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le __________________________

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Abstract

Key words: Impaired life annuities, indexation, Periodic Payment Orders, excess of loss reinsurance, casualty, motor insurance, mortality adjustments, cost of capital, risk margin, Solvency II, "Loi Barnier", reserving

This paper aims at presenting possible adjustments to standard mortality tables for modeling the mortality profiles of severely injured persons. The main point is to provide insurers with techniques for assessing the risk related to index-linked compensatory annuities. This type of indemnity can be awarded in France, in the United Kingdom and many other European countries as compensation for victims of severe injuries (motor third party liability, employer's liability…). We are also presenting approximations to show how much capital should be held to back compensatory annuity type liability. In parallel with these considerations, we will try to see how different types of excess of loss reinsurance products can constitute a hedge against the longevity risk and the inflation risk. And finally, we will make some simple considerations for assessing the share of the technical provisions which could constitute the Risk Margin or the present value of future capital costs.

Résumé

Mots clés : Rentes indemnitaires, indexation, mortalité aggravée, "Periodic Payment Order", réassurance en excédant de sinistres, assurance automobile, table de mortalité, ajustements de mortalité, coûts du capital, marge de risqué, Solvabilité II, Loi Barnier, provisionnement

Ce mémoire vise à présenter des possibilités d'ajustements sur les tables de mortalité standards pour modéliser les profils de mortalité de blessés graves. Le principal objectif est de fournir aux assureurs des techniques permettant d'évaluer leurs engagements prenant la forme de rentes indemnitaires indexées. Ce mode d'indemnisation peut être utilisé en France, au Royaume-Uni ainsi que dans de nombreux autres pays européens pour des victimes d'accidents graves (RC auto, RC employeur au Royaume-Uni, RC médicale…). Nous présentons ici aussi des approximations pour calculer le montant des capitaux nécessaires pour pouvoir supporter un risque de type rentes indemnitaires indexées. En parallèle de ces considérations, nous verrons comment différents produits de réassurance en excédant de sinistre peuvent constituer une couverture contre les risques de longévité et d'inflation. Finalement, par des considérations simples, nous tenterons d'évaluer quelle part des provisions pourrait constituer la marge de risque ou la valeur actuelle des coûts du capital futurs.

Synthesis

Since 2005, in the United Kingdom, it is possible for a claim for loss as a result of a negligent act to be settled with a periodic payment awarded as indemnity. A periodic payment can be awarded for any head of damage where recurrent costs/losses by the victim can be justified to the court. In most cases, the periodic payments are meant to cover the medical care of the claimant and the payments are usually indexed automatically following ASHE6115 (wage index; Annual Survey of Hours and Earnings for the sub-category of care assistants and home carers).

In France, annuities have been awarded for victims of road accidents for more than 35 years, offering the same benefits to the claimants as the UK has offered since 2005. In France, Swiss Re is still paying for an annuity which was awarded in 1947! In France however, the inflation used to be handled by a pool and following a recent change, for all the accidents which occurred after 01/01/2013, the insurers will have to pay for the inflation on the annuity payments and bear the risk.

From a social perspective PPOs compared to lump sums offer various benefits:

- Reduce the under/over compensation risk, offering a better hedge against :
  - Longevity risk
  - Cost of care inflation
  - Market risk
- Decrease the risk of poor asset management by the claimant's representatives
- Avoid the issue of disputes between defendant and claimant regarding life expectancy ...

For the non-life insurance/reinsurance market, these are materialising as a whole set of new risks to manage with the appropriate prudential rules. The new risks involved require a new technical approach, using techniques similar to the ones used by life insurance companies. A few risks remain specific to PPOs, among which are: the inflation of the salaries of the medical profession, the consideration of impaired life expectancies (depending on the type of injury suffered, the life expectancy of the claimant might have been significantly reduced), the lack of historical data for assessing these risks and the uncertainty surrounding their numbers both due to frequency of accident and to percentage of claims settling with an annuity payment.

In this paper we will try to answer the question: What techniques could we use when assessing the longevity risk? The aim of this study is to focus on the specificities of compensatory annuities and on the longevity risk which is one of the main risk factors. Because of the durations involved, decades, the cost of capital will represent a significant part of the liability. And we will present techniques and possible proxies to assess the present value of future cost of capital or Risk Margin.

In a first part, we will present general considerations about compensatory annuities in France and in the United Kingdom. The annuities are usually indexed in line with a consumer price index (or similar) in France and with a carers' wage index in the UK. There is no regulatory definition about how to reserve for the inflation risk yet (in both countries) and how much capital should be held to face this risk. The main risk for compensatory annuities, both in France and in the UK, is the inflation risk combined with the longevity risk.

So, in a second part, we will try to define a methodology for adjusting the mortality curves of the general population to reflect the specificities of a population of severely injured persons. The main type of injuries encountered after a car accident are brain and spinal injuries. It is hard to find studies about long term mortality of severely injured persons; in this paper we will present some results of studies which followed the lives of people who suffered a spinal injury. Notably we observe a very high mortality in the first two years after the accident; after this period in the different studies we can note that the younger the age of the victim the higher the super-imposed mortality (compared to the general population). This phenomenon could be explained by the fact that young victims tend to have suffered more severe car accidents than older victims, and as time goes by there is a selection which operates among the different victims.

In medical underwriting, life insurance for people with specific medical conditions, actuaries defined different adjustment techniques for factoring impairment in the mortality curves of the general population. We will present here some of these techniques and how they change the morality profile of the general population.

Insurers are usually buying excess of loss reinsurance covers as a protection against the cost of their largest losses. With compensatory annuities there are different kinds of covers available to deal with the annuity element of the liability. In a third part we will present different products which are offered by reinsurers in the current market:

- A capitalised product for which the annuity part is covered by a lump sum representing the reinsurer's share of the liability and offered to the insurer after the claim is settled,
- An un-capitalised product, the reinsurer makes the payments corresponding to their share of the liability as the annuity payments are realising, until the death of the claimant,
- A delayed capitalised product, working like an un-capitalised product for the first X years after which a lump sum is offered to the insurer to cover the remaining part of the liability.

We will present how the three products are working once a claim is settled on an annuity basis. We will also present an important clause which exists in reinsurance for sharing the inflation risk between the insurer and the reinsurer: the "index clause".

In insurance, an important component of annuity type liability to consider is the cost of capital: the cost relating to the necessity of holding the capital requirement until the term of the liability. In order to assess this cost we will present a way to assess the capital to hold regarding the longevity and the inflation risk. From this, we will use the solvency II formula for calculating the risk margin in order to assess the present value of the future cost of capital.

Using a specific example we will compare the benefits of the different products specifically for claims which settled with an annuity.

All the results will be presented from both the perspective of the insurer with and without reinsurance, for different types of excess of loss treaties.

Better modelling will help understanding the risks from an economic perspective, assessing the cost of holding the risk in the balance sheet, and preparing for the forthcoming regulatory regime: Solvency II.

Résumé

Depuis 2005, au Royaume Uni, il est possible pour les victimes d'accidents résultant d'un acte de négligence de recevoir une rente indemnitaire pour compensation. Une rente indemnitaire peut être attribuée pour n'importe quel poste de préjudice dès lors que l'intérêt de la rente peut être démontré au juge. La plupart du temps, la rente a pour but de couvrir les frais médicaux récurrents, notamment l'assistance, et la rente est indexée au cours du temps suivant l'indice ASHE 6115 (indice des salaires des professions médicales au Royaume Uni).

En France, les rentes indemnitaires existent depuis longtemps maintenant, offrant les mêmes avantages que ceux à disposition des victimes britanniques depuis 2005. Swiss Re paye encore aujourd'hui des indemnités pour une rente attribuée après un accident datant de 1947! En France néanmoins, l'inflation dans le passé n'était pas gérée par les assureurs mais par le FGAO (*Fonds de Garantie des Assurances Obligatoires de dommages).* Ceci a aujourd'hui changé et pour tous les accidents ayant eu lieu après le 1er Janvier 2013 les assureurs devront couvrir à la fois la rente et l'inflation, portant eux-mêmes ce risque.

D'un point de vue sociétal, l'attribution d'une rente indemnitaire offre de nombreux avantages comparativement à un capital forfaitaire:

- Cela réduit le risque de sous/sur –compensation, offrant une meilleure couverture contre :
    - Le risque de longévité
    - L'inflation du coût des soins
    - Le risque d'investissement
- Cela diminue aussi le risque de mauvaise gestion du capital par les représentants de la victime.
- Cela permet d'éviter les discussions entre l'assureur et les représentants de la victime sur son espérance de vie…

Pour le marché de l'assurance/réassurance non-vie, cela se matérialise par un nouveau jeu de risques à gérer tout en respectant les règles prudentielles. Les nouveaux risques impliqués requièrent une nouvelle approche technique, nécessitant l'utilisation de méthodes de modélisation proches des techniques utilisées par les assureurs vie. Quelques risques restent spécifiques aux rentes indemnitaires, parmi lesquels: l'indexation des rentes suivant les salaires de la profession médicale, la considération de personnes ayant une espérance de vie réduite (parfois significativement selon le type de blessures soufferts par la victime), le manque de données historiques pour évaluer ces risques et l'incertitude quant à la fréquence d'attribution de rentes indemnitaires provenant de l'incertitude sur la fréquence d'accidents graves dans l'année et le pourcentage de ces accidents graves se soldant par une/des rentes.

Dans ce mémoire nous tenterons de répondre à la question suivante: Quelles techniques peuvent être utilisées pour évaluer le risque de longévité? Le but de l'étude est de se concentrer sur les spécificités des rentes indemnitaires et sur le risque de longévité qui est un des principaux facteurs de risque. De par les durations en jeu (de l'ordre de plusieurs décennies) le coût du capital représentera aussi une part significative du passif. Nous présenterons des techniques et des

approximations possibles pour évaluer la valeur actuelle des futurs coûts du capital ou la Marge de Risque.

Dans un premier temps, nous présenterons des considérations générales sur les rentes indemnitaires en France et au Royaume Uni. Les rentes sont indexées suivant un indice similaire à l'indice des prix à la consommation en France, et suivant un indice des salaires des professions médicales au Royaume Uni. Il n'y a pas aujourd'hui de méthode réglementaire pour le provisionnement du risque d'inflation (ni dans un pays ni dans l'autre) ou pour le calcul du capital requis pour couvrir ce risque. Le principal risque lié aux rentes indemnitaires, à la fois en France et au RU, est la combinaison du risque d'inflation et de longévité.

Vis-à-vis du risque de longévité, nous présenterons ici quelque unes des techniques d'ajustement utilisées par les actuaires de la "souscription médicale" : assurance vie pour des personnes ayant des conditions médicales particulières. Les techniques que nous présenterons sont des ajustements apportés aux courbes de mortalité de la population générale pour prendre en compte la réduction d'espérance de vie des victimes d'accidents graves.

Pour se couvrir contre les coûts liés à leurs accidents les plus graves, les assureurs achètent une couverture en excédent de sinistre auprès de réassureurs. Pour les rentes indemnitaires différentes solutions de réassurances existent et sont disponibles sur le marché. Dans un troisième temps nous présenterons donc différents produits qui sont offerts par les réassureurs dans le marché actuel:

- Un produit en capitalisation pour lequel la partie en rente est couvert par un capital versé au moment de la constitution de la rente par le réassureur correspondant à sa part du sinistre.
- Un produit sans capitalisation, le réassureur paye sa part du sinistre au fil du temps à mesure que les différents paiements sont effectués jusqu'au décès de la victime.
- Un produit en capitalisation retardé, fonctionnant comme un produit sans capitalisation pendant X années après lesquelles le réassureur verse un capital correspondant à ses engagements.

Nous présenterons comment ces trois produits fonctionnent une fois que l'attribution de la rente a été décidée. Nous présenterons aussi une clause importante, présente dans la plupart des traités, déterminant les règles de partage de l'inflation entre l'assureur et le réassureur : la clause d'indexation ou de stabilisation.

Pour un assureur, une composante importante des engagements de type rente est le coût du capital : coût lié à la nécessité de posséder un capital suffisant pour garder le risque dans son portefeuille jusqu'à son terme. Pour évaluer le coût du capital nous présenterons un moyen d'évaluer les capitaux sous risque relatifs au risque de longévité et au risque d'inflation. A partir de là, nous utiliserons la formule de Solvabilité 2 pour calculer la Marge de Risque afin d'évaluer la valeur actuelle des futurs coûts du capital.

A l'aide d'un exemple spécifique nous comparerons les effets respectifs des différents produits de réassurance sur un sinistre se soldant par une rente.

Tous les résultats seront présentés à la fois sous les points de vue de l'assureur et du réassureur, pour les différents types de traités.

Une meilleure modélisation aidera à avoir une meilleure vision des risques d'un point de vue économique, à évaluer les coûts nécessaires pour porter le risque dans son bilan, et à préparer l'arrivée d'un nouveau régime de régulation : Solvabilité II.

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I would like to deeply thank **Paul Brennan**, head of the Property and Casualty UK pricing team for Swiss Re, for his openness in sharing his technical knowledge around periodical payment orders (British compensatory annuities) and all the guidance he could give to me. I would like to thank **Peter Saunders** for his good advices, and all the time he could spare for helping me with this project. I am also to the **UK P&C underwriting and pricing teams** for the support and knowledge they shared with me in London. I wish to thank **Efe Tokmen** for his inputs regarding Solvency II and other capital considerations. I am also thankful to **Riddhi Patel** for proofreading this paper and for the general comments she could provide me with.

On the other side of the Channel, **Alexis Valleron**, P&C chief underwriter in Swiss Re France, was a great advisor for understanding the specificities of French compensatory annuities and offered me a good expert guidance and deserves a special note of thanks. I am sincerely thankful to **Marc Belbenoit**, my "buddy" in Swiss Re, for the motivation he instilled in me.

Annuities stemming from non-life policies:

A changing environment,

Reserving and Risk Capital Considerations

General Introduction

Since 2005, in the United Kingdom, it is possible for a claim for loss as a result of a negligent act to be settled with a periodic payment awarded as indemnity. A periodic payment can be awarded for any head of damage where recurrent costs/losses by the victim can be justified to the court. In most cases, the periodic payments are meant to cover the medical care of the claimant and the payments are usually indexed automatically following ASHE6115 (wage index; Annual Survey of Hours and Earnings for the sub-category of care assistants and home carers).

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From a social perspective PPOs compared to lump sums offer various benefits:

- Reduce the under/over compensation risk, offering a better hedge against :
  - Longevity risk
  - Cost of care inflation
  - Market risk
- Decrease the risk of poor asset management by the claimant's representatives
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For the non-life insurance/reinsurance market, these are materialising as a whole set of new risks to manage with the appropriate prudential rules. The new risks involved require a new technical approach, using techniques similar to the ones used by life insurance companies. A few risks remain specific to PPOs, among which are: the inflation of the salaries of the medical profession, the consideration of impaired life expectancies (depending on the type of injury suffered, the life expectancy of the claimant might have been significantly reduced), the lack of historical data for assessing these risks and the uncertainty surrounding their numbers both due to frequency of accident and to percentage of claims settling with an annuity payment.

Research Question

What techniques could we use when assessing the longevity risk? The aim of this study is to focus on the specificities of compensatory annuities and on the longevity risk which is one of the main risk factors. Because of the durations involved, decades, the cost of capital will represent a significant part of the liability. And we will present techniques and possible proxies to assess the present value of future cost of capital or Risk Margin.

The results will be presented from both the perspective of the insurer with and without reinsurance, for different types of excess of loss treaties.

Better modelling will help understanding the risks from an economic perspective, assessing the cost of holding the risk in the balance sheet, and preparing for the forthcoming regulatory regime: Solvency II.

Part I. Introduction

1.1. Large bodily injuries

The majority of losses settling as an annuity in casualty (re-)insurance arise from motor insurance policies. In the United Kingdom, as in France and many other countries, there is no limit of cover to the insurance policies regarding bodily injuries. So losses can theoretically be unlimited.

The main focus during this study will be on large bodily injuries and per risk excess of loss treaties for the reinsurance aspects.

1.1.1. Heads of damage

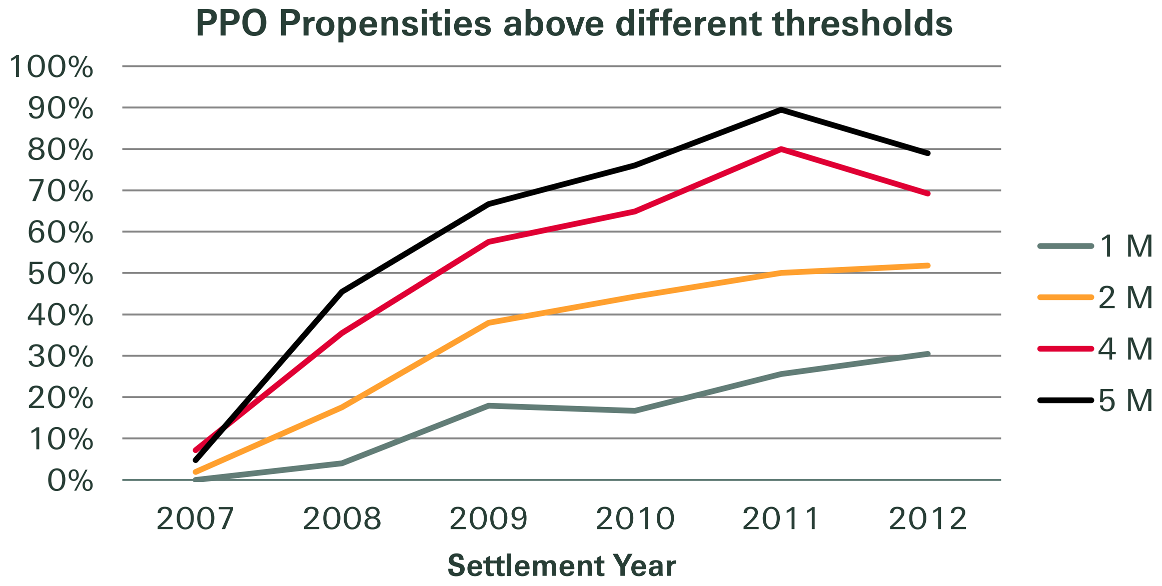
For large motor losses the main heads of damage are usually the cost of care and the loss of earnings.

In the United Kingdom (since 2005) and in France, there is a dual environment for large losses where indemnities can be paid as lump sums or as a blend of a lump sum element (usually loss of earnings and other heads of damage) and an annuity element (usually for the cost of care or assistance). The other heads of damage can include the building of facilities adapted to the new conditions of the claimant.

1.1.2. Large losses in the UK

When looking at large losses, not all the claims are annuity type claims. In the United Kingdom, Swiss Re has in recent years monitored the likelihood for claims to settle with a periodic payment order.

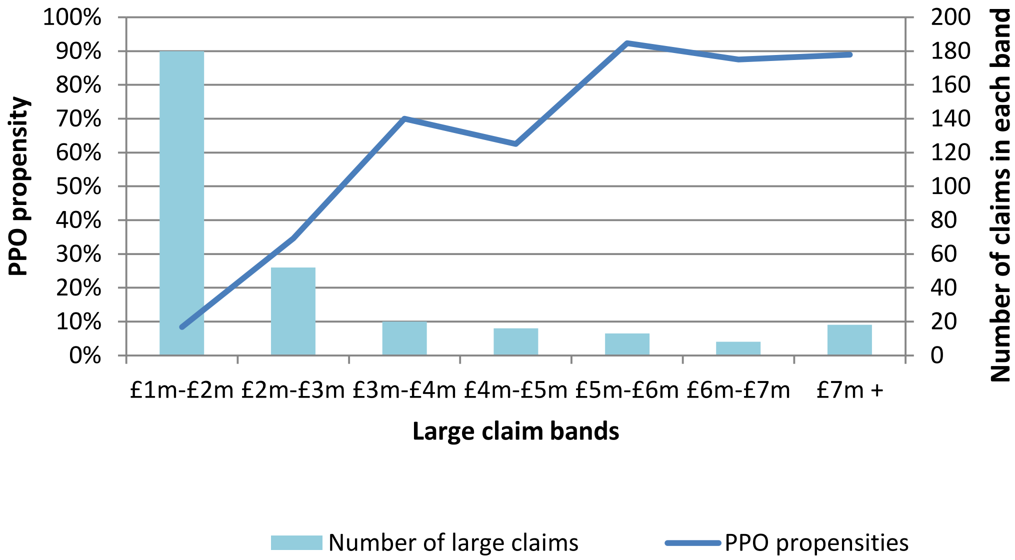
The graph below shows the trend across calendar years of the proportion of large claims settling on an annuity basis. The study compares the proportion of large claims settling as an annuity above various thresholds in today's monetary value[1]: £1m, £2m…



As we can see, claims only started settling as PPO recently. Yields being at a low level, a legal case changing the inflation linkage from prices to wages are assumed to be behind the observed increase in the proportion of claims settling as an annuity. The real discount rate used by the courts is at 2.5% and as the equivalent market based level would be significantly below this, the economic benefit of an annuity is clear. We can also see that the larger the claim the more likely it is that there is at least one victim who will receive a periodic payment order.

[1] For doing this study the annuity payments are discounted using 2.5% as a real discount rate (factoring both an inflation assumption and a return on investment assumption). 2.5% is used when calculating the present value of future cash flows by the courts when a lump sum is awarded. Therefore the different claims are all calculated on the same basis. The thresholds considered are de-trended when looking at the prior to 2013 years as an adjustment for inflation.

From the same study, a focus on the past 2 years[2], shows the trends in frequency at a market level (74% of the insurance market in premium is captured here):



Considering that for many small motor insurers the annual written premium is below £60m buying the right reinsurance cover can be crucial for the survival of the company. The same considerations and conclusions could be made regarding the French motor market.

1.1.3. Inflation and indexation

Whenever possible, if a change in future claimant's needs can be foreseen (e.g. the ageing of the family carers of the victim) the court can decide that the annuity is stepped up or down after a defined period (it is also possible to have several steps planned in a row).

Both in France and in the United Kingdom the annuity element is usually linked to an index chosen by the court to provide the claimant with some cover against the inflation risk. Basis risk is likely to remain.

1.1.3.1 United Kingdom; ASHE 6115

In the United Kingdom, since 2008 the most commonly used index for annuity payments relating to the cost of care is ASHE6115. It is a wage index published by the ONS (Office for National Statistics) based on a survey of hourly earnings of "care assistants and home carers". The ONS publishes the index for the average individual as well as different indices corresponding to different percentiles within the population of carers.

[2] The claims are calculated using a real discount rate of 2.5% but there is no adjustment regarding inflation. This results are corresponding to an exposure of around 35 million vehicles

The main cost driver are the wages of the carers so depending on the type of carers required by the claimant the court can award an annuity indexed using one percentile from the ASHE6115 or the other (the most common being the 70-80th percentiles).

Other indices can be used, including RPI (retail price index) or different wage indices. For future loss of earnings different wage inflation is more likely to be used in the scenario of a PPO being awarded, as the occupation of the individual is unlikely to be as a carer.

1.1.3.2. France; Change in the indexation environment

In France the inflation used to be handled by the FGAO (*"Fonds de Garantie des Assurances Obligatoires de dommages"*, which has an equivalent in the United Kingdom: the Motor Insurers' Bureau (MIB) protecting innocent victims against untraced/uninsured drivers).

For all the accidents occurring after 1 January 2013 (as a result of the "*Loi rectificative des finances"*[3] from December 2012*),* the insurers will bear the cost of the inflation of the annuity payments. Insurers will now have to take a closer look at this risk and adapt their prices and reinsurance strategy in consequence.

The main index used in France is an "old-age pension" index *("pension de vieillesse")* which follows a consumer price index. In the past 10 years the inflation has been fairly stable around 2%.

1.1.3.3. Variation Orders

In France, in case the health conditions of the victim deteriorates and requires a higher cost, the claim can be re-opened and the victim can claim a higher annuity from the insurer.

In UK, a variation order can be awarded by the court which gives the same possibilities to a British claimant. These orders are not common though (ca. 8%). One reason for awarding a variation order which can be invoked is the risk of contracting Syringomyelia[4]; a complication which can occur decades after a spinal injury. The court might then specify that the claim can only be re-opened for this specific reason and no other, and that the claimant can only claim a higher annuity for covering the costs related to this specific complication. As such the opportunity for reopening is significantly reduced in the UK versus France.

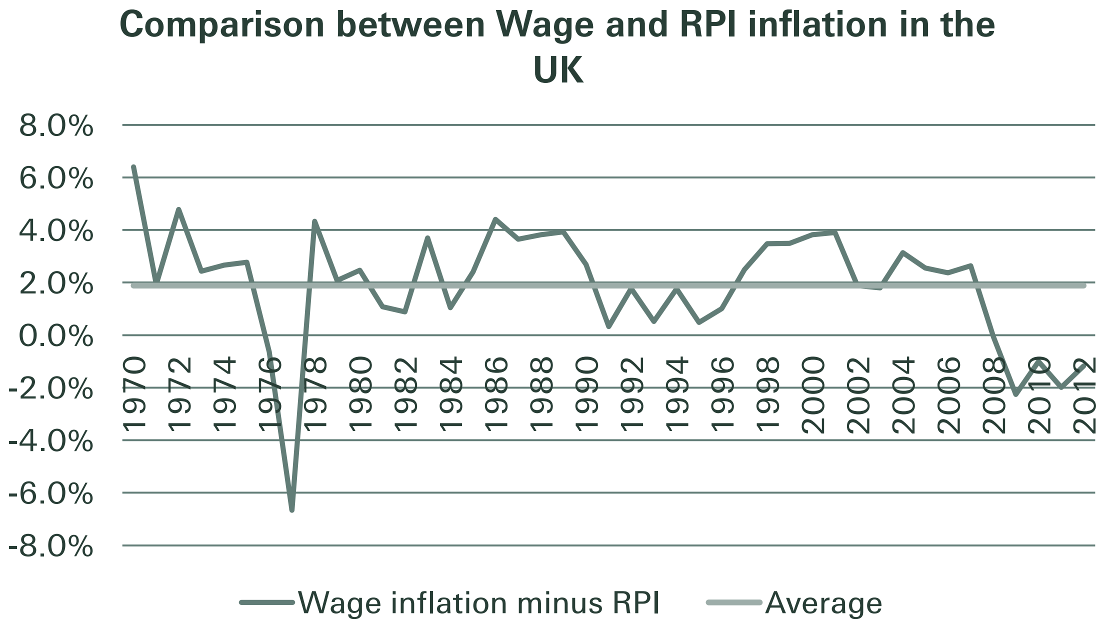
1.1.3.4. France versus United Kingdom

Insurers in France and in the United Kingdom are exposed to the inflation risk in different ways. French insurers will mainly be exposed to two risks, CPI inflation and re-opening claims/unexpected claim inflation for specific cases. UK insurers will mainly be exposed to a wage inflation risk (specifically wages on the medical profession).

[3] http://www.senat.fr/rap/l12-213-1/l12-213-187.html
[1] http://fr.milliman.com/publications/bulletin/pdf/la-reforme-du-FGAO.pdf
[4] http://en.wikipedia.org/wiki/Syringomyelia

So, the main risk factor to consider is the spread between the return on investments and the relevant index inflation.

The French inflation will be easier to hedge with French index linked GILTs ("OAT indexé"). But this will be an expensive hedge for the insurer and a high reinvestment risk remains as the term of GILTs available are below 30 years. In the UK, in the long term there is an average spread of 2% between RPI and wage inflation though it has been negative for the past 5 years. Hence an RPI hedge is probably not a good hedging strategy for wage inflation in the long run[5]:



We can see on this graph that long term wage inflation has been 2% above retail price inflation. But we can also see that in the past five years British workers have consistently lost purchasing power. And the 1970-2000 periods might not be a good estimator of what will happen in the next 30 years.

A significant difference between France and the United Kingdom is related to the currencies these countries are using. Indeed, it is not unlikely that in the future, if the debt level in England keeps increasing, the Bank of England will start printing money to "inflate the British debt out".

On the other side, the Bank of France is less able to use a monetary policy and influence inflation levels in France..

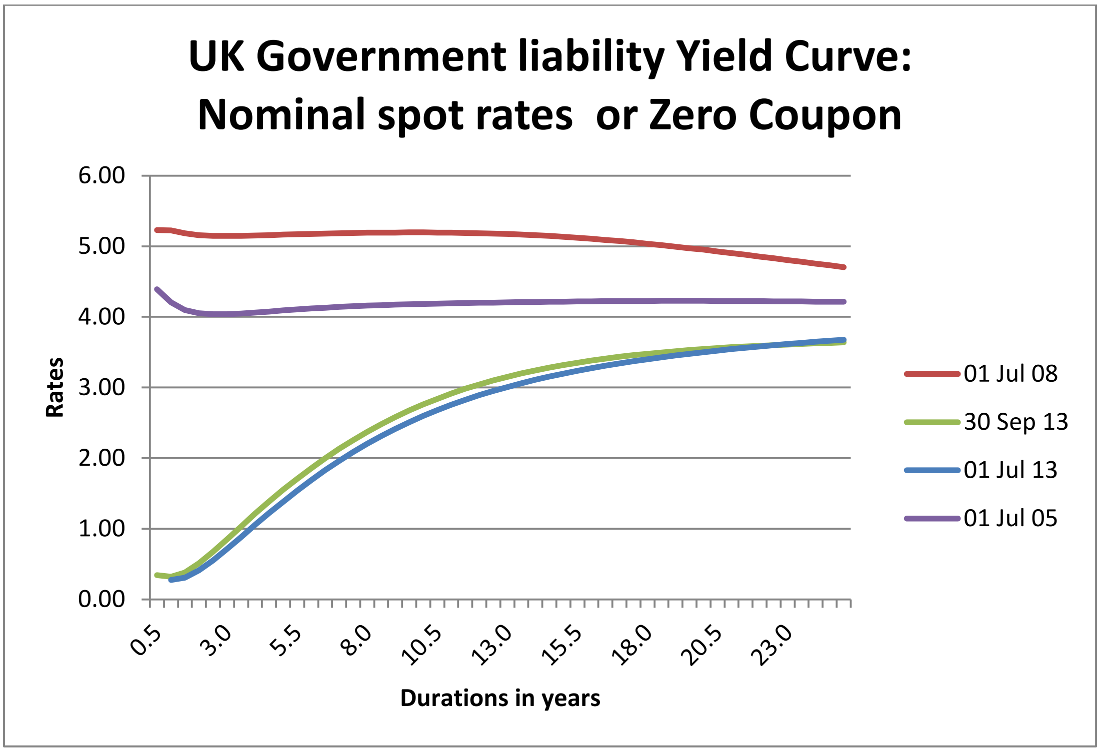
Based on different consideration both French and UK insurers can then decide whether they want to retain the inflation risk themselves or whether they want to try to hedge it partially with financial or reinsurance instruments.

[5] Source: Swiss Re, economic research and consulting

1.2. Discounting the reserves

1.2.2. Risk Free

The most recent prudential regulations (in most countries) are introducing a more cautious approach for assessing long term guarantees and discounting future expected cash flows to their present value. After the different market crashes in the recent years and the sovereign bonds crisis, the "risk free" rates have dropped significantly.



Regarding Solvency II, the discussions are still on going. Indeed, Solvency II recommends the use of the full term structure of the relevant risk free rate on a market consistent basis. With these curves being quite volatile (especially in the recent years) a high degree of volatility is introduced when evaluating any long term liability.

The EIOPA (European Insurance and Occupational Pensions Authority) is currently working on different solutions to tackle these issues related to short term volatility of yield curves and recently published a technical report: "Technical findings on the Long-Term Guarantees Assessment"[6] which is still not completely conclusive.

This is one of the most complex aspects of annuity type liability under Solvency II, I have chosen not enter into these technical topics.

[6] https://eiopa.europa.eu/fileadmin/tx_dam/files/consultations/QIS/Preparatory_forthcoming_assessments/final/outcome/EIOPA_LTGA_Report_14_June_2013_01.pdf

1.2.3. Current environment for casualty insurance liability

Both in France and in the United Kingdom a fixed rate is used by most insurers to discount future liability. The French regulation is more specific and states that the discount rate chosen by the insurer should be lower than 60% of the interest rate of French government long term bonds (a 24 months moving average of the so called TME, equal to 2.1% as for July 2013)[7], though below 3.5%. In practice, what is used by most insurers is 60% of the TME.

With insurers now required to pick up the inflationary element of annuity exposures in France, it is likely to see the regulatory discount rate becoming 60% of the TME minus something (rumours say -2.25%, set and changed regularly by decree). So, if this new regulation enters into force, the discount rate used to calculate the reserves will be close to zero (slightly negative).

In the UK, insurers are usually using a "discount" rate which factors in both an investment return rate on their assets and their assumption on future annuity inflation (ASHE 6115 inflation for instance). UK based insurers seem to have more flexibility on their assumptions though they have to respect similar prudential principles and both British and French insurers should get ready for the application of Solvency II. The British insurers are currently using different discount rates, from -1% to 2.5% for the most aggressive insurers.

In order to have a better idea of the impact of changing the discounting assumption or the inflation assumption, this is a table where cash flows of £1 for 40 years are discounted to today's value:

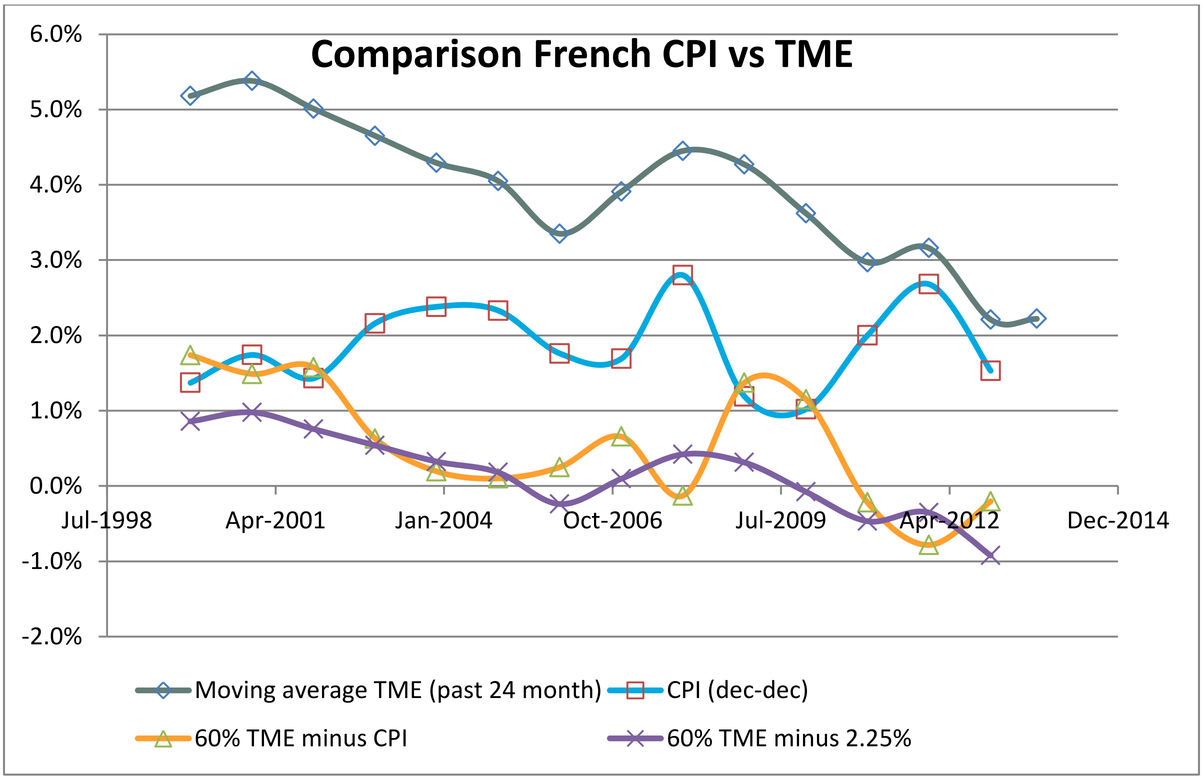
Discount rate (%)	3.5	3	2.5	2	1.5	1	0.5	0	-0.5	-1
PV of future cash flows	22.1	23.8	25.7	27.9	30.4	33.2	36.4	40.0	44.2	49.0
Relative increase		7.7%	8.1%	8.4%	8.8%	9.2%	9.6%	10.0%	10.5%	10.9%

We can see here that a relative change of 0.5% in the discounting assumption (or in the inflation assumption) can induce an increase/ decrease of around 9% of the present value of future cash flows and the longer the duration of the liability the heavier the effect.

[7] Article A331-10 of the "code des assurances" http://legifrance.gouv.fr/affichCodeArticle.do?idArticle=LEGIARTI000006787965&cidTexte=LEGITEXT000006073984&dateTexte=20130920

1.2.4. Inflation and discounting

The idea of having the inflation risk and the market risk together makes sense since what really matters is the spread between inflation and return on investment and there is a positive correlation between the two which partly offsets the volatility of each risk taken independently.



Regarding inflation and longevity risks, many French insurers will use a different (than what is regulatory) set of assumptions for evaluating *the risk on a more economic basis.*

Part II. Technical Aspects: Reserving

2.1. Non-life versus Life reserving

2.1.1. Solvency II prospective

Extract from the QIS 5 technical specifications:

TP.2.48. Where non-life insurance policies give rise to the payment of annuities, the approach laid down in the following subsection on substance over form should be followed. Consistent with this, for premium provisions, its assessment should include an appropriate calculation of annuity obligations if a material amount of incurred claims is expected to give rise to the payment of annuities.

Principle of substance over form

TP.2.49. When discussing valuation techniques for calculating technical provisions, it is common to refer to a distinction between a valuation based on life techniques and a valuation based on non-life techniques. The distinctions between life and non-life techniques are aimed towards the nature of the liabilities (substance), which may not necessarily match the legal form (form) of the contract that originated the liability. The choice between life or non-life actuarial methodologies should be based on the nature of the liabilities being valued and from the identification of risks which materially affect the underlying cash-flows. This is the essence of the principle of substance over form.

Solvency II provides insurance companies with principles and not rules. Though as can seen above, it states that annuity type liabilities arising from non-life policies should be assessed using life techniques <u>if</u> the exposure is material. The materiality principle seems to leave some flexibility for insurers to apply or not the substance over form principle to their annuities arising from their non-life policies. But in reality even if large losses represent less than 5% of the loss ratio the fact that the durations are longer will create an accumulation of such type of liability throughout the years and at some point the exposure will beyond doubt become material.

2.1.2. Methodology

In Non-life, a method which is traditionally used when assessing the reserves is a projection of a run-off triangle constructed on an aggregated basis. Because of the substance of the risk (life risk in substance, longevity and inflation) using cumulative triangles (aggregated claims) is not appropriate for PPOs. Reserving on a per claim basis, based on projected cash flows (consistent with a life and health approach) will allow for the characteristics of each claims and should provide a more robust best estimate of the liabilities.

What is recommended by the EIOPA (previously CEIOPS) to treat non-life reserves is to separate annuity type exposure from the rest and assessing this type of liability using life techniques.

The remaining obligations are then assessed using non-life techniques. This approach is already implemented and used within Swiss Re in the United Kingdom.

It is recognised that a discounted cash flow method should be used for assessing the risk but the main issue is then related to how to assess the mortality risk and which mortality curves should be used.

In this paper, we will only focus on the annuity part of the non-life insurers' obligations.

2.2. Mortality: Mortality tables and trends

Claimants who have been awarded an annuity have usually suffered a very severe accident and their mortality profiles will be expected to differ substantially from the ones of the general population. Depending on the type of injury, we should expect different life impairments, a reduction in life expectancy or no reduction at all, and an improving or a deteriorating health condition as the claimant survives. Based on the information available, an adjustment on the industry standard mortality curves could be made to calculate a best estimate of the reserve to use.

The quantity of information which is available is far from extensive. Usually, a remaining life expectancy assumption is provided by at least one and independent expert during the litigation and the type of injury (brain, spinal or other with a degree of severity) is known. These assumptions together with the age and gender of the claimant will be the main assumptions when setting up the reserve. As time goes by, in most cases, the insurer will not get any information on the current state of health of the insured[8]. The only information available for updating the reserves is whether the insured is alive when each annuity payment is due.

Different mortality adjustments are currently used in the market.

2.2.1. In practice

The French portfolio of compensatory annuities is quite different than the British one. First, annuities have been awarded for much longer in France, more than 35 years, while in the UK PPOs (cf. graph part 1.1.2.) were only awarded since 2008 (actually 2005, but in very small number). So, the portfolio is more mature (mortality improvement effects being neglected) in France and more stable, while the UK is still in a phase of accumulation of PPO claims in the balance sheet solely because of duration considerations. Secondly, the propensity for claims to settle as annuities in the UK is currently only at high levels (above 30%) for large claims (>£1m), while in France the range of claims is wider; claims are settling as annuities at much lower levels.

2.2.1.1. In France

When reserving for bodily injuries in France, the framework is well defined and simple. The survival curve is the so called TD 88-90 approved by the decree of 27 April 1993 and used since 1996, Article A331-10 of the "Code des assurances". The fact that the table used is:

- the same since 1996,
- based on the male population of 1988-1990,
- built for reserving mortality exposure and not longevity exposure and

[8] In the UK, in recent cases, insurers obtained the right to receive a medical examination regarding the health of the victim in order to purchase an annuity from a third party or to review their reserve (with a limitation to the frequency of the demands). Wallace v Follett (2013) is an example where such request can be formulated once every 7 years.

- is not factoring improvements in life expectancies between generations (no differentiation between cohorts and not a prospective table),

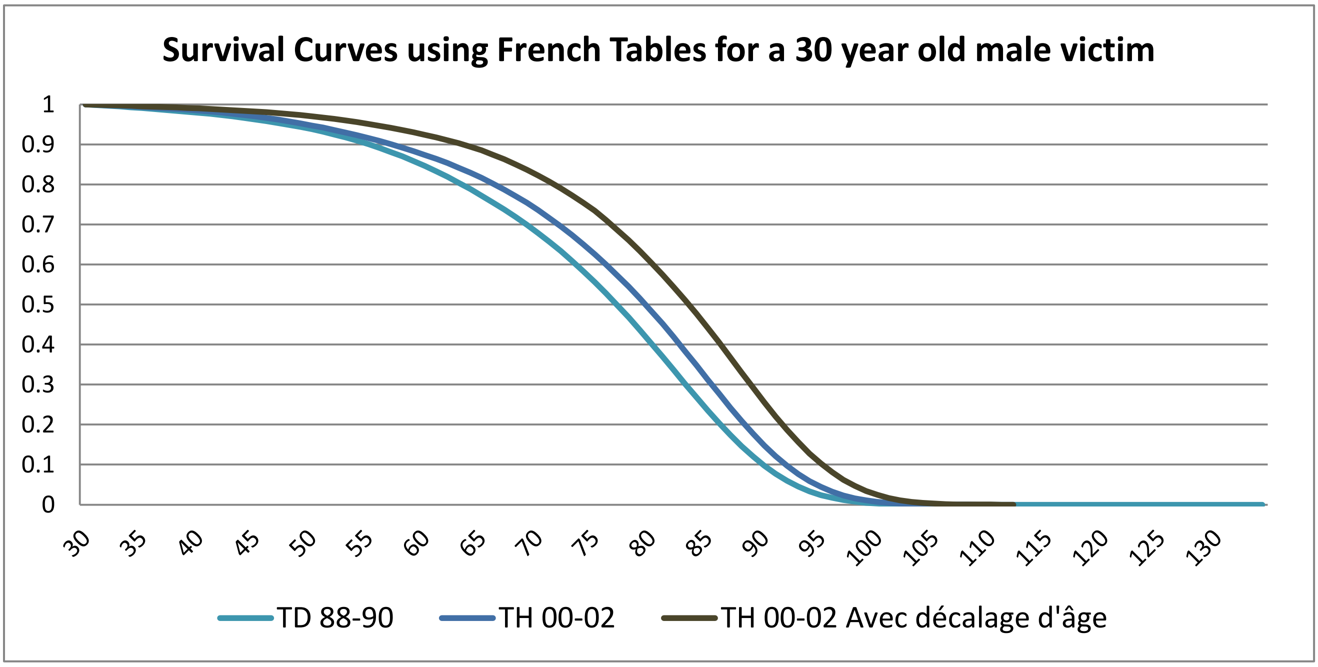
might be many reasons to factor in impairment consideration.

However, it is still possible for an insurance company to use its own survival curves after review and approval by an independent actuary recognised by the ACP ("Autorité de contrôle prudential", French regulator).

This method has the advantage of being simple and easy to audit. It also makes it easier to compare the reserve positions of different casualty insurers. However, the table has now significantly drifted away from the most recent tables (even more in comparison to prospective tables) and it is not as helpful anymore for having a prudent view on the annuity risks.

At a portfolio level, regularly monitoring the differences between actual and expected deaths is important for assessing the adequacy of the mortality table for the portfolio and for having smoother reserves (e.g. avoiding heavy reserve deteriorations when updating the mortality table).

Indeed it is verified that the higher the annuity, the more severe the injury and the more impaired the life expectancy of the victim will be. Therefore, for reinsurers, that will only see relatively large losses on their books, the mortality should be higher than the average. For a reinsurer the results will be driven by the few biggest claims for which it is likely to have substantial gaps between the life expectancy inferred from the statutory table and the expert's view (based on the nature of injuries and the individual's profile). A more tailored approach could then be taken when reserving.



French insurers are already considering the possibility that the regulation might change in a near future, indeed the TH 00-02 (males) and TF 00-02 (females) might become the reference tables for reserving.

2.2.1.1. In the United Kingdom

There are no specific requirements on how reserves for PPO should be set in the UK. But the methods used still have to be consistent with the prudential principles. So, the insurer has the choice on how to consider and adjust for mortality impairment. Each insurer will also have its own set of assumptions regarding discount rate and future inflation.

A common approach is to use a "rated age" approach as described below with the so-called "Ogden Tables" as a basis.

2.2.2. Recent evolution in survival curves

One of the most critical issues with severe bodily injuries is the lack of credible data for assessing the longevity risk. In the past 60 years medical practices have been improving tremendously for instance the graph below[9] shows the improvement in survival in the 24 months following a severe spinal injury in the USA.

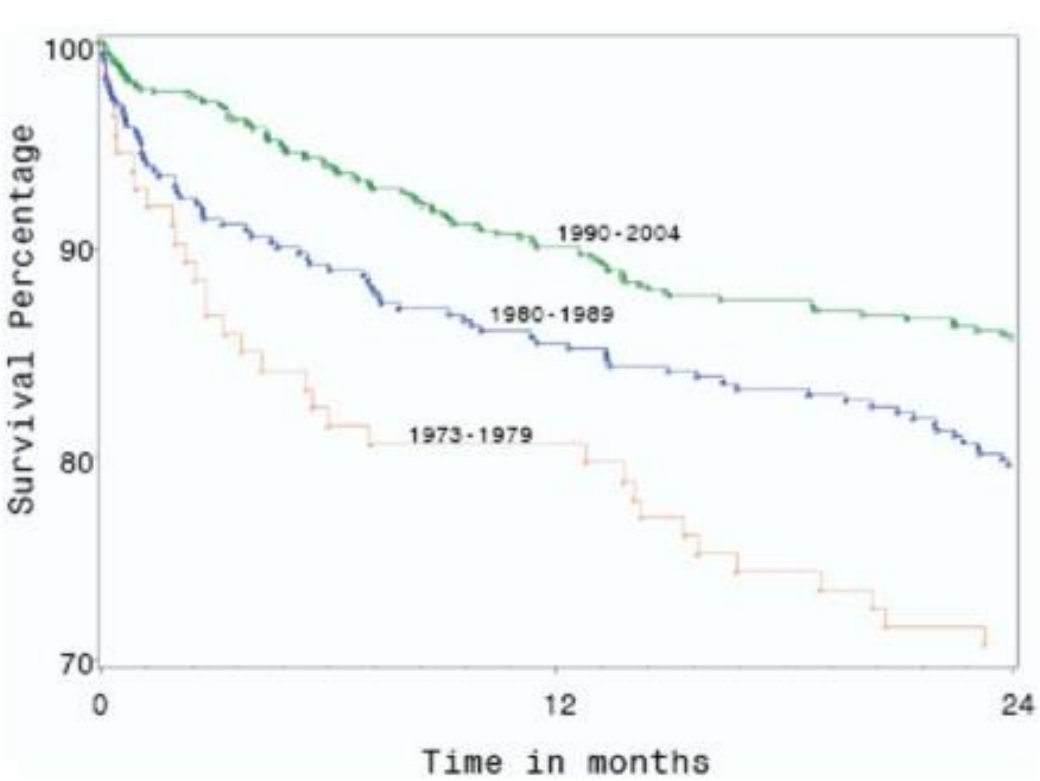


Fig 1. Two-year Kaplan-Meier survival curves for C1-4 grade A, B, and C injuries by period of injury; age greater than 30.

[9] Strauss DJ, DeVivo MJ, Paculdo DR, Shavelle RM (2006), Trends in life expectancy after spinal cord injury. Archives of Physical Medicine and Rehabilitation, 87:1079-1085.

The trend in the mortality improvements after these first most critical years remains a mystery, the statistical credibility of the data available being much lower (smaller population which received a different; less advanced; kind of care in the past). An article published in 2000[10] also mentions that after 2 years, the time since injury becomes a minor risk factor compared to others.

Though, a lot of uncertainty remains and the study suggests that the reason why mortality rates after 2 years have not improved much in the past 20 years could be because of the postponements of deaths which would have occurred in the first years post injury.

[10] Strauss DJ, DeVivo M, Shavelle RM (2000). Long-term mortality risk after spinal cord injury. Journal of Insurance Medicine, 32:11-16, page 11 paragraph 4

2.3. Mortality: Potential Adjustments

On the subject of life expectancy and mortality profiles of persons who survived a severe injury (spinal cord injury, brain injury or other medical conditions), the website: www.lifeexpectancy.org offers a wide range of studies and publications. Using actuarial and bio-statistical standard the group of researchers who manages the website specialises in the assessment of life expectancies for persons with specific medical conditions. The website references many articles on the subject.

In France a reference study is the Tétrafigap (1639 patients between 1995 and 1996) published in 1998 and an update[11] published in 2007 which monitored the survival of the same patients. In the UK a reference study is Frankel HL et al. (1998), "Long-term survival in spinal cord injury: a fifty year investigation"[12], which follows the lives of more than 3000 people who suffered from a spinal cord injury.

Regarding moderate and severe brain injuries, the uncertainty toward life expectancy is even greater than for spinal cord injuries. The divergence of opinions between the claimant's and defendant's experts is in general greater than for spinal injuries. And these claims, in number, make up more than 70% of the claims where Swiss Re is involved (through an excess of loss treaty).

Without entering into specific medical considerations we can consider here different adjustment methods on the general population mortality curves which are used in medical underwriting (life insurance for people with very specific medical conditions) and which could be used when reserving or pricing compensatory annuities for severely injured victims.

Having the adjustments relative to the general population, might help for considering future mortality improvements. Indeed, the results being relative to the general population mortality, using and updating the prospective tables published by the INSEE (France) and the ONS (UK) will factor in part of the future expected changes across generations, especially mortality at older ages.

[11] Espagnacq M (2008), "Mortalité à long terme et devenir social des blessés médullaires tétraplégiques" or Long term mortality and social future of quadriplegics, p.97

[12] Frankel HL et al. (1998). Long-term survival in spinal cord injury: A fifty year investigation

In the following parts we will describe different approaches and the effect on a specific claim:

Lump sum element	£1m
Annuity element	£100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Discount rate	1%

<u>Notation:</u>

- q_x : probability of dying within a year at age x
- q_x^{1990} : probability of dying within a year at age x for someone who was born in 1990
- Y is the number of years passed after the settlement

2.3.1. Rated age approach

In the "rated age approach" the mortality curve which is used for considering the impairment of the victim is the one relating to an older individual of the general population. The age chosen usually only reflects the life expectancy reduction of the injured person; the age is back solved from the life expectancy assumption provided by the expert. This method is mainly used because it is easy to use and to implement, and was market practice under the previous lump sum environment as it is a sufficiently accurate simplifying assumption to calculate the present value.

Mathematically the adjustment would follow the formula:

$$q_{age}^{adjusted} = q_{age+d}$$

And for the following years

$$q_{age+y}^{adjusted} = q_{age+y+d}$$

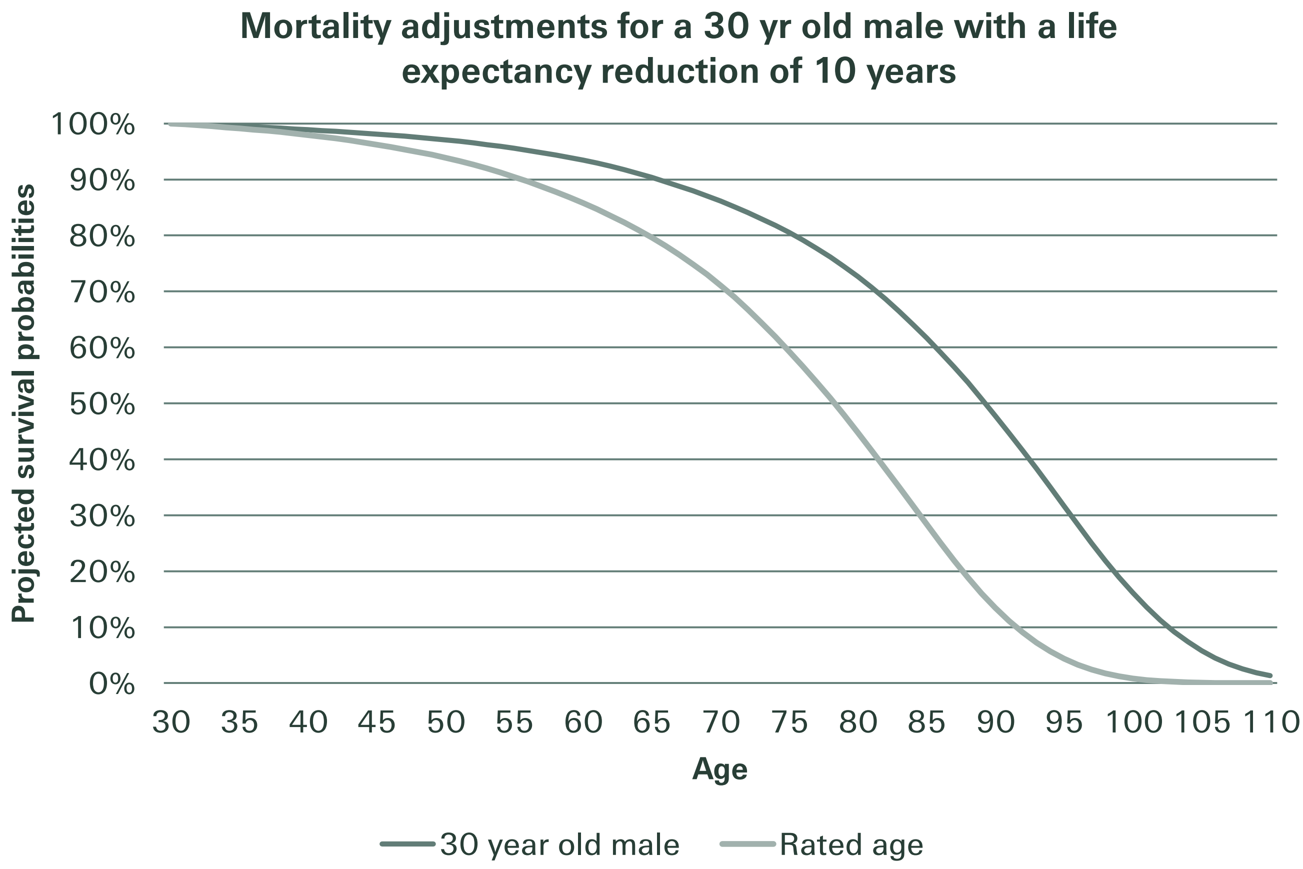
Where d is the additional number of years added to the actual age of the victim for factoring in the impairment.

In practice, what is often done by insurers in the UK is to use the Ogden tables[13] which are generational tables to back solve the age corresponding to the life expectancy of the victim. This is equivalent to this adjustment:

$$adjusted\ q_{age+y}^{year\ of\ birth} = q_{age+d+y}^{year\ of\ birth-d}$$

Where d is the additional number of years subtracted to the year of birth of the victim for obtaining a given life expectancy. So in reality, there are two effects which are factored in the same adjusting method for modelling the impairment: an age adjustment and a cohort or generational adjustment (the older the generation the shorter the life expectancy in the table).

Here is a graphic showing the result of this type of adjustment on a mortality curve using the Ogden mortality tables:



The main issue which could arise is related to the fact that for the general population mortality rates usually increase as years go by, while for severely injured persons the early years post-injury (or the younger ages) are the most critical. In the graph we can see that most of the gap between the two curves is appearing after 15-20 years. So, the early mortalities would be underestimated and the tail or the latter mortalities might be underestimated.

[13] Cf. Appendix 1

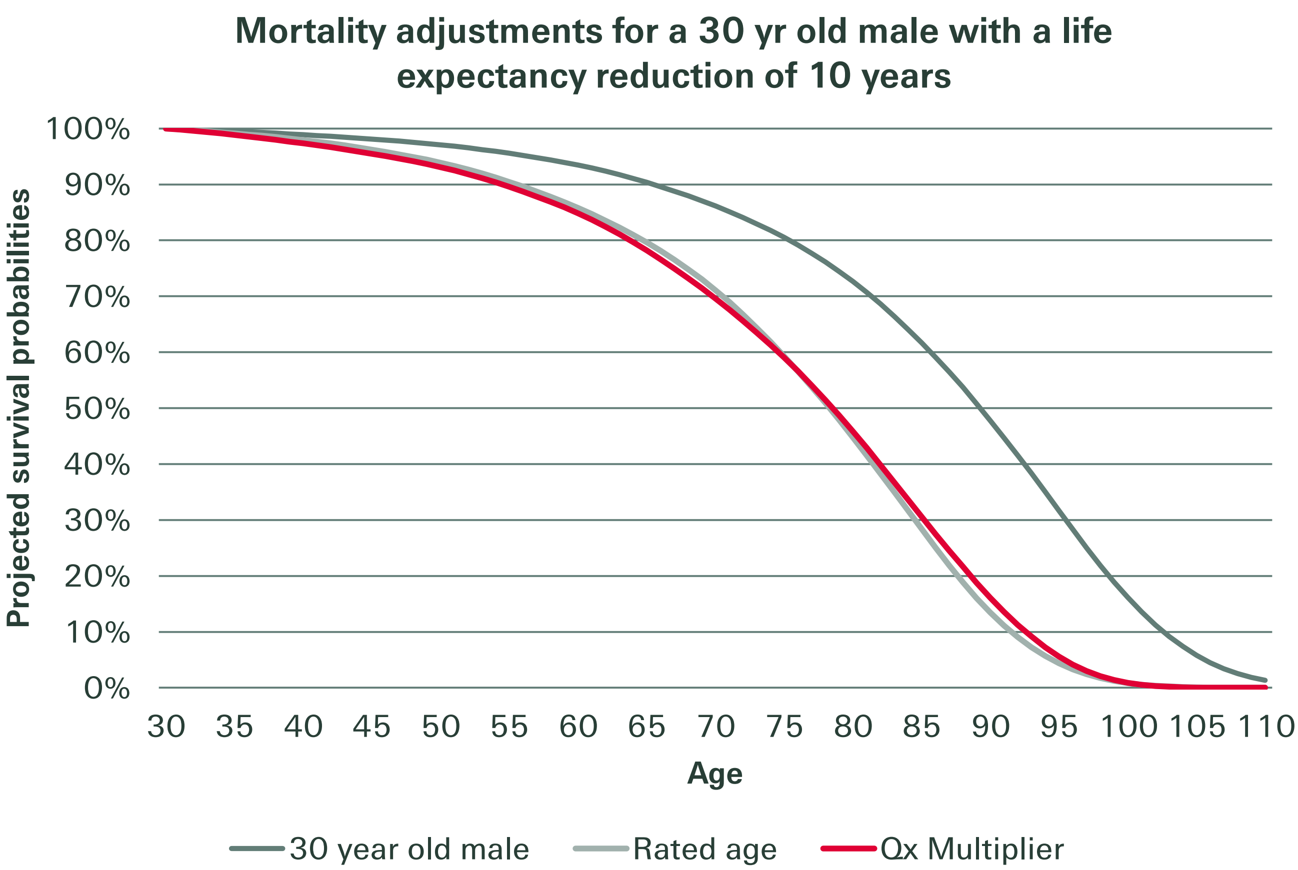
2.2.2. Qx multiplier or Standardised mortality ratio

The two methods described below are conceptually identical; the only thing that differs is the scope which is considered for the calibration of the adjustment.

2.2.2.1. Qx multiplier

For this method we say that the mortality curve of an injured person is the mortality curve of the general population multiplied by a fixed factor. It can model a deteriorating health status as time goes by. The main issue is again related to the fact that early years post-injury will be under-estimated for young claimants, except if the multiplying factor is unrealistically high, since mortality rates at age 30 are very low (<0.07%). This method results in mortality profiles which are very similar to the rated age method.

$$q_{age+y}^{adjusted} = Multiplying\ factor * q_{age+y}$$



There are different ways to calculate a mortality multiplier. The multiplying factor can be based on an expert judgment or can simply be calibrated on the expert's assumption for the life expectancy of the claimant. For example, in the graph above, to get a reduction of 10 years in the life expectancy of a 30 year old male the factor needed is 2.5.

2.2.2.4. Standardised Mortality Ratio

Another method which can be used at a portfolio level when the risk profile of the total portfolio does not vary much year on year is the standardised mortality ratio or SMR. The standardised mortality ratio can be calculated on a yearly basis using this formula:

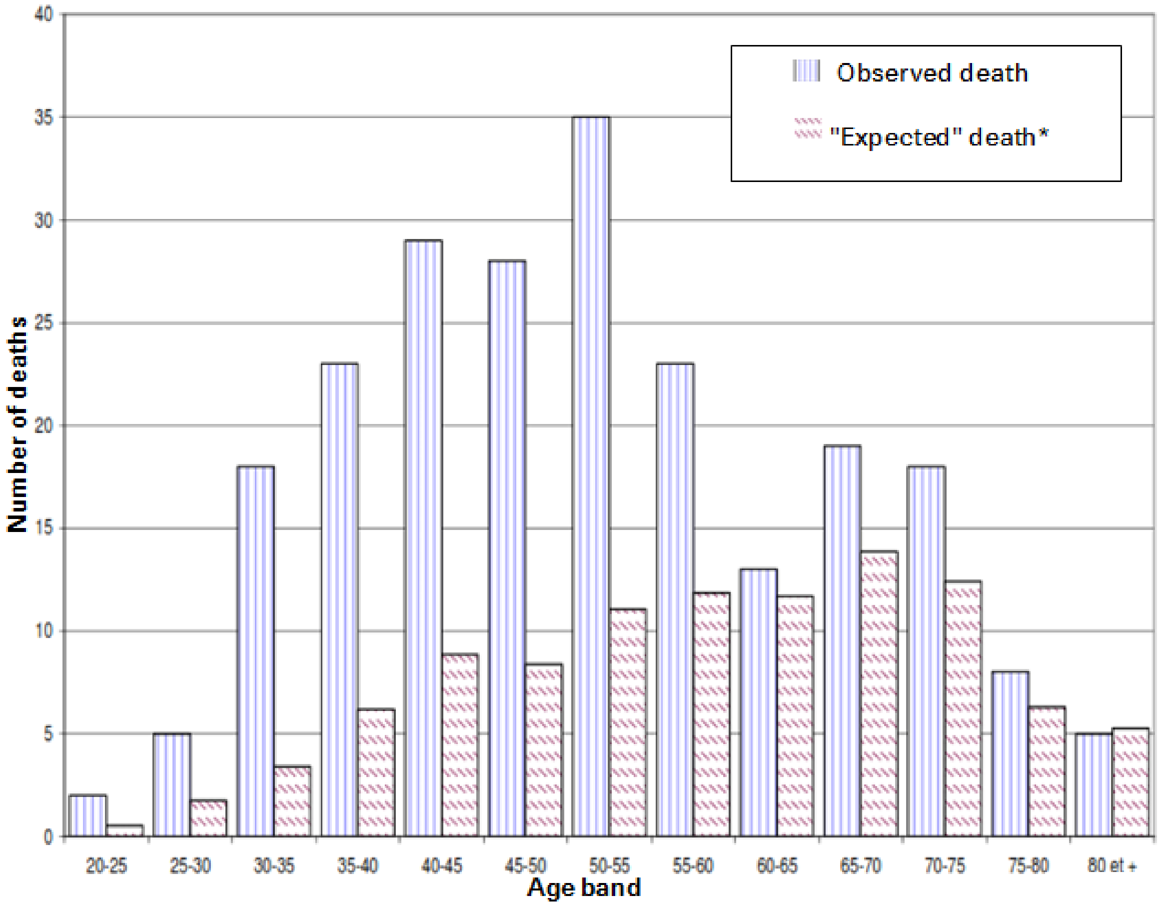
M: Number of deaths observed in the portfolio
A: Number of anticipated deaths in the portfolio based on a reference mortality table

$$SMR = \frac{M}{A}$$

Once again, this approach, though it could be correct at a portfolio level, will underestimate the mortality for younger victims and overestimate it for older victims.

A study published in France in 2008[14], following a population of 1090 quadriplegics who suffered from a SCI (spinal cord injury), compares the number of deaths seen in this population between 1996 and 2007 to the "expected" deaths calculated using the experience mortality tables of 1999-2001 published by the INSEE (French ONS) for different age bands:

[14] Espagnacq M (2008), "Mortalité à long terme et devenir social des blessés médullaires tétraplégiques" or Long term mortality and social future of quadriplegics, p.97



The study only considered persons who survived for at least two years after the injury, since, as we saw in part 2.2.2, these two years constitute the most critical period for determining whether the victim could survive from its injuries, and after these two years the time since injury becomes a minor risk factor compared to other factors. For insurance purposes, those that do not survive post two years will usually have a small claim, and no on-going loss, hence are not as relevant when considering annuities from an insurer perspective.

As we can see here, the younger the age of the victim is, the higher the standardised mortality ratio. At older ages 75+, there are no credible differences between the mortality of the general population and the quadriplegic population. The main reason advanced on the study for explaining this difference is that younger quadriplegic will have mainly suffered a motor injury with multiple other damages while older quadriplegic will be people who had their injury 20+ years ago, and there is also a selection factor; the persons with the least severe injury survive longer.

This study concludes that a credible statistical range for the SMR on the quadriplegic population is ranging from **1.7 to 2.2**.

An older US based study[15], which was following more patients with different kinds of SCI injuries, calculated different SMRs for different age bands and different injury groups:

Injury group	Age at injury	Number in group	Expected dead	Actual dead	SMR	Lower 95% CL	Upper 95% CL	US SMR*
C1-C4 ABC	0–30	53	0.38	3	7.84	1.48	19.22	10.94
	31–45	21	0.57	1	1.77	0.00	6.93	9.78
	46–60	17	1.65	8	4.86	2.08	8.81	5.24
	61+	15	2.45	10	4.08	1.94	7.00	3.07
C5-C8 ABC	0–30	294	2.87	24	8.37	5.35	12.05	5.07
	31–45	97	2.76	17	6.15	3.57	9.42	6.30
	46–60	66	6.20	26	4.19	2.74	5.96	3.83
	61+	51	8.51	30	3.53	2.38	4.90	3.07
Para ABC	0–30	411	4.13	13	3.14	1.67	5.09	3.86
	31–45	152	5.59	17	3.04	1.77	4.66	3.74
	46–60	72	9.57	21	2.20	1.36	3.23	1.96
	61+	27	4.35	16	3.68	2.10	5.71	2.21
All D	0–30	228	2.01	4	1.99	0.52	4.41	2.58
	31–45	74	2.40	11	4.58	2.27	7.68	2.03
	46–60	59	8.61	12	1.39	0.72	2.29	1.66
	61+	35	10.20	14	1.37	0.75	2.19	1.68

*DeVivo MJ and Stover SL. 'Long-Term Survival and Causes of Death'. Chapter 14 in: Stover SL, DeLisa JA, Whiteneck GG, eds. *Spinal Cord Injury: Clinical Outcomes from the Model Systems*. Aspen Publishers, Inc., Gaithersburg MD, 1995

2.3.3. Qx addition

This technique is another adjustment done to the mortality curve of the general population. An additional probability of death is added to the "normal" mortality for a given number of years. This fixed addition can be calculated from the impaired life expectancy assumption (back solving) or it can be calibrated from the type and severity of injury.

The simplest model is to have a flat additional yearly probability of death across the whole life of the injured. A better approach, considering the results of the studies mentioned in the previous sections, will be to have an age dependant additional factor: the older the age, the smaller the additional super-mortality; reducing to 0 after a given age (between 60 and 70). For a case where only deterioration is to be expected the additional factor could be set to go increasing with the age of the victim.

This method has the benefit of being easy to understand, easy to implement, and more consistent with the experience. Again the calibration of the additional factors is the issue. This method has the benefit that using it means that the extra mortality as a proportion of total mortality decreases over time and a number of disorders follow this pattern.

$$q_{age+y}^{adjusted} = q_{age+y} + q^{additional}$$

- Where $q^{\text{additional}}$ is the additional mortality which can depend on age, severity of injury, sex …

[15] **Frankel HL et al.** (1998). Long-term survival in spinal cord injury: A fifty year investigation, Table 3 p. 268

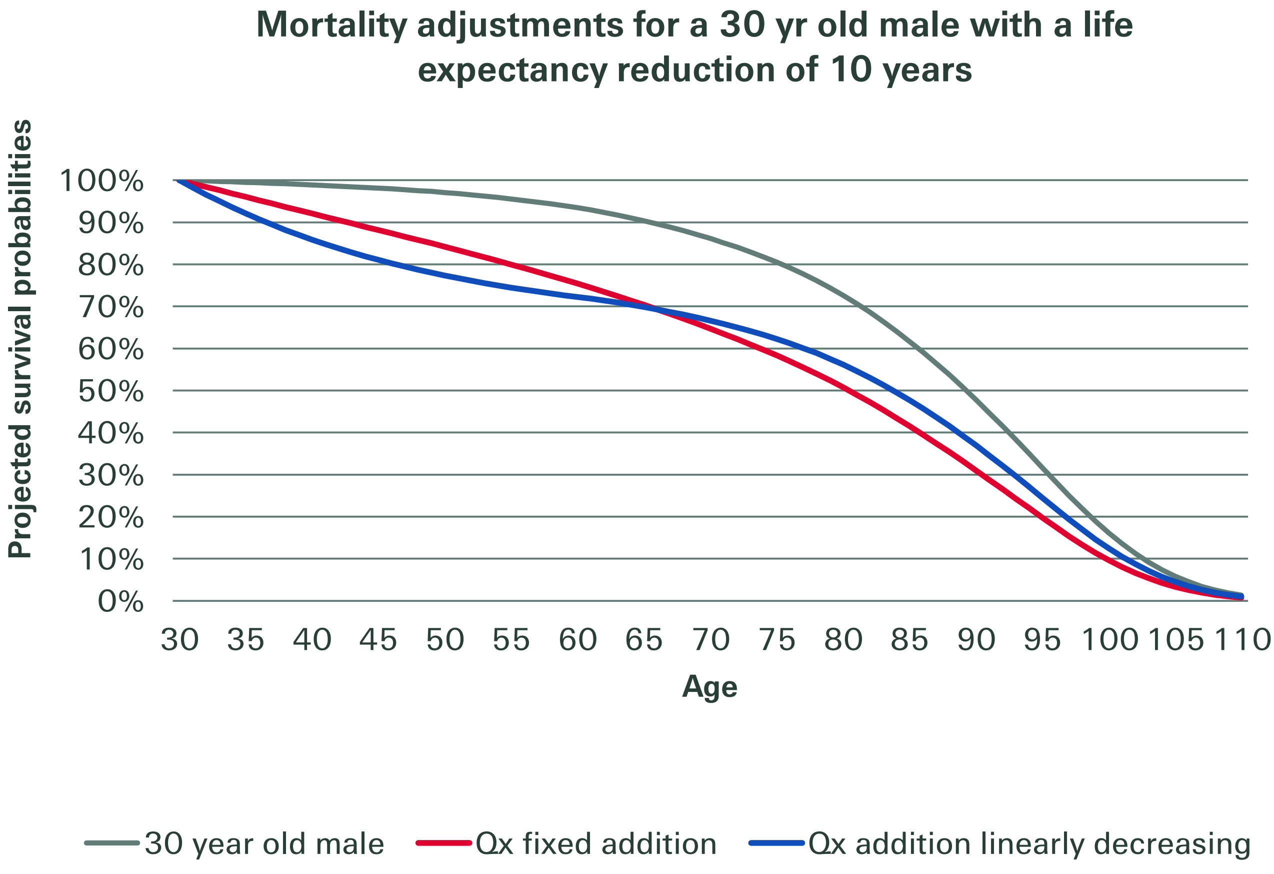
Let's consider two approaches for adjusting the mortality for a 30 year old male with a 10 year reduction of life expectancy as an example:

- First being a fixed additional yearly probability of death across the whole mortality curve; every year the probability of dying of the injured is 0.7% higher than the one of the general population (of a male of the same age).

$$q_{30+y}^{adjusted} = q_{30+y} + 0.7\%$$

- The second approach is an addition decreasing linearly from 1.7% at age 30 to 0 at age 60.

$$q_{30+y}^{adjusted} = q_{30+y} + 1.7\% * \max(\frac{30-y}{30}, 0)$$



The second pattern, with the additional super-mortality decreasing linearly, is more consistent with what we observe at the level of the general population of severely injured persons.

2.3.4. Comparison of the reserves obtained

Let us compare the reserves for the different adjustment technics and the same set of assumptions:

Assumptions	
Lump sum element	£1m
Annuity element	£100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Real Discount rate	0%

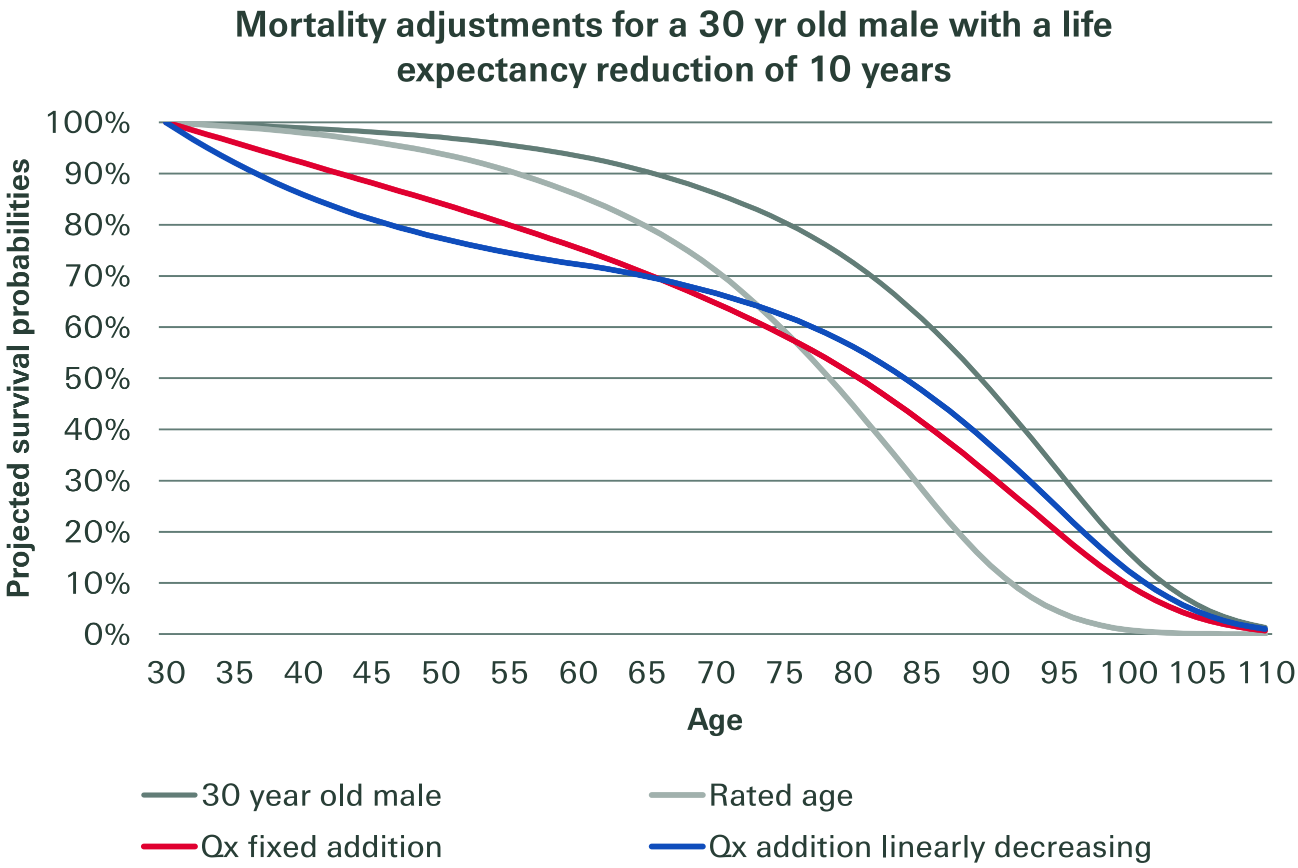
Result after lump sum paid	Normal life expectancy	Rated Age	q_x Multiplier	q_x fixed addition	q_x addition linearly decreasing
Reserves	£ 5,583,836	£ 4,526,250	£ 4,524,195	£ 4,528,579	£ 4,522,539

We can see here that for the different mortality adjustments the results are in a close range, which could be expected since the life expectancy are the same and the discount rate is equal to 0. But the run-off profiles will be quite different. Using the same survival curves and given that the victim survives for 10 years the reserves will become (and assuming that the annuity in 10 years' time is still £100k p.a.):

Result 10 years post settlement given survival	Normal life expectancy	Rated Age	q_x Multiplier	q_x fixed addition	q_x addition linearly decreasing
Reserves	£ 4,740,930	£ 3,710,512	£ 3,734,506	£ 3,979,338	£ 4,300,263

We can see here, that the assumption that the victim survives for more than 10 years is much stronger, much lower in likelihood of occurrence than the others, when the adjustment method is the "q_x addition linearly decreasing" since the mortality is heavier in the first years and tends toward a normal mortality in later years.

2.3.5. Remarks on mortality adjustments



From the different potential adjustments, the first thing we can see is that the sole life expectancy assumption is not a sufficient risk measure. Indeed, we could see that with the same life expectancy assumption (or reduction in the life expectancy) we could obtain 3 very different mortality curves which would result in significant changes in the reserves run-off profiles of the liability.

While using the same table for the whole portfolio can be easier to administer and easier to use, for severe losses the general result is often driven by the few largest losses, where the injury and the victim's profile are very specific. A possible example can be a person who had a car accident at a very young age when its organs were not completely developed and the injury affected their development, the victim needs an annuity payment in excess of £500k per annum and is ventilator dependant. Would it then make sense to apply the same mortality table than the one used for all the other victims? And potentially heavily over-estimate the reserves? For such cases, an independent medical/actuarial expert can provide the insurance company with more details on likely developments and help with assessing the risk.

A possible hybrid approach could be to use a mortality curve at a portfolio level and use tailored curves for the few largest/more specific cases.

The GIRO's "PPO Working Party"; a group of actuaries from different companies focusing on technical aspects of PPOs; on a document published in 2010[16] is discussed some advantages and disadvantages about different mortality adjusting methods. "Periodic Payment Orders working party update – GIRO 2012"[17]. published in October 2012 not only provides an important set of information regarding PPOs but also new considerations and possibilities for setting UK specific impaired life tables per type of injury or per impacts of injury (ability to perform a number of tasks), using medical databases for calibrating these tables. More results should be published in the next paper at the end of the year 2013.

[16] www.actuaries.org.uk/system/files/documents/pdf/plenary-4-paper.pdf
The 3 methods described here are also mentioned in this document page 71 and 72

[17] **GIRO PPO Working party**, Periodical Payment Orders working party update – GIRO 2012, p.84

Part III. Reinsurance

3.1. Principle

3.1.1. Excess of Loss Cover

As a hedge against extreme risk and as a way to reduce their balance sheet volatility most motor insurers will purchase a cover from reinsurers for their largest losses. The insurance company negotiates an excess of loss reinsurance treaty for its whole motor book, usually for one underwriting year.

The main type of protection against large losses related to motor insurance policies is the "per risk XL" or "working excess of loss" treaty. Each insurance company will have its own definition of what a large loss is. Then depending of its risk appetite and reinsurance purchasing budget, the insurance company defines how much of the risk it wants to retain (or the attachment point at which to buy reinsurance). When a large loss occurs the insurer will pay for the whole loss and recovers from the reinsurer what is above the deductible defined in the reinsurance treaty. In practice, insurance companies buy reinsurance from different reinsurers and reinsurance treaties are structured in layers: £1Mxs£1M, £3Mxs£2M, £5Mxs£5M, £15Mxs£10M…

Nowadays in the United Kingdom and in France, annuities often represent a significant share of large losses in motor and liability insurance (the cost of care often being the main head of damage). With annuities, the insurer is required to pay compensation and hold reserves over a much longer period and it is yet another level of complexity to calculate the expected recoveries from the reinsurers regarding these claims. The reinsurers are now offering different types of cover to the insurers to address specific kind of hedges against large losses the insurers might need.

3.1.2. Decision factors

Each risk transfer solution offers different protection and has different characteristics in terms of:

- Exposure to reinsurers' default risk
- Cash flow management
- Hedge against :
  - Inflation risk (ASHE 6115 inflation or RPI)
  - Longevity risk
  - Market risk
- Capital Relief
- Complexity of administration

3.2. Indexation and stabilisation Clause

There were many episodes of high inflation in the past, and large losses inflation, notably driven by higher expectations of the standard of care needed (i.e. need for more carers), has been at high levels for years. To share the inflation risk between the insurer and the reinsurer, similar clauses have been introduced in many markets (among which are the French and British markets). We can take the example of the **London Market Index Clause**.

In practice, the effect of the clause or the "indexation" is to have the inflation risk shared between the insurer and the reinsurer. The way the calculation is processed is often complex in practice and is dependant of the specific wording of each clause.

For the application of **London Market Index Clause** an index (usually a wage index) is chosen to represent the inflation experienced from the accident year or treaty year to the settlement year. All the attachment points and limits are then inflated from their original values (defined in the reinsurance treaty) in line with the index.

Calendar year	Theoretical Index inflation	Index Value
2013		1.00
2014	1%	1.01
2015	0%	1.01
2016	4%	1.05
2017	3%	1.08
2018	5%	1.14
2019	2%	1.16
2020	4%	1.21

As a theoretical example, if an insurer is buying reinsurance in excess of £1M in 2013 and if the wage inflation is as shown in the table above, the effective deductible applied for claims settling in 2020 will be £1.21M. So, all the attachment points are shifted up, and the sizes of the layers are also increased by the same factor.

After the settlement, the inflation of the payments is easier to quantify since the index followed is defined by the court when the annuity is awarded.

When there are payments after the settlement the indexation of the attachment points is like a pro-rata of different indexations for the successive payments, and is calculated as followed:

$$\begin{aligned}&\textit{Indexation post settlement}\\&\qquad = \textit{Index value at settlement} * \frac{\textit{Sum of all actual payments}}{\textit{Sum of all payments detrended}}\end{aligned}$$

A de-trended payment is the value of a payment as defined at the point of settlement, if the index followed for inflating the payments from the point of settlement is the ASHE6115 then for anyone specific payment:

$$\boldsymbol{Detrended\ payment} = \boldsymbol{actual\ payment} * \frac{\boldsymbol{Value\ of\ ASHE6115\ at\ settlement}}{\boldsymbol{Value\ of\ ASHE6115\ when\ the\ payment\ is\ done}}$$

Example:

An insurer is buying reinsurance in excess of £1m for the year 2013. If a claim on a policy attached to the year 2013 settles in 2020 with the payment of a £3m as a lump sum and an annuity of £100k p.a. indexed in line with ASHE 6115 starting in 2020. If we suppose that future ASHE 6115 is constant and equal to 4% the reinsurance payments will be calculated as follows:

Calendar year	Index inflation	ASHE inflation	Wage Index	ASHE INDEX	FGU Payments	Indexation applied
2013			1.000			
2014	1%		1.010			
2015	0%		1.010			
2016	4%		1.050			
2017	3%		1.082			
2018	5%		1.136			
2019	2%		1.159			
2020	4%		1.205	1.000	3.100	1.205
2021		4%		1,04	0.104	1.207
2022		4%		1,08	0.108	1.209
2023		4%		1,12	0.112	1.214
2024		4%		1,17	0.117	1.219

So, in 2020 the insurer will pay £3.1m and the reinsurer will pay £3m+£100k - £1m*1.205 ≈ £1.895m.

In 2021 the insurer will pay £104k and will recover from the reinsurer:

£104k -£1m*1.207 + £1m*1.205 ≈ £102k

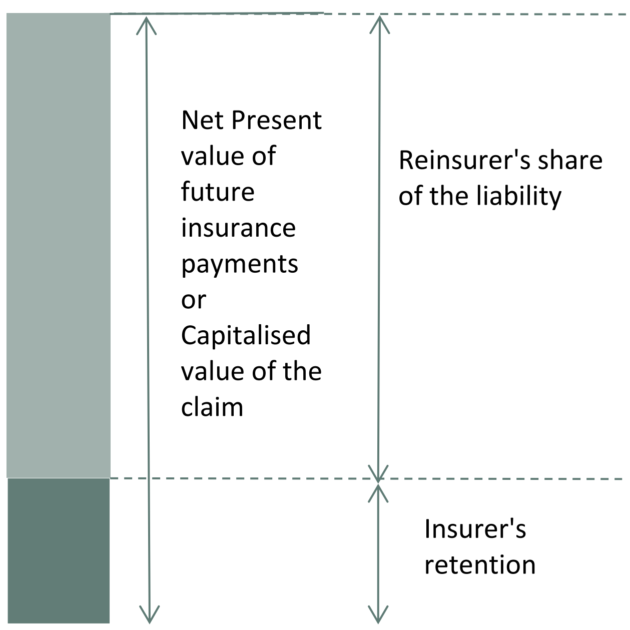
3.3. Reinsurance solutions

Along with the development of the legal environment for large losses, and the possibility to award periodic payment orders as an indemnity to claimants, different reinsurance solutions have been developed to help insurers deal with the annuity part of the liability. Three families of excess of loss treaties, with different advantages/disadvantages, are defined here.

3.3.1. Capitalised product

With a conventional capitalised solution, the reinsurer typically pays a lump sum (corresponding to his share of the liability) to the insurer directly after the claim settles. Different methods exist for defining the reinsurers' share of the liability. A common technique is to calculate the "capitalised" value or net present value of the claim using a discount rate and a mortality table defined in the reinsurance treaty. The "capitalised" value of the claim minus the deductible is reinsurers' share of the liability which the insurer will receive as a lump sum.

Capitalising a claim



A difficult consideration to make is relating to the mortality assumptions to use. In France, it is often the TD88-90 which is used and no further impairment needs to be included. In the UK, the IUA (International underwriting association) produced a tool which uses the Ogden tables for calculating the capitalised value of a claim. For incorporating the impairment, the method used is a rated age approach calibrated using the expert's assumptions regarding the life expectancy of the victim.

This solution reduces the insurer's exposure to its reinsurers' default risk. It also puts the insurer in a better position in terms of liquidity. Administratively this is the easiest solution to handle. After the capitalisation, the insurer becomes solely liable for the inflation risk, the longevity risk, the market risk… even though the hypothesis for calculating the capitalised value of the claim should represent a best estimate view on the risks. These are the main reason why this product is usually cheaper than the others.

3.3.2. Un-capitalised product

With a "follow the fortune" (or un-capitalised) product, the reinsurers make payments corresponding to their share of the liability as the annuity payments are due, until the death of the claimant.

Different ways of calculating the reinsurer's share of the liability exist depending on how the reinsurer and the insurer want to share the longevity and the inflation risk. The most common way is to consider the annuity payments as any other payments and apply the London market index clause described above (3.2).

This solution offers the largest cover commercially available; longevity and partially inflation risk (often even including the risk of re-opening claims). The insurer and reinsurers are bound for a much longer period, so the exposure to counter party default risk will be higher than for other products. The reinsurer may not start paying reinsurance recoveries for a relatively long period of time depending on the attachment point of the cover. For the reinsurer, the payments are fractioned in time, as opposed to the capitalised product.

3.3.3. Delayed Capitalised product

A delayed capitalised product is an alternative product which works as a "follow the fortune" product for a defined number of years after which the reinsurer pays a lump sum for its share of the remaining liability. This product is only offered in the UK. As opposed to the capitalised product, there is no adjustment regarding the impairment. So the recovery received by the insurance company at the point of capitalisation is calculated using the prospective mortality table of the general population.

This solution is a good compromise for mitigating the different risks involved. Indeed, we have seen that most of the uncertainty regarding the mortality of the victim is in the younger ages. This is also reduces the exposure to the reinsurers' credit risk. The insurer and reinsurer will also share the inflation risk for a longer period of time than for the capitalised product. The main risk which is then left to the insurer is the inflation risk after the point of capitalisation and longer than expected (general population) longevity risk.

3.3.4. Reinsurance benefits for a specific case

Let us compare the present value of reinsurance recoveries for the different reinsurance products for a set of reasonable assumptions described below; for the purpose of applying the indexation and stabilisation clause we will add an inflation assumption:

Assumptions	
Lump sum element	£1m
Annuity element	£100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Mortality adjustment	Qx addition linearly decreasing, as described in 2.3.3.
Discount rate	3%
Inflation assumption	3%
Delay to Settlement	7 Years
Reinsurance structure	Unlimited in excess of 2 million pounds
Indexation of the deductible at settlement (cf. part 3.2.)	1.20
Delay to Settlement	7 Years

The London market index clause applies for the three reinsurance products.

For the capitalised product, the table used will be the Ogden 7th with a rated age adjustment for the impairment (consisting in selecting an older than actual age from the table) and a discount rate of 1.5% (most commonly used rate) for calculating the capitalised value of the claim at settlement.

For the delayed capitalised product, the table used will be the Ogden 7th with a "no impairment" assumption and a discount rate of 1.5% for calculating the capitalised value of the claim at settlement, the claim being capitalised 20 years after the accident (13 years after the settlement here).

Incurred status at settlement	Un-capitalised	Capitalised	Delayed Capitalised
Present value (PV) of recoveries	£2,531,172	£1,905,428	£2,233,676
Incurred PV costs net of reinsurance	£2,991,367	£3,617,110	£3,288,862
Total PV of the claim	£5,522,539	£5,522,539	£5,522,539

The three products have different prices and offer different covers, after 30 years if the claimants have survived the recoveries will be very different. Looking from a pure cash flow perspective, net nominal paid and cumulative recoveries, the results will be:

30 years post-settlement	Un-capitalised	Capitalised	Delayed Capitalised
Total Recoveries	£ 2,303,017	£ 1,939,000	£ 3,845,893
Net payments	£ 3,454,525	£ 3,818,542	£ 1,911,649
Total FGU payments	£ 5,757,542	£ 5,757,542	£ 5,757,542

40 years post-settlement	Un-capitalised	Capitalised	Delayed Capitalised
Total Recoveries	£ 4,440,866	£ 1,939,000	£ 3,845,893
Net payments	£ 4,099,260	£ 6,601,126	£ 4,694,233
Total FGU payments	£ 8,540,126	£ 8,540,126	£ 8,540,126

These are the results obtained for one specific example (set of assumptions). To get a view on which cover offers the best cover or, preferably, which cover offers the best match with the insurer's risk appetite, one should consider different aspects or scenarios:

- Frequency of claims settling as lump sums
- Deductible levels
- Inflation scenarios
- Interest rates scenarios
- Increasing longevity
- Claimant's profile
- Multiple claimants
- Default of one or more reinsurers
- Investment strategy
- Regulatory environment
- Capital allocation

Part IV. Capital implication

An indirect cause of change for the insurers, partly relating to the duration of the liabilities and to the future application of the Solvency II regulation and increasing capital requirement levels, is the capital costs consideration. Indeed, non-life insurers are usually dealing with short term liabilities for which the capital requirement is held for a shorter period of time. Therefore the cost of capital is usually a relatively small part of the overall economic liability.

But for compensatory annuities this is not the case, and the uncertainty is also much higher than traditional life insurance obligations. Therefore, the risk margin or the present value of the cost of holding the required capital for annuity type liability will be substantial.

The cost of capital is a difficult notion to quantify. For Solvency II, it is the cost of providing the amount of eligible own funds (capital requirement) to support the insurance or reinsurance obligations over the lifetime thereof. Under this section, we will use a simplified approach consistent with what is suggested in the QIS 5 Technical Specifications (Solvency II) for assessing the "risk margin". The risk margin is calculated by discounting all the future capital costs arising from the necessity to hold the SCR (Solvency Capital Requirement). Solvency II recommends using a cost of capital rate of 6% above risk free, meaning that the cost of holding the SCR for a year for insurers is 6% times the SCR. In reality, depending on the profile of the insurance company (e.g. growth perspective, level of debt, reputation, credit risk, etc.) the cost of capital rate will be lower or higher.

4.1. Capital Requirement Calculation

As long as the legitimate regulatory capital requirement criterion is met, an insurance company can have different methods for assessing a target capital requirement:

- Regulatory Frameworks:
    - Solvency I, formula based, in general equal to a percentage of the reserves for P&C
    - Solvency II, principle based, 99.5th percentile of your possible balance sheet deteriorations within a year period, standard formula is the standard approach
    - ICA (Individual capital assessment), applied in the United Kingdom, bridge between SI and SII
    - SST (Swiss Solvency Test), Swiss version of Solvency II, internal model is the standard approach, using shortfall (TailVar at 99% - Best Estimate) as a risk metric
- Rating agencies models : AM Best, S&P capital models
- Own internal "target capital" model

Companies often express their target capital as a percentage of the regulatory capital.

The general trend regarding the frameworks for assessing a capital requirement is to go toward market consistent models and economic models.

4.1.1. Longevity Risk

4.1.1.1. Description of the method

Under Solvency II, the 1 in 200years scenario which is recommended for the longevity risk is a shock on the mortality rates: a permanent 20% decrease in mortality rates for each age and each policy. Because of the way that the shock is applied, this method will result in a higher relative shock for older ages or more impaired lives (where the mortality is at high levels).

- q_x : mortality rate or probability of dying within a year at age x

$$For\ each\ policy\ and\ accross\ all\ ages:\ q_x^{after\ shock} = 80\% * q_x$$

This is what is considered to be a relevant scenario for a standard portfolio exposed to longevity risk. We have seen in part 2.3. different possible mortality adjustments for impaired lives and depending on the adjustment chosen for assessing the best estimate of the reserves this shock might be more or less appropriate.

Let us have a look at the results of the different shocks on the same mortality adjustments as presented in part 2.3. (for a 30 year old male with a life expectancy reduction of 10 years):

	Life expectancy				
	Normal Life Expectancy	**Rated Age**	**Qx Multipler**	**Qx fixed addition**	**Qx addition linearly decreasing**
Before Shock	56.8	46.2	46.2	46.2	46.2
After Shock	59.5	48.8	48.9	50.1	50.3
Relative Increase	4.7%	5.7%	5.8%	8.4%	8.9%

Assuming that the Expert's judgement provided is a best estimate of the remaining life expectancy of the victim and not a prudent view, then one should expect significantly more uncertainty on the longevity risk for severely impaired persons than for the general population. Therefore the combination of the "rated age" or "qx multiplier" and the solvency II longevity shock does not seem to provide a sensible result. Furthermore this effect will be even greater if the impairment is heavier. Indeed, for a heavy impairment, the rated age will be very old and the uncertainty (in years) around the expected life will be relatively small.

In addition, though the shock is effective directionally (higher impairment or older age implies higher uncertainty) depending on the type of table which is used when factoring the impairment we can also question the level of the shock which is calibrated for a general portfolio.

Another shock scenario which can be possible is to consider that the impairment becomes null, meaning that there is no difference between the life expectancy of a severely injured person and an average person. This will result in our example in a more than 20% increase in the life expectancy of the victim.

For the rest of the study we will keep using the Solvency II shock with the "qx addition linearly decreasing" method.

For motor mono-liner or P&C multi-liner, having annuity exposure will constitute a diversification of the risks recognised by Solvency II since the risk is treated as Longevity risk under the Life module[18].

4.1.1.2. Impact on a specific case

Let us use the same example as before to see the impact of the shock on the reserves:

Assumptions	
Lump sum element	1m
Annuity element	100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Mortality adjustment	Qx addition linearly decreasing, as described in 2.3.3.
Discount rate	3%
Inflation assumption	3%
Delay to Settlement	7 Years
Reinsurance structure	Unlimited in excess of 2 million pounds
Indexation of the deductible at settlement (cf. part 3.2.)	1.20
Delay to Settlement	7 Years

The London market index clause applies for the three reinsurance products.

For the capitalised product, the table used will be the Ogden 7th with a rated age adjustment for the impairment and a discount rate of 1.5% (most commonly used rate) for calculating the capitalised value of the claim at settlement.

For the delayed capitalised product, the table used will be the Ogden 7th with a "no impairment" assumption and a discount rate of 1.5% for calculating the capitalised value of the claim at settlement, the claim being capitalised 20 years after the accident (13 years after the settlement here).

[18] Cf. Appendix 4, structure of SCR

We have seen that for this claim and for different reinsurance treaties the reserves after settlement are:

Outstanding status at settlement	Un-capitalised	Capitalised	Delayed Capitalised
Present value of recoveries	2,531,172	1,905,428	2,233,676
Outstanding reserve net of reinsurance	1,991,367	2,617,110	2,288,862
Lump Sum Element	1,000,000	1,000,000	1,000,000
Total reserve	5,522,539	5,522,539	5,522,539

If we apply the longevity shock to this settled claim the reinsurance absorption of the increase in reserves under each treaty will be as follows:

Increase in reserves following SII longevity shock	Un-capitalised	Capitalised	Delayed Capitalised
Present value of recoveries	292,748	0	78,259
Outstanding reserve net of reinsurance	102,367	395,115	316,857
Total reserve	395,115	395,115	395,115

We can see here that regarding the longevity risk most of the shock is absorbed when the un-capitalised reinsurance product is purchased, the increase in the primary insurer's share of the liability is due to the application of the indexation clause and related to the sharing of future inflation risk. Nothing is absorbed by the capitalised product as the capitalisation provided finality to the reinsurer. The Delayed Capitalisation product covers the insurer against the early mortality not occurring, hence the capital benefit is lower than for the un-capitalised product, but provides greater protection than the capitalised product.

4.1.2. Inflation Risk

4.1.2.1. Ideas for assessing the risk

The inflation risk is probably the most difficult to assess and the most expensive to cover for reinsurers. Indeed while a reinsurer can expect diversification and mutualisation benefits, regarding the longevity risk, from having shares in many different treaties and exposure to different annuities, it is completely different for the inflation risk which is systemic. The inflation is the same across the whole portfolio (neglecting the differing effect of the indexation on different deductibles). Therefore, reinsurers will have to closely manage their exposure to treaties with a follow the fortunes or un-capitalised clause, as, if the spread between inflation and investment income widens the reinsurer takes a hit across all treaty years.

Regarding Solvency II, there are no specifications on how to treat the wage inflation risk regarding the capital requirement. Regarding, Retail Price Inflation the risk could be estimated using financial mathematics techniques since index linked government treasury bonds exist and are quite liquid. In France the risk taken by (re-)insurers with annuities is very similar to consumer prices inflation risk and should therefore be easier to hedge than in the UK. Indeed, in the UK the ASHE6115 (wage index; Annual Survey of Hours and Earnings for the sub-category of care assistants and home carers) is even less stable and predictable than the country wide wage index. It is still possible to assume than on the long term it is not likely to have a gap between general wages in the UK and wages in the medical profession (otherwise the medical profession would become more attractive for students, more carers will be formed creating an auto-regulation) but this is just an assumption among others.

The materialisation of the risk regarding inflation will be the change on the long term view of the average spread between inflation and investment income that could occur within a year with a probability of 0.05%. This is difficult (if not impossible) to assess using historical data. The risk could be treated together with the market risk since the risk is mainly related to the impact of a diverging effect between inflation and return on investment.

A rule of thumb could be to say that the worst case scenario, when the inflation risk is not hedged using a financial product, is an increase of X% in the long term spread between the investment incomes and the inflation. The impact of the "shock" will then be the difference between the present value of the reserves using one discount rate and the other. This would represent the appearance of a gap between the liability and asset matching this liability. As an example here we can take 0.5%.

One should also consider scenarios. Indeed depending on the duration of the liability, an insurer might be more exposed to inflation in the short term (e.g. 1-5 years). So, instead of having one stress scenario it can only be beneficial (for the understanding of the risk) to test a range of economic scenarios (inflation and yield).

4.1.2.2. Impact on a specific case

Using the same set of assumptions as before, we can stress the long term inflation/discounting assumptions going from a real discount rate of 0% to -0.5%:

Central Scenario	
Discount rate	3%
Long term Inflation assumption	3%

Shock Scenario	
Discount rate	3%
Long term Inflation assumption	3.5%

We can see the impact of the shock on gross reserves for same claim as before and for the different reinsurance's types of clauses:

Increase in reserves post shock	**Un-capitalised**	**Capitalised**	**Delayed Capitalised**
Impact on the PV of reinsurance recoveries	511,141	-	134,317
Net of reinsurance	181,729	692,870	558,552
Total impact on the claim	692,870	692,870	692,870

Just like for the longevity risk, in respect of the inflation risk post settlement most of the shock is absorbed when the un-capitalised reinsurance product is purchased. The increase in the primary insurer's share of the liability is due to the application of the indexation clause and related to the sharing of future inflation risk. Nothing is absorbed by the capitalised product as the capitalisation provided finality to the reinsurer. And the delayed Capitalised product covers the insurer against the inflation risk in the first years post-settlement.

For a different shock scenario:

Shock Scenario	
Discount rate	3%
Long term Inflation assumption	4%

Increase in reserves post 1% inflation/discounting shock	Un-capitalised	Capitalised	Delayed Capitalised
Impact on the PV of reinsurance recoveries	1,149,389	-	277,429
Net of reinsurance	399,423	1,548,811	1,271,383
Total impact on the claim	1,548,811	1,548,811	1,548,811

We can see here, as one could expect for long term liability, the reserves are very sensitive to the real discount rate. This is principally an issue in the UK where no instruments exist for covering the ASHE6115 inflation risk.

In general, the higher the duration of the liability, the higher is the exposure to the inflation risk and the higher the SCR is as a percentage of the reserves. This is the opposite of the longevity risk.

4.1.3. Alternative

In practice, with just 60 claims arising from 20 treaty years with different reinsurance clauses at different deductible levels, the amount of effort and time to define and perform a rigorous calculation of a SCR consistent with the Solvency II principles would be considerable. So, defining approximations such as the ones presented in the two previous parts could be useful.

Another approximation which could be used, before trying to implement a methodology for capturing the risks specific to compensatory annuities more accurately, is to have a "risk factor". The "risk factor" would be applied to the best estimates of reserves for compensatory annuities at a portfolio level for calculating the capital needed to back the risk. This approach will be easier to communicate, to understand and to implement especially for assessing the Risk Margin which requires calculating all the future capital requirements on a run-off basis.

4.2. Cost of Capital

4.2.1. Risk Margin under Solvency II

According to the technical specifications of the QIS5[19], the Risk Margin should:

- Ensure that the value of the technical provisions is equivalent to the amount that an insurer would be expected to require in order to take over and meet the insurance and reinsurance obligations (Market Value Margin)

For calculating the risk margin, Solvency II recommends taking a cost of capital approach.

<u>Notation</u>:

- $SCR_{RU}(t)$ = the SCR for year t as calculated for the reference undertaking[20],
- r_t = the risk-free rate for maturity t; and
- CoC = the Cost-of-Capital rate = 6%

$$\mathrm{RM} = \mathrm{CoC} * \sum_{t \geq 0} \frac{SCR_{RU}(t)}{(1 + r_{t+1})^{t+1}}$$

Hierarchy of Simplifications used for projecting SCRs:

1. Full Calculation
2. Approximate individual (sub)risks used for SCR calculation
3. Approximate whole SCR in future years (e.g. by using a proportional approach)
4. Estimate all future SCRs at once (e.g. by using a duration approach)
5. RM as a percentage of the best estimate (17% for casualty non-proportional business[21])

The risk margin can be a very efficient way of capturing the cost of capital attached to long term guarantees, and in general it can be very efficient for having an idea of the <u>risk adjusted</u> cost of a cover. It is also a prudent approach in the sense that it does not allow for diversification benefits arising from the underwriting of future business.

[19] See V.2.5 of the QIS5 Technical Specifications
[20] The reference undertaking is described on the QIS5 Technical Specifications, page 55, TP.5.4.
[21] QIS5 Technical Specifications, p. 63-64 A simple method based on percentages of the best estimate (level 5 of the hierarchy)

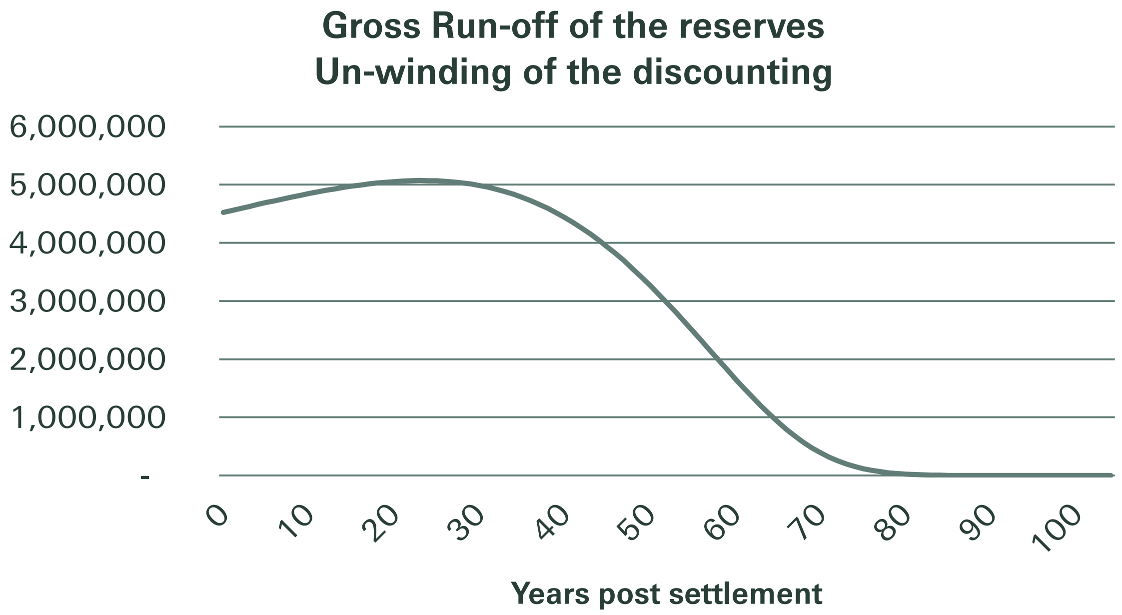
4.2.2. Assessment of the Risk Margin

For assessing the SCR, we need to introduce the notion of diversification. Indeed even for a pure motor insurer, there will be some diversification benefits in having longevity risk exposure (annuities stemming from non-life policies).

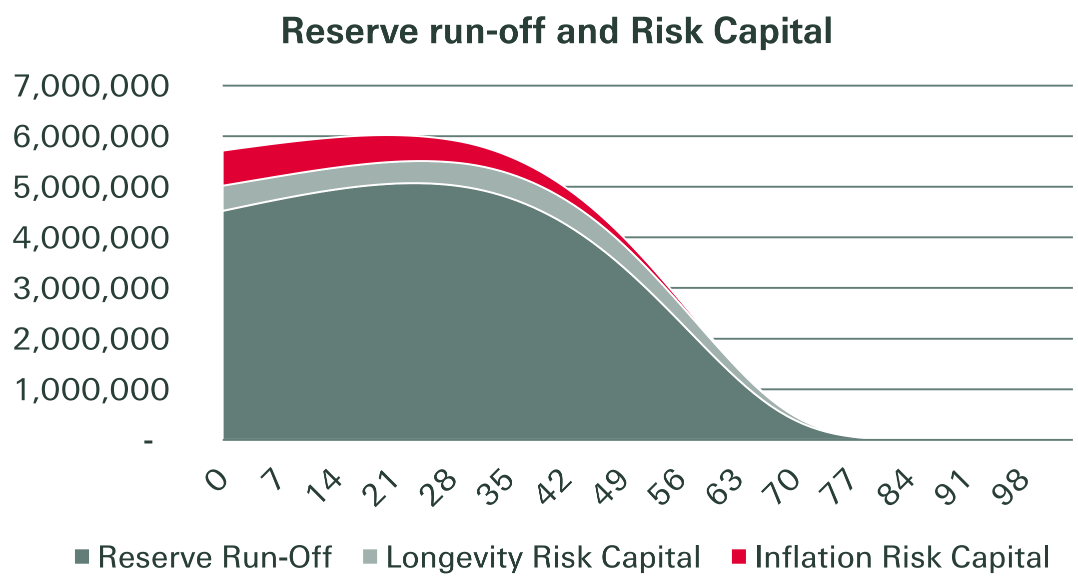
As a simplification, we will use the same example and project the claim in the future as before:

Assumptions	
Lump sum element	1m
Annuity element	100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Mortality adjustment	Qx addition linearly decreasing, as described in 2.3.3.
Discount rate	3%
Inflation assumption	3%

If we project this claim the run-off profile of the claim unwinding the discounting will follow this pattern:



If we apply the longevity and inflation shocks as described in part 4.1.1. and 4.1.2. to all future years assuming the central scenario is realised we obtain this risk run-off profile :



We can see that as time goes by, the duration of the liability is decreasing and the inflation risk as a percentage of the reserves decreases while the longevity risk capital increases as a percentage of reserves.

If we consider only these risks and with no diversification we can apply the formula described in part 4.2.1. and calculate a risk margin for these isolated risks. We obtain this result:

	Gross Position
Best estimate of the Reserve	4,522,539
Risk Margin	**1,187,807**
Gross Technical Reserve	5,710,346
Risk Capital Longevity Yr1	395,115
Risk Capital Inflation Yr1	692,870

Using the same example as before, we obtain a risk margin of 1.2m. Meaning that around **20%** of the cost of holding this claim in the insurer's book is meant to cover the cost of holding the capital until the claim completely runs off. This result relies on a probabilistic approach which would make more sense if we were to consider more than one claimant to observe the actual diversification effects regarding the life risk.

If we were to use a simplified approach, the "risk factor" which results in the same Risk Margin for this specific claim would be of 15%. Having the capital requirement as a constant 15% of the best estimate of the liability is equivalent to the method presented above regarding the same Risk Margin for this specific claim. The "risk factor" mainly depends on the duration of the liability, the longer the duration the higher the "risk factor".

4.2.3. Impact of reinsurance and Risk Margin Relief

One of the benefits of the reinsurance is related to the fact that reinsurers usually have a better diversification of their risks. Therefore the capital they require for holding a risk is lower than what a mono-liner would be needing, which results in a lower charge for covering the cost of capital.

Here we can consider which capital relief, and risk margin relief can be gained from the different reinsurance products which were considered before. Again, we will use the same hypothesis as before:

Assumptions	
Lump sum element	1m
Annuity element	100k p.a.
Age at settlement of the victim and Gender	30 years Male
Impairment	Life expectancy reduction of 10 years
Mortality table	Ogden 7th
Mortality adjustment	Qx addition linearly decreasing, as described in 2.3.3.
Discount rate	3%
Inflation assumption	3%
Delay to Settlement	7 Years
Reinsurance structure	Unlimited in excess of 2 million pounds
Indexation of the deductible at settlement (cf. part 3.2.)	1.20
Delay to Settlement	7 Years

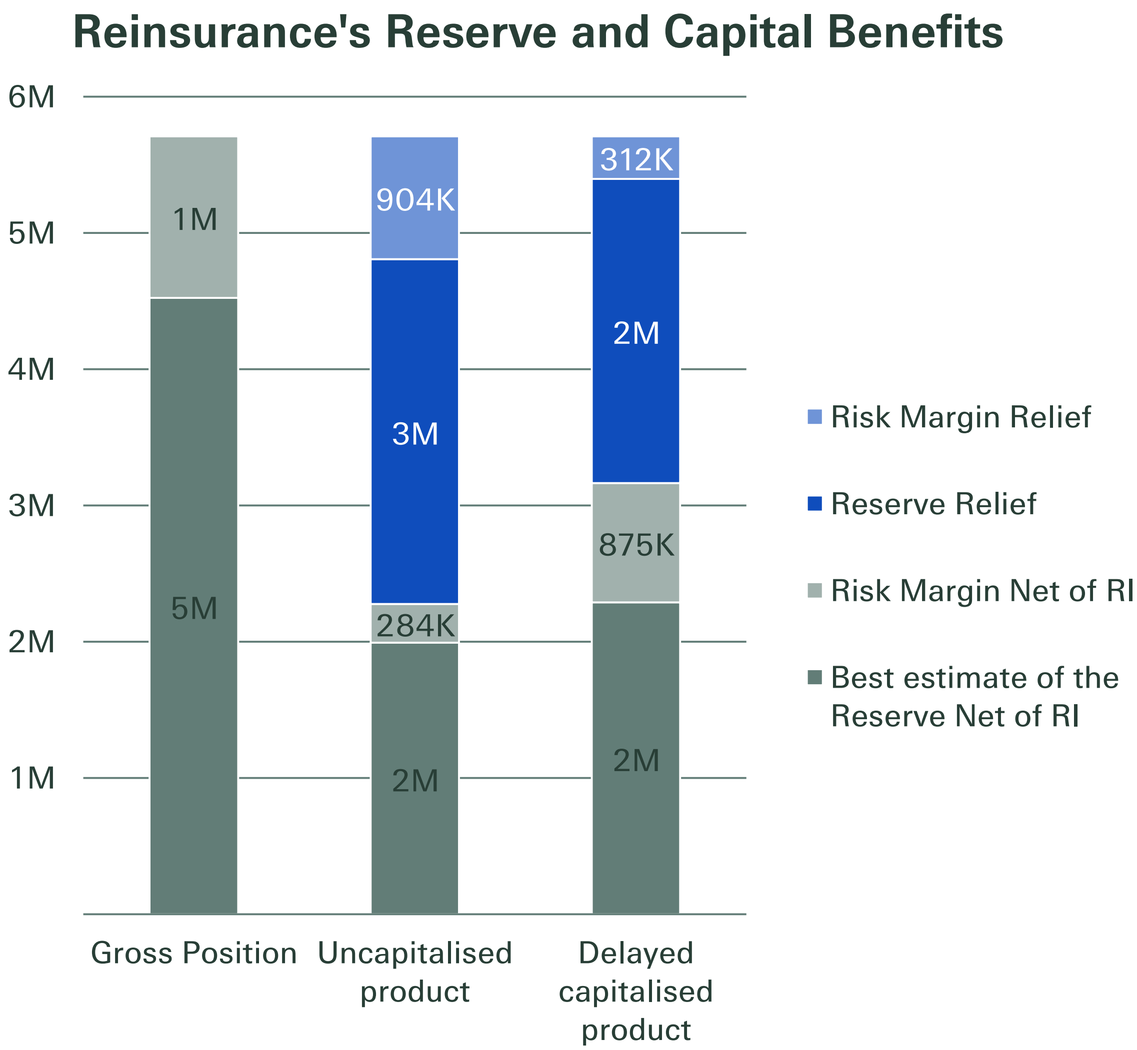
The London market index clause applies for the three reinsurance products.

For the delayed capitalised product, the table used will be the Ogden 7th with a "no impairment" assumption and a discount rate of 1.5% for calculating the capitalised value of the claim at settlement, the claim being capitalised 20 years after the accident (13 years after the settlement here)

If we project the same settled claim applying the 3 different treaties, and use the same techniques as described in 4.2.2. for assessing the capital requirement regarding this claim, the results are as follow:

	Gross Position	**Net of Uncap**	**Net of delayed cap**
Best estimate of the Reserve	4,522,539	1,991,367	2,288,862
Risk Margin	1,187,807	284,096	875,409
Gross Technical Reserve	5,710,346	2,275,463	3,164,271
Risk Capital Longevity Yr1	395,115	102,367	24,109
Risk Capital Inflation Yr1	692,870	181,729	47,412

The capitalised product is not displayed here since it does not offer any capital benefit once the claim is settled. The following graphic shows the same results:



On this graph we can see that the sole consideration of the reserve relief and the cash compensation offered by a reinsurance product should not be the only criteria for choosing a treaty rather than another. As we can see here the best cover regarding the tail risks, higher than expected longevity or inflation, is the follow the fortunes or un-capitalised product. Hence regarding these risks the benefits of the delayed capitalised product are more limited, and there are no benefits gained from the capitalised product after the claim has settled. This ignores the relative costs of the products, the budget constraints of the insurer and the exposure to reinsurers' credit risk. If the un-capitalised product is too expensive it may be more efficient to buy the delayed capitalised product which offers a hedge partial against inflation and a hedge against the risk of an over-estimated impairment (capitalisation assuming no impairment).

This is just one example, and as seen in part 1.1.2., not all the large losses are settling as annuities and all the claims are different. But directionally, for annuities, the conclusions of this approach are correct and the covers provided by the different treaties are very different and should match the insurer's risk appetite.

One thing which is important to consider, is that pragmatically the protection against longevity and inflation risk under the un-capitalised product will only be efficient if the reinsurer is still around in the future to make the payments, a risk which is much smaller for the capitalised and delayed capitalised products. The first conclusion is that the insurers buying this product have to manage closely their exposure to reinsurers' credit risk. The second implication will be that the insurers will also have to hold capital for covering the reinsurers' default risk under Solvency II.

Another point which is not evoked here is related to the cash flow management; indeed the capitalised products offer the benefit of providing the insurer with cash which will help constituting the reserves.

Conclusion

It is interesting to note that originally, one of the reasons why life insurance was separated from what we call by opposition non-life insurance was for protecting long–term liability from conjectural economic downturns which could affect short duration policies. Hence, life and non-life were separated for protecting life policyholders from potential GI insurers' short-termism behaviour.

The border between life insurance and GI insurance is now blurred by compensatory annuities. Indeed, the risk in substance is a life risk; therefore it should be assessed on this basis using life insurance techniques. We have seen that compensatory annuities are usually awarded to people who survived a severe accident and suffered severe injuries. So, traditional life actuarial techniques will not fully qualify for providing a best estimate view of the risk. As we could see another component of the risk is inflation. Annuities can be indexed according to a retail price (or similar) index or to a general or specific wage (or similar) index. This risk, the spread between inflation and the return on investment that the insurance company will achieve are another considerable unknown attached to compensatory annuities. The aim of this paper was to provide simple consideration for assessing the main direct and indirect costs attached to compensatory annuities.

In a very specific field of the insurance industry; medical underwriting; different adjustments exist and are used for loading general mortality when the insured has specific conditions (smoker, heart diseases, diabetes, HIV…). But these adjustments are used for much older people with a lower life expectancy than 10 years. We discussed how different methods from this field could be applied for adjusting mortality profiles of the general population to a population of impaired persons. The number of studies on the subject is scarce, and as the purpose is to predict future trends in mortality the credibility of the studies available is also limited. The "qx addition" technique, with an additional to average probability of death (linearly decreasing over time), seems to be a good compromise between simplicity and consistency with the conclusions of the above-mentioned studies regarding long term mortality after a spinal cord injury.

For covering their largest losses, motor insurers buy excess of loss covers from reinsurers. With compensatory annuities the cover can take different forms, and as the risk gets more complex the insurer can share the tail risks in different ways with the reinsurer. We could see to which extent the different covers could help an insurer to hedge the inflation and longevity risk and obtain a capital relief. A significant share of the technical reserves should be meant to cover for the cost of capital and the adverse development that the insurer could experience and depending on the type of reinsurance treaty the insurer will share or retain these components of the liability.

The calculations are made without entering into the full consideration of the Solvency II modules, trying to only focus on the two main risk factors for getting an economic view of the risk. These considerations can help when trying to define a risk appetite and assess which risk an insurer is willing to keep and which should be transferred (at which cost is the cession interesting). In the near future, new regulations will come into force both in France and in the United Kingdom and by understanding the substance of the risks and the extant of the covers that insurers are buying the insurers will make the transition to the new environments easier.

A next step could be to include the consideration regarding capital requirement into the group picture of the risk. This would allow for diversification benefits at a group level and help the reinsurer to make on a decision on where the best risk to deploy capital is and where a risk transfer solution should make more sense.

APPENDIX 1: Ogden Tables[22]

Table 1 Multipliers for pecuniary loss for life (males)

Multiplier calculated with allowance for projected mortality from the 2008-based population projections and rate of return of

Age at date of trial	–2.0%	–1.5%	–1.0%	–0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	Age at date of trial
0	264.76	195.32	147.14	113.22	88.96	71.35	58.34	48.60	41.17	35.41	30.89	0
1	259.11	191.95	145.15	112.06	88.31	71.00	58.18	48.54	41.18	35.46	30.96	1
2	252.28	187.68	142.46	110.35	87.22	70.30	57.73	48.24	40.98	35.33	30.87	2
3	245.58	183.46	139.78	108.64	86.12	69.58	57.26	47.94	40.78	35.19	30.78	3
4	239.02	179.29	137.12	106.93	85.01	68.86	56.78	47.62	40.56	35.05	30.68	4
5	232.59	175.19	134.48	105.22	83.89	68.12	56.30	47.29	40.34	34.90	30.58	5
6	226.29	171.15	131.87	103.52	82.78	67.39	55.80	46.96	40.12	34.75	30.47	6
7	220.14	167.18	129.29	101.83	81.66	66.65	55.31	46.63	39.89	34.59	30.36	7
8	214.13	163.28	126.74	100.15	80.55	65.90	54.80	46.28	39.65	34.42	30.24	8
9	208.23	159.43	124.21	98.48	79.43	65.15	54.29	45.93	39.41	34.25	30.13	9
10	202.47	155.64	121.71	96.81	78.31	64.39	53.78	45.58	39.16	34.08	30.00	10
11	196.83	151.92	119.23	95.15	77.19	63.63	53.25	45.22	38.91	33.90	29.87	11
12	191.33	148.26	116.79	93.50	76.07	62.86	52.72	44.85	38.65	33.72	29.74	12
13	185.95	144.67	114.37	91.87	74.96	62.09	52.19	44.47	38.39	33.53	29.61	13
14	180.69	141.14	111.98	90.24	73.84	61.32	51.65	44.10	38.12	33.34	29.47	14
15	175.56	137.67	109.62	88.63	72.73	60.55	51.11	43.71	37.84	33.14	29.32	15
16	170.55	134.27	107.30	87.02	71.61	59.77	50.56	43.32	37.57	32.94	29.17	16
17	165.66	130.93	105.00	85.44	70.51	58.99	50.01	42.93	37.28	32.73	29.02	17
18	160.89	127.66	102.74	83.86	69.41	58.22	49.46	42.53	37.00	32.52	28.87	18
19	156.25	124.45	100.52	82.31	68.31	57.44	48.91	42.14	36.71	32.31	28.71	19
20	151.72	121.31	98.32	80.76	67.22	56.66	48.35	41.73	36.41	32.10	28.55	20
21	147.28	118.22	96.15	79.23	66.13	55.88	47.78	41.32	36.11	31.87	28.39	21
22	142.94	115.17	94.00	77.70	65.04	55.09	47.21	40.90	35.81	31.64	28.22	22
23	138.69	112.17	91.87	76.18	63.94	54.30	46.63	40.48	35.49	31.41	28.04	23
24	134.54	109.22	89.77	74.67	62.85	53.51	46.05	40.05	35.17	31.17	27.86	24
25	130.49	106.33	87.69	73.17	61.76	52.71	45.46	39.61	34.85	30.92	27.67	25
26	126.54	103.50	85.65	71.69	60.68	51.91	44.87	39.17	34.51	30.67	27.48	26
27	122.69	100.72	83.63	70.22	59.59	51.11	44.28	38.73	34.18	30.42	27.28	27
28	118.90	97.98	81.63	68.74	58.51	50.30	43.67	38.27	33.83	30.15	27.08	28
29	115.20	95.28	79.64	67.28	57.42	49.49	43.06	37.81	33.48	29.88	26.87	29
30	111.59	92.63	77.69	65.83	56.34	48.68	42.45	37.34	33.12	29.60	26.65	30
31	108.09	90.04	75.78	64.40	55.27	47.87	41.83	36.87	32.76	29.32	26.44	31
32	104.68	87.52	73.89	62.99	54.20	47.06	41.22	36.40	32.39	29.04	26.21	32
33	101.36	85.04	72.04	61.60	53.15	46.26	40.60	35.92	32.02	28.75	25.99	33
34	98.10	82.61	70.21	60.21	52.09	45.45	39.98	35.44	31.65	28.46	25.75	34
35	94.92	80.21	68.39	58.83	51.03	44.63	39.35	34.95	31.26	28.15	25.51	35
36	91.82	77.86	66.60	57.46	49.98	43.82	38.71	34.45	30.87	27.84	25.27	36
37	88.78	75.55	64.83	56.10	48.93	43.00	38.07	33.95	30.47	27.53	25.01	37
38	85.81	73.27	63.08	54.74	47.87	42.18	37.42	33.44	30.06	27.20	24.75	38
39	82.89	71.03	61.35	53.39	46.82	41.35	36.77	32.91	29.65	26.86	24.48	39
40	80.05	68.83	59.63	52.05	45.76	40.51	36.11	32.39	29.22	26.52	24.20	40
41	77.27	66.67	57.94	50.72	44.71	39.68	35.44	31.85	28.79	26.17	23.91	41
42	74.56	64.55	56.28	49.41	43.67	38.84	34.77	31.31	28.35	25.81	23.62	42
43	71.92	62.47	54.63	48.10	42.62	38.01	34.10	30.76	27.91	25.45	23.32	43
44	69.34	60.43	53.01	46.81	41.59	37.17	33.42	30.21	27.45	25.08	23.01	44
45	66.82	58.43	51.41	45.52	40.55	36.33	32.73	29.65	26.99	24.70	22.69	45
46	64.36	56.46	49.83	44.25	39.52	35.49	32.05	29.08	26.53	24.31	22.37	46
47	61.96	54.53	48.28	42.99	38.49	34.65	31.35	28.51	26.05	23.91	22.04	47
48	59.63	52.64	46.74	41.74	37.47	33.81	30.66	27.94	25.57	23.51	21.70	48
49	57.35	50.79	45.24	40.50	36.45	32.97	29.97	27.36	25.09	23.10	21.36	49
50	55.14	48.99	43.76	39.29	35.45	32.14	29.27	26.78	24.60	22.69	21.01	50
51	52.99	47.23	42.31	38.09	34.45	31.31	28.58	26.19	24.11	22.27	20.65	51
52	50.90	45.51	40.89	36.91	33.47	30.48	27.88	25.61	23.61	21.85	20.29	52
53	48.87	43.83	39.49	35.74	32.49	29.67	27.19	25.02	23.11	21.42	19.92	53
54	46.90	42.19	38.12	34.60	31.53	28.85	26.50	24.43	22.61	20.99	19.55	54
55	44.99	40.60	36.79	33.47	30.58	28.04	25.81	23.85	22.11	20.56	19.18	55
56	43.15	39.04	35.48	32.37	29.64	27.25	25.13	23.26	21.60	20.12	18.80	56
57	41.35	37.53	34.19	31.28	28.71	26.45	24.45	22.67	21.09	19.68	18.42	57
58	39.59	36.04	32.93	30.19	27.78	25.65	23.76	22.08	20.58	19.23	18.02	58
59	37.87	34.57	31.67	29.11	26.85	24.85	23.07	21.47	20.05	18.77	17.62	59
60	36.17	33.12	30.42	28.04	25.92	24.04	22.36	20.86	19.51	18.30	17.20	60
61	34.52	31.69	29.19	26.97	25.00	23.23	21.65	20.24	18.96	17.81	16.77	61
62	32.91	30.30	27.98	25.92	24.08	22.43	20.95	19.62	18.41	17.33	16.34	62

[22] Source : ONS
http://www.gad.gov.uk/Documents/Other%20Services/Ogden%20Tables/Ogden_Tables_7th_edition.pdf

63	31.36	28.95	26.80	24.89	23.17	21.63	20.25	19.00	17.86	16.84	15.90	63
64	29.85	27.63	25.65	23.88	22.28	20.85	19.55	18.38	17.31	16.35	15.47	64
65	28.40	26.37	24.54	22.90	21.42	20.08	18.87	17.77	16.77	15.86	15.03	65
66	27.02	25.14	23.46	21.94	20.57	19.33	18.20	17.17	16.24	15.38	14.60	66
67	25.68	23.96	22.41	21.01	19.74	18.59	17.54	16.58	15.70	14.90	14.16	67
68	24.38	22.81	21.39	20.10	18.93	17.86	16.88	15.99	15.17	14.42	13.73	68
69	23.13	21.69	20.39	19.21	18.12	17.14	16.23	15.40	14.64	13.93	13.29	69

Table 1 Multipliers for pecuniary loss for life (males) *continued*

Age at date of trial	Multiplier calculated with allowance for projected mortality from the 2008-based population projections and rate of return of											Age at date of trial
	–2.0%	–1.5%	–1.0%	–0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	
70	21.91	20.60	19.41	18.32	17.32	16.41	15.58	14.81	14.10	13.44	12.84	70
71	20.70	19.52	18.43	17.44	16.53	15.69	14.92	14.21	13.55	12.94	12.38	71
72	19.52	18.44	17.46	16.56	15.72	14.96	14.25	13.60	12.99	12.43	11.91	72
73	18.34	17.38	16.49	15.67	14.92	14.22	13.57	12.97	12.42	11.90	11.42	73
74	17.18	16.32	15.52	14.79	14.10	13.47	12.89	12.34	11.83	11.36	10.92	74
75	16.04	15.27	14.56	13.90	13.29	12.72	12.19	11.70	11.24	10.81	10.40	75
76	14.93	14.25	13.62	13.03	12.48	11.97	11.50	11.05	10.64	10.25	9.88	76
77	13.86	13.26	12.70	12.18	11.70	11.24	10.82	10.42	10.05	9.69	9.36	77
78	12.83	12.31	11.82	11.36	10.93	10.53	10.15	9.79	9.46	9.15	8.85	78
79	11.86	11.40	10.97	10.57	10.19	9.84	9.50	9.19	8.89	8.61	8.34	79
80	10.94	10.55	10.17	9.82	9.49	9.18	8.88	8.60	8.34	8.09	7.85	80
81	10.10	9.75	9.43	9.12	8.83	8.56	8.30	8.05	7.82	7.60	7.38	81
82	9.33	9.03	8.74	8.47	8.22	7.98	7.75	7.53	7.33	7.13	6.94	82
83	8.62	8.36	8.11	7.88	7.65	7.44	7.24	7.05	6.87	6.69	6.53	83
84	7.97	7.74	7.53	7.32	7.13	6.94	6.76	6.59	6.43	6.28	6.13	84
85	7.36	7.16	6.98	6.80	6.63	6.47	6.31	6.16	6.02	5.88	5.75	85
86	6.79	6.62	6.46	6.31	6.16	6.02	5.88	5.75	5.62	5.50	5.39	86
87	6.25	6.11	5.97	5.83	5.71	5.58	5.46	5.35	5.24	5.14	5.04	87
88	5.74	5.62	5.50	5.38	5.27	5.16	5.06	4.96	4.87	4.78	4.69	88
89	5.26	5.15	5.05	4.95	4.86	4.76	4.68	4.59	4.51	4.43	4.35	89
90	4.81	4.72	4.64	4.55	4.47	4.39	4.31	4.24	4.17	4.10	4.03	90
91	4.40	4.32	4.25	4.17	4.10	4.04	3.97	3.91	3.85	3.79	3.73	91
92	4.01	3.94	3.88	3.82	3.76	3.70	3.65	3.59	3.54	3.49	3.44	92
93	3.65	3.59	3.54	3.49	3.44	3.39	3.34	3.30	3.25	3.21	3.17	93
94	3.33	3.29	3.24	3.20	3.16	3.11	3.07	3.03	2.99	2.96	2.92	94
95	3.06	3.02	2.98	2.94	2.91	2.87	2.84	2.80	2.77	2.74	2.71	95
96	2.83	2.79	2.76	2.72	2.69	2.66	2.63	2.60	2.57	2.54	2.52	96
97	2.62	2.59	2.56	2.53	2.50	2.48	2.45	2.42	2.40	2.37	2.35	97
98	2.44	2.41	2.38	2.36	2.34	2.31	2.29	2.27	2.24	2.22	2.20	98
99	2.27	2.25	2.22	2.20	2.18	2.16	2.14	2.12	2.10	2.08	2.06	99
100	2.11	2.09	2.07	2.06	2.04	2.02	2.00	1.98	1.97	1.95	1.93	100

Table 2 Multipliers for pecuniary loss for life (females)

Age at date of trial	Multiplier calculated with allowance for projected mortality from the 2008-based population projections and rate of return of											Age at date of trial
	–2.0%	–1.5%	–1.0%	–0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	
0	285.20	208.39	155.57	118.70	92.57	73.74	59.95	49.69	41.92	35.94	31.26	0
1	279.01	204.72	153.41	117.45	91.86	73.36	59.76	49.62	41.91	35.97	31.32	1
2	271.81	200.28	150.65	115.73	90.77	72.67	59.33	49.34	41.73	35.86	31.24	2
3	264.75	195.89	147.91	114.00	89.68	71.97	58.88	49.05	41.55	35.73	31.16	3
4	257.83	191.56	145.19	112.28	88.58	71.27	58.43	48.75	41.35	35.60	31.08	4
5	251.06	187.30	142.49	110.56	87.49	70.56	57.97	48.45	41.15	35.47	30.99	5
6	244.43	183.11	139.83	108.85	86.38	69.85	57.50	48.14	40.95	35.34	30.89	6
7	237.94	178.98	137.18	107.15	85.28	69.13	57.03	47.83	40.74	35.19	30.80	7
8	231.59	174.92	134.57	105.46	84.18	68.40	56.55	47.51	40.52	35.05	30.70	8
9	225.38	170.93	131.98	103.77	83.07	67.67	56.06	47.18	40.30	34.90	30.60	9
10	219.31	167.00	129.43	102.10	81.97	66.94	55.57	46.85	40.08	34.75	30.49	10
11	213.37	163.14	126.90	100.43	80.86	66.20	55.07	46.52	39.85	34.59	30.38	11
12	207.57	159.34	124.40	98.78	79.76	65.46	54.57	46.18	39.62	34.42	30.27	12
13	201.89	155.60	121.92	97.13	78.65	64.71	54.07	45.83	39.38	34.26	30.15	13
14	196.33	151.93	119.48	95.49	77.55	63.96	53.55	45.47	39.13	34.09	30.03	14
15	190.91	148.32	117.06	93.86	76.44	63.21	53.03	45.12	38.88	33.91	29.90	15
16	185.61	144.77	114.67	92.25	75.34	62.45	52.51	44.75	38.62	33.73	29.77	16
17	180.42	141.28	112.31	90.64	74.24	61.70	51.99	44.38	38.37	33.55	29.64	17
18	175.36	137.86	109.98	89.05	73.14	60.94	51.46	44.01	38.10	33.36	29.51	18
19	170.42	134.50	107.68	87.46	72.05	60.17	50.92	43.63	37.83	33.16	29.37	19
20	165.60	131.20	105.42	85.89	70.96	59.41	50.38	43.25	37.56	32.97	29.22	20
21	160.88	127.95	103.17	84.33	69.86	58.64	49.84	42.86	37.28	32.76	29.08	21
22	156.26	124.76	100.95	82.78	68.77	57.86	49.28	42.47	36.99	32.56	28.92	22
23	151.72	121.60	98.74	81.22	67.67	57.08	48.72	42.06	36.70	32.34	28.76	23
24	147.29	118.50	96.56	79.68	66.57	56.29	48.16	41.65	36.40	32.12	28.60	24
25	142.97	115.46	94.41	78.15	65.48	55.50	47.58	41.23	36.09	31.89	28.43	25
26	138.74	112.47	92.28	76.63	64.38	54.71	47.01	40.81	35.78	31.66	28.26	26
27	134.61	109.53	90.18	75.12	63.29	53.92	46.43	40.38	35.46	31.42	28.08	27
28	130.57	106.65	88.11	73.62	62.20	53.12	45.84	39.95	35.14	31.18	27.90	28
29	126.63	103.81	86.05	72.13	61.11	52.32	45.25	39.51	34.81	30.93	27.71	29
30	122.78	101.02	84.03	70.65	60.02	51.52	44.65	39.06	34.47	30.68	27.51	30
31	119.02	98.29	82.03	69.18	58.94	50.71	44.05	38.61	34.13	30.41	27.31	31
32	115.34	95.60	80.06	67.72	57.86	49.90	43.44	38.15	33.78	30.15	27.11	32
33	111.75	92.97	78.11	66.27	56.77	49.09	42.83	37.68	33.42	29.87	26.89	33
34	108.24	90.37	76.18	64.83	55.69	48.27	42.21	37.21	33.06	29.59	26.67	34
35	104.80	87.81	74.27	63.40	54.61	47.45	41.58	36.73	32.69	29.31	26.45	35
36	101.45	85.31	72.39	61.98	53.53	46.63	40.95	36.24	32.31	29.01	26.22	36
37	98.17	82.84	70.53	60.57	52.46	45.81	40.31	35.75	31.93	28.71	25.98	37
38	94.97	80.42	68.69	59.17	51.38	44.98	39.67	35.25	31.54	28.40	25.74	38
39	91.83	78.04	66.88	57.78	50.31	44.15	39.03	34.74	31.14	28.09	25.48	39
40	88.77	75.71	65.08	56.39	49.24	43.31	38.37	34.23	30.73	27.76	25.23	40
41	85.78	73.41	63.31	55.02	48.17	42.48	37.71	33.71	30.32	27.43	24.96	41
42	82.86	71.16	61.56	53.66	47.10	41.64	37.05	33.18	29.90	27.09	24.69	42
43	80.01	68.94	59.84	52.31	46.04	40.80	36.38	32.65	29.47	26.75	24.41	43
44	77.23	66.77	58.14	50.97	44.98	39.95	35.71	32.11	29.03	26.39	24.12	44
45	74.52	64.65	56.46	49.64	43.93	39.11	35.03	31.56	28.59	26.03	23.82	45
46	71.87	62.56	54.81	48.32	42.87	38.27	34.35	31.01	28.14	25.67	23.52	46
47	69.28	60.51	53.17	47.02	41.83	37.42	33.67	30.45	27.69	25.29	23.21	47
48	66.77	58.50	51.57	45.73	40.79	36.58	32.98	29.89	27.23	24.91	22.90	48
49	64.32	56.54	50.00	44.46	39.76	35.74	32.30	29.33	26.76	24.53	22.58	49
50	61.93	54.62	48.44	43.20	38.73	34.90	31.61	28.76	26.29	24.14	22.25	50
51	59.60	52.73	46.91	41.95	37.71	34.06	30.91	28.19	25.81	23.74	21.92	51
52	57.33	50.88	45.40	40.71	36.69	33.22	30.22	27.61	25.33	23.33	21.57	52
53	55.11	49.07	43.92	39.49	35.68	32.38	29.52	27.02	24.84	22.92	21.22	53
54	52.96	47.30	42.46	38.28	34.68	31.55	28.82	26.44	24.34	22.50	20.87	54
55	50.86	45.57	41.02	37.09	33.68	30.71	28.12	25.84	23.84	22.07	20.51	55
56	48.83	43.88	39.61	35.91	32.69	29.88	27.42	25.25	23.34	21.64	20.14	56
57	46.84	42.22	38.23	34.75	31.71	29.05	26.72	24.65	22.83	21.21	19.76	57
58	44.89	40.60	36.86	33.59	30.74	28.22	26.01	24.05	22.31	20.76	19.37	58
59	42.99	38.99	35.50	32.44	29.76	27.39	25.29	23.43	21.78	20.30	18.98	59
60	41.12	37.41	34.16	31.30	28.78	26.55	24.57	22.81	21.24	19.83	18.57	60
61	39.30	35.86	32.83	30.16	27.80	25.70	23.84	22.18	20.69	19.35	18.15	61
62	37.52	34.33	31.52	29.03	26.83	24.86	23.11	21.54	20.13	18.86	17.72	62
63	35.79	32.84	30.24	27.92	25.86	24.02	22.38	20.90	19.57	18.37	17.28	63
64	34.11	31.39	28.98	26.83	24.91	23.19	21.65	20.26	19.01	17.87	16.84	64
65	32.50	29.99	27.76	25.77	23.98	22.38	20.93	19.63	18.45	17.38	16.40	65
66	30.94	28.64	26.58	24.73	23.07	21.58	20.23	19.00	17.89	16.88	15.96	66
67	29.44	27.32	25.43	23.72	22.18	20.78	19.52	18.38	17.34	16.39	15.52	67
68	27.99	26.05	24.30	22.72	21.29	20.00	18.83	17.76	16.78	15.89	15.07	68
69	26.57	24.80	23.19	21.74	20.42	19.22	18.13	17.13	16.22	15.39	14.62	69

continued

Table 2 Multipliers for pecuniary loss for life (females) *continued*

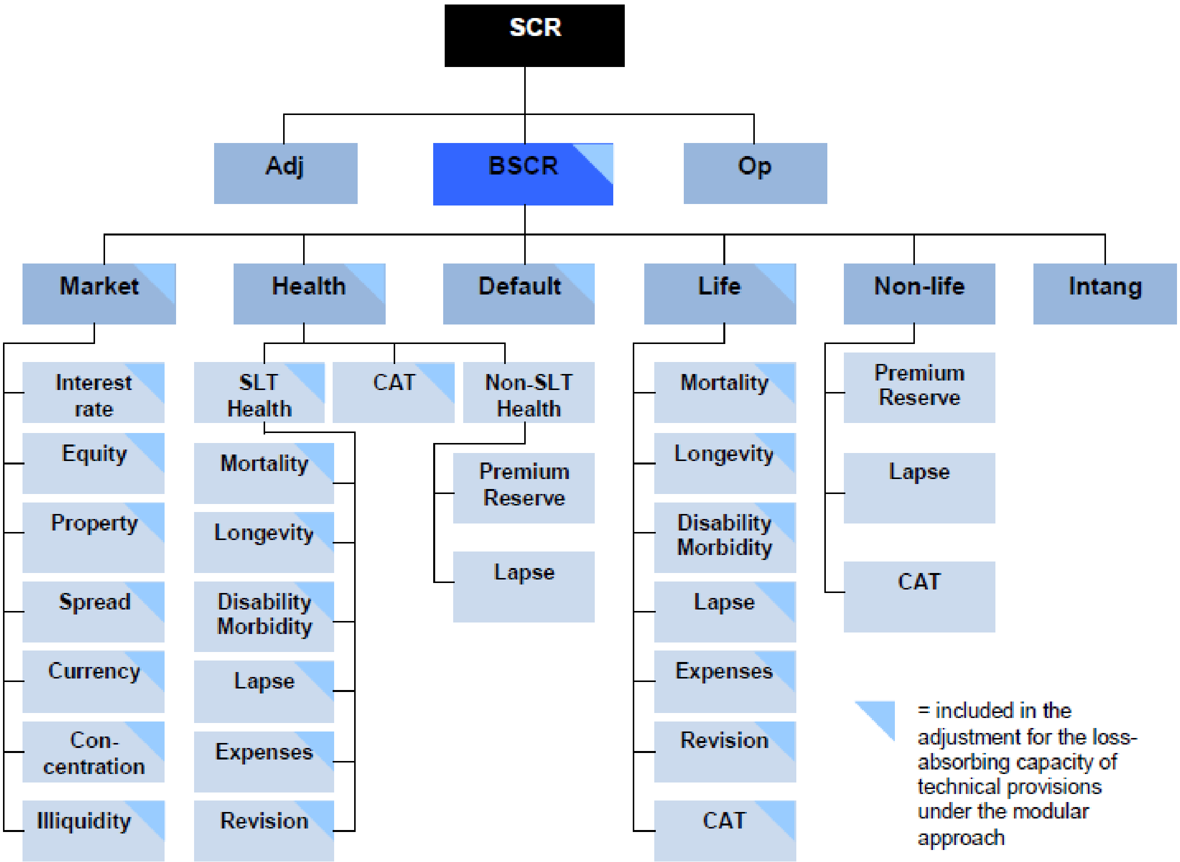
Age at date of trial	Multiplier calculated with allowance for projected mortality from the 2008-based population projections and rate of return of											Age at date of trial
	–2.0%	–1.5%	–1.0%	–0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	
70	25.19	23.57	22.10	20.76	19.55	18.44	17.43	16.50	15.65	14.87	14.15	70
71	23.83	22.35	21.01	19.79	18.67	17.65	16.72	15.86	15.07	14.35	13.68	71
72	22.47	21.14	19.92	18.81	17.79	16.85	16.00	15.20	14.48	13.80	13.18	72
73	21.13	19.93	18.83	17.82	16.89	16.04	15.25	14.53	13.86	13.24	12.66	73
74	19.80	18.72	17.73	16.82	15.99	15.21	14.50	13.84	13.23	12.66	12.13	74
75	18.48	17.53	16.64	15.83	15.08	14.38	13.74	13.14	12.58	12.06	11.58	75
76	17.20	16.35	15.57	14.84	14.17	13.55	12.97	12.43	11.92	11.45	11.01	76
77	15.95	15.21	14.51	13.87	13.28	12.72	12.20	11.72	11.27	10.84	10.45	77
78	14.75	14.10	13.50	12.93	12.40	11.91	11.45	11.02	10.62	10.24	9.88	78
79	13.62	13.05	12.52	12.03	11.56	11.13	10.72	10.34	9.98	9.64	9.32	79
80	12.56	12.07	11.61	11.17	10.77	10.38	10.02	9.69	9.37	9.07	8.78	80
81	11.58	11.15	10.75	10.37	10.02	9.68	9.36	9.06	8.78	8.51	8.26	81
82	10.67	10.30	9.95	9.62	9.31	9.02	8.74	8.48	8.23	7.99	7.76	82
83	9.83	9.51	9.21	8.92	8.65	8.39	8.15	7.92	7.70	7.49	7.29	83
84	9.06	8.78	8.52	8.27	8.03	7.81	7.59	7.39	7.19	7.01	6.83	84
85	8.34	8.10	7.87	7.65	7.45	7.25	7.06	6.88	6.71	6.55	6.40	85
86	7.66	7.45	7.25	7.07	6.89	6.72	6.56	6.40	6.25	6.11	5.97	86
87	7.01	6.84	6.67	6.51	6.36	6.21	6.07	5.93	5.80	5.68	5.56	87
88	6.41	6.26	6.11	5.98	5.85	5.72	5.60	5.48	5.37	5.26	5.16	88
89	5.84	5.71	5.59	5.47	5.36	5.25	5.15	5.05	4.95	4.86	4.77	89
90	5.31	5.20	5.10	5.00	4.90	4.81	4.72	4.64	4.55	4.47	4.40	90
91	4.82	4.73	4.64	4.55	4.47	4.40	4.32	4.25	4.18	4.11	4.04	91
92	4.37	4.29	4.22	4.15	4.08	4.01	3.95	3.89	3.83	3.77	3.71	92
93	3.97	3.90	3.84	3.78	3.72	3.67	3.61	3.56	3.51	3.46	3.41	93
94	3.62	3.56	3.51	3.46	3.41	3.36	3.31	3.27	3.22	3.18	3.14	94
95	3.32	3.27	3.23	3.18	3.14	3.10	3.06	3.02	2.98	2.94	2.91	95
96	3.06	3.02	2.98	2.94	2.91	2.87	2.84	2.80	2.77	2.74	2.71	96
97	2.84	2.80	2.77	2.74	2.70	2.67	2.64	2.61	2.58	2.56	2.53	97
98	2.64	2.61	2.58	2.55	2.52	2.49	2.47	2.44	2.42	2.39	2.37	98
99	2.45	2.42	2.40	2.37	2.35	2.32	2.30	2.28	2.26	2.23	2.21	99
100	2.27	2.25	2.22	2.20	2.18	2.16	2.14	2.12	2.10	2.08	2.06	100

APPENDIX 2: TD 88 90[23]

TD 88-90							
Age	Lx	Age	Lx	Age	Lx	Age	Lx
0	100 000	27	97 222	54	88 011	81	35 824
1	99 129	28	97 070	55	87 165	82	32 518
2	99 057	29	96 916	56	86 241	83	29 220
3	99 010	30	96 759	57	85 256	84	25 962
4	98 977	31	96 597	58	84 211	85	22 780
5	98 948	32	96 429	59	83 083	86	19 725
6	98 921	33	96 255	60	81 884	87	16 843
7	98 897	34	96 071	61	80 602	88	14 133
8	98 876	35	95 878	62	79 243	89	11 625
9	98 855	36	95 676	63	77 807	90	9 389
10	98 835	37	95 463	64	76 295	91	7 438
11	98 814	38	95 237	65	74 720	92	5 763
12	98 793	39	94 997	66	73 075	93	4 350
13	98 771	40	94 746	67	71 366	94	3 211
14	98 745	41	94 476	68	69 559	95	2 315
15	98 712	42	94 182	69	67 655	96	1 635
16	98 667	43	93 868	70	65 649	97	1 115
17	98 606	44	93 515	71	63 543	98	740
18	98 520	45	93 133	72	61 285	99	453
19	98 406	46	92 727	73	58 911	100	263
20	98 277	47	92 295	74	56 416	101	145
21	98 137	48	91 833	75	53 818	102	76
22	97 987	49	91 332	76	51 086	103	37
23	97 830	50	90 778	77	48 251	104	17
24	97 677	51	90 171	78	45 284	105	7
25	97 524	52	89 511	79	42 203	106	2
26	97 373	53	88 791	80	39 041	107	0

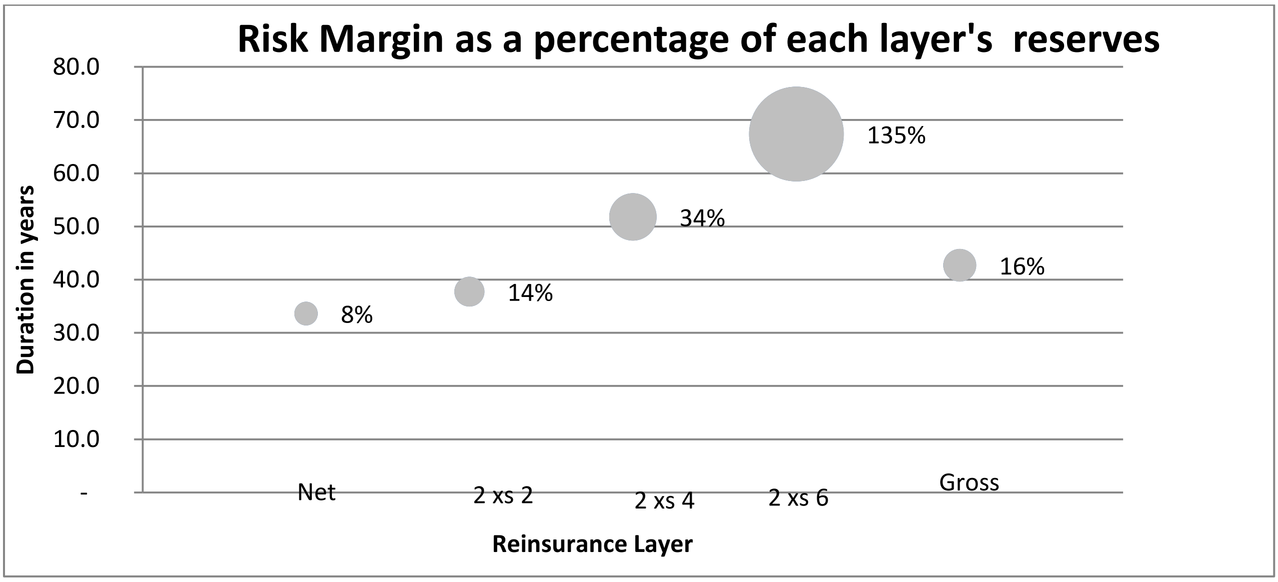
[23] Source: www.actuaris.com/fr/infotech/actuariat/tables_de_mortalit-/table_td_88-90.html

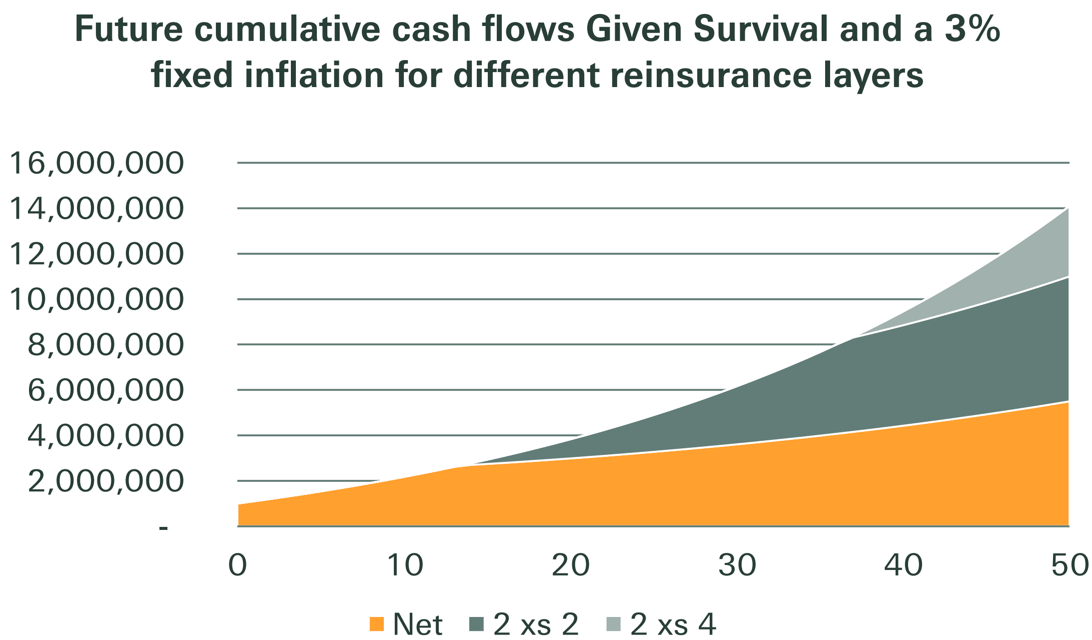
APPENDIX 3: Overall structure of SCR[24]



[24] QIS5 Technical Specifications, page 90

APPENDIX 4: Risk Margin for different layers





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http://www.gad.gov.uk/Documents/Other%20Services/Ogden%20Tables/Ogden_Tables_7th_edition.pdf : Link to the Ogden 7th tables and advisory about how to use the table

http://www.senat.fr/rap/l12-213-1/l12-213-187.html : extract from the “loi réctificative des finances”

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