

In contrast to the BSP, the nSP does not permit the option of contracting out. Consequently, those who contracted out prior to April 2016 are required to pay more contributions to the National Insurance. The Additional State Pension was abolished in April 2016, making this type of pension inaccessible in conjunction with the new State Pension (PPI, 2023).

2.2 Private Pension Schemes in the UK

In the private pension schemes, the responsibility for establishing the applicable rules lies with the company. This type of pension scheme is funded exclusively by the

company that sponsors the fund. In contrast to public schemes, the state does not contribute to this type of scheme (PPI, 2023). The most prevalent private pension schemes in the UK are DB, DC and hybrid schemes. The graphs below illustrate the number of schemes and total membership figures for each private scheme in UK:



Source:https://www.thepensionsregulator.gov.uk/en/document-library/research-and-analysis/occupational-defined-contribution-landscape-2023

2.2.1 Defined Benefit

In a DB Scheme, the amount that the member will receive upon retirement is calculated based on the salary received during the member's service, the service accrued and the accrual rate of the pension. The most commonly used formulas are the Career Average Revalued Earnings (CARE) and the final salary. The final salary formula is illustrated by the following equation (1):

$$B = \alpha\, S\, n \quad (1)$$

In equation (1), *B* represents the accrued benefit that it will be received in each year, α denotes the accrual rate per year of service, which is defined in accordance with the specific scheme in question. Depending on the rules of the scheme, the final pensionable salary (*S*) may be either the average of the member's salaries during the member's service or the last final pensionable salary that the member received prior to retirement. The *n* is the number of years of accrued service.

Regarding the CARE, the equation used in this approach is as follows:

$$B = \alpha\,(S_1\,(1 + rev_1) + \cdots + S_n\,(1 + rev_n)) = \alpha \sum_{i=1}^{n} S_i\;(1 + rev_i)^{n-i} \quad (2)$$

In the CARE approach, the annual benefit is calculated as the sum of the revalued final pensionable salary for each year of service multiplied by the accrual rate, as illustrated in formula (2). The pensionable salary is multiplied by the revaluation factor, rev_i, which varies from year to year. This will revalue the pensionable salary since year i until year n. In this manner, all member's salaries are considered, from the date of their initial entry into the scheme until the last salary received.

In the DB schemes, the company has the responsibility to guarantee that all contributions are paid in a timely manner, in order to ensure that members are able to

receive the benefits to which they are entitled to upon reaching retirement age. In this way, the employer assumes all the risk. This means that the employer is obligated to contribute the amount required to ensure that the employee will receive the defined level of benefit upon retirement (PPI, 2023). The amount that the fund is obliged to pay to the employee is referred to as the Liability, which will be discussed in more detail in the next chapter. In this type of scheme, the normal retirement age may vary, depending on the scheme. The minimum age is stipulated at 55 years (PPI, 2023).

2.2.2 Defined Contribution

In a DC scheme, the contributions of the employee and the employer are defined in advance and are typically expressed as a percentage of the employee's salary, as in the DB Schemes. These contributions can be made by both the employee and the employer. Upon reaching the retirement age, the pension will be the accumulated capital accrued throughout the individual's working career. The amount of the pension is contingent on the contributions made by the employer and the employee, as well as on the returns on investments. If the investment fund demonstrates a low rate of return, the resulting benefit will be less than the contributions made. As with DB schemes, the minimum age for accessing the benefits is 55 years old (PPI, 2023).

2.2.3 Hybrids

The Hybrid scheme represents a combination of the DC and DB schemes, exhibiting characteristics of both. An example of this type of scheme is the underpin scheme, where the benefit is determined by the greater of two benefits: the benefit calculated by using the DB scheme formula, as demonstrated in equations (1) and (2), and the contributions made to the DC scheme fund.

Note that this report will exclusively consider the DB schemes, given that the objective is to examine the Liability variations in the context of the COVID-19 pandemic.

3. Valuation of the Liabilities of DB Schemes

The Liability represents the fund's financial obligation to each and all members of the scheme upon reaching the designated retirement age. Consequently, employer sponsors are obliged to make contributions to the fund in accordance with the expected Liability in order to be able to meet its obligations (The Pensions Regulator, 2021).

As a result, each scheme is obliged to undertake an actuarial valuation at least every three years. This is done to determine whether the fund is overfunded or underfunded, which determines the recommended contribution. A fund is in an overfunded position if the value of its assets exceeds its expected Liabilities, and underfunded if the opposite is true. The aim is to ensure that the funds have a funding level at least of 100%. If the fund is overfunded, the fund can use the resulting gain to pay fixed costs (PWC, 2024), such as administrative or actuarial expenses. Alternatively, the fund can reduce the contributions if the fund is not accruing additional benefits (PWC, 2024). If the fund is underfunded, a recovery plan must be implemented for a period of up to 15 months, accompanied by the need for new investments (The Pensions Regulator, 2021). Subsequently, the actuary performs the calculations to determine the expected responsibility, in this way they will be able to inform the scheme sponsor of the contributions required (Abramson, et al., 1981). The contributions made by the fund are called Normal Contributions and are discussed later in this chapter. It is important to note that the expected Liability is a provision, given the inherent uncertainty surrounding the specific circumstances of the members, including the timing of their death, the accrual of further service if they remain active, and other variables.

3.1 Total Pension and Guaranteed Minimum Pension

Prior to discussing the calculation of Liability and the associated assumptions, it is necessary to address the total pension. The total pension is divided into two distinct components: the Guaranteed Minimum Pension (GMP) and the Excess. The total pension of a member is thus constituted by the sum of the Excess and the GMP.

The GMP represents the minimum pension that a company is obliged to provide when a member of their scheme opted out of the Additional State Pension, between 6 April 1978 and 5 April 1997 (UK Government, 2021). The GMP only becomes payable when the member reaches the GMP Payment Age, which is 60 for females and 65 for males. The opted out option was predominantly considered in the Defined Benefit schemes.

In order to calculate the Liability, it is necessary to consider the different types of assumptions, including economic and demographic assumptions.

3.2 Assumptions

3.2.1 Economic Assumptions

The economic assumptions are affected by the current market, which include the inflation rate, the salary increase and the discount rate (PCAAA, 2004).

The inflation rate is used to increase or revalue the members' pensions in accordance with the stipulations of the scheme. The Consumer Price Index (CPI) or the Retail Price

Index (RPI) are the inflation indices used in the UK. Additionally, certain schemes use a fixed rate for specific benefits, rather than incorporating one of these indices, which reduces the risk of high inflation. In the UK, there are pre-established statutory increases or revaluations that have been established by the government, which some pension schemes use as their rules when increasing or revaluing their benefits. These statutory increases/revaluations represent the minimum that the fund must set; however, there are some funds that are more generous, and set higher increases/revaluations for their funds. The following points set out the statutory increases and revaluations:

- In the case of retirement pensions that have already been paid out, the pensions that were accrued prior to 5 April 1997 have 0% increase. The post 1997 pensions are increased by the September CPI. For the pensions accrued between the dates 6 April 1997 and 5 April 2005, the upper limit is 5%. For pensions accrued from 6 April 2005 onwards, the upper limit is 2.5%. In the case of GMP, a fixed rate of 0% is applicable for accrued GMP between 6 April 1978 and 5 April 1988. For accrued GMP between 6 April 1988 and 5 April 1997 is applied the September CPI with an upper limit of 3%.
- In the case of deferred benefits with an accrued pension between January 1986 and April 2009, the revaluation will have a cumulative cap of 5% in the September CPI. For pensions accrued from April 2009 onwards, the revaluation will have a cumulative cap of 2.5% in the September CPI. In the case of GMP, the section 148 is applied according to each member's date of leaving active status.

The discount rate is used to determine the present value of future benefits. The salary increase represents a provision of the salaries that the members will receive in the future, based on the inflation and their performance.

3.2.2 Demographic Assumptions

The Demographic assumptions are set with respect to withdrawal, disability, retirement, proportion married, and age difference, and mortality (PCAAA, 2004).

The withdrawal assumption is defined as the probability of an individual becoming a deferred member and ceasing to accrue service.

The disability assumption concerns the probability that a member will retire before the NRA as a consequence of a health-related disability, thereby becoming unable to engage in further employment. In such cases, the pension will not be reduced.

The retirement is divided into three distinct categories. Normal Retirement refers to a situation where a member retires at Normal Retirement Age (NRA) as stipulated in the scheme's rules. Late Retirement occurs when a member retires after the NRA; in this case, the pension is increased in accordance with the factors applied in the scheme. To illustrate, a member aged 66 who should retire at age 65 with a benefit of £1,000, at this valuation will receive a benefit of £1,030 ($Benefit * (1 + LRF)^{NRA-AGE}$), assuming a Late Retirement factor (LRF) of 3% per annum. Early Retirement occurs when a member retires before the NRA; in this case, the pension is reduced in accordance with the factors applied in the scheme. To illustrate, if the member retires at age 64 and the Early Retirement factor (ERF) is 1% per annum, the benefit will be £990 ($Benefit * (1 - ERF)^{NRA-AGE}$).

The proportion married is the probability of a member being married. The age difference is defined as the difference between the ages of the member and their partner. These assumptions are set by the actuary according to the characteristics of the population under consideration. Alternatively, if the marital data is available, the actuary will use it instead of the assumptions. Both assumptions are used to calculate the probability of the spouse surviving.

The mortality assumption sets the mortality rates, which are the probabilities of a person with a specific age dying within t years. This is represented by the function $q(x,t)$, where the x is the age of the member and t is the year. The surviving rate is defined as $p(x,t) = 1 - q(x,t)$ (Dickson et. al., 2020). Typically, the actuaries carry out mortality experience studies to understand the expected future lifetimes of the members. Studying the mortality experience by classifying members according to the region where the person lives and their occupation, may be the best way to know the population of the fund. The geographical area in which an individual resides, and the nature of their occupation are both factors that can be linked to the probability of death. Geographic disparities in mortality have proved to be persistent, since even as the population of an area is changing its high or low mortality often remains (James, et al., 2018) - in spite of differences might be in fact caused by different socioeconomic conditions or access to health care, for instance.

To be able to analyse the behaviour of the mortality rates from one year to another, it is possible to apply the mortality improvement factor, which will compare the mortality rates for the same age in consecutive calendar years, see equation (3) below:

$$MI(x,t) = 1 - \frac{q(x,t)}{q(x,t-1)}, \qquad (3)$$

where $MI(x,t)$ is the mortality improvement factor at age x and in year t (Dickson et. al., 2019).

3.3 Continuous Mortality Investigation

The Institute and Faculty of Actuaries (IFoA) administers the Continuous Mortality Investigation (CMI), a research facility that analyses mortality data provided by UK pension funds (IFoA, n.d.). Annually, the CMI centre produces projected mortality tables, using data on mortality in England and Wales provided by the Office for National Statistics (ONS) (CMI, 2024). These projected mortality tables are used for most of the UK pension schemes for the purpose of calculating the expected Liability (IFoA, n.d.).

Until 2019, the following naming convention has been used for the mortality improvements models (CMI, 2020):

$$CMI\_Year\_G\_(LTR\%; S_k; A\%). \qquad (4)$$

The variable Year represents the year of the model. G is the gender. LTR% is the Long-Term rate, which is adjusted according to the actuary's expectations of future improvements in mortality behaviour, which is related to medical advances and economic constraints (Deloitte, 2021). S_k is the Smoothing parameter used to adjust past data with future projections. The influence of the actual data decreases as S_k increases (Deloitte, 2021). A% is the Initial Addition for mortality improvements,

subject to adjustment where the scheme population differs from the ONS data. Higher A% implies higher life expectancy (Deloitte, 2021).

The parameters described above can be modified. Except for LRT%, each parameter has a default value: 0% for A% and 7 for S_k. When the core values are employed, the model exclude these parameters.

3.3.1 CMI_2020

The 2020 model introduces a new variable, W, representing the weight of the 2020 mortality data. The naming convention is as follows (CMI, 2021):

$$CMI\_2020\_G\_(LTR\%; S_k; A\%; \mathrm{W}\%). \qquad (5)$$

As in the previous model, the core values are unchanged. The default value for the weight in the 2020 model is 0%, which means that no mortality data from 2020 has been included in the model. If a weight of 100% is used, this means that the entire mortality data from 2020 is being used. The CMI models are calibrated with mortality data from the last 40 years, when using the core values only 39 years are used (CMI, 2021).

The introduction of the weight parameter was driven by the observation that the projected mortality increases and life expectancy decreases when the full weight is applied, a scenario that is likely to be considered excessive by the majority of the actuaries (CMI, 2021). This can be seen by comparing the unweighted and fully weighted models for 2020, where the life expectancy falls by -5.2% for males and -3.4% for females (CMI, 2021), assuming a Long-Term rate of 1.50% for both.

3.3.1.1 CMI_2020 Mortality Rates

The annual mortality improvement in 2019 was 3.8%, while in 2020 the annual mortality improvement fell to -11.8% (CMI, 2021). This shows a notable shift in the mortality rates. Considering only non-Covid-related deaths in 2020, the mortality improvement rises to 3.5% (CMI, 2021), which is more consistent with previous years. These results are in line with expectations given the impact of the pandemic on mortality. Also, the mortality improvements observed in 2020 represent the lowest recorded in the last four decades (CMI, 2021), with a mortality improvement of -12.4% for males and -11% for females (CMI, 2021). The lowest improvements over the past four decades before the pandemic were -3.3% for males and -5% for females (CMI, 2021).

3.3.2 CMI_2021

Similar to the 2020 CMI model, a new variable has been introduced for the 2021 model due to the persistence of elevated mortality rates associated with the Covid-19. This parameter is referred to as the 2021 weight. The naming convention for the CMI_2021 is defined as follows (CMI, 2022):

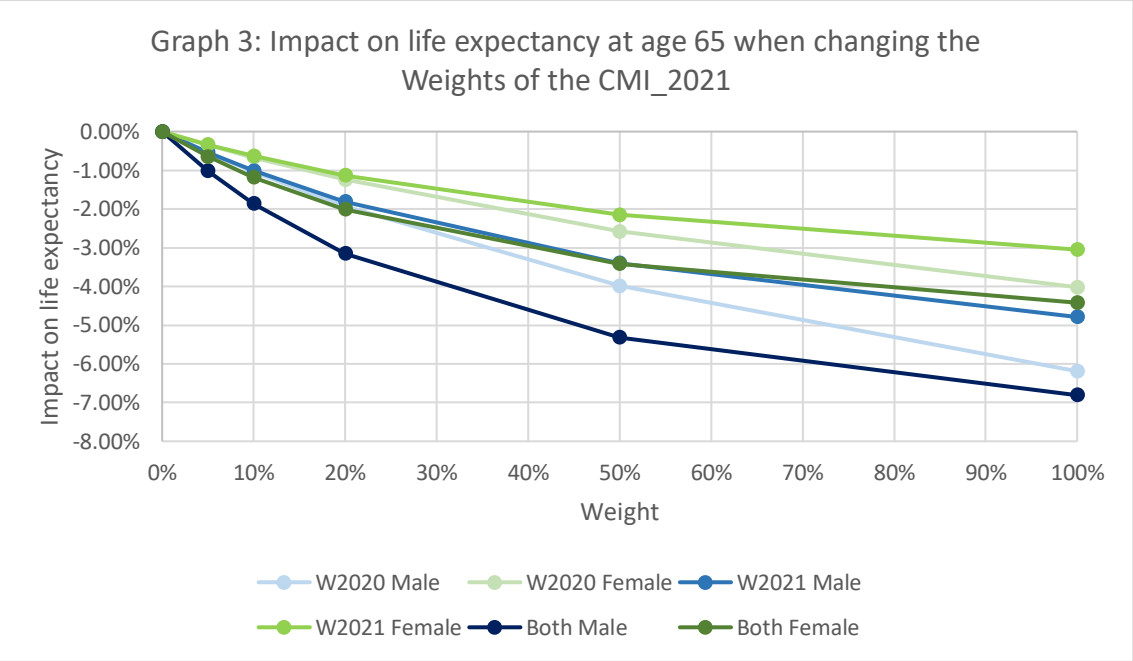
$$CMI\_2021\_G\_(LTR\%; S_k; A\%; W_{2020}\%; W_{2021}\%) \qquad (6)$$

The default values for the parameters remain the same as for the CMI_2020 model. The default value of the weight for 2021 is 0%. When using the core values, there is no mortality data from 2020 and 2021. The CMI_2021 model incorporates data from 1981

to 2021. However, when using the default values, the model is only using the data from 1981 to 2019 (CMI, 2022).

3.3.2.1 Influence of the Weights on the Life Expectancy

The graph below illustrates the influence of different weights on life expectancy when comparing the CMI_2021 with a Long-Term rate of 1.50% and no weight at age 65:



Source:
https://www.actuaries.org.uk/system/files/community/documents/142685/CMI%20WP160%20v01%202022-03-09%20-%20CMI%20Mortality%20Projections%20Model%20CMI_2021.pdf

In Graph 3, W2020 represents the impact on life expectancy when the 2020 data is modified and the other weight is 0%, while the W2021 is the opposite. “Both” means that the same weighting has been applied.

Graph 3 illustrates that the impact for females on life expectancy is less pronounced than for males for all weights. In addition, it is evident that the weight from 2020 has a greater impact than the weight from 2021 for both sexes. The impact is greater when both weights are included than when only one of the weights is used.

The impact of using only one weight is very similar for weights up to 10%. The discrepancy between the two weights is more pronounced for larger weights and, as expected, the maximum impact is when the full weight is used. The impact for the 2020 weight is -4.02% for females and -6.19% for males, while for the 2021 weight it is -3.05% for females and -4.79% for males. This yields a difference of almost 1% for females and 1.4% for males. The impact of using the same weight is less than the sum of the individual impacts. To illustrate, for females, when both weights are set at 100%, the impact is -4.42%, while when the other impacts are summed, the result is -7.07%, which is a discrepancy of approximately 2.65%; the same happens for males.

3.3.2.2 CMI_2021 Mortality Rates

The mortality rates exhibited a decline between 2020 and 2021, with an annual mortality rate of 4.8% for both sexes combined (CMI, 2022). This indicates that the number of individuals dying in 2021 is lower than in 2020. However, when comparing 2021 and 2019, the mortality improvement is -8.3% (CMI, 2022). This indicates that the mortality continues to be higher than before the pandemic. The mortality improvement is 5.3% for males and 4.1% for females (CMI, 2022). This differs from the CMI_2020 model, where males had a higher mortality rate than females.

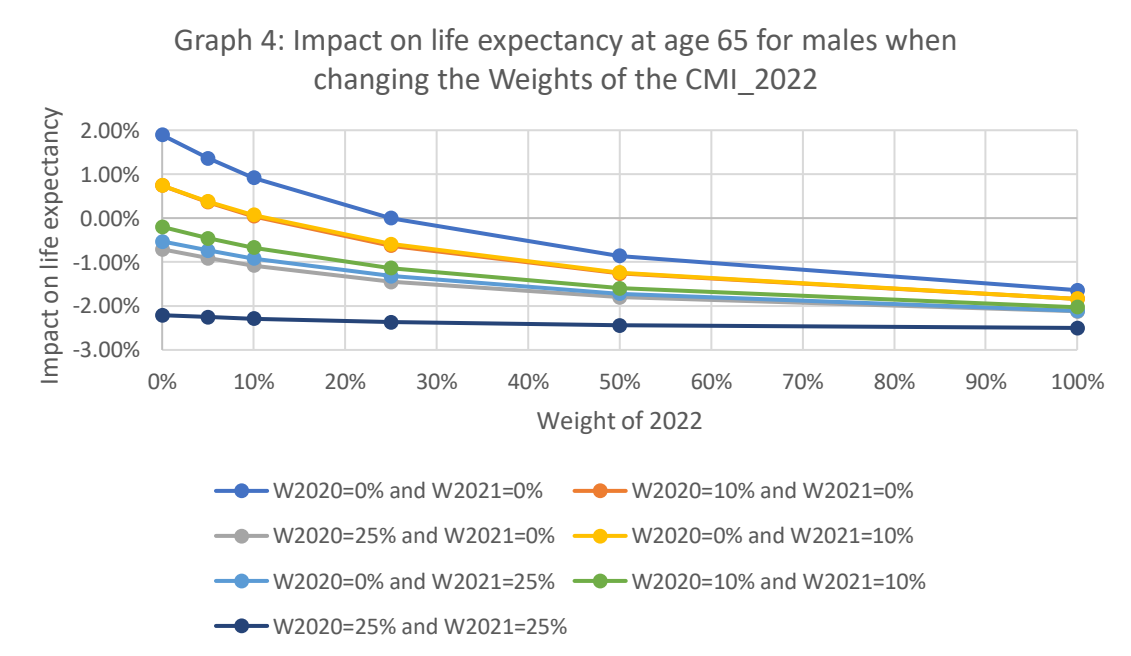
3.3.3 CMI_2022

The naming convention for the CMI_2022 is defined as follows (CMI, 2023a):

$$CMI\_2022\_G\_(LTR\%; S_k; A\%; W_{2020}\%; W_{2021}\%; W_{2022}\%) \qquad (7)$$

As in the previous models, a new variable has been introduced with a weight of 2022. The default values for the parameters remain the same as in the previous model. The default value of the weight for 2022 is 25%. This means that no mortality data from 2020 and 2021 was included in the 2022 model and 25% of the data from 2022 was taken into account. In this year's model, a higher weight was chosen for 2022 because deaths were less volatile compared to deaths at the beginning of the pandemic (CMI, 2023b). Also, the excess deaths (deaths not related with Covid-19) in 2022 are superior to the Covid-19 deaths in 2022, suggesting that 2022 mortality may be indicative of future mortality, according to CMI (2023b).

3.3.3.1 Influence of the Weights on the Life Expectancy



Source:
https://www.actuaries.org.uk/system/files/community/documents/142685/CMI%20WP177%20v01%202023-06-22%20-%20CMI%20Mortality%20Projections%20Model%20CMI_2022_0.pdf

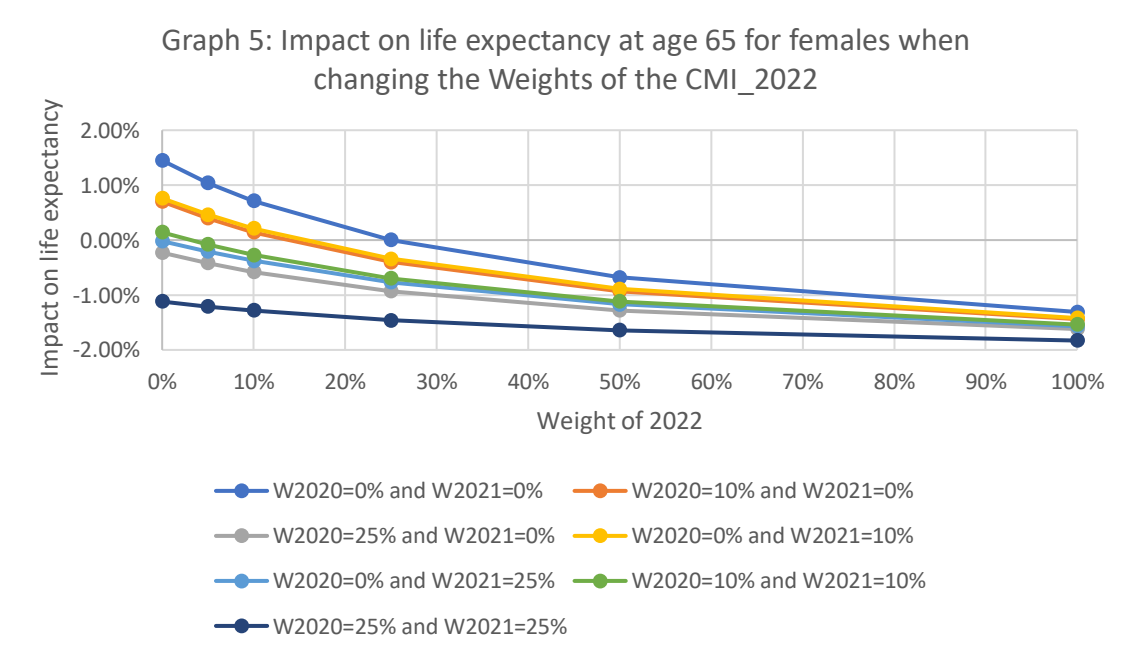
The graph above illustrates the influence of different weights on life expectancy when comparing with the CMI_2022, which uses the core values and a Long-Term rate of 1.50% at age 65 for males.

When the weight of 2022 is set at 100%, the impact is between -1.64% and -2.5%. The impact is more significant when the weight of 2020 and 2021 is 25%. The range is -2.21% and -2.5% when the weights of 2020 and 2021 are 25% and the weights for 2022 goes from 0% and 100%, which is considerably lower than the observed discrepancy. To illustrate, when the weight of 2020 is set at 25%, the 2021 weight at 0% and the 2022 weight at 100%, the impact is -2.12%. This is higher than the -2.21% when the 2022 weight is 0% and the remaining weights are set at 25%.

The effect of setting one of the weights at 25% and the other at 0% will be consistently negative when the weight of 2022 is between 0% and 100%. The range of impact for a weight of 2020 equal to 25% and a weight of 2021 equal to 0% is between -0.71% and -2.12%, and the reverse is between -0.53% and -2.11%. This indicates that using the core values of CMI_2022 results in a higher life expectancy than employing one of the 2020 and 2021 weights of 25% and the other weights of 0%.

When setting the weights of 2020 and 2021 at 0% and the weight of 2022 is between 0% and 100%, the range is between 1.89% and -1.64%. The impact is negative when the weight of 2022 is higher than 25%.

Setting one of the weights of 2020 and 2021 at 10% and the other at 0%, and setting the weight of 2022 between 0% and 100%, gives a range of between -1.84% and 0.74%. The range is the same, but the impact of changing the weight of 2022 between 5% and 50% is different, with a larger impact when the weight of 2020 is 10% and the weight of 2021 is 0%. The impact is negative when the weight of 2022 is equal to or higher than 25%.



Source:
https://www.actuaries.org.uk/system/files/community/documents/142685/CMI%20WP177%20v01%202023-06-22%20-%20CMI%20Mortality%20Projections%20Model%20CMI_2022_0.pdf

The graph above illustrates the influence of different weights on life expectancy when comparing with the CMI_2022, which uses the core values and a Long-Term rate of 1.50% at age 65 for females.

Graph 5 shows that the impacts in males and in females are very similar, and that the impact on life expectancy is higher for males than for females.

When all weights are zero, the impact in females is 1.45%, which is lower than that observed for males (1.89%). The impact is positive when the weight of 2022 is between 0% and 10% and the remaining weights are equal or less than 10%. Conversely, the impact is negative when the weight of 2022 is 25% or higher and the weight of 2020 and 2021 are equal to or below 10%. This is consistent with the observed impacts on males. However, the impact is also positive when the weight of 2022 is 0% and the other weights are 10%. This differs from the impact observed for males.

Setting the weights for 2020 and 2021 at 0% and increasing the weights for 2022 will result in impacts closer to 0% than males, with a range between -1.31% and 1.45%. As in males, the impacts when one of the weights of 2020 and 2021 is 0% and the other is 10% are very similar, and the impact is greater when the 2020 weight is 10%.

In contrast to the male impacts, when the weight of 2022 is set at 0% and the remaining weights are maintained at 25% (-1.12%), the impact is less pronounced than when the weight of 2022 is set at 100% and the weights of 2020 and 2021 are below 25% (-1.83%).

3.3.3.2 CMI_2022 Mortality Rates

As in the previous years, the CMI_2022 model includes data from the last 40 years, from 1982 to 2022. However, the CMI_2022 dataset has changed due to the Census 2021 (CMI, 2023a). The population in the model from 2021 is therefore different and this has an impact on the population between 2012 and 2020, which is predicted to decrease slightly over this period (CMI, 2023a).

With the update of the data between 2012 and 2022, the mortality improvements have changed compared to the model of 2020 and 2021. The mortality improvement for both sexes in 2020 is -13.9% (CMI, 2023a), which is much lower than in the 2020 model, where it was -11.8% (CMI, 2021). The 2021 mortality improvement has also fallen to 4.1% (CMI, 2023a), compared with 4.8% (CMI, 2022) in the 2021 model. The annual mortality improvement for 2022 is 2.7% and compared with 2019 is -6.2% (CMI, 2023a). This reflects a recovery from the high mortality at the start of the pandemic, but not a stabilisation of mortality compared with the pre-pandemic period.

3.3.4 CMI_2023

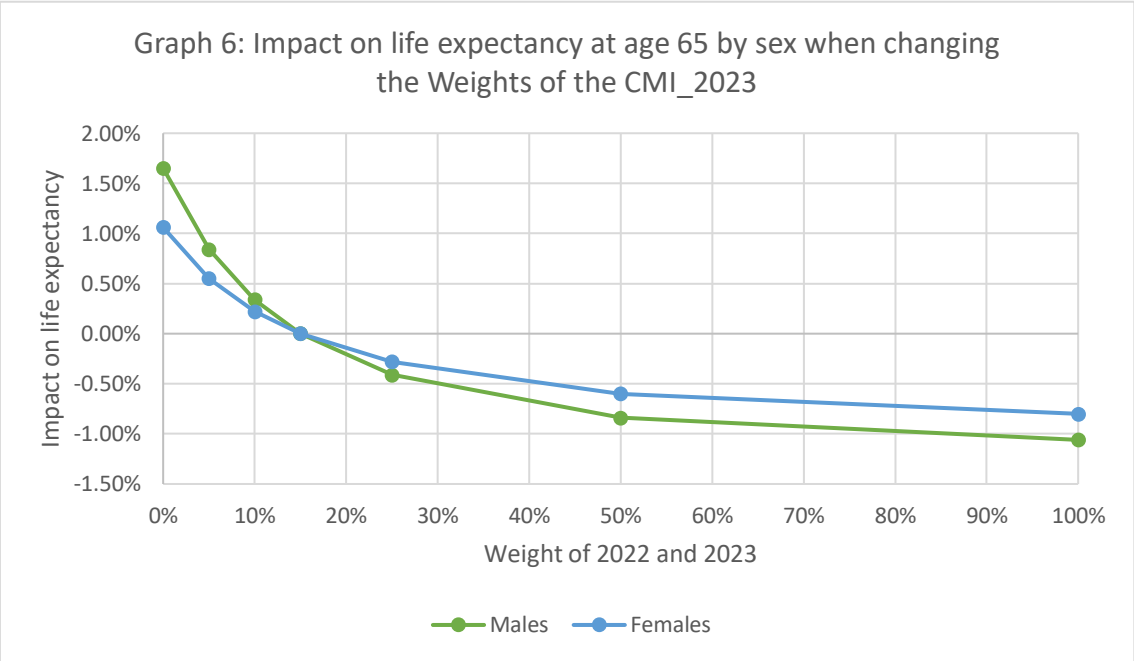
The naming convention for the CMI_2023 is defined as follows (CMI, 2024):

$$CMI\_2023\_G\_(LTR\%; S_k; A\%; \mathrm{W}\%) \qquad (8)$$

In this model, it is not possible to modify the weights assigned to the 2020 and 2021 data. The only weight that can be changed is the combined weight for 2022 and 2023, represented by W% in the formula 8. In contrast to the previous model, the weights for 2022 and 2023 are defined collectively. The core value for the weight is 15%, which is

lower than in the previous model. As in previous years, the CMI_2023 model includes data from the last 40 years, from 1983 to 2023. For the period between 1983 and 2019 the full weight is used and for the period between 2020 and 2021, the weight is 0% (CMI, 2024). The core values for the other parameters are the same as in the previous model.

3.3.4.1 Influence of the Weights on the Life Expectancy



Source:
https://www.actuaries.org.uk/system/files/community/documents/172527/CMI%20WP189%20v02%202024-05-24%20-%20CMI%20Mortality%20Projections%20Model%20CMI_2023.pdf

The graph above illustrates the impact of modifying the weights on life expectancy when compared to the CMI_2023 with core values and a Long-Term rate of 1.50% at age 65 split by sex. Graph 6 reveals that the impact on life expectancy decreases as the weight increases. This indicates that the mortality remains higher than it was prior to the pandemic.

The impacts in the females are closer to the 0% than for males, suggesting that the impact on females is lower than on males. The range is between -0.8% and 1.06% for females and between -1.06% and 1.65% for males, as weight increases.

3.3.4.2 CMI_2023 mortality rates

The mortality improvement for 2021 has increased to 5.5% (CMI, 2024) compared to 4.1% (CMI, 2023a) in the 2022 model. The mortality improvement for 2022 has increased to 3.2% (CMI, 2024) compared to 2.7% (CMI, 2023a) in the CMI_2022 model. The mortality improvement for 2023 is 1.1% (CMI, 2024).

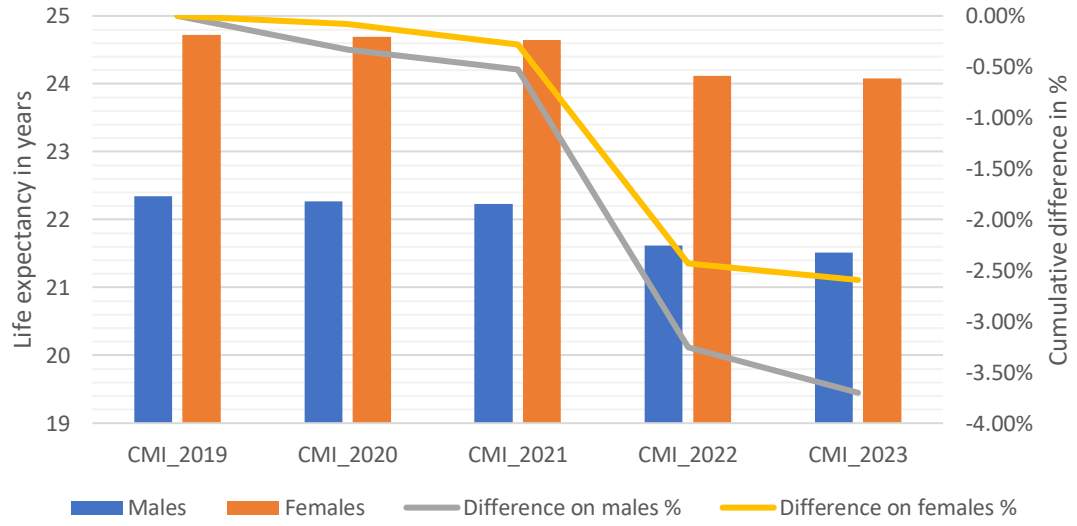
As evidenced by the data presented above, there were significant changes in mortality improvements between the CMI_2022 and CMI_2023 models, for a few reasons. The 2022 data presented in the CMI_2022 model was an estimate, whereas the CMI_2023 model uses the actual 2022 data, as provided by the ONS (CMI, 2024). The 2021 data in

the CMI_2022 model was updated in accordance with the most recent census conducted in 2021. In the 2023 model, the 2021 data is updated with the actual 2021 data, also provided by the ONS (CMI, 2024). Despite the changes in the data, the mortality remains higher than it was prior to the pandemic, as evidenced by the subsequent graph.

3.3.5 Comparing Life Expectancies between CMI_2019 and CMI_2023

The graph below illustrates the projected life expectancy at age 65 for each CMI model from 2019 to 2023, with the calculations based on the core values of each CMI model and a Long-Term rate of 1.50%.

Graph 7: Impact on life expectancy at age 65 for CMI models between 2019 and 2023 split by sex



Source:
https://www.actuaries.org.uk/system/files/community/documents/172527/CMI%20WP189%20v02%202024-05-24%20-%20CMI%20Mortality%20Projections%20Model%20CMI_2023.pdf

In the 2019 model, the life expectancy was 24.72 years for females and 22.35 years for males, resulting in a difference of 2.37 years. The 2020 and 2021 models exhibit minimal discrepancies in life expectancy compared to the 2019 model, as the 2020 and 2021 mortality data are not incorporated into the models.

In the 2020 model, the life expectancy has a difference of one-week for females and 3.8-week for males when compared with the CMI_2019. In 2021, the difference in life expectancy between the 2021 and 2020 models is more pronounced for females (2.5 weeks) than for males (2.2 weeks). However, when comparing the CMI_2021 model with the CMI_2019 model, the discrepancy is more pronounced for males, with a difference of 6 weeks, compared to a difference of 3.5 weeks for females. This is due to the fact that the difference in life expectancy between 2019 and 2020 was significantly greater for males than for females.

In the 2022 and 2023 models, the mortality data of 2022 and 2023 were already incorporated, which contrasts with the other models. This resulted in a more

pronounced discrepancy when comparing with the 2019 model. In the 2022 model, the life expectancy has a decrease of 27.7 weeks for females and 31.7 weeks for males when compared with 2021. A comparison with the 2019 model reveals a difference of 31.2 weeks for females and 37.7 weeks for males. These differences exceed six months for both sexes when compared with the 2019 or 2021 models. In the 2023 model, the life expectancy has a decline of 2.1 weeks for females and 5.2 weeks for the males when compared with the 2022 model. A comparison of the 2023 model with the 2019 model revealed a decrease in life expectancy of -2.59% for females and -3.7% for males. This corresponds to a reduction in life expectancy of approximately 33.3 weeks for females and 43 weeks for males when compared to the 2019 model. This indicates that the decline in life expectancy for males was more significant than for females when compared with the CMI_2019. Furthermore, the discrepancy between the sexes has increased, with the difference now standing at 2.56 years, up from 2.37 years in the CMI_2019. This indicates that, according to the CMI (2024), men will live approximately two and a half years less than women.

3.4 Methods to calculate the Liability

Having considered the assumptions associated with the Liability, we will now turn our attention to the question of how the Liability itself should be calculated. The present value of future benefits (PVFB) represents the expected future benefits payments to be made to the members of the plan (PCAAA, 2004). This incorporates all the decrements discussed in the demographic assumptions section, with each future payment discounted from the NRA to the valuation date (PCAAA, 2004). This is merely a provision as it is not possible to determine when members will die, whether they will continue to work for the company and accrue service after the valuation date, or whether the member will receive a salary increase in accordance with the actuary's assumptions.

The PVFB is divided into three components: the actuarial Liability, the normal cost, and the present value of future normal costs (PVFNC). The actuarial Liability represents the past service of the PVFB, which is calculated at the valuation date. The normal cost, also known as the normal contribution, is the portion of the PVFB for the current year of service and it is a part of the PVFNC. The PVFNC represents the future service of the PVFB (PCAAA, 2004).

3.4.1 The Projected Unit Credit Method and the Attained Age Cost Method

To calculate the future benefits, it has to be addressed that the most prevalent methodologies are the Projected Unit Credit Method and the Attained Age Cost Method. The Projected Unit Credit values the cost of the benefits accruing between valuation date and the control period (WTW, 2024). The control period is a fixed period, usually between 1 and 3 years, that it is analysed in relation to the future service benefits, this means that the period is between valuation date plus the fixed period. The Attained Age Cost values all future service benefits up to the member's death, retirement or withdrawal (WTW, 2024). The distinction between the Attained Age Cost Method and the Projected Unit Credit Method resides in the normal cost.

The Liability at valuation date for the Attained Age Cost Method and the Projected Unit Credit Method is as follows:

$$L_{VD} = B_{VD} * p(VA, NRA - VA) * v^{NRA-VA} * a_{NRA} \quad (9)$$

The B_{VD} represents the annual accrued benefit at valuation date. This is defined in accordance with the formulas (1) and (2), where the salary is at NRA and the service is at valuation date. In equation 9, only the probability of surviving between Valuation age (VA) and NRA is considered, $p(VA, NRA - VA)$. However, other decrements discussed in section 3.1.2 could also be included. v is the discount factor, which is equal to $\frac{1}{1+d}$, where d is the discount rate which is equal to $\frac{i}{1+i}$, where i is the interest rate; a_{NRA} represents the present value of the annuity of an individual who will live and work until NRA. Furthermore, the calculation of the spouse's pension is not included.

The Normal Cost for the Projected Unit Credit Method is as follows:

$$NC\% = \frac{S_{VD} * CP * \alpha}{PVFS_{VA}} * 100 * p(VA, NRA - VA) * v^{NRA-VA} * a_{NRA} \quad (10)$$

Where, CP is the control period, and $PVFS_{VA}$ represents the present value of future salaries during the control period at valuation date.

In the Attained Age Cost Method, the Normal Cost formula is as follows:

$$NC\% = \frac{S_{VD} * EFWL * \alpha}{PVFS_{VA}} * 100 * p(VA, NRA - VA) * v^{NRA-VA} * a_{NRA} \quad (11)$$

Here, $EFWL$ represents the expected future working life, and $PVFS_{VA}$ represents the present value of all future salaries until retirement at valuation date.

3.4.2 Deferreds and Pensioners Liability

Following an examination of the Liabilities for active members, we will proceed to an analysis of the methodology for calculating Liabilities for deferred, retiree, and dependent members. The Liability for a deferred member is calculated as follows (WTW, 2019):

$$L_{VD} = Pension_{DOL} * p(VA, NRA - VA) * v^{NRA-VA} * a_{NRA} \quad (12)$$

$$Pension_{DOL} = RPen_{DOL} * (1 + Rev)^{NRA-VA} + NRPen_{DOL} \quad (13)$$

Formula (12) is a simplification since some decrements described in the demographic assumptions section are not included. In the formula (13) the $RPen_{DOL}$ represents the revalued pension at Date of Leaving (DOL) from Active Status. This is revalued with the revaluation Rev; the $NRPen_{DOL}$ represents the non-revalued pension at Date of Leaving from Active Status. As the name indicates, this pension does not include revaluations. For Retiree and Dependant members the Liability is calculated as follows (WTW, 2019):

$$L_{VD} = Pension_{VD} * a_{VA} \quad (14)$$

Here, the a_{VA} represents the annuity at valuation date. Formula (14) is a simplification for retirees since the Liability for retirees includes the spouse pension in the calculations.

The subsequent section will present an investigation of the diverse Liabilities that can be calculated when applying different CMIs, alongside a subsequent analysis of the impact of the pandemic on the Liability.

4. Case Study

4.1 The Data

The dummy data and software were provided by WTW for the purpose of calculating and examining the effects on the Liability associated to the changes in mortality improvements in the UK between 2019 and 2023. The effective date used was 31 December 2023. The dummy data provided was employed for three distinct populations: the first assumed all members were male (Population 1), the second assumed all members were female (Population 2), and the third assumed the actual sexes provided by WTW (Population 3). This distinction was made to be able to analyse if different sexes will get different Liability and if the impact on Covid-19 was higher in males or females or if it was the same. The economic and demographic assumptions can be found in the Appendix. The data summary for all populations is presented in the table below.

Table 1 – Data Summary for Populations (1167 members)

Status	Number of members	Average age	Annual Total Salary/Pension at effective date (£)	Number of males / females (pop 3)
Actives	212	59	8,917,619.52	148 / 64
Deferreds	519	57	1,826,211.01	280 / 239
Retirees	383	76	1,591,978.01	274 / 109
Dependants	53	77	120,355.72	5 / 48

The following 3 sections will use each population to observe the behaviour of the Liabilities when the Long-Term rate, the Initial Addition rate and the weights for each CMI are modified. The CMI_2019_(1.50%) model will be used as the basis for subsequent analysis and as the assets of the fund. This is the CMI_2019 model with a Long-Term rate of improvement of 1.50% and core values for Initial Addition rate (0%) and Smoothing parameter (7). The assets will be different for each population, the total assets are £166,987,322 for population 1, £168,480,705 for population 2, and £167,312,392 for population 3. Therefore, the pension fund will be fully funded when the assets exceed the Liabilities, as previously stated. It should be noted that all Liabilities and the assets previously mentioned in this chapter were calculated using the WTW software.

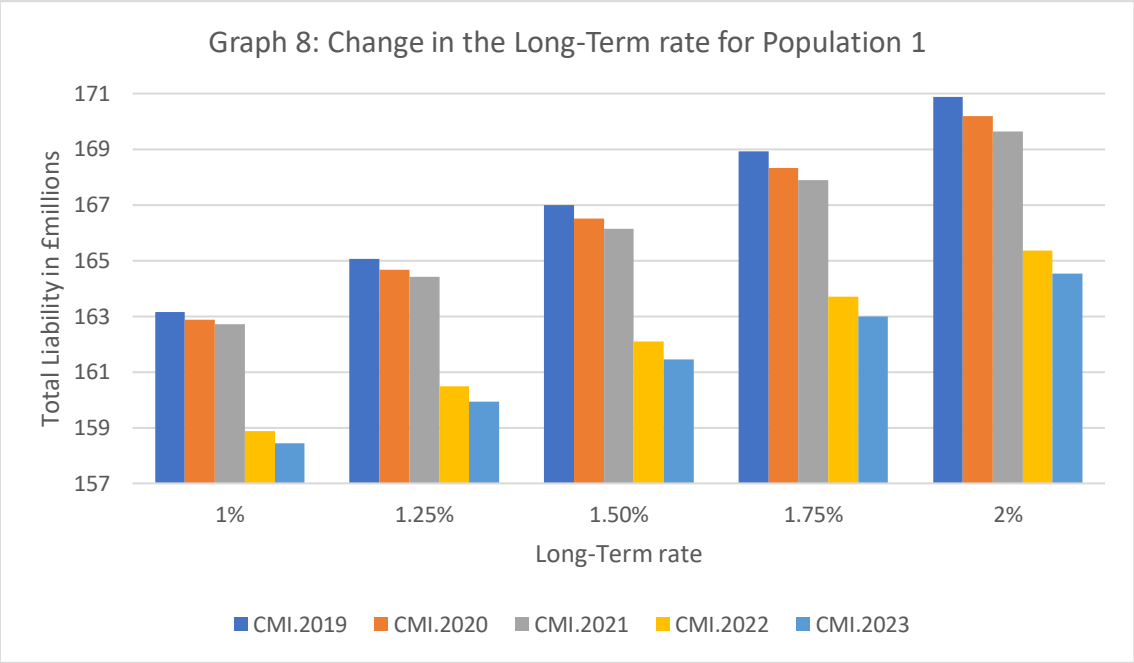
As the three subsequent sections are identical in structure and contain the same analysis, the resulting text is somewhat repetitive.

4.2 Results for the Liability in Population 1 (males)

As previously mentioned, the total value of the assets for population 1 is £166,987,322.

4.2.1 Changes in the Long-Term rate

The following graph illustrates a variety of Long-Term rates (LTRs) for each CMI, with the analysis assuming core values for the remaining parameters.



In the CMI_2019, when setting the LTR at 1% results in a Liability of £163,162,702. For each subsequent 0.25% increase in the LTR, the Liability is increased by between 1.16% and 1.17% compared to the previous Liability.

In the CMI_2020, the Liability is £162,883,165 when the LTR is 1%. For each subsequent 0.25% increase in the LTR, the Liability increases by 1.1% compared to the previous Liability. A comparison of the Liability generated by the CMI_2020 model with the assets reveals a decrease in the Liability between -2.46% and -0.29% until the LTR is 1.50%. When the LTR is greater than 1.50%, the Liability is between 0.81% and 1.91%. The model is overfunded when the LTR is 1.50% or less, with a maximum of funding level of 102.52%. When the LTR is greater than 1.50%, the model is underfunded, with a minimum funding level of 98.12%.

In the CMI_2021, the Liability is £162,722,812 when the LTR is 1%. For each subsequent 0.25% increase in the LTR, the Liability increases by between 1.04% and 1.05% compared to the previous Liability. When the Liability generated by this model is compared with the assets, there is an impact of between -2.55% when the LTR is 1% and 1.59% when the LTR is 2%. The 2021 model is overfunded when the LTR is 1.50% or lower, with a maximum of funding level of 102.62%. When the LTR is greater than 1.50%, the model is underfunded, with a minimum funding level of 98.43%.

In the CMI_2022, the Liability is £158,887,761 when the LTR is 1%. For each subsequent 0.25% increase in the LTR, the Liability increases by 1% compared to the previous Liability. When the assets are compared with this model, there is a reduction of between -4.85% at a LTR of 1% and -0.97% at a LTR of 2%. In terms of the funding position, the funding level exhibits a range between 105.1% when the LTR is 1% and 100.98% when the LTR is 2%.

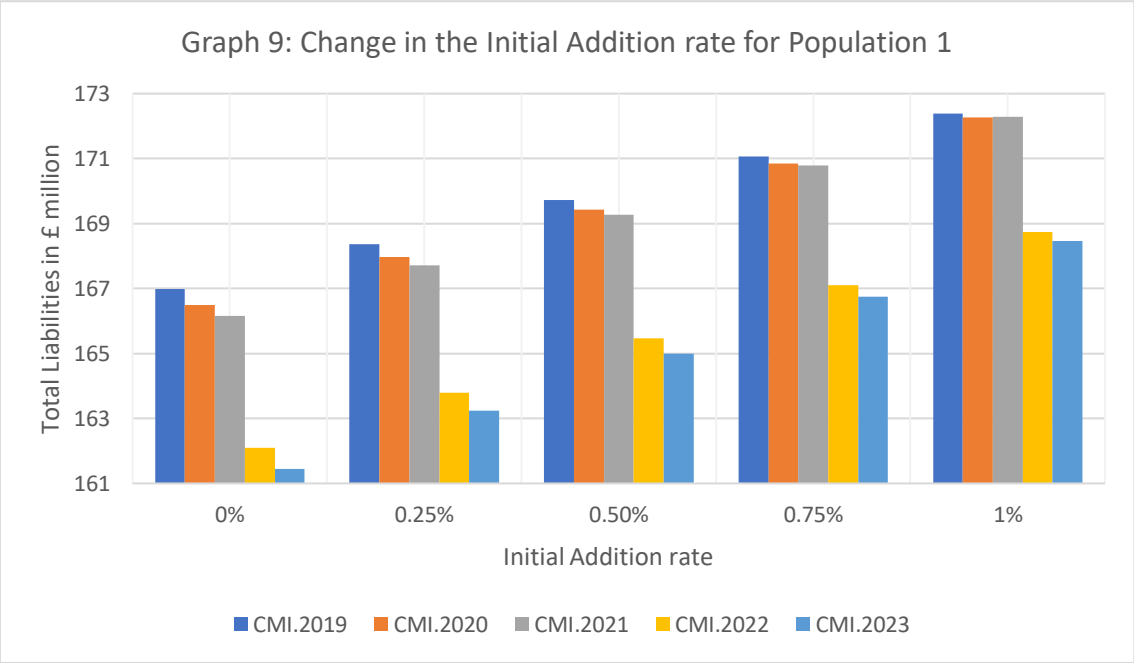
In the CMI_2023, the Liability is £158,430,442 when the LTR is 1%. For each subsequent 0.25% increase in the LTR, the Liability increases by 0.95% compared to the previous Liability. Compared to the assets, there is a reduction of between -5.12% at a LTR of 1%

and -1.47% at a LTR of 2%. In terms of the funding level, the model shows a range between 105.4% when the LTR is 1% and 101.49% when the LTR is 2%.

From another perspective, it is also observed that applying the same LTR, the increase in Liability is lower when the year of the CMI model is increased. To illustrate, if the LTR is set at 1.25%, the increase is 1.17% for CMI_2019, 1.1% for CMI_2020, 1.05% for CMI_2021, 1% for CMI_2022, and 0.95% for CMI_2023, compared to a LTR of 1%. Furthermore, a comparison of the same CMI model reveals that the increase in Liability remains consistent when an additional 0.25% is added to the LTR. To exemplify, the difference between the Liability of the CMI_2020 with a LTR of 1.25% and 1% is 1.1%, and the difference between the Liability of the CMI_2020 with a LTR of 1.50% and 1.25% is also 1.1%.

4.2.2 Changes in the Initial Addition rate

In the following graph were applied distinct Initial Addition rates (A) to each CMI. In this analysis, we have assumed a LTR of 1.50% and have set the other parameters to their core values.



The Liability of the 2019 model with an A of 0% is £166,987,322. The CMI_2019 demonstrate an increase in Liability of 0.83% when the A is 0.25%, 0.81% when the A is 0.5%, 0.79% when the A is 0.75% and 0.77% when the A is 1%. This results in a Liability of £172,385,950 when the A is 1%.

In the CMI_2020, the Liability is £166,499,974 when the A is 0%, indicating a decrease of 0.29% when compared with the assets. As the A is increased, the Liability also rises by 0.88% when A is 0.25%, 0.86% when A is 0.5%, 0.84% when A is 0.75%, and 0.83% when A is 1%, when compared with the previous Liability. The Liability is £172,265,821 when the A is 1%, representing a difference of 3.16% when compared with the assets.

In the 2021 model, the Liability is £166,151,546 when the A is 0%, representing a 0.5% decrease in comparison with the assets. As the A value is increased, the Liability will increase by 0.94% when the A is 0.25%, 0.92% when the A is 0.5%, 0.90% when the A is 0.75%, and 0.88% when the A is 1% in comparison with the previous Liability. The Liability is £172,286,623 when the A is 1%, representing a difference of 3.17% when compared with the assets. When the A is 1%, the Liability is higher in the 2021 than in the 2020.

In the 2022 model, the Liability is £162,089,338 when the A is 0%, representing a decrease of 2.93% when compared to the assets. When the A is increased, the Liability will increase by 1.05% when the A is 0.25%, 1.02% when the A is 0.5%, 1% when the A is 0.75%, and 0.97% when the A is 1%. The Liability reaches £168,730,124 when the A is 1%, representing a difference of 1.04% when compared with the assets.

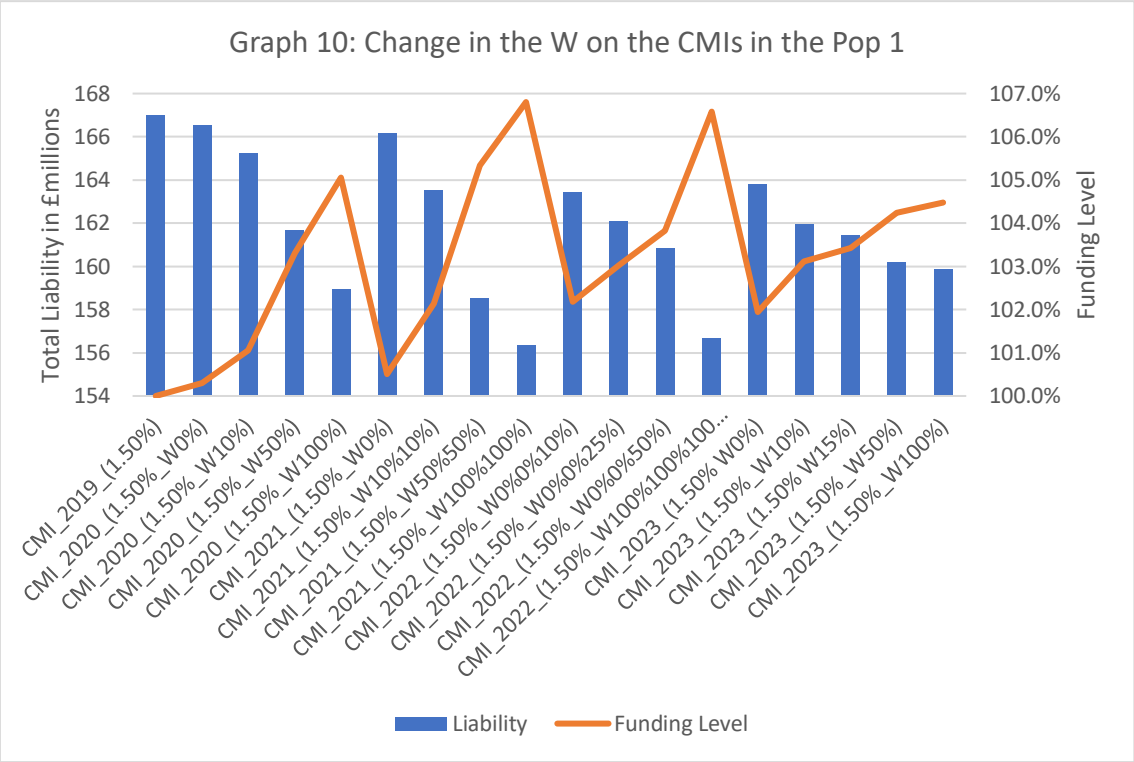
In the 2023 model, the Liability is £161,451,586 when the A is 0%, representing a decrease of 3.32% when compared to the assets. As the A is increased, the Liability will rise by 1.11% when the A is 0.25%, 1.08% when the A is 0.5%, 1.05% when the A is 0.75%, and 1.03% when the A is 1%. A Liability of £168,454,809 is reached when the A is 1%, representing a difference of 0.88% when compared with the assets.

When setting the same A is evident that the increase will be higher when the year of model is increased. To exemplify, when the A is 0.25%, the increase will be 0.83% in the CMI_2019, 0.88% in the CMI_2020, 0.94% in the CMI_2021, 1.05% in the CMI_2022 and 1.11% in the CMI_2023, when comparing the same CMI with an A of 0%. Furthermore, when the A is increased in the same CMI model, it can be concluded that the rise in the Liability will be less with each 0.25% increase in A. To illustrate, when the A is 0.5%, the increase will be 0.81% in the CMI_2019, 0.86% in the CMI_2020, 0.92% in the CMI_2021, 1.02% in the CMI_2022 and 1.08% in the CMI_2023, when comparing the same CMI with an A of 0.25%. This signifies a reduction in the increase of the Liability when comparing the A of 0.25% with the A of 0%.

With respect to the funding level, the CMI_2023 is overfunded when the A is 0% (103.43%) until the A reaches 0.75% (100.15%). When the A is 1%, the funding level is 99.13%. The CMI_2022 is overfunded when the A is 0% (103.02%) until the A is 0.5% (100.92%). At an A of 0.75%, the funding level is 99.93%, and when the A is 1%, the funding level is 98.87%. With respect to the CMI_2020 and 2021, the funding levels are 100.29% and 100.5%, respectively, when the A is 0%. These models will be underfunded when the A is 0.25% or above. When increasing the A until 1%, the 2020 model will have a funding level of 96.94%, while the 2021 model will have a funding level of 96.92%. As anticipated, a reduction in mortality will result in an increase in Liability.

4.2.3 Changes in the Weights

The next graph presents distinct weights (Ws) to each CMI. It was assumed the LTR of 1.50%, while the remaining parameters use the core values.



In the CMI_2020, the Liability is £166,499,974 when the W of 2020 is set at 0%, which is the core W of the 2020 model, representing a reduction of 0.29% in comparison to the assets. An increase in the W to 10% and 50% results in a decrease of 1.04% and 3.2%, respectively, when compared to the assets. The minimum Liability in the CMI_2020 is £158,948,479 when the W is set at 100%, representing a decrease of 4.81% when compared to 2019 Liability. All Liabilities in this model are overfunded, with a funding level of between 100.3% when W is 0% and 105.1% when W is 100%.

In the CMI_2021, the same value was applied to both Ws. Once the core value of the W is set (0%), the resulting Liability is £166,151,546, resulting in a reduction of 0.5% and 0.21% when comparing with the assets and CMI_2020 with no W, respectively. When the W is 10%, there is a decrease of 2.09% in the Liability when compared with 2019, which is twice as much as the decrease observed when the CMI_2020 is compared with 2019 (-1.04%). A 50% W results in a 5.07% decrease in Liability when compared with the assets. The minimum Liability will be £156,349,779 when both Ws are set at 100%, representing a decrease of 6.37% and 1.63% when compared to 2019 and the CMI_2020 with a W of 100%. The funding levels vary between 100.5% and 106.8%.

In the CMI_2022, with the W of 2020 and 2021 set at 0% and the W of 2022 set at 10%, the Liability is £163,419,506, representing a decrease of 2.14% compared to 2019. When the W is 15%, the core values of the Ws in the 2022 model, thus results in a decrease in the Liability of 2.93% compared to 2019. When the W is 50%, this results in a decrease of 3.69% compared to 2019. The minimum Liability will be when all the Ws are set at 100%. This results in a Liability of £156,671,476, reflecting a difference of -6.18% when compared to 2019. The funding levels vary between 102.2% and 106.6%.

In the CMI_2023, it is only possible to change the W of 2022 and 2023, and in this model the W is the same. When the W is 0%, the Liability is £163,802,671, representing a decrease of 1.91% compared to 2019. When the W is 10%, a decrease of 3.02% is

observed when compared to 2019. When the W is 25%, the core value of the 2023 model, the Liability is £161,451,586, representing a decrease of 3.32% compared to 2019. When the W is set to 50%, a decrease of 4.07% is observed when compared to 2019. The minimum Liability is noted when the W is set at 100% with a Liability of £159,836,243, reflecting in a decrease of 4.28% when compared to 2019. The funding levels exhibit a range of 101.9% to 104.5%.

It can be concluded that the higher Liability is reached when the CMI_2020 is used with no W, which is to be expected given that no mortality data from 2020 is incorporated. The lower Liability is reached when the CMI_2021 is used with the maximum W, which is to be expected since that it incorporates all mortality data from the peak deaths of the pandemic. Furthermore, when the W is set at 100%, the CMI_2023 is the model with the highest liability in comparison with the other models. This is anticipated to be lower than the other models with the maximum W, considering that the peak deaths of the pandemic are not included in this model (2021 and 2022 deaths). The CMI_2022, with a W of 100%, has an almost identical impact on the assets as the CMI_2021 with the same W. However, since the number of deaths in 2022 was considerably lower than in previous years, this results in an impact of -6.18%, which is lower than the -6.37% difference observed in the CMI_2021 in relation to the assets.

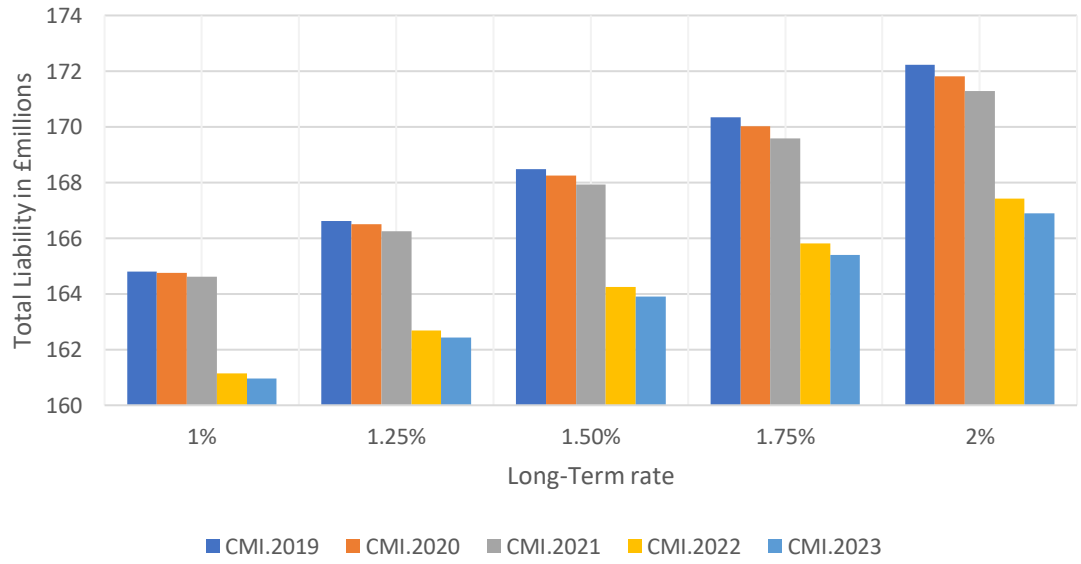
4.3 Results for Liabilities in Population 2 (females)

The total value of the assets for population 2 is £168,480,705.

4.3.1 Changes in the Long-Term rate

The subsequent graph illustrates the variations in the LTR for each CMI model in population 2, with the core values for the remaining parameters.

Graph 11: Change in the Long-Term rate for Population 2



In the CMI_2019, the Liability is £164,791,785 when the LTR is set at 1%. A subsequent increase of 0.25% in the LTR will result in an increase between 1.1% and 1.11%.

In 2020, the Liability is £164,766,314 when the LTR is 1%, representing a 2.2% reduction in comparison to the assets. A subsequent increase of 0.25% in the LTR results in an increase between 1.05% and 1.06%. When the LTR is 2%, an increase of 1.97% is observed when compared to the assets. The funding levels are between 98.07% and 102.25%.

In 2021, the Liability is £164,607,416 when the LTR is 1%, representing a 2.3% reduction compared to the assets, which is consistent with the reduction observed in males. A subsequent increase in the LTR of 0.25% results in an increase between 0.99% and 1%. When compared to the assets, an increase of 1.66% is observed when the LTR is 2%. The funding levels are between 98.37% and 103.35%.

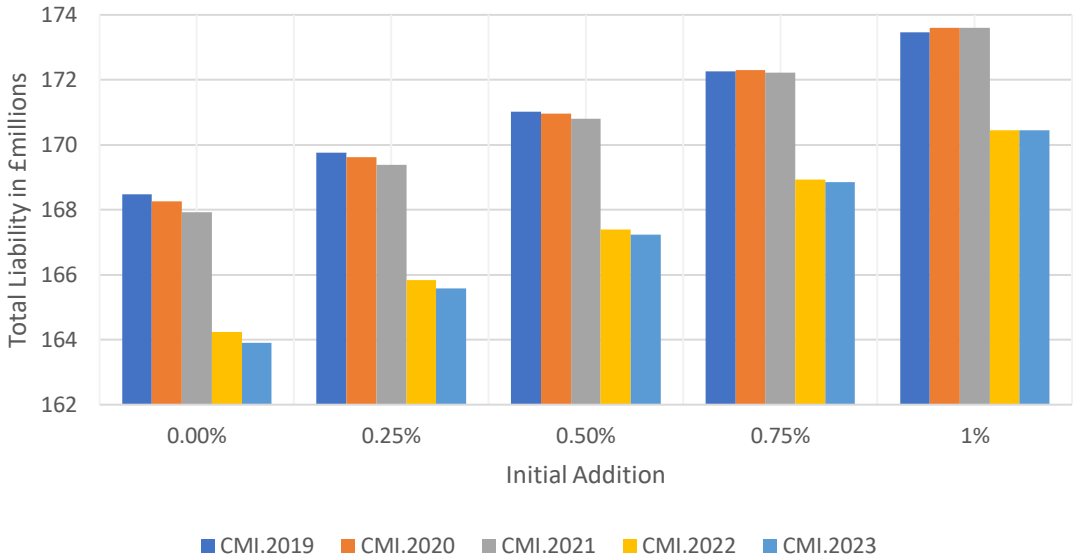
In 2022, the Liability is £161,139,044 when the LTR is 1%, representing a 4.36% reduction in comparison to the assets. A subsequent increase in the LTR of 0.25% results in a rise of 0.96%. When compared to the assets, a reduction of 0.63% is observed when the LTR is 2%. The funding levels are between 100.64% and 104.56%.

In the CMI_2023, the Liability is £160,959,450 when the LTR is 1%, representing a 4.46% reduction in comparison to the assets. A subsequent increase in the LTR of 0.25% results in an increase of 0.91%. When compared to the assets, a reduction of 0.94% is observed when the LTR is 2%. The funding levels are between 100.95% and 104.67%.

As in the male population, the increase in Liability will be lower when the year of the CMI model is increased, given the same LTR. Moreover, a comparison of the same CMI reveals that the increase in Liability is consistent when 0.25% is added to the LTR.

4.3.2 Changes in the Initial Addition rate

Graph 12: Change in the Initial Addition rate for Population 2



The graph above represents the Liabilities in population 2 when the A is changed for each CMI model, with a LTR of 1.50% and core values for the remaining parameters.

The Liability of the CMI_2019 with an A of 0% is £168,480,705. An increase in Liability of 0.76% is observed when the A is 0.25%, 0.74% when the A is 0.5%, 0.72% when the A is 0.75%, and 0.71% when the A is 1%, when compared with the previous A. This results in a Liability of £173,471,744 when the A is 1%.

In the CMI_2020, the Liability is £168,259,306 when the A is 0%, indicating a decrease of 0.13% when compared with the assets. As the A is increased, the Liability also increases by 0.81% when A is 0.25%, 0.79% when A is 0.5%, 0.77% when A is 0.75%, and 0.76% when A is 1%, in comparison with the previous A. When the A is 1%, the Liability is £173,594,183, representing a difference of 3.04% in comparison with the assets.

In the 2021 model, the Liability is £167,917,600 when the A is 0%, representing a decrease of 0.33% when compared with the assets. As the A is increased, the Liability will increase by 0.87% when the A is 0.25%, 0.85% when the A is 0.5%, 0.83% when the A is 0.75%, and 0.81% when the A is 1%, in comparison with the previous A. The Liability is £173,605,760 when the A is 1%, representing a difference of 3.04% in comparison with the assets. The Liability is higher in the 2021 than in the 2020, as observed in males.

In the 2022 model, the Liability is £164,247,040 when the A is 0%, representing a decrease of 2.51% when compared to the assets. When the A is increased, the Liability will increase by 0.97% when the A is 0.25%, 0.94% when the A is 0.5%, 0.92% when the A is 0.75%, and 0.9% when the A is 1%. The Liability is £170,442,075 when the A is set at 1%, representing an impact of 1.16% in comparison with the assets.

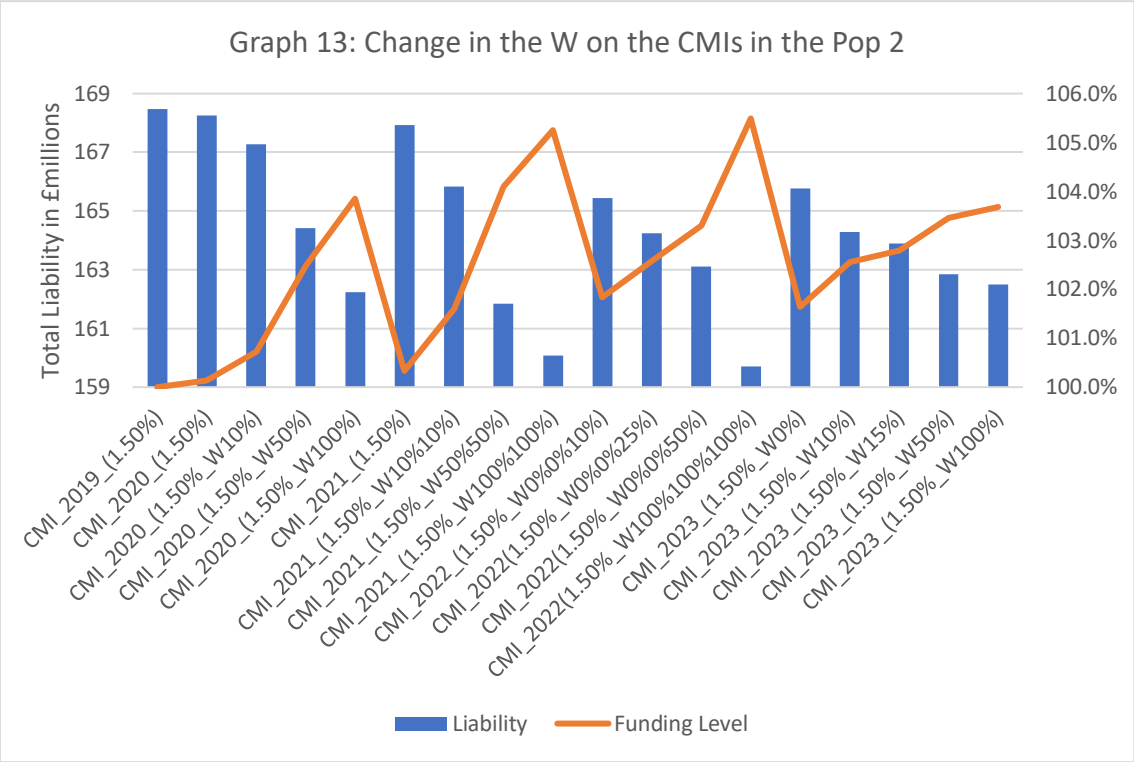
In 2023, the Liability is £163,900,121 when the A is 0%, representing a decrease of 2.72% when compared to the assets. As the A is increased, the Liability will rise by 1.02% when the A is 0.25%, 1% when the A is 0.5%, 0.97% when the A is 0.75%, and 0.95% when the A is 1%. A Liability of £170,445,280 is reached when the A is set at 1%, which corresponds to a difference of 1.17% in comparison to the assets.

As observed in the male population, when the same A is set for all models, it can be concluded that the increase in the Liability will be higher as the year of model is increased. Moreover, when the A is increased in the same CMI model, it can be concluded that the rise in the Liability will diminish with each 0.25% increase in the A. The Liabilities in the female population are higher than in the male population; however, the increase on the Liability when the A is increased in the same CMI model is more pronounced in the male population than in the female population.

With respect to the funding level, the CMI_2022 and 2023 are overfunded until the A reaches 0.5%, with funding levels of 100.65% for 2022 and 100.75% for 2023. Conversely, the minimum funding level is 98.85% when the A is 1% for both models. The CMI_2020 and 2021 models exhibit funding levels of 100.13% and 100.34%, respectively, when the A is 0%. These models will be underfunded when the A is 0.25% or above. When increasing the A until 1%, the 2020 and 2021 models will have a funding level of only 97.05%.

4.3.3 Changes in the Weights

The graph below represents the Liabilities for each CMI model with different Ws for the female population, with a LTR of 1.50% and core values for the remaining parameters:



In the CMI_2020 model, the Liability is £168,259,306 when the W is 0%, representing a reduction of 0.13% in comparison to the CMI_2019 model. An increase in the W to 10% and 50% represents a decrease in the Liability of 0.72% and 2.42%, respectively, compared to 2019. The minimum Liability is £162,241,379 when the W is set at 100%, representing a decrease of 3.7% when compared to 2019. All Liabilities in this model are overfunded, with a range of funding levels between 100.1% and 103.8%.

In the CMI_2021, the Liability is £167,917,600 when the W is 0%, representing a reduction of 0.33% and 0.2% when compared with 2019 and 2020, with no W, respectively. A 10% and 50% W results in a 1.58% and 3.94% reduction in the Liability when compared with 2019, respectively. The minimum Liability will be £160,076,509 when the W is 100%, representing a decrease of 4.99% and 1.28% compared with 2019 and the CMI_2020 with a W of 100%, respectively. The funding levels vary between 100.3% and 105.3%.

In the CMI_2022, when the W of 2022 is set at 10% and the remaining Ws are set at 0%, the resulting Liability is £165,445,405, representing a decrease of 1.80% compared to 2019. When increasing the W of 2022 to 15% and 50%, a decrease of 2.51% and 3.19%, respectively, is observed in comparison to 2019. The minimum Liability is £159,710,990, reflecting a difference of -5.21% when compared to 2019. The funding levels exhibit a range of variation between 101.8% and 105.5%.

In the CMI_2023, the Liability is £165,768,259 when the W is 0%, representing a decrease of 1.61% compared to 2019. When the W is set to 10%, 25% and 50%, there is a decrease of 2.49%, 2.72% and 3.35%, respectively, when compared to the assets. The minimum Liability is £162,501,302, reflecting a decrease of 3.55% when compared to 2019. As with the male population, the Liability with this W will be higher than that observed in other CMI models with W equal to 100%. The funding levels exhibit a range of 101.6% to 103.7%.

The female population exhibits a reduced funding level in comparison to the male population, given that the mortality rate in females is lower than that in males. The findings for the female population are largely consistent with those observed in the male population. The higher Liability is attained when the CMI_2020 is used, with no W, while the lower Liability is reached when the CMI_2021 is used with a W of 100%. Furthermore, when the W is set to 100%, the highest Liability is observed in the CMI_2023 model, while the CMI_2020 exhibits a Liability that is nearly identical to the CMI_2023, with a difference of -3.55% for the CMI_2023 and -3.70% for the CMI_2020 when compared to the assets. The CMI_2021 and CMI_2022 also exhibit comparable Liabilities when the W is set to 100%. When compared to the assets, these models demonstrate an impact of -4.99% for the CMI_2021 and -5.21% for the CMI_2022. This illustrates that the mortality rate was higher for females in 2022 than in 2021, which is contrary to what was observed in the male population.

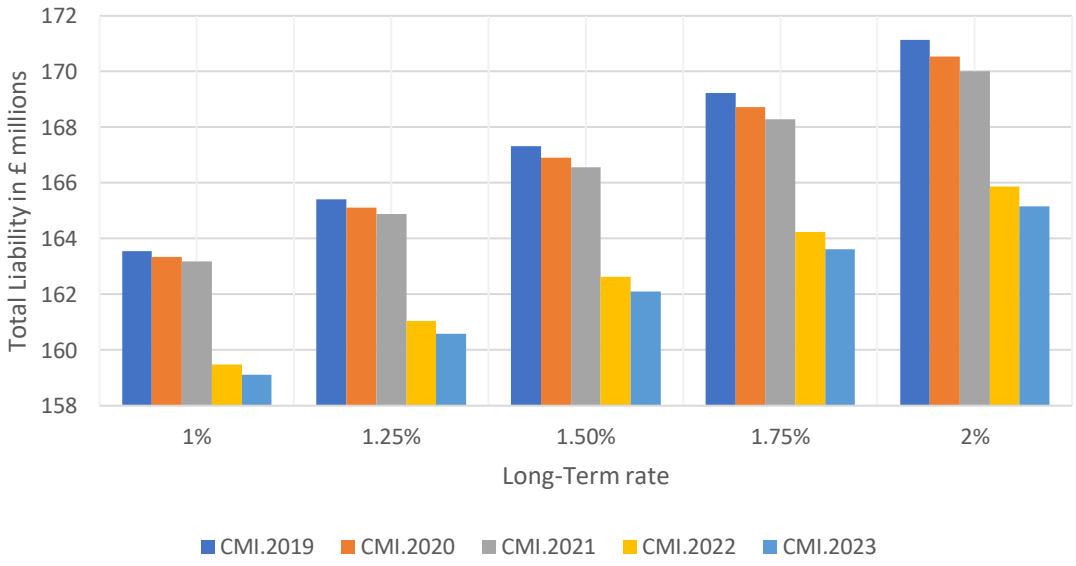
4.4 Results for Liabilities in Population 3 (real)

The total value of the assets for population 3 is £167,312,392.

4.4.1 Changes in the Long-Term rate

The graph below presents a visual representation of the variations in the LTR for each CMI model in population 3, with the core values for the remaining parameters. It is expected that the Liabilities in Graph 14 will fall within the range of Liabilities observed in Graphs 8 and 11.

Graph 14: Change in the Long-Term rate in Population 3



In 2019, an increase in the LTR results in an increase in Liability, from £163,540,460 when the LTR is 1% to £171,146,076 when the LTR is 2%. A subsequent 0.25% increase in the LTR results in an increase in the Liability between 1.14% and 1.15%.

In the CMI_2020, the Liability is between £163,346,835 (LTR is 1%) and £170,543,532 (LTR is 2%). This represents an increase of between 1.08% and 1.09% for each

subsequent 0.25% rise in the LTR. A comparison with the assets reveals a range of impacts between 1.93% (LTR is 2%) and -2.37% (LTR is 1%). The funding level is between 98.11% and 102.43%, indicating that the fund is overfunded until the LTR is at 1.50%.

In the CMI_2021, the Liability is between £163,189,654 (LTR is 1%) and £170,013,123 (LTR is 2%). This represents a 1.03% increase for each subsequent 0.25% increase in the LTR. A comparison with the assets reveals a range of impacts between 1.61% (LRT is 2%) and -2.46% (LTR is 1%). The funding level is between 98.41% and 102.53%, indicating that the fund is underfunded when the LTR is greater than 1.50%.

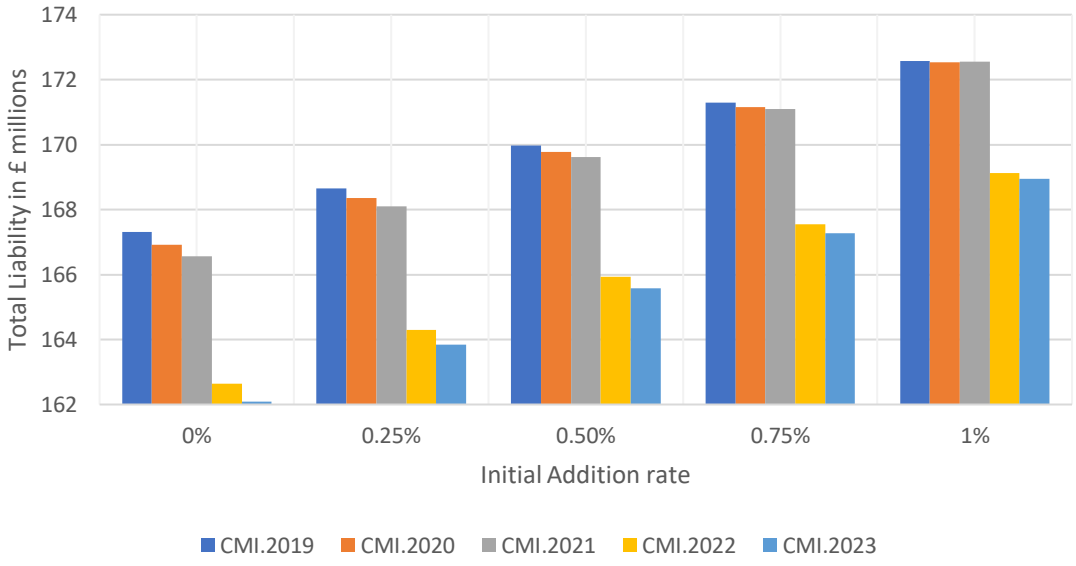
In the CMI_2022, the Liability is between £159,476,472 (LTR is 1%) and £165,868,318 (LTR is 2%). This represents a 0.99% increase for every subsequent 0.25% increase in the LTR. A comparison with the assets reveals a range of impacts between -0.86% (LTR is 2%) and -4.68% (LTR is 1%). The funding level is between 100.87% and 104.91%.

The CMI_2023 indicates a rise in Liability from £159,109,121 to £165,148,997. This implies an increase of between 0.93% and 0.94% for each subsequent 0.25% rise in the LTR. A comparison with the assets indicates a range of impacts in the Liability between -4.9% and -1.29%. The funding level is between 101.31% and 105.16%.

4.4.2 Changes in the Initial Addition rate

The graph below employs different A for each CMI model in population 3, with a LTR of 1.50%; the core values are assumed for the remaining parameters. It is anticipated that the Liabilities in Graph 15 will fall within the range of Liabilities observed in Graphs 9 and

Graph 15: Change in the Initial Addition rate for Population 3



The Liabilities of the 2019 model are between £167,312,392 (A is 0%) and £172,572,849 (A is 1%). This represents an increase in the Liability between 0.75% when the A is 1% and 0.8% when the A is 0% for each subsequent 0.25% increase in the A.

In the CMI_2020, the Liability is between £166,915,048 (A is 0%) and £172,533,984 (A is 1%). This represents an increase in the Liability between 0.8% (A is 1%) and 0.86% (A is

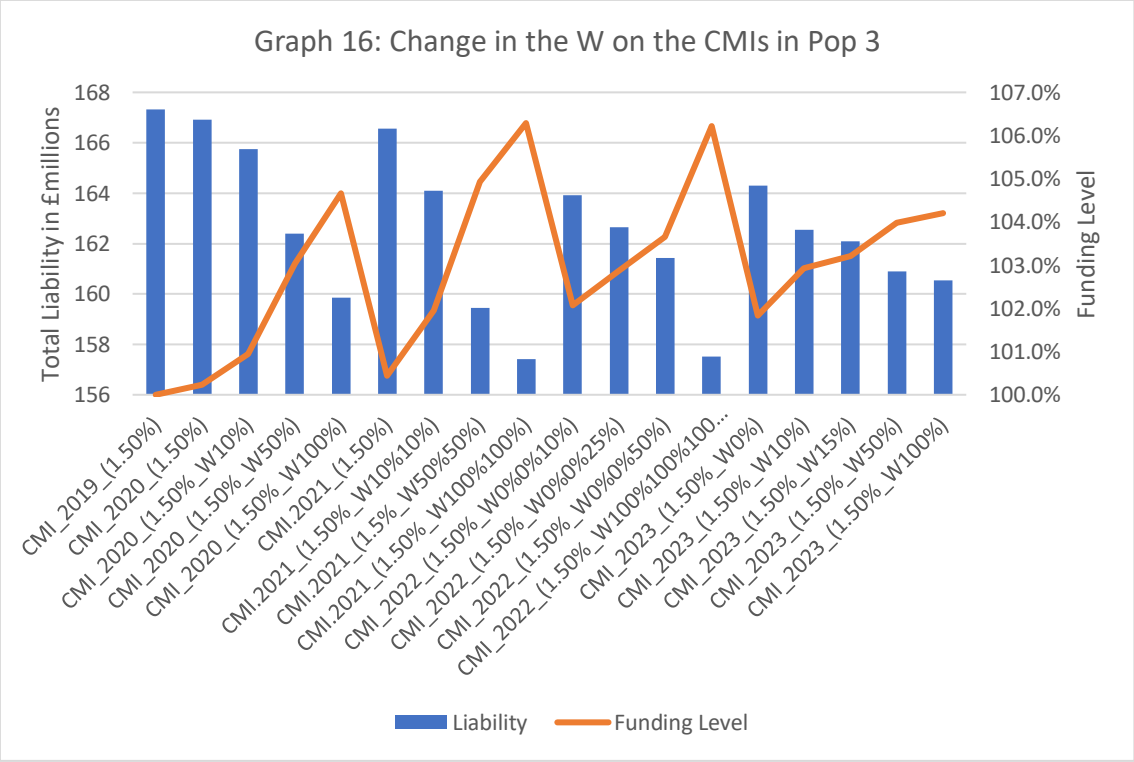
0%) for each subsequent 0.25% increase in the A. The impact when comparing with the assets is between -0.24% and 3.12%. The funding level is overfunded when the A is 0% (100.24%), and when the A is increased until 1%, the funding level is 96.97%.

In the CMI_2021, the Liability is between £166,571,874 (A is 0%) and £172,533,981 (A is 1%). This signifies an increase in the Liability between 0.85% (A is 1%) and 0.92% (A is 0%) for each subsequent 0.25% increase in the A. The impact is between -0.44% and 3.13% when compared with the assets. When the A is 0%, the funding level is 100.44%, and it is underfunded between 0.25% and 1%, with a minimum of 96.96%.

In the CMI_2022, the Liability is between £162,640,378 (A is 0%) and £169,127,471 (A is 1%), representing an impact of between 0.95% (A is 1%) and 1.02% (A is 0%) for each subsequent 0.25% increase in the A. The impact is between -2.79% and 1.08% when compared with the assets. The fund is overfunded when the A is between 0% (102.87%) and 0.50% (100.83%), and underfunded when the A is 0.75% (99.86%) and 1% (98.93%).

Finally, in the CMI_2023, the Liability is between £162,097,262 (A is 0%) and £168,941,707 (A is 1%), representing an increase of between 1% (A is 1%) and 1.08% (A is 0%) for each subsequent 0.25% increase in the A. The impact is between -3.12% and 0.97% when compared to the assets. The fund is overfunded when the A is between 0% (103.22%) and 1.75% (100.03%). Conversely, the fund is underfunded when the A is 1% (99.04%).

4.4.3 Changes in the Weights



The graph above uses different values of Ws for each CMI model in population 3, with a LTR of 1.50% and the remaining parameters were used the core values. It is also

expected that the Liabilities in Graph 16 will fall within the range of Liabilities observed in Graphs 10 and 13.

In the CMI_2020, the Liability is £166,915,048 when the W of is set at 0%, representing a reduction of 0.24% in comparison to 2019. An increase in the W to 10% and 50% has an impact in the Liability of -0.93% and -2.94%, respectively, in comparison to 2019. The minimum Liability in the CMI_2020 is £159,863,600 when the W is set at 100%. This represents a reduction of 4.45% when compared to 2019. All Liabilities in this model are overfunded, with a funding level of between 100.2% (W is 0%) and 104.7% (W is 100%).

In the CMI_2021, the Liability is £166,571,874 when the W is set to 0%, representing a 0.44% reduction when compared with the assets. When both Ws are set to 10% and 50% respectively results in a reduction in the Liability of 1.92% and 4.7 when compared with 2019. The minimum Liability is £157,412,712, representing a decrease of 5.92% compared to 2019. The funding levels vary between 100.4% and 106.3%.

In the CMI_2022, when the W of 2022 is set at 10% and the remaining Ws are set at 0%, the resulting Liability is £163,926,577, representing a decrease of 2.02% compared to 2019. An increase in the W of 2022 to 15% and 50% respectively results in a decrease of 2.79% and 3.52% in comparison to 2019. The minimum Liability is £159,710,990, reflecting an impact of -5.86% when compared to 2019. The funding levels demonstrate a range of variation between 102.1% and 106.2%.

In the CMI_2023, when the W is set to 0%, the resulting Liability is £164,291,366, representing a decrease of 1.81% in comparison to the 2019 Liability. Upon setting the W to 10%, there is a decrease of 2.85% when compared to 2019 and a decrease of 0.84% when compared to the 2022 model with the same W in the 2022 data. When the W is set to 25% and 50% respectively results in a decrease of 3.12% and 3.83 compared to 2019. The minimum Liability is £160,551,558, reflecting a decrease of 4.04% when compared to 2019. This Liability is higher than the Liability observed in other CMI models with W equal to 100%. The funding levels exhibit a range of 101.8% to 104.2%.

The population 3 is based on the actual sex indicated in the data, with the majority of members belonging to the male sex. Consequently, the resulting conclusions are identical to those of the male population, and the impact on the Liability for population 3 is less than that of the male population when compared with the assets of each population. As with the male population, the highest and lowest Liability is observed in the CMI_2020 with no W and the CMI_2021 with 100% W, respectively. Furthermore, when the W is set at 100% the model with the highest Liability is the CMI_2023. The liabilities of the CMI_2021 and CMI_2022 with W of 100% are found to be highly similar, with an impact of -5.92% and -5.86%, respectively. As observed in the male population, the impact is found to be higher in the CMI_2021 model.

5. Conclusion

The main goal of this report was to ascertain the impact of the Coronavirus pandemic on the Liabilities of DB pension schemes. In particular, it is investigated whether the Liabilities would continue to decrease, stabilise as pre-pandemic, or begin to rise using the CMI model. The pandemic has resulted in a significant number of deaths, which had a detrimental effect on the Liabilities of DB pension schemes when compared with 2019, as evidenced in the preceding chapter.

The CMI model incorporates a variety of parameters, including: The Long-Term rate, the Smoothing parameter, the Initial Addition rate, and the weights, which were only applied in the 2020 model onwards.

With respect to the LTR, one important conclusion is that an increase in the LTR from 1% to 2% will result in an overall rise in Liability for both sexes across all CMIs from 2020 until 2023. Additionally, it can be observed that the impact of males is more detrimental than the impact of females when a higher LTR is set in comparison to the assets, given that males have lower life expectancies than the females. Moreover, when CMI year rises, the impacts fall in comparison to the assets when setting the same LTR. To illustrate, when the LTR is set at 1%, the impact on males is -2.46% in the CMI_2020 and -5.12% in the CMI_2023. This behaviour is exhibited by the female population as well, but with higher impacts. Furthermore, the increase for each subsequent 0.25% increase in the LTR will decrease as the CMI year increases. To illustrate, the males had an increase of 1.16% to 1.17% in the CMI_2019. As the year of the CMI increases, the aforementioned increases declined, reaching 0.95% with CMI_2023. The observed behaviour in females is consistent with the previous description but with lower impacts.

In the CMI_2020 and 2021, the impact is negative for both sexes until the LTR reaches 1.75%, when compared to the assets. The highest impact is observed when the LTR is 2%, with a positive impact in comparison to the assets. In the case of CMI_2022 and 2023, the impact is observed to be consistently negative when compared with the assets. As in the model 2020 and 2021, the highest impact is observed when the LTR is 2%. In the CMI_2023, the impacts are lower than in the other models, with the lowest impact occurring when the LTR is 1%.

The impacts of the population 3 fall between the impacts of the male and female populations. The female population represents the greatest impact, while the male population represents the lowest impact.

With respect to the A parameter, a comparison of the same A with the previous A in the same model reveals that the impact on the Liability increases as the model year increases. To illustrate, if the A is set at 0.25% and compared with the previous A (0%), the impact for males is 0.83% for CMI_2019 and 1.11% for CMI_2023. Furthermore, an increase in the A within the same CMI model will result in a decrease in the impact on the Liability, with each 0.25% increase in the A. For example, setting the A at 0.5% results in an impact for males of 1.08% for CMI_2023. A comparison of this impact with the previous impact of the CMI_2023 reveals a decrease in impact when a higher A is set. Additionally, it can be concluded that the impacts on males are greater than those on females. However, the highest Liabilities are from the female population due to the life expectancies of females being higher than those of males.

When comparing the CMI_2020 and 2021 results with the assets, the conclusion is that the impact of females is closer to zero than the one of males. To illustrate, in males, the impact is observed to be between -0.5% and 3.17% in CMI_2021, while in females, the impact is between -0.33% and 3.04% in CMI_2021. Furthermore, the highest Liability in all populations is observed in the CMI_2021 when the A is set at 1%.

When the A is set at 1% for CMI_2022 and 2023, the model that will result in a higher Liability when compared to the assets will be CMI_2022 for males, at 1.04%. However, for females will be the CMI_2023 having an impact of 1.17%. This is observed since the mortality in females is higher in the CMI_2022 than in the CMI_2023, and the opposite is true for males. As the third population has more males than females, the same conclusion can be expected as for the male population.

With respect to the W, an increase in this parameter will result in a reduction in liabilities compared to assets, regardless of the chosen CMI and population. The lowest Liability for populations 1 and 3 is observed in the CMI_2021 with a full W, which is to be expected given that the CMI_2021 accounts for the first two years of the pandemic, during which there were higher mortalities. The impact on males is -6.37%. The lowest Liability in population 2 is found in the CMI_2022 when all Ws are set to 100%, with an impact of -5.21%. When the full W is set, the CMI with the highest impact is the CMI_2023, which has an impact of -4.28% on the males and -3.55% on the females. This is due to the fact that the CMI_2023 only incorporates the data from 2022 and 2023, and therefore the model excludes the years with the highest mortalities (2020 and 2021).

Analysing the W core values, we see that the CMI_2023 has the lowest impact across all populations. To illustrate, in CMI_2020 the impact for males is -0.29% and for females is -0.13%, and in CMI_2023 the impact for males is -3.32% and for females is -2.72%. This aligns with the trends observed in section 3.2 regarding life expectancy. The impacts of the population 3 fall between the impacts of the male and female populations, with the male population exhibiting lower impacts than the female population.

The main conclusion is that the Liabilities continue to decrease in comparison to the 2019 data, as a result of an increase in the W of the CMI models. An increase in the A and in the LTR will generate higher Liabilities. The males have the lowest impacts when compared with 2019, which is to be expected given that the males have experienced a decrease in the life expectancy higher than females, with a discrepancy of 2.56 years, compared to 2.37 years in 2019. In this way the females continue to have a higher life expectancy than males.

The high impacts observed in the CMI_2022 and 2023 when compared with 2019 can be attributed to the discrepancy in the data between 2012 and 2020 resulting from the recent census. To illustrate, the mortality improvement of 2020 for both sexes in the CMI_2020 was -11.8%, while in the CMI_2022 and CMI_2023 it was -13.9%. The mortality improvement for 2021 and 2022 were also affected.

The selection of the CMI model is dependent on the demographics of the population of the scheme. Note that only three years have elapsed since the virus first emerged globally. Consequently, our conclusions are limited to a short-term perspective. However, it will only be possible to ascertain whether this decline will persist or whether

mortality rates will begin to resemble those observed prior to the pandemic once a longer period of time has elapsed.

During this report, I experienced some challenges in carrying out the desired calculations. The WTW software presented certain limitations in terms of the available options for the CMI. This proved to be an obstacle in the intended calculations. The availability of this feature would facilitate the presentation of a more comprehensive range of results pertaining to the CMI_2021 Liabilities, given that the only option was to use the same percentage to both weights in this model. Additionally, for the 2022 model, the production of results was also limited. It was possible to vary the percentages for the 2022 weight, but the remaining two weights were represented by a combination of 0%. However, the only weight that could be combined with all other weights using the same percentage was the 100%. Additionally, it was not possible to obtain the minimum, i.e. when all the Ws are set at 0%.

Further research could be conducted on this topic. One potential research would be to use real data from before, during and after Covid-19 to determine the alignment between the selected models and the observed deaths within the scheme. It would also be interesting to consider two different populations with different mortality models. For example, one scheme could represent a company in the chemical industry, while the other could represent a company in the white-collar sector. This is because the white-collar workers would be expected to work from home during Covid-19, while the chemical company would continue to operate from factories. Another possibility would be to split the Liability by status, as the mortality rate for Active members is likely to be lower than for Pensioners, since Active members tend to be younger and healthier.

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Appendix

Economic and Demographic Assumptions

Table 2 – Economic Assumptions

Rates	Percentage
Discount Rate	2.5%
Salary Escalation	2%
Section 148	3%
GMP Fixed Rate	4%
RPI	3.3%
CPI	2.4%
RPI floor 0% and cap 5%	3.3%
RPI floor 0% and cap 2.5%	2.5%
CPI floor 0% and cap 3%	2.4%
CPI Revaluation cap 5%	2.4%
CPI Revaluation cap 2.5%	2.4%

Table 3 – Demographic Assumptions for Actives

Description	Sex	Element	Rating	Multiplier
Voluntary age retirement rates	Male	N/A	N/A	N/A
	Female	N/A	N/A	N/A
Impaired health retirement rates	Male	N/A	N/A	N/A
	Female	N/A	N/A	N/A
Withdrawal rates	Male	N/A	N/A	N/A
	Female	N/A	N/A	N/A
Death rates	Male	S3NMA	0	1
	Female	S3NFA	0	1
Salary scale	Male	N/A	N/A	
	Female	N/A	N/A	
Proportion married	Male	0.8	0	
	Female	0.7	0	
Age difference	Male	3	0	
	Female	-3	0	

Table 4 – Demographic Assumptions for non-Actives

Description	Sex	Element	Rating
Proportion married	Male	0.8	0
	Female	0.7	0
Age difference	Male	3	0
	Female	-3	0

Table 5 – Mortality Assumptions with the Assets Assumptions

Base mortality:		
Base table:	Male	S3PMA
	Female	S3PFA
Multiplier:	Male	1
	Female	1
Age rating:	Male	0
	Female	0
Mortality improvement allowance:		
Single set of improvements		
Table reference details:		
Table type:	Year of use	Effective date
Final age rating:	0	2023
Improvements:		
Improvement:	Male	CMI_2019_M_(1.50%)
	Female	CMI_2019_F_(1.50%)
Start Year:	2013	