Continuous Mortality Investigation

Working Paper 30

The CMI Library of Mortality Projections

November 2007

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1 Introduction

The CMI has in recent years incorporated projections of future mortality into its published mortality tables that have been extensively used by UK actuaries in pricing and valuing life insurance and pension scheme risks.

During its work on the "00" Series tables, the CMI undertook extensive research into mortality projections but came to the conclusion that it was unable to present a single view of the future, as had been attempted with preceding mortality tables. The final "00" Series tables adopted by the UK Actuarial Profession with effect from 1 September 2006 did not contain any projections. It soon became clear that the absence of projections left a gap that has caused much debate in recent months, both within the Profession and between the Profession and interested external stakeholders.

The CMI - and the Actuarial Profession as a whole - recognised the need to make the CMI's recent work more accessible to actuaries. As a result, the CMI formed a Task Force which it hoped would:

- Gather users' perspectives on how they actually use mortality projections and associated measures of uncertainty;
- Interpret the CMI's recent research and recommend tools or education (e.g. a seminar or workshops) in order to make the research more accessible to actuaries;
- Propose terminology that will facilitate disclosure of mortality projections where this is required; and
- Seek to develop sets of projections which can be used as benchmarks.

The membership of the Task Force was: Gordon Sharp (Chair), Richard Humble, Angus Macdonald, George Russell, Andrew Walton, Richard Willets and Brian Wilson, with Dave Grimshaw as Secretary.

The Task Force produced a draft "library" of mortality projections which was published, together with Working Paper 27, in July 2007. Meetings to discuss the draft library were held in Edinburgh on 18 July and at Staple Inn Hall on 20 July and 26 July.

The Task Force invited feedback on all aspects of the draft library of mortality projections and Working Paper 27. Over 40 responses were received from a variety of individuals and organisations, including many of the larger insurance companies and pension consultancies. The Task Force believes it can reasonably consider the feedback to be representative of the views of a wide spectrum of the UK Actuarial Profession.

The Task Force has considered all the comments received, together with points made in discussion at the various meetings, and whether – and how – these should be reflected in the initial library which the CMI is publishing simultaneously with this Working Paper.

The purpose of this paper is to summarise points made in feedback and the Task Force's reaction to these points.

A user guide has also been issued which documents the contents of version 1.0 of the library and which the CMI intends to update as and when the library is updated in future.

We would like to express our thanks to all those individual actuaries and organisations who took the time to respond to Working Paper 27. We did not state in that Working Paper that we would publish a list of respondents, so we have not named them in this paper.

Throughout this paper we have used quotations from responses to illustrate the views expressed. These are shown in italics to distinguish them from the views of the Task Force. Note that in some cases we have slightly altered the exact words to try to ensure the context of the comments is clear, when separated from other parts of that response; we hope that as a result we have not distorted the views of respondents. Given the large volume of feedback received, we hope also that respondents will understand if their points are not specifically addressed in this paper.

The structure of the remainder of this paper is as follows:

- Section 2 of this paper covers selected key themes to emerge from the feedback received to Working Paper 27 and the Task Force's responses to these.
- Working Paper 27 included a number of specific questions on which we requested feedback. A summary of responses, and the Task Force's reaction to them, is contained in Section 3.
- Section 4 documents other points of feedback that are not easily related to the specific questions.
- There was a small number of errors in the draft library and in Working Paper 27; these are documented in Section 5.
- The paper concludes with a summary of changes from the draft library to version 1.0 of the library in section 6.

Please note that as the changes made to the library are limited, the CMI is not undertaking a consultation exercise on the library. Any comments on this Working Paper and the library of mortality projections can be sent via e-mail to projections@cmib.org.uk or in writing to: Dave Grimshaw, CMI, Cheapside House, 138 Cheapside, London, EC2V 6BW. Such comments will be considered for future work.

2 Key points arising from responses

This section covers selected key themes to emerge from the feedback received to Working Paper 27 and the Task Force's responses to these.

2.1 The need for the library

This was not a question on which we sought responses, though perhaps we should! The vast majority of responses either explicitly stated that they welcomed the library or appeared to support its introduction from their general comments. Several though expressed concerns, along the lines of: "*There is a danger, however, that some actuaries or users of actuarial advice will place excessive reliance on the library without a full understanding of its limitations*." The Task Force is aware of such risks and is doing its utmost to mitigate them, and it believes it has support from a substantial majority of the Actuarial Profession to publish the updated version of the library alongside this Working Paper.

There were very few objections to the library. One questioned "*the need for, and value of, a library of projections in an environment where actuaries must come up with their own views; a library in itself does nothing to help this process*." The Task Force accepts this comment, although it hopes that Working Paper 27 and the consultation meetings did help actuaries to formulate views. This however was not the primary purpose of the library; its key aims were to make the CMI's recent work more accessible to actuaries and to standardise terminology and practice. We still believe that the library goes some way towards achieving these aims.

The other response that we have considered under this heading relates principally to the range of projections contained in the draft library:

> "*My concern is that, despite CMI and the Profession saying that the library is for illustration only, and that each Actuary should use his own judgement, the range of projections contained in the library may be seen by many as setting a likely range. Hence, the library could, almost by default, turn out to set quasi standards. ...I believe that the range of projections, as proposed, excludes a rate of improvement that would be regarded as prudent for the generations forming the greater proportion of accrued liabilities in final salary occupational schemes.*
>
> *I believe the publication of the 'library' in its present form ... will provide something to hide behind for those who wish to succumb to commercial pressures when making mortality assumptions. In the long term, that is likely to damage the reputation of both the CMI and the Profession. As an absolute minimum, I believe further tables should be added which show minimum improvement rates of two and three per cent*."

The Task Force has some sympathy with this view, but does not believe that the Actuarial Profession would be better placed if we did not produce the library. Indeed we believe that the production of the library has had a positive impact in stimulating debate and raising awareness of recent mortality improvements and the uncertainty in future projections. The specific point regarding higher rates of improvement is considered in section 2.3 below.

2.2 Naming convention

There were several questions regarding the proposed naming convention, both general and specific to P-spline and Lee-Carter projections (see the responses to questions 3.1, 3.2, 6.1 and 7.1 for more detail).

There was near-universal agreement on the desirability of a naming convention, but some responses suggested that further information needed to be included in the name. This led a few respondents to conclude that perhaps a unique naming convention was unachievable.

The Task Force recognises that the current names are incomplete, but also sees the benefit of brevity. We have therefore retained names similar to those in the draft library but have also amended the library itself to ensure that fuller details are included on the sheet containing the relevant projection.

The Task Force would like to re-iterate that none of the parameters should be regarded as 'standards' and that any can be varied by practitioners. However where a projection basis is being disclosed and the shorthand name from the library is used, then the projection should use the conventions set out in the library for that projection. Where a projection basis does not exactly follow the conventions set out in the library for that projection then either the variation(s) need to be disclosed when the shorthand name from the library is used, or the basis should be specified fully. This however should not be interpreted as implying that any such variants are inferior to those included in the library. The aim is simply that where projections are disclosed, they are described in sufficient detail to allow an independent actuary to replicate the annual rates of improvement.

2.3 The projections in the library

Working Paper 27 did not specifically ask whether any of the projections that had been included in the draft library should be removed, and only one response addressed this. This suggested that the variations to the Interim Cohort Projections should be excluded because of a concern that "*other adjustments not included in the library might then be deemed unacceptable*". The Task Force rejects this conclusion although it recognises that the message that the library is not a complete set of acceptable projections must be stressed in all communications.

Working Paper 27 did ask a number of questions as to whether additional projections should be included in the library – Q4.1 asked about any other previously-published tables of projections, Q5.3 about any other variations to the Interim Cohort Projections that are used, and Q6.2 and Q7.2 asked about other P-spline and Lee-Carter projections respectively. More details on the feedback and the Task Force responses can be found under the relevant sections later in this paper.

As far as other previously-published tables of projections were concerned, a number of suggestions were received and are documented under Q4.1. The only suggestion that was mentioned in more than one response was that the library should include actual unsmoothed improvements; however the Task Force did not consider this appropriate (see section 3.2).

In addition there was a suggestion that the CMI should seek the ONS 2004-based projections for males in Scotland, as the draft library included only the projection for England, Wales and Northern Ireland. (There is no such differentiation in the ONS 2004-based projections for females). The ONS kindly made these available and they are included in version 1.0 of the library.

Since the consultation period closed, the ONS has published the 2006-based National Population Projections. The Task Force would like to thank the ONS for making the detailed

projections available to the CMI very soon after publication, thereby allowing the CMI to include them within version 1.0 of the library. An overview of these projections is contained within the user guide that accompanies the library.

The CMI would like to express its thanks to the ONS for its support in this regard. Note that the CMI has not (yet) sought additional data from the ONS, and hence the P-spline and Lee-Carter projections included in the library only use data up to 2005. In addition, note that the ONS data used relates to England & Wales only, for both males and females, whereas the 2004-based and 2006-based projections apply also to Northern Ireland (males) and Northern Ireland and Scotland (females). We hope that these distinctions have been made clear in the revised names adopted for these projections in version 1.0 of the library.

Q5.3 asked whether other variations to the cohort projections are currently being used and most respondents indicated there were none. The exception was a request for an example of a percentage of a cohort projection with a minimum value applied; an example of this has been included in this version of the library.

One response requested the inclusion of projections using the Cairns/Blake/Dowd models. This caused considerable debate within the Task Force. None of us was aware of these models being used by actuaries currently, which might indicate that there was no need to include it in the library, however the Task Force recognised the danger of this becoming a self-fulfilling prophecy: although the library is not intended to be a closed shop, there is a risk that actuaries will only use projections in the library, so new methodologies will not be used in practice. The Task Force is therefore reluctant to insist on 'in current use' as a criterion for inclusion in the library.

On these particular models, the Task Force concluded that they had not yet received adequate exposure within the Profession for the methodologies to be understood nor their advantages and disadvantages for actuarial work to be assessed by the actuarial community. As a result the methodologies have not been subject to any form of 'road-testing' by actuaries in the same way as P-spline and Lee-Carter projections, through their application to different datasets in CMI Working Papers 20 and 25, respectively, and subsequent discussion at various seminars.

The Task Force therefore encourages the authors or an actuarial working party to undertake this research and expose it more widely within the Profession, and to generate actual projections that can be considered for inclusion in a future version of the library.

2.4 'Mind the gap'

There are (up to) three parts to any mortality basis:

- the base assumption, which relates to a past date;
- the 'link' that adjusts the base mortality up to the valuation date; and
- the projection into the future.

In practice, either the link or the projection could be selected from the library, but there is no need for these to be the same, a point that was not explicitly discussed in Working Paper 27.

There were a number of comments relating to the treatment of mortality improvements in the 'gap' between the base assumption and the start of the projection. In the light of these the

Task Force concluded that we should not seek to standardise all the permutations of the 'link' and the projection, though the terminology of the library may be applicable to either.

In particular the Task Force concluded that its previous treatment of the ONS 2004-based projections, where they had been 'forced' back to 1992 by appending smoothed actual improvements was inappropriate. These have now been removed and the ONS 2004-based projections now commence from values of 100% in 2004. Note that projections similar to those in the draft library could still be used with a "92" Series table, but (if required) should now be disclosed as, e.g.:

PSAC_Male_ONS_EW_2004_50 *for improvements up 30 June 2004*, and
ONS_2004_Male_EWNI_Principal *for improvements from 30 June 2004 onwards*.

2.5 Very old ages

In Working Paper 27 we drew attention to the commonly-used assumption of a limiting age of 120. There were several comments on this, but also on the assumptions that apply above age 90 more generally. With hindsight, the Task Force recognises that the use of a single assumption (which, for many of the projections, was that the same improvements apply at these older ages as at the highest age within the projection) did not convey the range of approaches that could be legitimately taken in dealing with an area of extreme data shortage, and we thank those respondents who drew our attention to this.

The comments received in this area are detailed in section 4.3. Assumptions at these very old ages are hugely uncertain, as there is very limited data to assess current rates of mortality, let alone interpret rates of improvement. The Task Force has therefore retained its original assumption for the projections in version 1.0 of the library, but has sought to illustrate this uncertainty by way of alternative scenarios in section 8 of the user guide.

2.6 Illustrating uncertainty

Prior to its publication, the Task Force debated at length how it could illustrate uncertainty in P-spline and Lee-Carter projections within the draft library. This is difficult to achieve for Lee-Carter, and the Task Force was concerned that including additional P-spline projections to this end might make the library unwieldy and might be interpreted as a preference for this methodology. As a result, the draft library contained only 'best estimate' projections, and we asked a number of questions about whether and how the library could be extended to illustrate uncertainty (questions 9.1 to 9.3).

There was support from respondents for incorporating additional P-spline projections, in particular for the 2.5 and 97.5 percentiles, but for many other percentiles too. However to do this for all the 9 P-spline projections within the draft library would have added a further 18 projections, yet not provided any simple method of accessing other percentiles.

The Task Force considered adding the percentile as a variable, so that any percentile could be generated for any of the P-spline projections, but this increased the size of the spreadsheet considerably, potentially impeding access to all the projections in the library. This approach was therefore rejected.

The Task Force has therefore opted for an alternative approach. Each of the P-spline projections has been extended to include not only the 50^{th} percentile projection (hard-coded) but also the additional values that enable a user to produce a projection for any percentile.

The user guide provides full details of how this is done and some sample annuity values to allow users to cross-check their calculations (the 50th percentile can also be reproduced by the user to this end, of course).

For the Lee-Carter model there appeared to be some support for the CMI producing CDs of sample projections. Arguments in favour included:

- "*It would support the Task Force's objective of consistency between actuaries using the 'same' projection*";
- "*It would support the need for prudence, which is not achieved with the central projection*"; and
- "*If we are illustrating uncertainty for P-spline by including standard errors then we should do so for Lee-Carter to avoid apparent favouritism.*"

However the Task Force was not convinced whether these CDs would actually be used in practice, particularly as a number of respondents expressed some doubts over the merits of the basic Lee-Carter model. We are not therefore making such CDs available at the current time, but will consider doing so if there is sufficient demand.

2.7 Suggested further reading

In Working Paper 27, we asked whether actuaries would find it helpful if a 'Recommended Reading' list (on mortality) were established on the Profession's website, and what else the Profession or the CMI should consider doing to help actuaries further enhance their understanding in this field (see the responses to questions 10.1 and 10.2 for more detail). Many of the suggestions received in response to these questions are outside the remit of the Task Force or even the CMI, but we will seek to ensure that these areas are discussed within the Profession.

However given that all the responses to question 10.1 indicated that a 'Recommended Reading' list would be very helpful, the Task Force is pleased to offer the following as a first draft of a suggested reading list for mortality projections:

- "Disease and Death" Love H. and Ryan D (available from www.sias.org.uk).
- "Two-dimensional mortality data: patterns and projections" Richards S. J., Ellam J. R., Hubbard J., Lu J. L. C., Makin S. J. and Miller K. A.
- "Longevity in the 21st century" R C Willets, A P Gallop, P A Leandro, J L C Lu, A S Macdonald, K A Miller, S J Richards, N Robjohns, J P Ryan and H R Waters,
- "National population projections 2004-based" (available from the ONS and GAD websites – see the References section at the end of this paper)
- "Should projections of mortality improvements be subject to a minimum value?" Baxter, S
- "The cohort effect: insights and explanations" R C Willets

(All of the other papers can be found on the Profession's website: www.actuaries.org.uk.)

We hope that actuaries will find our suggestions helpful. It is by no means a complete list, and many other useful documents exist; however we have deliberately sought to keep the list concise to encourage actuaries to read at least these papers.

3 Responses to specific questions

Working Paper 27 contained a number of specific questions for feedback. Many of the responses received covered each of these questions separately and these responses are considered below. In addition we have included in this section comments that were not made in response to a specific question, but where the Task Force felt that the response addressed similar areas. Other items of feedback that did not easily relate to a specific question are considered in section 4.

3.1 The draft library of projections

Section 3 of Working Paper 27 introduced the draft library of projections and discussed some generic technical aspects before the specific projections were introduced in subsequent chapters. It contained two specific questions:

Q3.1 Do you agree that a defined naming convention is a desirable feature of the library? If not, please state why.

Q3.2 Do you agree with the naming convention adopted for the draft library? If not please state suggested changes, with reasons.

Note that there were also two further specific questions, Q6.1 and Q7.1, regarding the naming convention for P-spline and Lee-Carter projections, respectively. In this section we seek to deal with the general responses on the naming convention and those relevant to projections, other than P-spline and Lee-Carter, in the draft library

All those who responded to question 3.1 agreed that a naming convention was desirable in order to provide clarity and to introduce consistency of disclosure (where required). One respondent suggested that "*it would be a bonus if other interested stakeholders such as TPR and PPF agreed to the proposed definitions"*.

One respondent did suggest that "*... it will need to be made clear that projections other than those included in the library may be suitable and therefore a projection which cannot be named using the library's naming convention can still be valid*." The Task Force thought that this point had been made in Working Paper 27 and in presentations, but is happy to reiterate this point.

One respondent agreed that whilst desirable "*...it seems almost impossible to define a naming convention that achieves a suitable balance between brevity and flexibility. Our preference, therefore, is to prescribe the areas which should be disclosed rather than wrapping them all up into a single 'code'*." This is discussed in section 2.2 and for P-spline projections in section 3.4.

One of the key areas that arose from responses to these questions concerned the fact that actuaries might often use a different projection to cover the gap between the date of a base table and the valuation date from the projection used for future improvements. The Task Force has now recognised this more explicitly and this aspect is discussed in section 2.4 ('Mind the gap').

The second key area was the completeness of the names of P-spline and Lee-Carter, where several respondents made comments along the lines of: "*As the suggested naming convention*

does not contain all information necessary to construct the particular P-spline or Lee-Carter projection this would need to be the case in order to ensure that the exact projection used is clear. However, this gives potential for the library to be seen to contain 'standard' parameters with any deviation from these being a 'deviation from standard'. This could give the wrong message." This is definitely not our intention. Other parameters may be equally valid and those used within the library are not intended to be regarded as standards. However we nonetheless have retained the abbreviated naming convention for these projections, to allow the specific projections from the library to be easily referenced.

There were also a number of points of detail raised in relation to the naming convention in the draft library. Specific comments are documented below:

- "*It was unclear why in both the P-spline and Lee-Carter projections 'Ass' appeared in the description of the non-ONS Projections. I suggest replacing with 'CMI'*". The Task Force intends to retain this shorthand for the dataset it has used, which is that for Permanent Assurances (i.e. whole life & endowment policies), as other CMI datasets might be used for projections.
- "*The naming convention in the draft library does not distinguish that the ONS projections included for males … relate to England, Wales and Northern Ireland whilst the female projection relates to the entire U.K. It would be useful for the naming convention to include this e.g. 'ONS_UK_2004_Females_Principal'.*" The Task Force only requested access to these particular projections for the draft library. However, as indicated in section 3.2 below, the CMI has subsequently requested – and received – the ONS 2004-based projections for males in Scotland and has included these in the library. We have amended the names appropriately.
- "*We think that clarification is needed as to whether this exact convention should only be applied to the appropriate library projection. For example, were we to refer to an in-house P-spline 50% projection for Male Assured data up to 2004 (perhaps run on different parameters to that in the library), could we also refer to that projection as PSAP_Male_Ass_2004_50? Or does this label only refer to an 'official' CMI library projection? If the latter, then we think it would be clearer to add an additional prefix acronym into the names – such as 'LP' – to indicate that this is a 'Library Projection'.*" The Task Force sought to make clear that the naming convention is a form of shorthand that can be used where external disclosure of a mortality projection is required. The convention relates solely to the projections in the library or to specified variations – if different parameters are used, these should be disclosed. Given this we do not see any need to append a prefix such as 'LP', as the shorthand necessarily refers to a projection from the library.
- "*We suggest fitting parameters, where relevant, be shown at the top of each projection sheet.*" A more complete set of parameters has been included within version 1.0 of the library.
- "*If one or more tables develop as a standard then perhaps a simpler name would be nice at that time.*" Agreed!
- "*Average (Medium Cohort_Long Cohort) seems an inflexible convention. A convention along the lines of Blend(50%Medium Cohort_50%Long Cohort) or simply (50%Medium Cohort_50%Long Cohort) would seem more flexible as it would also allow, for example, a 75%/25% blend to be specified. The 90% of Medium Cohort example could also fall within such a naming convention.*" The Task Force accepts the first point and has adopted this in version 1.0 of the library. Whilst we agree that

90% Medium Cohort is a specific example of a more general name, we saw merit in continuing to include one example as a specific illustration of this approach in the library.

- "*We suggest that the Cohort projections make reference to 92 e.g. '92 Short Cohort'.*" Whilst other projections may take account of cohort effects, the Task Force is not aware of other projections being referred to as 'Short/Medium/Long Cohort' so consider this unnecessary.
- "*Where minimums apply, they should be constructed and described as being independent of the 'unfloored' improvement rate. For example, actuaries should say 90% of Medium Cohort subject to a floor of 0.9% rather than 90% of {Medium Cohort subject to a floor of 1%}.*" The Task Force agrees that the former is clearer and has included a specific example within version 1.0 of the library to help encourage this practice. We hope that the brackets in the names of the projections also help to clarify this practice.
- "*Should the naming convention standardise practice where there is an age adjustment? For instance if there is a +2 year age adjustment should a 60 year old follow the improvement path for a 60 or 62 year old after the age rating is applied.*" The Task Force considers that the use of the naming convention means that the projection has been applied to the age that is intended, but accepts that this may not be appropriate if an age adjustment has been applied to the base mortality assumptions (for example, if the projection incorporates cohort effects). Using the projections with any adjustment from that set out in the library should be disclosed, if necessary, as an adjustment to the norm.

Finally, one respondent suggested the CMI should "*put together some standard examples of good descriptions of mortality improvements with a recommendation that improvements are disclosed in a similar way.*" The Task Force considers that unless drawn from the library or a recognised variation thereon, this is outside our scope, and may be more appropriate for regulators or others users of disclosures to consider.

3.2 Previously-published tables of projections

Section 4 of Working Paper 27 provided background information on the previously-published tables of projections included in the draft library, namely the "92" Series projections, the Interim Cohort Projections and the ONS 2004-based National Population Projections. It contained two specific questions:

Q4.1 Are there any other previously-published tables of projections that should be included in the library for use in the UK? If so, please state which tables, with references, and explain why these may be useful.

Q4.2 Do you agree with the use of smoothed improvements for 1992-2004 being appended to the ONS projections in the library? Is the P-spline age-cohort model an acceptable smoothing model?

The majority of those who responded to question 4.1 agreed that there were no other such tables that warranted inclusion. The suggestions that were received were:

- One respondent commented that "*It would be helpful if the library included the "80" series projection factors for reference purposes*" but another argued against this. The Task Force has retained its initial decision to 'commence' the library with the "92"

Series projections, as these are still in widespread use, either directly or through the Interim Cohort Projections but not to include any earlier projections.

- One respondent proposed that benchmark A from "Longevity in the 21st Century" be included because it "*...implies that current mortality improvements continue indefinitely which challenges a common recurrent theme of convergence.*" This particular projection has not been included in the library, as the 'current improvements' it used are less current than those on which many of the projections in the library are based. However, the area of developing alternative scenarios is one the Task Force thinks warrants further attention within the Profession.
- One respondent noted that "*...the draft library included ONS projections for England, Wales and Northern Ireland for males and for the entire UK for women – other regional variations would be useful additions.*" The CMI has subsequently requested – and received – the ONS 2004-based projections for males in Scotland and has included these in the library.

In addition, a number of suggestions were received that are not strictly-speaking 'previously-published tables of projections' including:

- Several respondents suggested "*...the unsmoothed improvement rates which underlie the various datasets (e.g. CMI Male Permanent Assurances from 1947 to 2005) should be included for completeness.*" The Task Force agree that the actual improvements warrant attention, but did not think they should be included in the library as it is intended to be a repository of projections. Given that the raw data on exposures and deaths has been made available alongside the projections software, it would be a duplication to also publish them separately. In addition the unsmoothed improvements are exceedingly volatile by age and year and hence difficult to use in practice.
- One respondent noted "*... other previously developed mortality models could be applied to the current datasets and considered for inclusion in the draft library.*" Models specifically referred to were Alho Spencer, Olivier Smith, and the work of Renshaw, Haberman, Sithole etc. The Task Force notes that considerable applied research is required to investigate the suitability of a projection methodology and does not intend including any projections based on these methodologies without such research having been undertaken and the Profession having an opportunity to review such analysis.
- One respondent noted "*... the ONS 2004-based projections only use target rates* [after 2029] *of 0% p.a., 1% p.a. and 2% p.a. Projections developed consistently, but converging to a wider range of long term improvement rates could usefully be added to the library.*" The Task Force would be happy for such projections to be developed and exposed to the Profession but felt it was outside its scope to attempt this. It was also concerned that in doing so, and adding such projections to the library at this stage, could be interpreted as giving them undue prominence.

Almost all the respondents answered "Yes" to both parts of question 4.2, although several noted that as we had not made available the actual changes in the ONS dataset for 1992-2004 they were unable to judge whether or not the P-spline age-cohort model is an acceptable smoothing model. One response went further in pointing out that this took away from an actuary the ability to satisfy him or herself that the smoothing process was reasonable and therefore came close to setting a technical standard in this regard.

Two respondents referred to the ONS's own smoothing model, one suggesting that actuaries understanding of the appropriateness of the ONS projections would be enhanced if the CMI could obtain permission from the ONS to publish the smoothed improvements on which the 2004-based projections were based. The Task Force believes that the ONS has published a reasonable level of information on the derivation of the 2004-based projections (see "National populations projections" in the references) that gives actuaries the opportunity to gain such understanding, whilst acknowledging that the actual projections are not available in sufficient detail to allow them to be incorporated into the library.

One respondent highlighted that "*...the approach adopted by the Task Force for the draft library resulted in undesirable discontinuities in the draft library around 2004 in the ONS 2004-based projections and that the ONS_2004_Male_Principal projection in the draft library, for example, could be described as:*

PSAC_Male_ONS_2004_50 up to the improvement between 2003 and 2004,

and ONS_2004_Male_Principal for improvements from 2004 onwards."

He concluded that the Task Force should not append improvements for 1992-2004 to the ONS projections included in the library, which should start from 2004.

Since publishing the draft library, the Task Force had also been considering this further and reached a similar conclusion. This is discussed in the earlier section 2.4 ('Mind the gap').

3.3 Adjusted Interim Cohort Projections

Section 5 of Working Paper 27 provided background information on variations to the Interim Cohort Projections that the CMI understood were currently being used and hence included in the draft library.

Within the draft library we included a single illustrative projection for each variation and the first two specific questions related to this:

Q5.1 Do you see benefit in including additional examples of each variation? If so, please state what examples and explain why these are needed.

Q5.2 Do any additional examples need to be included in the library, or within the CMI Tables Program?

With one exception, all the responses to Q5.1 supported the Task Force's initial view that there was no benefit in including additional examples of the adjusted cohort projections.

The respondent expressing a contrary view fully understood the reasoning for including a single illustrative example of each variation in the draft library, to ensure consistency of application across the Profession, but was concerned with the "*potential for herding*" whereby, despite the CMI's assertions, the projections are adopted as *de facto* standards. He evidenced this 'herding' by reaction to the Interim Cohort Projections, which occurred despite the warnings (in CMI Working Paper 2) that the projections were *"...three of a possible wide range spectrum of future projections...*" and that they were produced as *"...an aid to actuaries who can adjust (or ignore) the results as they judge appropriate*". His suggestion to reduce the risk of future 'herding' was that a range of minima (e.g. from 0% to 5% at intervals of ½%) and percentages should be included.

The Task Force acknowledges these arguments and considered parameterising these variables within the library. We have however concluded that the most practical approach is to include

a single illustrative example of each variation in the library, whilst seeking to ensure that the user guide continues to make very clear that the single example should not in any way be seen as recommended.

Several respondents noted that the two variations of minimum values included in the draft library were at a similar level (1% and 1.5%), which could be (incorrectly) interpreted as implying that where a minimum value is applied, it should be of that order. Consequently it was suggested that a significantly larger minimum (e.g. 3%) be used in one of the examples. The Task Force understands this argument but was concerned that changing the values used in the draft library might be misinterpreted to mean that the CMI now considers that those values were too low, when we do not intend saying anything about what the minimum should be. In addition, at many ages and in many years, applying a minimum as high as 3% would override the features of the underlying projection so that it would have limited benefit for checking purposes, and the purpose of using it as an illustration of the approach may be undermined.

Nonetheless, as noted under Q5.3 below, the Task Force saw the need to include an additional variation on a cohort projection (a percentage of a cohort projection with a minimum) and has used a higher minimum value for this example, at 2.5% p.a.

Most responses to Q5.2 indicated that no further examples needed to be included, although a number commented that it would be useful for the library or the CMI Tables Program (STP) to allow the minimum or percentage to be input as a parameter so that any example could be generated.

The third specific question asked whether the list of variations was complete:

Q5.3 Are there other variations to the cohort projections that are currently being used that might be suitable for inclusion within the library? Please provide full details.

Most respondents stated that no further variations needed to be included and a review of FSA returns for the year ending 31/12/2006 did not identify any other variations in sufficient volume to merit inclusion in the library.

The only exception was a request, from several respondents, for an example of a percentage of a cohort projection with a minimum value applied. The Task Force accepts that this is as valid as the other variations included in the draft library and has included an example within version 1.0 of the library.

The fourth specific question asked whether the method proposed by the Task Force to apply each variation was reasonable:

Q5.4 Do you disagree with the proposed method for applying any of these variations? If so, please explain your alternative approach with reasons, if possible.

Almost all the responses agreed with the approaches to applying the variations proposed in Working Paper 27 although one respondent noted that "*The problem lies in ensuring that, despite its publication in the library, this method is not seen as the* ***only*** *method for undertaking such manipulations.*" We hope that we make this sufficiently clear in the user guide.

The only exception arose from a comment on using a percentage of the cohort projection where, if a percentage of less than 100% is applied to a cohort factor, the resulting improvement factors can be lower than the original "92" Series projections. The respondent posed the question "*Should the "92" Series always be a minimum for any cohort projection?*" The Task Force agree that this may not be a desirable feature of a projection from 1992, given that the improvements up to 2000 in the "92" Series and the cohort projections reflect the smoothed actual improvements from that period, but felt that to impose a restriction would perhaps suggest that the method carries more credibility than it warrants.

The final specific question of this section asked a more detailed question on the method to apply a minimum value proposed by the Task Force:

Q5.5 In particular, should a minimum value be applied to m_x for consistency with ONS projections, rather than to q_x?

The majority of responses agreed with the approach used in the draft library of applying the minimum to values of q_x. One respondent noted that "*A minimum value to mortality improvements is most naturally interpreted as applying to the underlying convention of the projections themselves. Since the previously published CMI projections relate to improvements in q_x, and the ONS projections to improvements in m_x consistency is unlikely to be achieved by either approach. Further, a minimum value could meaningfully be applied to any projection in the library. A simple solution would be for the CMI to highlight that when using a minimum value with mortality projections it is necessary to disclose both the numerical value of the minimum and the quantity to which it has been applied.*" The Task Force accepts this comment generally but for the examples in the library where a minimum is applied to a cohort, considers it unnecessary for users to explicitly state that the minimum has been applied to values of q_x.

One respondent did suggest that the CMI might convert the ONS data into q_x's. The Task Force rejected this, not least because it would interfere with a recognised approach. Additionally it is worth highlighting that the ONS 2004-based projections use target values, applied to m_x, not minimum values.

Finally there was one response that suggested that the variations to the Interim Cohort Projections should not be included in the library at all, because of a concern that other variations not included in the library might then be deemed unacceptable. The Task Force rejects this conclusion although it recognises that the message that the library is not a complete set of acceptable projections must be stressed repeatedly.

3.4 P-spline projections

Section 6 of Working Paper 27 provided background information on P-spline projections and, specifically, the examples included in the draft library.

The first specific question related to the naming convention that had been adopted for the P-spline projections in the draft library:

Q6.1 The naming convention does not fully determine the projection for the P-spline model. Is it sufficient? If not, what other features of the fit do you think need to be included within the name?

Most respondents felt that the naming convention was acceptable. However there was a notable minority who disagreed, concluding that a 'full' naming convention should be used, for example "*By not including the full information in the naming convention there is a risk that users of the library will interpret this as indicating that either:*

- *The non-disclosed parameters are not significant and so need not be thought about; or*
- *The values used for the non-disclosed parameters are suitable 'defaults'.*"

The Task Force understands this argument but feels that a full description of all the parameters underlying a P-spline projection is too lengthy and becomes unwieldy. One respondent proposed the following, using the example of PSAP_Male_Ass_2003_50 from the draft library:

Model:	P-Spline, software as released by CMI on [date]	
Penalty:	age period	
Data set:	CMI Male Assured Lives, as released by CMI on [date]	
Data used:	ages 21-90, years 1947-2003	
Knot spacing:	age dimension	4 years
	year dimension	4 years
Knot position:	age dimension	90
	year dimension	last year of data
Penalty order:	age dimension	2
	year dimension	2
Degree of basis:	3	
Forecast period:	50 years	

The Task Force accepts the technical accuracy of such a description but decided to retain the proposed naming convention for the example P-spline projections in the library. This should not be interpreted as meaning that these are recommended projections or that these particular parameters are in any way preferred. We suggest that anyone needing to disclose a P-spline projection that is not itself contained in the library should disclose all the elements of the projection, or those that differ from one in the library, if this is easier.

One respondent suggested that "*each projection in the library should carry an identification number/label, which should be part of the naming convention, e.g. PSAP1_Male_Ass_2003_50. If a projection were included in the library which differed only in (say) the age-range, then that new projection would be named PSAP2_Male_Ass_2003_50.*" The Task Force rejected this idea as although it helps with projections included in the library, it does not help denote equally valid variations on these that are not included as examples in the library.

The second specific question asked whether other examples of P-spline projections could usefully be added to the library:

Q6.2 Are there other variations on P-spline projections that should be included in the library? If so, please state which projections and explain why these are needed.

Most responses indicated that no more examples of P-spline projections were required within the library itself. Suggestions that were made included:

- "*It would be helpful to have projection tables for datasets covering only (say) the last 20 years of experience (e.g. 1986-2005).*" Whilst more research into such matters might be illuminating, it is not currently planned by the CMI nor would the Task Force consider that such projections necessarily warrant inclusion in the library unless they had clear merit in comparison with the projections already in the library.
- "*Given the objective of making the CMI's recent work more accessible, it would be beneficial for the variations included to illustrate key features of the model. We would therefore welcome a wider range of cut off years for each data source to better illustrate variation from adding an additional years data.*" The Task Force does not believe that this is the role of the library – a fuller development is provided in Working Paper 20 and also feels that the 3 end-years included within version 1.0 of the library adequately illustrate the sensitivity of the P-spline projections in this regard..
- "*It would be useful for some variations to be included to help actuaries understand how the results can vary with different assumptions on knots or penalties (e.g. 5 year knot spacing compared to 7 year knot spacing). Depending on how sensitive the projections are to different assumptions then actuaries may find some guidance in the use of the assumptions useful. Whilst this is probably the role of the BAS, the CMI could help by giving an indication of the significance.*" A similar response to the previous point applies here.
- "*...the projections change significantly from year to year which is heavily influenced by recent experience. It would be useful to consider whether the use of different variables would help reduce some of this variability.*" The Task Force would welcome further research in this area, but has no plans of undertaking such research itself.

There were also some more general comments about P-spline projections made in response to these questions:

- A number of respondents made comments similar to "*...projections from the PSAP model are not particularly robust and can change dramatically depending on the estimation period used. We would therefore suggest that P-spline comes with a 'health-warning' to this effect within the library.*" Indeed, one respondent suggested they should not be included in the library at all for this reason. The Task Force believes that the inclusion of these projections does serve a valuable purpose in illustrating the variety of possible projections, even if actuaries choose not to use some examples as central assumptions.
- "*We have some concerns over the inclusion of projections based on ONS data. First, as the ONS data is not (currently) publicly available, actuaries are not able to generate variations on the ONS P-Spline projections provided. This would lead to the ONS P-Spline projections published in the library becoming the standard ONS P-Spline projections. This would seem to be at odds with the desire for individual actuaries to take responsibility for the details of the projections they choose to use.*" The Task Force would also prefer a clearly-defined ONS dataset to be more widely available, but in its absence does feel it is better to include these example projections in the library than not.
- "*...using the ONS dataset with P-Spline projections results in life expectancies that in some cases show extreme variation from year to year (e.g. 19.024 to 38.211 shown in the table on page 20 of Working Paper 27). This is perhaps due to the way the penalty function (which balances smoothness and goodness of fit) is set. The approach implicitly assumes fully accurate measurement of data (which is clearly*

incorrect in relation to the methods necessarily used in estimating effects of immigration etc in the exposure element of the ONS data) hence too much credibility is given to the data. The view may be taken that this data source should not be used with the P-Spline method, but its inclusion in the library could be viewed as supporting its reasonableness. On the other hand, it may be beneficial to include the examples to demonstrate the issue – however in our view a visible caveat would then be appropriate." The Task Force agrees that inclusion within the library should not lead to a projection being deemed 'reasonable'. Whilst we also recognise the issues regarding measurement within the ONS dataset, we consider it unlikely that any substantial dataset can be regarded as "fully accurate". Whilst the CMI uses its best endeavours to ensure the quality of data submitted for life offices and pension schemes, it is likely that there are issues that the CMI is unable to detect.

- "*We note the comments in Appendix B of Working Paper 27 relating to the criteria for inclusion of potential datasets (i.e. 20 years data and large amount of data for each year for ages fitted). However we would also observe that the Male Pensioner dataset (http://www.actuaries.org.uk/files/cmi/AOMPensionerCrude.zip) provided with CMI Working Paper 1 contains data from 1983 onwards (hence would now meet the 20 year criteria). In addition above age 70 it contains greater data volumes than the assured lives dataset (http://www.actuaries.org.uk/files/cmi/ALCrudeRates.zip). Given that the projected experience at higher ages is of particular relevance, we would suggest that clarification is provided as to why this dataset is viewed to be inappropriate for use with P-Spline techniques (over a restricted range of ages), or alternatively sample P-Spline projections using that dataset are provided (with caveats as appropriate).*" The Task Force was principally seeking to collate research that has already been undertaken and projections based on the Life Office Pensioner dataset have not previously been made available. One key reason for this is the lack of data at 'younger' ages means that cohort effects are less likely to be clearly identified. Inevitably, this means that cohort effects will also be absent from any projections based on that dataset. As a result the Task Force considers this dataset may be less useful for generating projections than the CMI Permanent Assurances and ONS datasets, but would welcome research into this.

3.5 Lee-Carter projections

Section 7 of Working Paper 27 provided background information on Lee-Carter projections and, specifically, the examples included in the draft library.

The two specific questions in this section were analogous to the P-spline questions above; the first related to the naming convention that had been adopted for the Lee-Carter projections in the draft library:

Q7.1 The naming convention does not fully determine the projection for the Lee-Carter model. Is it sufficient? If not what other features of the fit do you think need to be included within the name?

As for Q6.1, most respondents felt that the naming convention was acceptable. However there was again a notable minority who disagreed, concluding that a 'full' naming convention should be used, for similar reasons. One of the few comments made specific to Lee-Carter projections was: "*...the ARIMA process element of the Lee-Carter model means that it can be considered as a form of long-term trend averaging. Consequently it is important to understand the length of the period to which the model has been calibrated i.e. the dataset*

parameter in the library." The Task Force has again retained the proposed naming convention but accepts this particular point, noting that use of a different length of dataset is one of the items that should be disclosed if the naming convention is used but the projection is not exactly as specified in the library.

The second specific question asked whether other examples of Lee-Carter projections could usefully be added to the library:

Q7.2 Are there other variations on Lee-Carter projections that should be included in the library? If so, please state which projections and explain why these are needed.

Again the responses to this question were very similar to those to Q6.2 and are not repeated here. Several responses suggested including some projections from the Lee-Carter age-period-cohort version, whilst accepting that further work was required first. It was also suggested that a version of the CMI projection software incorporating this method would also be welcome.

There were fewer general comments about Lee-Carter projections made in response to these questions than to the corresponding questions on P-spline projections. This may reflect the more recent publication of the CMI's research in this area. The few comments that were received expressed concerns about the inability of the basic Lee-Carter model to project cohort effects.

3.6 Illustrating the choice of projection

Section 8 of Working Paper 27 sought to initiate a discussion of alternative approaches to illustrating projections, particularly to non-actuaries.

The first specific question related to the approaches included in Working Paper 27:

Q8.1 We would welcome views on which method(s) of illustrating differences in projections are found to be the most useful.

There were views expressed in favour of each of the 4 approaches illustrated in Working Paper 27, whilst others recognised that all were useful and the preferred would depend on the particular purpose. Some of the comments on the specific methods are set out below:

a) Heat maps

- "*... particularly useful in enabling the features of the relative improvement rates to be quickly seen, particularly when cohort effects are present.*"
- "*... are inconvenient for reading off the numbers.*"
- "*... useful for actuaries to compare different projections ... too complex for the majority of situations ...*"
- "*...can be effective for illustrating general trends, but poor for comparing alternative projections.*"

b) Mortality improvement graphs

- *"... simpler than heat maps ...convey messages without the need for a huge amount of additional explanation."*
- *"Some of the more technical information that would be conveyed using a heat map is lost ... making these less suitable for detailed technical analysis."*

- *"... allow comparison of alternative projections, but only capture the effect for a given cohort, which may be unrepresentative of the wider picture."*
- *"... can be quite confusing if too many alternatives are shown on the same graph."*
- *"... can be misleading."* This comment is considered further below.

c) Expectations of life

- *"... (and annuity values) are more practical for comparing several of the projections and are easier to understand for a wide range of audience."*
- *"... (and annuity values) are more accessible but provide less information about the underlying assumptions."*
- *"The recipients of actuarial advice are often pensions trustees with less highly trained analytical skills. With an audience of such nature it is often far easier to discuss assumptions in terms of quantities which the audience has an inherent understanding of – namely expectation of life."*
- *"...the most intuitive though but does exaggerate the differences so annuity factors are necessary to help quantify the financial impact."*
- *"... important because of the FSA requirement that these are disclosed."*
- *"... increasingly used by analysts as a measure for comparison of firms' mortality bases."*
- "*... a single distinct figure and as such hides a number of factors, most notably the split of the base and improvement elements of the mortality basis. In order to overcome this we advocate the view that it would be better to quote an overall expectation of life and, in addition, the split of this figure into a base and improvement element (i.e. the base element accounts for x years and the improvement element the remaining y years)."*
- "*... does not give an indication of the financial impact of using different mortality projections due to the disproportionate weight given to cash flows occurring far into the future.*"

d) Annuity values

- "*Expectation of Life and Annuity Values are both useful methods of comparing the effect of projection bases. The former allows for an intuitive check into the strength of a basis, whereas the latter is more useful in a financial context.*"
- "*... useful to quote results for a range of interest rates to highlight the impact of changes in the economic environment on these values.*"
- "*As with expectation of life, the base and improvement elements remain "hidden" when using annuity values and this is a big disadvantage.*"

As noted above, one respondent found the mortality improvement graph on page 18 of Working Paper 27 misleading, "*... it appears to indicate that use of the P-spline projections is considerably stronger (i.e. higher improvements) than the use of Long Cohort. From this, we would expect the annuity value at age 65 to be higher. But this is not so in the table on page 20 (13.503 compared to 13.209)*". The Task Force accepts that the comparison provided in Working Paper 27 is misleading; the projections in the annuity values started from 2000, whereas the graph only started from 2005. The apparent 'strength' of Long Cohort, in comparison with the P-spline projections arises from the higher rates of improvement between 2000 and 2005, not in the subsequent improvements. The user guide now shows annuity values from 2007 (see below) and the apparent inconsistency no longer arises.

Finally, one respondent noted that "*…it is important that the use of the projections for life assurance is not overlooked in favour of the use of the projections for annuity business. Hence for annuity business it may be more common to look at views starting at older ages, but this is not the case for life assurance where a younger age profile is likely to be more common.*" The Task Force accepts this comment but notes that the library is aimed principally at pension and annuity business. This is considered further in section 4.1.

Q8.2 Are there alternative suggestions for illustrating different projections?

- Our attention was drawn to recent work on fancharts by Blake, Dowd and Cairns (see references to the Pensions Institute documents, PI-0705 and PI-0704).
- "*Also useful is expression in terms of equivalent constant annual rates of improvement.*"
- "*Ultimately, showing the actual results (e.g. Pension scheme balance sheet and contributions) on different projections is the best way of illustrating sensitivity.*"
- "*Age-period cross-sections of the heat maps can also be useful in addition to the age-cohort cross-sections envisaged in 8(b).*"
- "*We believe that the use of 2-D graphs showing improvements in life expectancy over time for different age groups (perhaps 5-year bands) would be more useful than heat maps in at least some situations as such graphs are more easy to read and interpret.*"
- "*It might be useful to express the projections as changes to life expectancy. For instance one of the projections gives an expected change in life expectancy from 27.661 to 42.029 years over a twenty year period. This could be expressed as a 2.11% per annum improvement in life expectancy.*"
- "*The mortality improvement graphs in section 8b) show the improvements for a life with a given year of birth. An alternative approach is to show improvements at a given age (i.e. a horizontal rather than diagonal slice through the heat maps referred to in 8a). This latter approach may be preferred as it illustrates only the variation of improvements over time.*"
- "*It is often useful to convert the grids of improvements to what they mean in terms of mortality (or survival) curves. This is because it is possible to generate improvement factors that seem plausible, but once converted to mortality curves (either for a particular birth cohort or calendar year) contain features that are harder to reconcile (e.g. 'humps').*"
- "*Age adjustments could be used to illustrate different mortality improvement assumptions*" noting, in particular, that this offered some respite from the 'limiting age' issue.

The Task Force notes that there are a number of suggestions that have advantages (and disadvantages) compared with the four approaches included in Working Paper 27. We are concerned that use of a wide range of means of illustrating projections may confuse users of actuarial advice and that they may be drawn into inappropriate conclusions by the particular method used, but do not think this is an area where the CMI has a role beyond stimulating the initial debate.

The final specific question related to the annuity values and expectation of life values given in Working Paper 27 to illustrate the different projections:

Q8.3 Does the range of ages and values within these tables provide a useful means of comparing the various projections? If not please state how you would suggest amending them.

Most responses indicated that the range was adequate, however there were some comments suggesting that additional values would be helpful:

- "*For completeness, it would also be useful to have values for ages 75.*"
- "*...values for age 85 and older would be useful.*" Whilst the Task Force acknowledges the principle, it deliberately did not show values above age 80, given the arbitrary nature of the projections at the oldest ages (90+) noted earlier in section 2.5.
- "*... values at younger ages are required for pricing and reserving for life assurance.*" As noted under Q8.1 above, the library is aimed principally at pension and annuity business.
- "*It would be helpful to illustrate the annuity values on more than one interest rate.*"
- "*The discounting to age 65 in the deferred annuity values is unhelpful as it prevents comparison with the immediate annuity at age 65.*"
- "*Continuous annuities would be preferred.*"
- "*Annuity values at a lower interest rate to illustrate the effect of inflation linked policies would be useful.*"
- "*It would help if some projections were shown as at 31st December as these would tie in with the expectations of life which need to be reported in the FSA Returns.*"
- "*It would be insightful to include a single life annuity with attaching 45% reversionary annuity which would be indicative of the impact on pension scheme valuations. This value is particularly helpful when comparing projections that have substantial differences in the assumed improvements in mortality rates at the older ages since the inclusion of the reversionary annuity can materially alter conclusions on the financial impact. Such annuities could usefully be included at ages 65 and 75 (to assess the financial impact in respect of current pensioners) and at ages 45 and 55 with deferred periods of 20 and 10 years respectively (to assess the financial impact for future retirees).*"

The Task Force appreciates the merits of these suggestions, but has not altered the range of annuity and expectation of life values included in the user guide from those in Working Paper 27, other than as noted below. We felt that to allow for all the suggestions would produce far too many numbers and thereby possibly make the exercise less meaningful. Actuaries can of course calculate their own comparisons, and may find the figures in the user guide useful as a check on their calculations.

The main change to the values included in the user guide arises from two responses that highlighted a misleading aspect of the values included in Working Paper 27. As stated on page 21, the base mortality for these calculations was set to 100% PCXA00 as at mid-2000, but were calculated for a life aged x exact on 1 July 2005. As a result the values in the table also included the improvement between 1 July 2000 and 1 July 2005, which differed between the projections. Readers of Working Paper 27 may have inferred misleading views of the strength of projections from the relative annuity and expectation of life values of the different projections as a result of the different level of improvements between mid-2000 and mid-

2005. The Task Force would like to apologise for any confusion caused by this misleading comparison.

In addition, one response asked why we had shown values at 1 July 2005, rather than a more recent date such as 1 July 2007.

As a result of these two points, the tables in the user guide illustrate annuity and expectation of life values as at 1 July 2007 using a common assumption regarding base mortality at that date. The differences between these values (for males and females separately) is then only a function of the future projection from that date.

3.7 Illustrating uncertainty

P-spline and Lee-Carter models both produce measures of uncertainty, but the projections in the draft library did not illustrate this uncertainty. Section 9 of Working Paper 27 discussed these measures of uncertainty and sought views on whether and how they should be incorporated in the library through three specific questions, the first of which related to P-spline projections:

Q9.1 We have not included any P-spline projections other than 50th percentiles in the draft library. Do you see benefit in including examples based on other percentiles? If so, please state what examples and explain why these are needed.

A number of respondents suggested it was unnecessary to include any other percentiles, given that the CMI has made illustrative software freely-available and illustrated uncertainty for the P-Spline and Lee-Carter methodologies in Working Papers 20 and 25 respectively, however most respondents felt that including percentiles other than the 50^{th} would be beneficial.

Arguments in favour included to validate actuaries own use of the software and to provide easy access to illustrations of uncertainty for those not prepared to use the software. Another important point made was that individual actuaries may only be able to generate results using the CMI dataset, as the ONS data has not been made publicly available.

As to what examples should be included, there were specific requests for a range of percentiles (97.5^{th} and 2.5^{th}, 95^{th} and 5^{th}, 90^{th} and 10^{th}, 75^{th} and 25^{th}, etc), each made with supporting arguments. The Task Force decided that it would be impractical to incorporate such a range of percentiles for each of the P-spline projections within the library without making it unwieldy.

The Task Force considered adding the percentile as a variable, so that any percentile could be generated for any of the P-spline projections, but this increased the size of the spreadsheet considerably, potentially impeding access to all the projections in the library.

The Task Force has therefore opted for an alternative approach, suggested by two respondents. Each of the P-spline projections has been extended to include not only the 50^{th} percentile projection (hard-coded) but also the additional values that enable a user to produce a projection for any percentile. The user guide that accompanies the library provides full details of how this is done and some sample annuity values to allow users to cross-check their calculations (the 50^{th} percentile can also be reproduced by the user to this end, of course).

The other specific questions in this section related to Lee-Carter projections:

Q9.2 We have only included central Lee-Carter projections in the draft library. Do you see benefit in illustrating uncertainty from the Lee-Carter model within the library?

Q9.3 If so, should this be done by:

- ***Including percentiles based on ranking mortality rates at each age, or***
- ***Including percentiles based on ranking annuity rates, derived using a stated set of assumptions regarding base mortality and interest rates, at each age, or***
- ***Making available CDs containing sets of (say) 1,000 simulations for actuaries to manipulate themselves?***

In response to Q9.2, there was again a mixed response with a majority in favour of some illustration of uncertainty.

As to how this might be done, there were relatively few responses in favour of percentiles ranked by either mortality rates or annuity rates, one response noting that both would need to be provided as neither gives information about the other. Further any illustration using annuity rates would need to provide a wide variety of ages, deferred periods and interest rate assumptions, which destroys the benefits of trying to summarise the data via the use of percentiles.

Of those who felt further information would be useful, the majority favoured the CMI making available sets of simulations on CDs or via the website. Supporting comments noted that this would provide a degree of consistency to illustrating uncertainty in this area and also that the production of such scenarios using the illustrative software is labour- intensive.

Although there was some support for the production of CDs, the Task Force was not convinced whether these would actually be used in practice, particularly as a number of respondents expressed some doubts over the merits of the basic Lee-Carter model. We are not therefore making such CDs available at the current time, but will consider doing so if there is sufficient demand.

3.8 Recent trends in mortality

Section 10 of Working Paper 27 provided some information on recent trends in mortality. The two specific questions both related to what the Actuarial Profession or the CMI should do to help actuaries develop and maintain their knowledge in this area:

Q10.1 Would actuaries find it helpful to establish a "Recommended Reading" list on the Profession's website? Suggestions for inclusion would be welcomed.

Q10.2 What else should the Profession or the CMI consider doing to help actuaries further enhance their understanding in this field?

All the responses to question 10.1 indicated that a 'Recommended Reading' list would be very helpful. As far as the content of the reading list is concerned:

- "*...the References section of Working Paper 27 provides an excellent starting point*";
- "*...a number of recent SIAS and Sessional papers contain references that could also usefully be collated*";
- "*...review articles by Wong-Fupuy and Haberman, and Patacco, are useful references*"; and

- "*...it would be especially useful if relevant recent medical research papers could be included.*"

Additional helpful suggestions regarding the reading list included:

- "*Where links are provided, some indication of the order by popularity would allow actuaries to focus their research*"; and
- "*It would be useful if each item on the list was accompanied by a brief summary to help actuaries identify which papers are most relevant to a particular issue.*"

Finally, one response noted that this could be seen "*...as setting a precedent for other topical areas, where such lists would be equally useful!*" We will seek to discuss this comment and others noted above with the relevant areas within the Profession however, in the interim, we have suggested a short 'further reading' list in section 2.7.

Question 10.2 was intended to elicit suggestions on further steps that the Profession or the CMI should consider to support actuaries. Some respondents – notably larger firms – explicitly commented that appropriate steps are already in place. Other comments included:

- "*The CMI should continue to publish technical updates and advice on the parameterisation and use of the projection software. Most actuaries will be infrequent users and require some 'hand-holding' in the running and best use of the software.*"
- "*P-spline and Lee Carter techniques are pure look-back statistical methodologies for curve fitting and projection. Actuaries need to adjust the emerging statistical results for known or anticipated medical and demographic factors, to develop an appropriate projection basis for use in valuation and pricing. The Profession needs to include relevant articles and research from outside experts on its website. Input from such sources should be considered central to developing a fully reasoned projection basis.*"
- "*Regular training sessions/seminars would be useful.*"
- "*Perhaps the CMI could consider organising a further convention/conference on this subject once the consultation on the library has been completed.*"
- "*Focus research on understanding the drivers of future mortality rather than statistical modelling and further development of standardisation of disclosures. More research into modelling uncertainty and approaches used to combine sources of uncertainty (model, parameter, stochastic etc.) to quantify the likelihood and impact of future events.*"
- "*Research on whether mortality improvements will (or are expected to) level out, possibly by investigating improvement by cause. This could collate the research done by other professions into actual and potential medical developments together with possible threats from diseases.*"
- "*Further research into the impact of smoking on recent trends in mortality, and what the implications of subsequent changes in smoking habits might mean for future rates of improvement.*"
- "*Readily available, standardised, annual updates on mortality improvements together with appropriate commentary.*"
- "*...the Profession, perhaps through the CMI, should seek to facilitate and/or encourage the following activities related to this field:*
  - *Continued research*
  - *Workshops on new developments*

  - *Review and commentary on new academic models*
  - *Monitoring and commentary on international developments.*"
- "*The most important thing for the Profession or CMI to do is stimulate actuaries into thinking about mortality, including constantly reminding us that things are always changing. To do this it is necessary to get across simple early messages about what is going on to the whole profession. If we wait until a small group come to well argued judgments there are delays in general acceptance.*"
- "*Is it worth the Profession considering benchmarking mortality assumptions? This is done in the insurance industry by Auditors and Consultancies for statutory liabilities. The risk is that benchmarks can drag assumptions to the average. The benefit could be that developing trends might become obvious earlier.*"
- "*A mortality 'area' within the Profession's website would also be useful, including relevant CMI papers, links to other research (both actuarial and non-actuarial), presentations, etc.*"
- "*More in-depth coverage of the subject in the actuarial examinations.*"
- "*A CPD course in mortality, akin to the practical financial economics course.*"
- "*Exposure / deaths data for CMI Life Office Pensioners should be made available to allow actuaries to consider recent trends at higher ages.*"
- "*The understanding of many actuaries would be enhanced if Working Paper 27, or any other consolidation type documents / seminars also made reference to key weaknesses / criticisms of the newer techniques (P-Spline and Lee-Carter), as in section 8 of Working Paper 25.*"
- "*Practical training on using the P-Spline and Lee-Carter models (and any subsequent models) would be useful along the lines of that provided initially.*"
- "*Develop models based on cause of death, or enable interpretation of projections in terms of cause of death. Research on improvements outside the cohort.*"
- "*Produce more accessible explanatory material on the projections, for actuaries who do not have a day-to-day involvement in mortality studies, and non-actuaries who have an interest in the subject, including:*
  - *The features of each projection type;*
  - *Any assumptions which are implicit in each projection type;*
  - *Any known advantages or shortcomings of each projection type.*"
- "*Persuade the ONS to publish their data on a regular basis to support further research and develop understanding in this area.*"

We have not commented on these suggestions in this paper. Indeed many of the suggestions are outside the remit of the Task Force or even the CMI. However we will seek to ensure that these areas are discussed within the Profession.

3.9 Future updates

The final section of Working Paper 27 considered the process by which the library should be maintained in the future. The first two specific questions related to this process:

Q11.1 Do you have any comments on the draft criteria for including new projections within the library, including suggestions for additional criteria?

Most respondents indicated that the draft criteria were reasonable, although there were a number of helpful comments.

Several respondents made comments similar to this: "*What is meant by 'Independently Peer Reviewed' in the context of a set of projection factors to which the CMI (rightly, in our view) ascribes no opinion as to whether they are suitable for use?*"

The Task Force is very keen that the library is a 'living' document to which new and revised projection methodologies can be added and certainly does not intend that the library be limited to projections researched within the CMI nor, necessarily, even peer reviewed by the CMI. Indeed, as one response noted the library should be open to projections developed by demographers and others.

However we believe there is a need for some form of 'quality control' before new projections are included within the library, and feel that some form of review within the Profession is appropriate, even if the projection is developed elsewhere to ensure that it has some relevance in actuarial work. As one respondent suggested, "*...the CMI ... would need to satisfy itself that there is sufficient science and accuracy behind the projections...*"

Another respondent asked what quantitative checks are envisaged, referring to back-testing and tests of robustness. Whilst we feel that such checks are to be welcomed, we did not feel that particular specified tests should necessarily be prerequisites for inclusion.

There was a suggestion that "*...where projections are in some sense arbitrary examples of a technique, the projections should ideally be capable of reproduction by individual actuaries, to allow actuaries to use equally valid or more appropriate alternative. For example, if the knot spacing or age range for P-Spline projections should be considered by individual actuaries before use, then individual actuaries should be able to produce projections with alternative parameters. If this is not possible, then the specific projections included in the library will be seen as standard projections.*" Whilst the Task Force accepts that "*capable of reproduction*" is a desirable feature of projections, we are reluctant to regard it as a necessary criterion for inclusion given that, as the respondent went on to note, "*Such a criteria would mean that for example the ONS P-Spline projections would not be included (unless the data could be made publicly available).*" We think that illustrating methodologies using two datasets is of considerable benefit in enhancing understanding, and that the library would be poorer for excluding these projections.

One respondent commented "*In order not to raise unnecessary barriers, the Working Party overseeing inclusion of new methodologies should not have a rigid set of documentation requirements, but instead maintain a flexible approach that encourages inclusion of alternative bases, whilst maintaining an adequate standard of documentation, so the end users understand the assumptions underlying the proposed basis.*" The Task Force concurs with this view and has not sought to prescribe the criteria for future changes to the library, although minor amendments to the draft criteria set out in Working Paper 27 have been incorporated into the indicative list included in the user guide.

It was also suggested that the absence of projections for the full age and calendar year range of the library should not prevent inclusion in the library. Examples quoted were where no improvements are calculated after age 90, on the basis that there is no data after this age, and

the recent SIAS paper ("Disease and Death" by Hande Love and Daniel Ryan), which only shows results until 2020, on the grounds that projection beyond this point is too speculative.

The Task Force agrees that the limited range of a projection should not preclude inclusion within the library and the arbitrary nature of the assumption for ages after 90 in many of the projections in the draft library is highlighted in section 2.5 of this paper. However one of the aims of the library was to encourage consistency and the need for actuaries to make arbitrary assumptions for improvement rates after age 90 or beyond 2020 creates an issue in this regard.

If and when any such projections are proposed for the library, it will be appropriate to consider whether it is preferable to include the 'limited' projection or to extend it in some way (recognising that alternative means of this may be equally valid). The Task Force therefore suggests that this might form part of the 'consultation process' it envisages for future additions to the library. We agree, though, that such projections should not be excluded from the library on these grounds alone.

Q11.2 Do you have any other comments on the process by which future versions of the library should be managed?

A number of comments were received on additions to the library. One was quite specific about the process that might be involved; with the CMI approving (or declining to approve) new projections for inclusion with the decision and justification being reported (for noting) to FIMC. As with the criteria discussed above, the Task Force feels that this issue is best resolved according to the degree of prior exposure to the Profession of new additions, and that it would be inappropriate to stipulate a process at this time.

There were a number of comments relating to how projections come to be considered for inclusion:

- "*...the onus should be on the authors of a methodology not included in the library to put it forward for inclusion in the library, and this process should be well publicised.*"
- "*...the place for consultation on new methodologies is alongside the Working Paper exposing the new methodology.*"
- "*The CMI must proactively look to develop the library and associated research rather than rely on submissions. If this requires the profession to expand the CMI's remit, then it should do so. Actuaries are perceived to be leading experts in this area, and our credibility is at stake if insufficient resources are devoted to what is a vital area.*"

Whilst the Task Force concurs with much of the sentiment behind these comments, there are a number of points we would like to make in response. We had some doubts about the emphasis on the author in the first comment, in that this may have the effect of excluding non-actuarial projections from the library, as the authors may have little interest in the library. Furthermore it is arguable whether the authors are necessarily the most appropriate advocates for a potential new methodology. The Task Force is keen that potential new methodologies have an advocate within the Profession, even if they are not themselves the author.

The Task Force does not necessarily expect that the CMI will always be the advocate for new methodologies, so that the use of the term "*Working Paper*" in the second comment may be

inappropriate. We suggest that Sessional papers, for example, are equally valid vehicles for projections to be exposed to the Profession for consultation.

Whilst the Task Force accepts the need for the library to be developed proactively, further discussion is required to establish where this responsibility sits within the Profession and whether it does indeed rest with the CMI. Regardless of this, the Task Force does not believe that this can be a sole responsibility, and that all actuaries with an interest in mortality should consider whether non-actuarial methodologies should be considered for inclusion.

Finally, we received two comments on the withdrawal of projections from the library:

- One noted "*Working Paper 27 mentions that it is unlikely that any of the projections will be withdrawn; this carries the risk that the library may become too extensive to maintain and manage.*" The Task Force recognises this, but does not see this as an argument for 'withdrawing' projections which will, in any case, be required for reference if they have previously been used in any disclosed work.
- The second comment suggested "*...projections should be removed from the library if subsequent research shows flaws in any of the projections.*" The Task Force accepts this argument in principle, but again recognises that the flawed projection may have been used whilst it was in the library and that some form of historical reference must be maintained.

We therefore suggest that the approach to any possible withdrawal of projections be determined at the time, taking account of the particular circumstances.

The final specific question in this section related to future research:

Q11.3 Do you have any views on what other projection methodologies the Profession should seek to research and how such research is best organised?

There were numerous suggestions for areas for further research. The two most common were the Lee-Carter Age-Period-Cohort model, developed by Renshaw and Haberman and a more general call for the Profession to stimulate research into the likely future trends of mortality by cause. On the latter, one respondent noted that if projections by cause cannot be reliably undertaken then we should at least do more analysis of historic improvements by cause to inform us whether current improvement rates are sustainable.

Other suggestions were:

- "*Research into the biological limits of lifespan, informed by expert opinion.*"
- "*Collaboration with the medical profession and others to build a framework reflecting the expected impact of known medical advances, or postulated scenarios, against which extrapolation-type models could be tested. Other models requiring some form of target long-run mortality improvement rates or 'ultimate' mortality could also be informed by such a framework.*"
- "*A review of mortality models developed for other countries.*"
- "*Improvements to the more recent techniques to overcome identified shortcomings.*"
- "*Research into ways of deriving floors and whether these should vary with age.*"
- "*Research into the improvements required for the UK to reach the known significantly lower levels of mortality in other developed countries. For example what*

improvements are required in the UK to first reach the levels in e.g. Japan and the US, with these improvements occurring over say 10/20 years?"

- "*Research into age adjustments as a means of developing scenarios of mortality projections.*"

The Task Force would welcome further research in all these areas, but it is clear that a considerable increase in resource would be required to achieve these. The CMI will seek to stimulate discussion with the Profession over how further research can be undertaken effectively.

4 General comments

This section seeks to review comments made that did not relate particularly closely to any of the specific questions we posed in Working Paper 27. In order to make this section clearer we have tried to group the comments into various 'themes'.

4.1 The scope of the library

A number of responses commented on the importance of the assumptions on base mortality. The Task Force recognises this, but deliberately sought only to address future improvements in mortality, although assumptions should clearly be adopted in a consistent manner and some issues regarding communication and disclosure overlap.

One response suggested "*... 2100 is too short a period for the projections, as this limits their use for lives born after 1980, who are now entering pension schemes.*" A later end-year of 2120 or 2150 was suggested. The highly speculative nature of such projections was noted, but it was felt desirable to achieve consistency in using projections across the whole range of ages and birth years. The Task Force accepted the logic of this argument and have extended the projections in version 1.0 of the library to 2130. This involved a minor alteration to the CMI's illustrative projection software and a revised version is being sent to all registered users. Note that for the P-spline projections, the use of a longer projection period affects the fit of the model, and some of the values in version 1.0 of the library up to 2100 may have altered from those in the draft library even if this was the only change.

The same response also suggested "*... it would be useful for the projections to cover the full range of ages down to age 0, using a pragmatic approach (such as setting equal to values at the lowest defined age) where necessary.*" The Task Force felt that such an extension would rarely be required for actuarial purposes. Given that most of the projections were not developed with younger ages in mind and have not necessarily been tested on younger ages, the Task Force have not extended the projections in version 1.0 of the library below age 20.

One respondent suggested "*...it would be helpful to include projections within the library with the values in 2000 equal to 100% [rather than 1992 values equalling 100%, as in the draft library] to facilitate use with the "00" Series tables even though the calculation is trivial.*" The Task Force rejected the idea of adding additional projections for this purpose, but was prompted to reconsider whether 1992 was indeed the most appropriate year to set the values equal to 100%. In particular, consideration was given to setting the values equal to 100% in 2000, to tie in with the "00" Series tables, or to 2006 or 2007 to better reflect the difference between the 'link' and the future projection (see 2.4), or even to use a different year for each projection reflecting the 'known' element. None of these arguments was sufficiently strong for the Task Force to amend the use of '1992 = 100%' adopted for the draft library for most of the projections in version 1.0 of the library, but as noted previously the ONS 2004-based and 2006-based projections now start from 2004 and 2006 respectively.

There were several comments noting the bias in the draft library towards annuity/pension portfolios and that the need for actuaries to project mortality improvements for life assurance purposes had been ignored. The particular issue around projecting smoker-differentiating mortality was also highlighted, as future improvements are likely to be markedly different to those in aggregate mortality. The Task Force accepts these comments but note that the library was deliberately aimed principally at pension and annuity business. Separate considerations

apply at younger ages that the Task Force has not sought to address, for example the different pattern of deaths by cause and the inability to detect cohort features in younger age groups may mean that other projection methods need to be considered for portfolios where the focus is on younger lives. Additional research is likely to be required before smoker-differentiated projections could be generated.

4.2 Suitability of projections

One respondent commented that "*... for the age cohorts that form the greater proportions of the accrued liabilities for final salary occupational schemes, it would be imprudent to assume an annual rate of mortality improvement less than the order of two to three per cent. ... My concern about the library is that none of the proposed tables reflects that conclusion. ... Against that background, the relevant cohorts continue to experience ... higher rates of improvement and show no signs of the rate of improvement lowering.*" The Task Force has some sympathy with this view, but feels that its work – and the earlier work of the CMI – has done much to bring such considerations to the attention of actuaries. Whilst we have consciously sought not to comment on the suitability of the different projections within the library (or any not in the library), we do not accept that improvements continuing at the high levels observed recently is a foregone conclusion. Understanding of the drivers behind these improvements is clearly required before such a conclusion can be reached.

Another commented on the letter from the Presidents that was issued at the same time as the draft library was published. This letter referred to concerns over the Medium Cohort projection and the response concluded that "*It would be helpful for the CMI and the Profession to highlight the wide variation in projections and to emphasise the need for actuaries to take into account the sensitivity of any calculations to the assumptions made in relation to future rates of mortality rather than to imply certain projections are inadequate.*" Although the Presidents' letter was distinct from the draft library, the Task Force is happy to respond to this point. We did not feel that the letter was inappropriate and indeed felt it was helpful in drawing attention to the fact that the Medium Cohort projection is now relatively close to the original "92" Series projection, as most of the cohort effect is assumed to have worn off. This is quite different from saying that the projection is inadequate, but merely highlights that it no longer reflects recent rates of improvement which have not yet shown clear evidence of the cohort effect wearing off.

One response noted that "*Some of the projections lead to year of birth tables that have the mortality rate decreasing with age ... This cannot be a sensible scenario. For one year of birth we have mortality rates peaking before age 100, and then falling to less than 0.1 at 119. The working paper should emphasise the issue that at ages above 90, the resultant values of q_x tend to break the actuarial belief in an increasing force of mortality with age.*" The Task Force is happy to draw attention to this, and notes that it arises where the assumed rate of improvement is higher than the increase in q_x with age. This arises particularly at the oldest ages where the rate of increase in q_x with age is relatively low in some CMI tables. We do not however concur that this necessarily invalidates the projection and consider that decreasing mortality with age in a year of birth table is feasible, without opining on its likelihood.

Furthermore, instances of mortality rates falling with age can occur in a year of use table in the later years of the projection, a feature that is not limited to the older ages. P-spline

projections, for example, are essentially a form of extrapolation, which can act over an extended period to counteract the improvements with age in the base mortality table.

Both these examples serve to illustrate that actuaries must consider whether the projection is suitable for their purpose in conjunction with their chosen base table.

Another response related to the suitability of projections asked "*...whether there should be some adjustment to the projections to prevent male mortality becoming lighter than female mortality.*" The respondent noted the example of PSAC_Male_ONS_2004_50 and PSAC_female_ONS_2004_50 which showed expectations of life at 65 in 2025 of 41.004 years for males and 36.723 for females in Working Paper 27. The Task Force feels that such an arbitrary adjustment would be entirely inappropriate. The P-spline projections generate future rates of improvement from the recent past and – if male mortality improves at a significantly faster rate than female mortality – the possibility of males having lower mortality than females becomes quite plausible.

4.3 The oldest ages

There is minimal data available at the oldest ages, either in the CMI datasets or, indeed, at a UK population level, making it difficult to assess mortality rates with any accuracy, still less to determine assumptions on rates of mortality improvement.

The P-spline and Lee-Carter projections included in the draft library were based on datasets with maximum ages of 89 (for ONS data) or 90 (for the CMI data). In order to extend these projections to older ages, the Task Force had to make assumptions regarding improvements at the 'oldest ages' (considered here to be 90+). Indeed, similarly speculative assumptions underlie the other projections in the draft library even though the Task Force did not have to make these assumptions itself.

The assumption adopted in the draft library was that rates of improvements at ages in excess of those covered by the relevant dataset equalled those at the oldest age in the dataset (except age 120 – see below). As one respondent noted "*This is one possible approach amongst a wide variety*".

The Task Force considered including additional projections within the library, based on alternative assumptions at these oldest ages, perhaps using an approach similar to that described in Richards et al (2007). However we have illustrated an alternative approach (assuming that improvement rates at the oldest ages decrease to zero at age 119) in Scenario 3 in section 8 of the user guide, to illustrate the sensitivity to assumptions at these ages. The Task Force should stress that all it has now done is to illustrate "two possible approaches amongst a wide variety", to paraphrase the comment noted above, and that neither is considered preferable to any other plausible approach at these ages.

Another implication of the assumption used in the draft library at these oldest ages was that the 'limiting age' assumption of 120 represents a sharp discontinuity in mortality rates from q_{119} to q_{120} in some projections. The arbitrary nature of this latter assumption was referred to in Working Paper 27 and several responses commented on this. We were encouraged to consider this further, as the CMI should not allow "*grounds of convenience regarding existing computer programs*" to influence its work. As for the assumptions applied at ages

90+, the Task Force took the decision not to extend the library in this regard, but has sought to illustrate the impact of varying this assumption in section 8 of the user guide.

4.4 The detailed calculations

Section 3 of Working Paper 27 contained some very specific points regarding the use of the projections in the (draft) library. The aim was that if two actuaries use the same unadjusted projection then they arrive at the same answer. Different assumptions are equally valid, but may need to be disclosed to ensure transparency.

There were two responses that questioned the need for such detailed prescription:

- "*This is a highly precise and proscriptive specification. It is not obvious that there is unique theoretical model for the projecting mortality. Fragmenting mortality by part year of age and calendar year is beginning to stretch the simple assumptions underlying the calculation and use of q_x. The important issue is that mortality rates need to improve each year into the future.*"
- "*I found the age and year definitions in section 3 confusing and am not sure whether this level of specification is useful as it is most important that any definition used is consistent between valuation and the experience study the rates are based on.*"

The Task Force agrees on the need for consistency between experience analyses and assumptions used in pricing and valuation and on the need to focus on the overall impact of the mortality assumptions and not get distracted by the technical aspects. However, these will usually be 'internal' discussions, whereas the more detailed specification proposed in the library is directed at the use of mortality projections for 'external' disclosure and has therefore been retained in the user guide.

Other comments received relating to these detailed calculations:

- "*We would like to see the Profession reach a consensus in terms of whether to apply past improvements on top of the '00' tables from 2001 or later years? Different competitors apply Medium Cohort improvements from different years i.e. 2001, 2004, 2005 etc. Applying improvements from 2001 seems to make most sense in terms of keeping CMI experience up to date.*" We hope that our separation of the 'link' from the 'projection' (see 2.4) clarifies our views. Unless otherwise stated the Task Force considers that the "00" Series tables relate to mid-2000. What improvements are (or are not) applied to the base table are at the discretion of the actuary, but allowing for improvements from a different date may mean that the base mortality assumption is not what was intended.
- "*The projections assume that the mortality rates apply to lives attaining each particular age at 30 June 2000. We feel it would be useful if some further commentary were included to justify this assumption.*" As noted on page 6 of Working Paper 27, "The actual point to which mortality rates graduated from [the 1999-2002] dataset apply depends on how data volumes are spread over the quadrennium and how experience varies over the quadrennium." However if one assumes constant data and constant experience over the quadrennium, then the central year of the period is mid-2000 to mid-2001. Note that this is not a new' view formed by the Task Force, but has been stated in relation to previous CMI tables and is included in the FAQ section of the website.

- "*We understand and agree with the reasoning behind the 30th June timing definition for applying the "00" series mortality rates and subsequent calendar year mortality improvement factors. However, we strongly suspect many companies have not to-date applied mortality rates and improvement factors in this way, instead favouring a year-end (31/12) to year-end definition system. Further, they may wish to continue to do so due to system constraints or cost of system change. With this in mind we suggest it would be useful if the CMI put forward a draft wording for companies to use when disclosing this difference from the standard approach set out in the Working Paper.*" The Task Force did not consider that this was its role, as allowance for the half-year could be factored into the base assumption or a link projection. For the avoidance of doubt in matters of public disclosure, it may be appropriate to also incorporate a specimen annuity or expectation of life value, as in life company FSA Returns.
- "*I suggest that the majority of actuaries would use 0.5 rather than 184/365 to adjust to 31/12. If we are going to be this accurate, what should we do about leap years?*" The Task Force has considerable sympathy with this view, but deliberately opted for the 'day-count' approach to accommodate dates other than 31 December, such as 5 April, which would not have been well-defined had we merely used ½ in our example. We note that the conventional CMI practice of rounding values of q_x to 6 decimal places is likely to mean that for many ages, there is no practical difference between these approaches, but have altered the wording in the user guide from that in Working Paper 27 to something we hope is more sympathetic with this comment.

4.5 Miscellanea

This final section encompasses some points made in responses that did not comfortably sit in any of the previous categories.

'Overlaying' the cohort effect
One respondent noted "*...from comparing the CMI and ONS historic experience, it appears that the cohort effect is centred on different birth-years. The peak effect occurs earlier in CMI data, perhaps because higher social classes adopted whatever lifestyle changes have generated the cohort effect (e.g. reduced smoking) earlier than for lower social classes. Given that different insured portfolios or pension schemes will have different mixes of social classes it would be helpful if a way could be found to separate the cohort overlay from the underlying "92" Series projection, so that it could be applied centred on a different birth-year (rather than being limited to the single birth-year implied by the Interim Cohort Projections).*" A standard naming convention to describe how the cohort overlay is incorporated was also requested.

The Task Force feels there is considerable scope for development of alternative scenarios, perhaps recognising this feature or alternative application of the ONS methodology to other datasets (and with other target rates, as noted earlier). However it would be extremely disappointed if such further work was undertaken by way of adjusting the Interim Cohort Projections and recommends that it uses more recent data as the starting point. Such development is, though, outside the scope of the Task Force and would require consultation within the Profession before it could be included in a future version of the library.

'Commonly-used' versus 'plausible' variations

One response suggested "*... the inclusion of certain 'commonly-used' variations on the Interim Cohort projections may suggest to actuaries that these are the only plausible variations, or that the variations cannot be applied to other projections. Additional plausible variations/projections should be included in the library even though they are not currently commonly-used. For example, the reason for applying a minimum value (e.g. as a simple method of reflecting an underlying level of ongoing improvement believed to be attainable from medical advances) means that they could be considered for use with any projection in the library.*"

The Task Force certainly accepts the argument that if a minimum value is considered a reasonable assumption, then it can be applied to any projection. It did not choose to include any such examples within the draft library, in part due to a concern that introducing projections that had neither been researched or were currently-used would be misinterpreted as meaning that this was 'the CMI's preferred projection'. As noted above, we feel there is great scope for the development of 'plausible' projections within the Profession and would welcome work in this area.

The Cairns-Blake-Dowd models

We received only one response that specifically advocated the inclusion of projections derived from another methodology from those in the library (P-spline and Lee-Carter), namely the Cairns-Blake-Dowd (CBD) two-factor model published in the "Journal of Risk & Insurance" (see the References section) and discussed in the LifeMetrics report (Pensions Institute Discussion Paper: PI-0701).

The Task Force understands that the CBD model has significant differences from the methodologies included in the library and certainly warrants serious consideration. We further understand that the authors are currently working on studies that investigate the application of the 2-dimensional CBD model in more detail. In addition, the LifeMetrics report also discusses an extension of the 2-dimensional CBD model with three factors as well as a cohort effect which was found both to work well with England and Wales males data and to be robust.

The Task Force concluded that the CBD models have not yet received adequate exposure within the Profession for the methodology to be understood nor the advantages and disadvantages for actuarial work to be assessed by the actuarial community. As a result the methodology has not been subject to any form of 'road-testing' by actuaries in the same way as P-spline and Lee-Carter projections, through their application to different datasets in CMI Working Papers 20 and 25, respectively, and subsequent discussion at various seminars.

The Task Force therefore encourages the authors or an actuarial working party to undertake this research so that it can be presented to, and discussed by, actuaries and considered for inclusion in a future version of the library.

Cumulative versus annual rates of improvement

One response noted that the CMI's approach has been to publish annual mortality improvement factors and requested that we did not change the format without good reason. The Task Force did not consider historic practice but was aware that the spreadsheet containing the Interim Cohort Projections, released alongside Working Paper 1, did indeed calculate cumulative improvement factors from the annual ones.

The respondent suggested that amending the approach would cause considerable issues for computer programs, especially if the previous approach had to be retained for older projections.

The Task Force notes the concern and would not have changed the approach unnecessarily. Whilst it is true that the Interim Cohort Projections were derived and expressed as annual rates, this was not how they were held within the CMI Tables Program (STP) and differences between calculations using the annual rates from the spreadsheet and STP had been noted some years ago. Consequently it was in order to avoid any such differences arising between the draft library and the STP, that the draft library was expressed in terms of cumulative improvements.

This approach has therefore been retained for version 1.0 of the library.

5 Errata

The most significant issue to emerge with the draft library related to the exposure data within the CMI Permanent Assurances dataset that has been used throughout the CMI's recent work on mortality projections.

The mortality projections software that the CMI has made publicly available and used itself in its research into P-spline and Lee-Carter projections fit forces of mortality (i.e. $\mu_{x,t}$) to the data. It therefore requires that the exposure data that is input is central exposure. In error, the dataset used contained initial exposure but was used as if it contained central exposure. This dataset was additionally made available to users, without explicitly stating whether it was central or initial exposure. Users could reasonably expect the dataset could be used with the software without adjustment.

Central exposures can be estimated for each age and year from the initial exposures using the following formulae:

Central Exposure = Initial Exposure – 0.5 x Deaths.

For the avoidance of doubt, this issue did not affect projections using the ONS dataset, as we understand that the exposure data supplied by the ONS is mid-year population estimates.

This inconsistency is obviously a matter of considerable regret and was widely communicated as soon as the issue was confirmed. Please see "Errata to CMI Working Papers 20, 25 and 27" for more details. Note that Working Paper 20 and Working Paper 25 were revised and re-issued in November 2007. (Working Paper 27 was not revised, as we felt it preferable to retain the version on which consultation took place. In addition it has effectively been superseded by this paper and the user guide.)

Other issues in Working Paper 27 and the draft library that were drawn to our attention or identified by the Task Force itself were of less significance:

- At the bottom of page 5 of Working Paper 27 the Interim Cohort Projections were referred to as being "projections from 1992". In fact, they only reflected smoothed actual improvements up to 1999 for one particular cohort, as was subsequently explained in the description of their derivation in section 4.
- In the example under the table on page 7 of Working Paper 27, the improvements from the library were applicable to age 66, not age 65 as stated. Using these (incorrect) values should have produced a value of q_{65} at 31/12/2000 of 0.012581 (not 0.125810). A corrected example is contained in the user guide.
- The names of some of the projections in Appendix A of Working Paper 27 (pages 30 to 31) differed to the names in the draft library. Consistent names have now been used between version 1.0 of the library and the user guide.
- The table of fitting parameters for the P-spline age-period projections on page 34 referred to 'cohort dimension' but should have referred to 'period dimension'.
- There were two issues relating to the improvements for 1992-2004 that the CMI appended to the ONS 2004-based projections:
  - Working Paper 27 and the draft library both stated that the improvements over 1992-2004 for ages 90+ were the average of the improvements at ages 87-89, when in fact the projections used only the improvements at age 89.

  - In the draft library, Note 3 on the adjustment of the ONS projections for 1992-2004 was incorrect; the description in Working Paper 27 was correct.

  As noted in section 2.4 of this paper, the improvements between 1992 and 2004 have been removed from these projections in version 1.0 of the library anyway.

- In the draft library, two projections were missing values for age 23 (PSAP_Male_ONS_2004_50 and PSAP_Male_ONS_2005_50). These values were in any case identical to those at ages 22 and 24.

6 Summary of changes from the draft library

This section summarises the changes between the draft library and version 1.0 of the library. Please see the relevant section of this paper for further details of each change:

- The CMI has requested – and received – the ONS 2004-based projections for males in Scotland and has included these in version 1.0 of the library (see 2.3).
- Since the consultation period closed, the ONS has published the 2006-based National Population Projections. These have been included within version 1.0 of the library (see 2.3).
- The smoothed actual improvements for 1992-2004 that the Task Force had appended to the ONS 2004-based projections in the draft library have been removed so that these projections now commence from values of 100% in 2004 (see 2.4).
- Each of the P-spline projections has been extended to include not only the 50th percentile projection (hard-coded) but also the additional values that enable a user to produce a projection for any percentile (see 2.6).
- Minor amendments have been made to some of the names of the projections (see 3.1). In particular the region of the UK has been clarified in the names of the ONS projections and the projections generated by the CMI based on ONS data.
- An additional variation on the Interim Cohort Projections has been included in version 1.0 of the library to illustrate the methodology, namely a percentage of a cohort projection with a minimum applied (see 3.1 and 3.3).
- The projections in the draft library ceased in 2100; these have been extended to 2130 in version 1.0 of the library (see 4.1).
- The points noted in the errata (section 5) have all been corrected. Most significantly all the P-spline and Lee-Carter projections using the CMI Permanent Assurances dataset have altered slightly because of the difference in the exposure.

References

Only those documents explicitly referred to in this paper are given below. Please see Working Paper 27 and earlier CMI Working Papers for other important papers.

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CMI Working Paper 2: Responses to the draft report entitled 'A proposed interim basis for adjusting the "92" Series mortality projections for cohort effects' and further commentary thereon. (December 2002)

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http://www.jpmorgan.com/pages/jpmorgan/investbk/solutions/lifemetrics

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