

## ABSTRACT OF THE DISCUSSION

## HELD BY THE FACULTY OF ACTUARIES

**Professor D. Blake** (a visitor; introducing the paper): The problem which we consider here is a serious one — that of longevity risk; the risk that aggregate survival rates are higher than were forecast at the time when key products, such as annuities, were sold to customers. Longevity risk is now accepted as a significant risk factor in the products provided by life insurers and pension funds in particular. In the paper we discuss capital market solutions for managing this risk.

There are a range of responses for companies to deal with longevity risk:

- they can accept it as a legitimate business risk;
- they can try to lay it off through reinsurance policies;
- they can try to share the risk with policyholders through products such as participating annuities with survival credits;
- they can use the capital markets, and try to securitise some of the longevity risk on their books; or
- they can try to manage the risk with the new class of mortality-linked securities which is discussed in the paper.

The various stakeholders in this new market clearly include the hedgers who want to lay off the longevity risk which they face. There could also be general investors who seek low beta securities for their diversified portfolios, and we believe that mortality-linked securities will have relatively low betas with existing classes of securities. Speculators are essential for providing liquidity to the market for any new traded security. Arbitrageurs are also important for the survival of the market, but they need to have well defined pricing relationships between various classes of securities, so that, if those pricing relationships get out of line, they can enter the market and help to correct these pricing anomalies. Also, the Government is a key stakeholder as insurer of last resort. If we do not create a market in mortality-linked securities, then the next generation of taxpayers will have to pick up the bill for the failure of our generation to come up with an effective solution.

There have been a couple of attempts so far to introduce mortality-linked securities: one of which has been successful; one of which has not. The Swiss Re mortality catastrophe bond, issued in 2003, a short-term three-year instrument, which was intended to reduce Swiss Re's own exposure to catastrophic mortality events, was a success. This instrument was oversubscribed, and the second tranche, on less favourable terms to investors, was issued in April 2005, and that was also oversubscribed. The European Investment Bank (EIB) and BNP Paribas attempted to issue the world's first longevity bond in November 2004. It was to be a 25-year instrument. The underlying mortality index was based on the lives of 65-year-old English and Welsh males. Late in 2005 it was withdrawn because of insufficient investor demand.

We discuss various types of both spot market and derivative instruments. The first is the classical longevity bond, (or survivor bond, as it was originally known). This pays declining mortality-linked coupons until the last member of the reference population dies. This bond has a number of practical problems, such as the requirement to make small payments (linked to the lives of a small number of long-lived survivors) many years after the bond was issued.

The 25-year fixed-term version of the bond by BNP Paribas also had problems, one of which was that the capital outlay was regarded as being too high for the risks insured. So, we have suggested geared longevity bonds, to reduce the capital outlay. These work on the basis that the range of payouts is restricted. Another problem which was recognised is that the early cash flows are fairly predictable, and that the real longevity risk applies to the later cash flows. Therefore, investors are paying too much, in present day terms, for the early cash flows, so deferred longevity bonds might be another way of saving capital. The success of the Swiss Re bond, which was a principal-at-risk bond, could be another useful design feature.

Turning to derivatives, the simplest one which is likely to get off the ground is a mortality swap. This swaps fixed-for-floating payments against a mortality index, just like a fixed-for-floating interest rate swap. It can be flexible and tailor made. This was the type of swap which was embedded into the design of the original EIB bond.

We can also imagine mortality futures, linked to an underlying cash market instrument, such as a longevity bond, or to a mortality index. In France, the Association of French Pension Funds (AFPEN) is considering introducing futures contracts on annuities linked to the United Kingdom annuities market. We can also think of various option products: survivor caps; survivor floors; and even options on annuity futures.

Most financial market derivatives have counterparts in the mortality derivatives market, but we must learn lessons from studying these particular contracts, in particular why some of them survived and why some of them failed. One of the most important reasons for the success of a futures contract is having a liquid spot market. Also, spot prices must be sufficiently volatile to create both hedging needs and speculator interest. The underlying instrument must either be homogeneous or have a well-defined grading system, so that both sides of the deal know precisely how to price the instrument. The market requires the active participation of both hedgers and speculators, and possibly arbitrageurs as well.

One of the most important design problems which we face is the choice of mortality index to use in the contract. This choice is regarded as critical because of the problem of the basis risk, the difference between the mortality experience of the reference population and the mortality experience of the hedger. If that difference is wide and diverging, then the underlying instrument will not be an effective hedge. There are also problems over the calculation of the index. Swiss Re, while wanting to hedge the mortality risk on its own books, decided to use population mortality indices for its bond, since these were cleaner and had greater integrity than any index which it could have compiled on the basis of its own mortality experience. So, we have a choice of whether we should use population tables, CMI tables or the hedger's own mortality experience as the underlying reference population.

Credit risk is another issue which must be taken into account. The hedger needs to be confident that the counterparty will deliver. Standard solutions can also be applied here: credit enhancement; credit derivatives; and various forms of securitisation tied to a separately capitalised special purpose vehicle.

We have identified a number of barriers to the development of the market. The EIB bond did not generate sufficient demand to be launched, and this has been put down to design issues, pricing issues and institutional issues.

#### *Design issues*

The capital outlay was regarded as too high relative to the hedging capacity. There was no capital left over for hedging other risks — one of the most important of which was inflation risk. The EIB bond was a fixed-income bond, and it was not indexed to inflation. The payments were going to be made for 25 years, yet there was no inflation hedge built in. In addition, basis risk was regarded as too high, because of the wide gap between the population index and the mortality index relevant for a hedger, such as a pension fund. The index was based on 65-year-old males, but pension funds have pensioners at many ages, so that there was basis risk in terms of age. There was also gender basis risk, because the index was based on males, yet pension funds also have female lives.

#### *Pricing issues*

The EIB calculated that the longevity risk premium was 20 basis points, but we have no idea whether that was a fair estimate or not. There were also demand versus supply issues. While we can imagine that the demand for these bonds was potentially quite high, some have argued that there is a natural shortage on the supply side. Who are the natural issuers of mortality-linked instruments? Whose balance sheets have a natural mortality hedge within them which would enable such an institution to issue longevity bonds? We can think of pharmaceutical companies, for example, having some form of natural mortality hedge in their balance sheets, but

pharmaceutical companies, in aggregate, are far too small to be the only institutions on the supply side of this market. We also need to find out more about the impact of basis risk on price.

#### *Institutional issues*

The issue size of the EIB bond was clearly too small to create a liquid market, being only £540 million. Consultants were reluctant to recommend it to trustees; there was an unwillingness to be the first to leap. Fund managers do not have a mandate to manage longevity risk at the moment. There was insufficient reinsurance capacity. The EIB/BNP could not find either a U.K. or a European Union reinsurer to be the mortality swap counterparty. Partner Re, based in Bermuda, limited cover to £540 million.

What does a futures and options market need in order to survive? Most important, it needs a liquid spot market. It needs the underlying mortality index to be fair and trustworthy. It needs the underlying reference populations to be few in number, but also appropriately graded. A small number of contracts helps to increase liquidity, but it also leads to basis risk. We believe that basis risk can be reduced with suitably graded contracts.

Thus, our conclusions are that mortality-linked securities are potentially very useful tools for managing longevity risk. Once the teething problems have been overcome, the way will be clear for markets in these securities to develop and to mature. We would then be on the cusp of a completely new global market in mortality-linked securities.

**Mr J. Hibbert** (Institute Affiliate; opening the discussion): This paper seems to me to be hugely ambitious, covering a very large range of topics. I will focus on systematic longevity risk, which is possibly a topic which actuaries have not thought very much about until the last ten years. This risk has been brought to our attention very sharply by mortality rates improving considerably faster than anticipated in the past, and creating issues with which we are all familiar for insurers and society in general. This focus on the management of *systematic* rather than individual mortality risk is extremely important.

The authors provide a very comprehensive guide, not just to instruments which have been traded (or have been attempted to be traded) in the market, but to a whole range of *possible* instruments — different ways in which longevity exposure could be packaged and traded in the future.

Professor Blake touched on the issue of the mortality risk premium. The questions in my mind, as I read through that key section of the paper, included: “What is different about mortality risk compared to any other financial asset risk which might be traded in the market? Why might it not be easily tradeable like an interest rate risk or an equity risk? What should or could I be paid for bearing this risk?” These are key questions for insurers which are considering selling mortality risk. Bearing in mind that, when we choose to trade these risks, they are not eliminated. The risk exposure is simply moved elsewhere within the financial system. Before undertaking such a transaction, an insurer should consider what the market reward is for retaining and bearing that risk. Is an insurance company the appropriate organisation for carrying that risk? If not, is a hedge fund or some other entity a better place to carry the risk and to provide capital against it? If this does turn out to be the case, then we need to understand why.

Certainly, the numbers presented in the paper suggest that hedging can be quite ‘expensive’, although, as the authors demonstrate, that estimate is very sensitive to the parameters which are chosen. It is worth bearing in mind that, in a theoretical sense (using the Capital Asset Pricing Model), if we take the view that this sort of risk is largely diversifiable, we should not expect to be paid a large risk premium for bearing it.

There is a hint, in ¶7.5, of incomplete markets and the impact which the absence of an underlying liquid tradeable instrument has on the pricing of mortality protection. It would be interesting to see this theme explored in more detail, to help us to understand the likely impact on pricing in real world markets.

I found that the suggestions on pooling, in ¶2.1, and on innovative ways of packaging mortality were thought provoking.

It was interesting to review the checklist of critical criteria for the success of a mortality derivatives contract: the need for a large liquid 'spot' market in longevity; and the active participation of hedgers and speculators. This made me quite cautious about the potential development of this market in the short term. There are clearly some significant challenges. Overall, on the plus side, I agree with the authors that all of us should welcome the development of this market. It would not only allow the efficient transfer of risk, but would make the whole concept of market consistent reserving and pricing for annuity business substantially more coherent. The paper also brings a benefit in the way in which we think about the pricing and the management of risk. It is a truly modern approach, in the sense that it encourages insurers and actuaries to organise, price and manage this risk in an economically coherent way. In places the paper is quite speculative, but this glimpse of a *possible* future is interesting.

Despite the practical barriers to implementation, there must be some genuine opportunities for improving risk management practice in this area. I agree that, at some stage, the capital markets will find a way to make this new class of instruments effective, although there is no doubt that this has already proved much harder than most people expected. There has been significant effort from a number of investment banks over the past few years to make these contracts work, with relatively little success to date.

I have some other minor points of caution. There is an implicit assumption, at times, that removing mortality risk does fix some problems. In some situations this may be true. However, the impact of a hedge does depend on the presence of other risks which the hedger faces. In the context of an annuity business, it is often the case that, in the presence of significant credit risk in an annuity book, simply removing the longevity risk (irrespective of basis risk) does not have a significant marginal impact. In other words, we need, sometimes, to deal with *all* of the risks present before we can hedge risk completely. That needs to be borne in mind when designing hedging strategies.

Basis risk is interesting. Intuitively, it sounds to me to be something of a red herring, in that we are trying to capture significant 'surprises', in the sense of very large unexpected changes in mortality over long horizons. It would be interesting to see some estimates across countries of mortality improvements, to get a sense of how big that basis risk really is.

The authors conclude that the market for longevity risk will develop and enable insurers and others to hedge their risks. While this is one potential outcome, it seems to me that it is not the only one. The other alternatives are either that markets take the view that insurance company balance sheets are the most efficient places to hold mortality risk, that is that insurance companies have the most expertise in understanding and managing these risks. Alternatively, contract designs and the nature of promises made by society change, so that risks are effectively shared among the generations which generate those risks. That is probably in line with some of the ideas floated by the Pensions Commission.

**Mr S. J. Richards, F.F.A.:** In ¶1.1.1 the authors write that the British welfare state began in 1948. In fact, as far as longevity risk is concerned, the British welfare state began in 1909, when the first means-tested pension was introduced. It is interesting to note that this pension had a retirement age of 70, at a time when the male cohort life expectancy from birth was 56.8 years. I find that a very interesting contrast, because it was actually later, in 1925, when the state pension age was reduced to 65 for males, which means that it has been unchanged for 80 years. In contrast, the Pensions Commission's recent suggestion that the state pension age should be increased to 67 or 68 years by 2050 looks distinctly timid compared to the terms of the original state pension.

**Professor A. D. Wilkie, C.B.E., F.F.A., F.I.A.:** This is a most interesting and innovative paper, which is particularly interesting in discussing several securities which do not yet exist, which seems a very good speculative piece of work.

However, I should like to step back from the details, and ask why all this potential

repackaging of longevity risk is at all necessary. As the opener said, insurance companies are the natural institutions to take on such risks. They need sufficient capital to support them, that is to stand the possible losses, and they need to have the prospect of sufficient profits to attract that capital. That means that they need sufficiently high prices or sufficiently low annuity rates. If existing insurers do not wish to carry the risk, would not others come into the market to accept it, if the price was good enough?

Of course, good prices for the insurers means poor annuity rates for the customers, but do the customers, the pensioners, really wish to pass on this risk to insurers anyway? I understand that the purchase of individual life annuities is very limited at present. All the longevity risk comes from pension annuities, yet individuals seem not to wish to take pensions if they have the choice of a lump sum. Most individuals take the maximum lump sum available in their pension arrangements, even if the terms are not all that good. Further, there is active pressure on the Government to allow postponement of the age at which personal pensions must be taken.

If insurers do not wish to take on longevity risk and customers do not wish to be relieved of it, why is it there? Obviously, it is there because of the tax system. Savings through pension schemes attract tax benefits, though less than they used to, but the important element is the tax-free lump sum; that is the carrot. The sticks are capital gains tax and inheritance tax, which inhibit personal, non-pension saving.

If there were not such a bias in the tax system, a perfectly reasonable strategy for very many people would be to save privately during their working lifetimes, then live on the income from their savings, perhaps dipping into capital as required, but keeping much of it for emergency use, for example if they had the heavy expense of long-term nursing home care in their last years. At the end, they would leave the capital to their heirs. Much of the longevity risk would fall on their heirs, who might receive their inheritance at a later age than they might have expected, but their own capital savings would be supplemented by their inheritance.

Life insurance cover against the risk of dying too soon would remain important in such a system, but annuities might have rather a small place. In many countries there is only a small market in annuities, because the pension system does not favour it. Those with limited resources, and perhaps those with no close heirs, might choose annuities. Those at the lowest income levels would be unable to save significantly any way, and would rely, as they do at present, on the state pension scheme.

Of course, those in the financial world might not encourage such a system. The various measures encouraged by the Government through the tax system, from pensions to ISAs, put financial institutions in a privileged position. That they take good advantage of it is seen by the very large bonuses distributed by the City institutions to privileged staff at the year-end, supported, ultimately, by the hefty charges which individual savers are having to pay. I suppose that some actuaries are among the beneficiaries, but I would not be surprised to see a reaction in due course against the privileges of financial institutions, and some political party seeing that votes can be gained by opposing them. If that happened, I would expect that the longevity risk carried by institutions would diminish substantially, and that all the new instruments described in the paper, mathematically and economically interesting though they are, might become superfluous.

Concerning mortality indices, as the authors say, there is a moral hazard problem about using the experience of individual life offices. Those in the offices and those in the CMI secretariat, if they were aggregating the figures, would know the results well before the market did. National figures are better, and the fact that weekly figures for total deaths for England and Wales are available to all means that a good estimate of the overall level of mortality is known quickly, even if the detailed figures are not published for many months. That 18 months' delay means that some individuals in the Office of National Statistics (ONS) will have access to market sensitive data for quite a long time.

The authors point out, in ¶4.3.12, that individual age mortality rates are available only up to age 89 in the national statistics. In fact, in the relevant publication deaths at individual ages up to age 109 are given, but population estimates only up to age 89, with ages 90 and over grouped. There is no obvious reason for this grouping, but I suppose that the ONS has the figures, and I suppose that it might be persuaded to publish them.

However, there is a problem about the denominators, the population estimates. Those which are used are based on the results of the latest census, updated for known and estimated events, births, deaths and migration, since then. Then, ten years later, another census becomes available. With the benefit of hindsight, a better estimate of the mid-year populations in the intervening years could be made by working backwards from the later date, or using both censuses with an appropriate weighting. I do not know whether the ONS does this, but if its estimates based on the earlier census were badly out when they reached the later one, revision of all the last ten years' figures would be justifiable. This is not a good basis for a financial index.

I do not like the idea of indices of mortality statistics being used for financial purposes. I have had enough experience of looking at these statistics to know how many errors and peculiarities can creep in, certainly in the life office data which come to the CMI. I do not know how much better the national statistics are, but mortality statistics are not like the Retail Prices Index, used for index-linked bonds, which has the merits of being produced quickly, of being subject to strict procedures, and of never being revised.

**Mr R. C. Tanna, F.I.A.:** I am slightly sceptical about the merit of the Government coming into the market issuing mortality bonds. If the Government were to come in, it may well crowd out the limited capacity which might be there, and may limit the ability of insurers and pension funds to go into the market and to hedge out their mortality risk.

Concerning the EIB/BNP bond, I am not sure that I understand how issuing a bond with a 20 basis point lower rate of return would encourage take up of a bond compared to a vanilla bond. Surely, a bond with more risk would need a higher rate of return to attract investors?

**Professor A. J. G. Cairns, F.F.A.:** It is certainly a very important question which you have posed. In terms of the 20 basis points spread, if there is no risk premium at all, then you will be charged a certain rate. Buyers of the bond are intended to be hedgers (e.g. pension funds), for which ownership of the bond will reduce risk rather than increase it. This means that they may be prepared to pay more than the actuarial fair price in order to lay off their longevity risk. A higher price corresponds to a lower interest rate. I am not sure whether that makes things slightly clearer. Certainly, the direction in which the interest rate is going is the opposite direction to what you might normally expect. It is because the bond is designed for the purchasers to lay off their risks. So, those who are on the other side of the transaction (the issuers) are the ones who are going to get a higher rate of return, by the fact that the pension funds are paying this 20 basis points spread.

**Mr D. O. Forfar, F.F.A.:** Paragraph 2.1(6) suggests that: "Annuity providers might choose to replace traditional non-participating annuities with participating contracts ..." However, several offices already offer annuities on a 'participating' or 'with-profits' basis. Provided that the expectations of 'participating' annuity policyholders have been set appropriately, there should not be anything to stop a life office from taking into account its longevity or other experience. The 'participation' concept should be sufficiently wide to deal with several risks, including longevity risk. We know that longevity risk cannot be hedged, because of the withdrawal of the only instrument which might have helped — the longevity bond from EIB/BNP. It seems to me that the 'participation' principle is the way in which to deal with longevity risk. Indeed, the principle of 'participation' seems to be needed to deal with unhedgeable risks in general, whether they be longevity risks, interest rate risks, expense risks, stock market risks, or other risks.

The public interest seems to be best served if more offices go down the 'participation' annuity route than if offices withdraw from the annuity market altogether, because of unhedgeable longevity risks. Also, as professionals under Professional Conduct Standards we owe a duty to act in the public interest.

If you have 'participation' policies of any sort, then it is essential to have an 'estate' within the 'participating' fund, as there will always be unhedgeable or residual risks which you can never hedge perfectly. On top of this, there may be smoothing of overall experience, whether of investment returns, interest rates, expenses or longevity risk. I feel that it will be found that

shareholders are not prepared to bail out 'participating' funds, so it is of little use relying on shareholders for this. Because discretion is given to the directors of a life office over the bonus structure, the public must trust that life offices will deal, and are dealing, fairly with policyholders in the 'participating' fund.

Life offices were formerly trusted, in the public's eyes, to deal fairly with their policyholders. However, in recent years there has been a change, as one senior actuary put it: "... the former trust of the public, that all policyholders would be treated fairly, must be restored, both in the interests of the life industry and in the interests of the actuarial profession." I think that we all agree with this. As another actuary has rather graphically put it: "... some of the public's current lack of trust in life offices stems from the way that estates have been 'ripped-out' of 'participating' funds in certain of the demutualisations that have taken place. This cannot be seen to be 'serving the public interest'." I also agree with this statement.

As has been pointed out by several actuaries, it is illogical to have on the one hand:

- (a) a ministerial statement saying (in regard to the attribution of estates in a proprietary company): "... in assessing policyholders' reasonable expectations the Department would expect this ratio [i.e. only 10% to shareholders — the balance of 90% to policyholders] to be used as the basis of attribution ..."; and, on the other hand,
- (b) allowing 100% of estates to be taken out of 'with-profits' or 'participating' funds in demutualisations. The figures published by Professor O'Brien, an actuary, on the internal financial strength within 'participating' funds, make interesting reading. They demonstrate graphically that certain offices, which were previously among the financially strongest in the life industry within their 'participating' funds, have now become some of the weakest. The tables of actual results published in *Money Management* graphically demonstrate that certain offices which were once at the top of *Money Management* league tables are now at the bottom. It is widely felt that this is because of the 'ripping-out' of estates. It cannot be in the public interest to see this happening, because strong estates are necessary to deal with longevity risk, among other risks which currently cannot be hedged.

Paragraph 1.1.4 makes perfect sense in relation to guaranteed annuity rates (GARs) on 'unit-linked' policies, but I do not think that it is a fair analysis of GARs on 'participating' policies. The authors do not bring out the essential difference in the nature of the option between a GAR on a 'participating' policy and a GAR on a 'unit-linked' policy: between the expectations which were given by most offices to their 'participating' GAR policyholders; and the expectations which certain GAR policyholders of the Equitable Life felt that they had been given, primarily by the Equitable's bonus notices, and on which the court case was based.

The view is widely held that the Equitable Life lost its legal case in the House of Lords primarily because of the nature of the bonus notices sent each year to policyholders. The Equitable Life's bonus notices had given a statement to the GAR policyholders, with no qualification until 1995, of the amount of the accrued terminal bonus, and it had ignored the level of interest and annuity rates which pertained at the time. By so doing, Equitable Life had denied itself, however inadvertently, the flexibility which the bonus structure was designed to create. In my view, Equitable Life's absence of an estate was also a contributory factor.

Most life offices which I know have given their policyholders the expectation that the terminal bonuses on their GAR policies cannot be determined until policy maturity, and must take into account, not only the total experience over the period until the maturity date, but also the level of interest and annuity rates at maturity. To me, it was always a time honoured actuarial principle that terminal bonus under a GAR policy, written as a deferred annuity, could not be determined until maturity, and must take into account the experience of the whole term, including the level of interest and of annuity rates at maturity.

As far as I am aware, no other office fell into the same trap as the Equitable Life, as they were careful to quote, only at the maturity date, the rate of terminal bonus which would apply. Offices have given policyholders expectations commensurate with their principles. I am not alone in thinking that to have applied the particular judgment of the House of Lords in the Equitable Life case to other life offices was a wrong interpretation of the law. It was a unique situation.

The practices which led to Equitable Life's problems were unique to Equitable Life, and not of general application.

I do not think that it is possible to hedge the exposure for a GAR on a 'unit-policy'. This view seems to be backed up by the profession's Guaranteed Maturity Working Party (GMWP), but seems somewhat contrary to what is stated in ¶1.1.4. It has been pointed out by many actuaries that a 'unit-linked' GAR, not only depends on the level of interest rates, but also on the performance of the stock market, and has longevity and retirement risks as well. There is longevity risk because the policyholder may live longer than is expected, and there is retirement risk because the GAR can often be taken at any time when the policyholder chooses to retire between ages 60 and 70, or even 75. Therefore, a 'unit-linked' GAR is subject to four risks: interest rate risk; stock-market risk; longevity risk; and retirement risk.

The experts on hedging with whom I have talked say that it is not possible to hedge these four risks in practice, as opposed to theory, as financial markets do not supply the necessary instruments. They say that, under a 'unit-linked' GAR, you would need to invent an instrument, which they humorously call a 'Bermudan quanto-swaption with a longevity rider and a retirement rider', in order to deal with all aspects of the four risks. As far as I, or they, are aware, no such hedging instrument has ever been issued. Swaptions alone are inadequate, because they only deal with one of the risks, namely the interest rate risk.

The 'participation' principles which I think should be applied are:

- (1) The bonus structure on a 'participating' policy should be allowed to be flexible enough to cope with longevity and other risks. I believe that the Actuarial Profession has a duty in 'serving the public interest' to make sure that this is the case.
- (2) The estate inside the 'participating' fund should be large enough to cope with any residual risks, for example when the guaranteed level of bonus on an endowment policy 'bites' or the 'floor' level of the pension on a GAR policy (written as a deferred annuity) 'bites', or when the guaranteed payments 'bite' on a 'participating' annuity.
- (3) Terminal bonus cannot be determined until a payment vests, and expectations consistent with this principle should be given to policyholders.

If the level of freedom of the 'participation' structure, as expressed in these three principles, is not allowed under 'participating' annuities (or 'participating' policies in general), then, to my mind, this is not serving the public interest at the very time when the 'participating' principle is most needed to cope with unhedgeable longevity risk, as well as other risks.

**Professor Cairns:** Mr Forfar is quite right to say that there is a much greater complexity in the Equitable Life problem than we have described in the paper. We think that longevity risk was a small part of it. One can argue about the legal side of things, but the improvements in longevity were part of the fact that annuities became rather more expensive. We have done some separate calculations which are not described in this paper, but which have shown that, looking forward 20 or 30 years, if you compare interest rate risk and longevity risk as part of the overall package of risk in the price of an annuity, longevity risk is about 25% of the total risk.

**Mr A. M. Eastwood, F.F.A.:** Professor Wilkie asked whether the development of a market such as that proposed is necessary or desirable. Accepting what he says about tax distortions in the pension system, annuities are probably here to stay, at least for a while. In this case it is desirable to have some kind of market. This would inevitably improve efficiency in the transfer of longevity risk. Life offices may be best placed to take on longevity risk, but to take on such risk you need capital. Even if you start out with a huge amount of capital, inevitably, in trading, the amount of capital which remains will vary as other risks manifest themselves. So, it is desirable that the longevity risk which you have can be traded and passed on elsewhere.

I have a few comments, from the perspective of someone who has worked in a life office for a number of years, on how I might have viewed the BNP longevity bond. I was consulted on it, but this is about my personal thoughts, not the response of my employer. One of the key thoughts is that the longevity bond proposed was very new, and, because it was so new, one would not



have wanted to have invested a huge amount in such an instrument. At the same time, there were many other things going on which required a great deal of actuarial attention and thought. I think that this is one of the reasons why that bond did not get off the ground; it required a lot of thinking through as it was new. However, as has been said, the scale of it was not great, and so it did not really feel as if it was ever going to become a liquid investment.

The other thoughts which would have gone through my mind concern basis risk. I do not think that you need to eliminate all aspects of basis risk, but if you are trying to launch something new, basing it only on mortality rates for a 65-year-old male, which feels instinctively a long way away from what you need to hedge the risk to which life offices and pension schemes are exposed more effectively, means that it is unlikely to get off the ground. You need to be closer to hedging the risks to which potential investors are exposed. Without having thought fully through the points which Professor Wilkie made about the risk with ONS-based statistics, I feel that something based on an ONS statistic has inherently less moral hazard than the alternatives considered.

Another point as to why the BNP longevity bond did not get off the ground was that it relied on there being a reinsurer behind it. It did not seem to be accessing anything other than the existing appetite for longevity risk. That is something which the Swiss Re bond, if I understand it correctly, did seem to address. It is passing longevity risk on to other players. That would seem to be something essential if anything like this is going to get off the ground and be useful. If I wanted to reduce longevity risk significantly, I would go round the reinsurers as one of my first ports of call, no doubt including Partner Re, accessing the existing risk appetite directly, rather than trying to dabble in something which is very new. To be successful, the bond would need to access the parts which reinsurance cannot reach.

At the end of ¶6.3 it states: "... it seems likely that the market for longevity zeros would be quite illiquid, as most such bonds would be bought on a buy-and-hold basis." That comment surprised me. I would have thought that zeros would be likely to be more liquid than a packaged product. Once the things are off the ground, I would have expected institutions to take advantage of a zero-type structure to rebalance their portfolios from time to time. If you are trying to eliminate the risk, then naturally you will have to keep an eye on it and manage it. Zeros would have seemed to be a very useful way of doing that. Perhaps why not is because the authors have better knowledge than I have of how zeros have worked with conventional bonds.

**Professor Cairns:** I am not sure that I have an answer to that point. I think that you are right in the sense that zeros give a greater opportunity for companies to hedge their positions more accurately. The direction from which we are coming is that, if you look at the gilt strips market — and I am certainly not at all an expert on that — the impression which I get is that the gilt strips market is very much a buy-and-hold market, whereas the primary gilts market is highly liquid.

**Mr P. H. Grace, F.F.A.:** The paper has highlighted many of the difficulties associated with developing new products to meet the risks associated with longevity. It also mentions reinsurance, which has been in use for some time, and a development, in recent years, of mortality swaps. I have had some involvement in both of these types of solution. Reinsurance involves some credit risk for the ceding company, and there have been some recent transactions where a portfolio of annuity business has been transferred to another company, thus removing the credit risk from the issuer of the annuity business.

Section 8 draws attention to the wide disparity of market rates at any particular time, and how that disparity can vary over a period. A major distortion for the market in annuities is commercial requirements. A company might wish to attract annuity business as a natural hedge to another part of its business, as suggested in ¶2.1, and to do so quotes competitive rates. However, having attracted sufficient business, it then seeks to withdraw from the market by quoting less competitive rates. There are some companies with a large portfolio of personal pension business which do not quote very competitive rates in the marketplace, because they

expect to receive as much annuity business as they can cope with from the maturities within their portfolio of personal pensions. Conversely, a company with negligible or no personal pension business might wish to have a permanent place in the annuity market to balance its portfolio, and achieves this by always having competitive rates.

Another kind of unusual situation is a closed life fund with a difficult situation to manage; its retirement annuity contracts guarantee the level of pension, but not the cash option. The policies provide that the cash option is generated by reference to the company's current annuity rates. If the rates are too low, the cash option is inflated and the policyholder laughs all the way to the bank; if the rates are too high, the cash option is depressed and the fund can retain too much annuity business, resulting in excessive demands on its limited capital. In practice, it needs to follow the market fairly closely and try to lay off its exposure by way of reinsurance.

In ¶10.3.2.1 ONS is referred to as a 'trustworthy government department'. I would not like to comment on the word 'trustworthy', but I did notice a reference in the press recently to some financial organisations looking elsewhere, as they did not rely on the ONS statistics.

We are well aware of variations in mortality experience around the country. We are told that in the west of Scotland the life expectation is only a little over 50% of what it is for people born in Edinburgh, for example. We are also aware that there are differences in mortality between various industries and occupations. While insurance companies normally have fairly balanced portfolios of annuity business, that is not the case for many occupational pension schemes. It is homogeneous so far as that industry is concerned, but it is not representative of the whole population. If a market for mortality futures was developed, there is a danger of selection against that market by certain occupational schemes where mortality experience is at one extreme or the other. This could, in turn, encourage insurance companies to start quoting for annuity business having regard to the experience of the occupational scheme, just as they do for death in service benefits at the present time.

**Mr J. Hastings, F.F.A.:** One of the problems with pricing longevity is a supply and demand issue. Therefore, I was intrigued by what Professor Wilkie said about just how much demand there should be. On the basis that you were able to contain the demand, then you might actually make better use of natural hedgers. In his introductory remarks Professor Blake mentioned pharmaceutical companies, maybe not at a company specific level, but at least at the level which might allow individuals to reinsure your drug purchases for the remainder of your life.

Similarly, long-term care insurers might be natural hedgers, on the basis that your time in long-term care is likely to be short, but it is the timing of the incidence which is really what you want to hedge. Longevity also seems a natural place for reinsurers.

All of these hedgers are long-term hedgers, and, initially, this is what you are looking for — counterparties which are going to be there for the very long term. However, once you have developed a market of that nature, then you might get some greater efficiency of pricing being introduced by short-term hedgers (such as hedge funds), particularly if longevity instruments are tradeable. It seems to me that, ignoring many of the difficult problems in establishing the market, this looks as if it is potentially quite attractive.

I also thought that Professor Wilkie's remarks about individuals as being natural hedgers of their own longevity risk was helpful, although, with low real interest rates at the moment, one of the difficulties is that the annual income relative to a capital sum is not particularly generous. To some extent, countries are probably natural hedgers as long as they can reduce the exposure at lower ages. A state would need to push up its pension age significantly in order to be comfortable with accepting greater longevity risk, for example by underwriting annuity providers. The difficulty of this approach for the individuals concerned is that it probably introduces at least two decades of some form of cohort risk. They might get caught out, to the extent that their pension age was pushed up and then some natural disaster compressed any benefit from higher life expectancy.

Many people have fallen into the trap of believing that longevity can only really go one way. There is the possibility of global warming. One of my lateral outliers would be that the terrorism to which we are probably most subject is at microbe level. There is also avian flu, or a disease

of that nature. One naturally thinks that it is the weakest part of the population which would suffer from that sort of attack. However, some work which has been done around the flu pandemic suggests that the most vulnerable group was reasonably fit individuals in their thirties or forties, who suffered anaphylactic shock because their immune systems overdosed when trying to fight off the virus. So, it is not at all obvious, for example, that an attack of this nature will necessarily cause a problem for the oldest in society, but might cause a greater problem with regard to the dependency ratio.

**Dr D. J. P. Hare, F.F.A.:** In ¶9.1.2 reference is made to the need for a good stochastic mortality model, but I do not know whether one exists. I am not entirely sure why it is sensible, as some people seem to suggest, and as I understand it, to project mortality forward into the future simply using splines based on the past, and to ignore all the epidemiological and medical evidence which we have. I suspect that one of the things which will affect how quickly this market takes off is how confident life offices get in the underlying stochastic mortality models and the arithmetic and the pricing consequences of them, in order that we can understand if we are actually getting a good deal or not in the process. Because there are so many other things requiring actuarial thought, digging into some of the key technical things here is not always feasible in the short term. We are all risk managers now, to use the Finance, Investment and Risk Management Board's phrase, and we are choosing which risks to run and are trying to quantify them in our ICA and in our economic capital calculations. So, we probably want to understand this better, but we want to have confidence in the numbers so that we can make wise and informed choices.

With the benefit of hindsight, why did BNP think that it could sell this bond? It is eloquently explained why it did not work. Presumably, it was not the only investment bank which was working on such investments, so why did all the other ideas not even get off the ground? Were people waiting for the ideas in this paper to come along, or are there other issues behind the scenes which make this a much longer journey than one might have thought?

**Professor Cairns:** I am not an employee of BNP and never have been, so I can only speculate as to why it might have thought that it was a good design. There were many good things about that bond. There still is a perceived need for financial market contracts to help companies to hedge their longevity risks. It had clearly thought through a number of the issues in terms of the choice of index, and so on. If you are the first company which is coming into the market with a long-term contract to deal with longevity risk, there will inevitably be things which, perhaps, you had not thought about.

If nothing else, one of the good things which I hope will come out of the bond is that it will encourage other people to design other financial securities which will be taken up by pension funds, life insurers and others.

**Professor Blake:** The other banks were waiting to see what happens. They were going to try to improve the design afterwards. Many of the criticisms which we picked up came from the other banks, which were waiting and watching. A learning process is going on here. However, somebody has to be the first. BNP started first, and it thought that the bond would fly, but, for a whole range of reasons discussed in the paper, it did not.

**Mr Forfar:** I would have bought the BNP bond. I think that it was cheap. The yield was 20 basis points less than a gilt. I think for that, and the hedge which it provided against longevity risk, the BNP bond was cheap.

**Professor Blake:** The reference group had to live for just about five months longer, on average, than was anticipated, and the longevity risk premium of 20 basis points would have paid for itself.

**Mr Forfar:** To partly answer Dr Hare's points, for at least the past 20 years the CMI has

published mortality projection factors into the future — not only the current mortality, but also what the mortality is likely to be in the future on a purely deterministic basis, but not on a stochastic basis. Roughly, population mortality has been improving over the past 40 years by about 1% to 1.5% p.a. There is a danger that population mortality might improve by 2% p.a. That is not impossible. The standard deviation round the 1% to 1.5% p.a. is about one percentage point. So, an improvement of 2% p.a. is not unbelievable. The difference is about 0.5% p.a. Although this is a rate of improvement in mortality, in my view it translates directly into 50 basis points in yield terms. I think that, for 20 basis points, the BNP bond is cheap.

**Professor Wilkie:** The CMI has been doing forecasting certainly for the past 30 years, to my direct knowledge. For quite a long time before that there were forecast mortality tables. The  $a(m)$  and the  $a(f)$  ones at the beginning of the 20th century were also based on forecasts.

Another aspect of the failure of the bond, which the authors mention in ¶12.5(3), but do not elaborate, is that, while an insurance company investment department may be able to say, if they are looking at the whole range of products: “Here is a new product. We can have a look at it”. However, if pension fund monies are being invested through mandates to an equity manager and a bond manager and a gilt manager, and so on, none of the managers has any responsibility for looking at something new.

That might also have been a problem with index-linked bonds to begin with, because they were not equities, they were not conventional bonds, and nobody was responsible for looking at them and buying them if the investment was cut up into separate mandates. In fact, index-linked bonds did very well. The style of them has been slightly changed recently by the Debt Management Office, in order to follow the line of other countries, but, in comparison with mortality bonds, they were very much simpler.

**Mr Richards:** Returning to Professor Wilkie’s point about the revision of census information and thus the restatement of past mortality rates, that has already happened. In 2005 the ONS revised its population exposure for most of the mid and late 1990s, which delayed our paper on mortality trends (Richards *et al.*, 2006).

Concerning Mr Forfar’s remarks on the rate of mortality improvement being 1.5% or 2% p.a. in aggregate, it is worth pointing out that at age 75 — a crucial age for many pension funds and annuity portfolios — the population mortality rate is improving by 4% to 5% p.a. among U.K. males.

#### REFERENCE

RICHARDS, S.J., KIRKBY, J.G. & CURRIE, I.D. (2006). The importance of year of birth in two-dimensional mortality data. *British Actuarial Journal*, **12**, 5-61.

**Professor Blake:** Many of the remarks have been about whether longevity risk can be hedged or not, or whether it is simply a case of moving it around the system from one party to another. Even if you do move it around from one party to another, you want to know the fair price at which you move it. The best way which we know of determining the fair price is if the markets provide you with that price.

The other point is that the risk might not simply be moved around within one generation. It might actually be moved down to the next generation, and then that generation ends up bearing that risk, and has not willingly agreed to do so. At least being able to price the risk helps you to transfer it, not only within one generation, but it helps you to transfer it more fairly across generations as well.

**Dr D. C. Bowie, F.F.A.** (closing the discussion): Growing old, being old, or perhaps just being older, is something which most of us want to be able to do, and, generally speaking, we have to pay for the things which we want. Thus, the issue is how we finance growing old most efficiently.

This is an excellent example of a paper on a topic which we recognise as being actuarial, but written in the language and with the attitude of modern financial practice and theory. Some have called that amalgam ambitious, and I echo that and applaud it.

Several speakers have used efficiency as an underlying theme in what they have said; others have mentioned it explicitly. Efficiency, in this context, is about tying up the minimum amount of capital in order to be able to function and to do what you set out to do in your business.

One of the most interesting parts of the discussion was whether pension funds and insurance companies are actually end investors in longevity risk. My view is that most pension funds and insurance companies do not see themselves particularly as competing on their ability to manage or to absorb longevity risks, but rather to see them as a largely exogenous risk to their businesses. Insurance companies compete more on product innovation and client service, on marketability, cost effectiveness of internal processes, etc., rather than on longevity management. Pension funds, similarly, do not particularly compete on longevity risks, but rather on providing a set of benefits which are securely funded, so that employees can be attracted to a particular employer.

There is an intertemporal issue in insurance companies competing on the management of longevity risks which would suggest that longevity derivatives would still be of interest to them. An insurance company may take a view on longevity risk now, and issue policies with which it believes that it can exploit that view profitably. However, over time its view on longevity risk might change, and, when it does it may wish to reverse the position without also having to default on the issued policies. It is in that context that derivative type instruments would also be extremely useful.

Recognising inefficiency has been one of the key drivers in terms of the development of financial engineering, services and derivative products. I was delighted also to hear the words 'risk management' mentioned several times. The Profession has aims to become more active in this sphere, and these products are absolutely integral to enhancing our reputation in the risk management arena, as applied to industries where we already have some recognition. To my mind, the risk management moniker can sound a little limiting. It conveys the impression of being a goalkeeper, where you stop the risks where they emerge and do your best to mitigate them. That is rather different from being a playmaker, where you direct the risks into the place where there is perceived competitive advantage. In other words, the risk management framework within which we should work is one where the people who take the risks are the most likely to generate a reward for taking them on.

I agree with the authors that managing mortality risk is not an all or nothing task. I accept, as many of the speakers mentioned, that there has to be some consideration of all the other risks, but if there are risks which are not part of your core business and which can be removed, then that would seem an attractive thing to be able to do. In order to exploit competitive advantages — and this is what the authors' thesis is — the methods of transfer have to be sufficiently accurate so that the speculators, the hedgers and the traders in longevity can get what they want from that risk transfer. The authors set out a wide range of instruments which would help in that role; that is to help actuaries as risk managers to find the counterparties and to organise the risks, so that they could be managed to best effect.

Several speakers have mentioned that many of these instruments do not exist, and, as we read through the paper, many of us thought, perhaps, that the authors were being rather fanciful. The fact that the authors went into quite a lot of detail about their hypothetical products does mean that they came across much more tangibly than if they had just speculated about them in name and function.

There has also been much discussion about the attempts, both successful and unsuccessful, to date, in constructing mortality-linked securities. Judging from the discussion, many of us have found that the proximity of the detailed analyses of these actual products to the hypothetical products to be a very positive feature in suggesting a way forward.

Many of us, too, recognised our pet reasons for the limited uptake of the EIB bond. The lists of reasons and the analysis of the two bonds were particularly useful. With hindsight, some of the issues which hindered the EIB bond issuance seem to be pretty obvious, but, as the authors

commented, knowing how strong those influences would have been in aggregate at the outset was definitely not clear.

Emerging from the discussion, it would seem that a key requirement for getting some of these hypothetical products off the ground is to strike a balance between measuring mortality in a way which is unambiguous, timely and trustworthy, against measures which are sufficiently relevant so that the hedging, the trading and the speculating necessary for a market can be achieved. Historically, actuaries have been instrumental in bringing the analysis of mortality into financial products. There is a nice symmetry here in discussing how the concepts of the financial engineering world may be suggesting new areas for actuaries to work with mortality risks.

The discussion has not produced a strong consensus on how fervently or otherwise actuaries should be pursuing these ideas. The authors and several other speakers, including me, feel that there is an opportunity for us. Others were far more sceptical about the future of this area.

As mentioned already, the insurance companies and the investment banks have started down the road of developing many of these derivative type instruments, or at least talking about them, and trying to exploit the willingness of different parties to hedge, trade and speculate. In terms of the market developing, one of the big hindrances seems to be the absence of a place for longevity risk to go. Several of the speakers made comments about the natural hedges for longevity, for example, long-term care products were mentioned, as were pharmaceutical companies. In other countries where whole of life assurance policies are more prevalent, these would also represent natural hedges. There are many other companies which specifically sell to the elderly — different types of insurers, sellers of holidays, etc. Because longevity for these companies is not part of their core business risk, in the sense that they do not take views on longevity, but sell products to people who are getting old, so being able to hedge that business risk would seem like an attractive thing, and should be something which they are willing to pay for in order to be able to compete where they have their most focused advantage.

As I was listening to other speakers, I had a fanciful moment of my own, thinking that the Government ought to represent us. If we all want to live longer, should not the Government be more than an insurer of last resort for longevity? Should it actively encourage longevity, and therefore actively seek to prevent any slowdown in longevity improvements?

There were several comments on measurement issues being non-trivial. These strike me as something to which actuaries are ideally suited.

There has been a mixture of responses in terms of sharing the authors' optimism about solving some of the implementation difficulties, or, indeed, whether they should be solved at all. My view is that the Profession should continue to encourage innovation in this area, and the U.K. appears to be the ideal market: we have legacy mortality risks within the pensions arena; and there is a pressure to develop new and attractive retirement products to replace defined benefit schemes. Thus, there are plenty of shorter-term commercial drivers to provide incentives for work here, as well as it being an issue which needs to be tackled in a coherent, long-term framework.

I would caution that mortality is not the only area where there is a desire to develop financial engineering products. Even if the capital markets are very big, there are capacity constraints, particularly in terms of absorbing new types of products. I suggest that there is, perhaps, even some urgency in trying to get some of the initial work done if actuaries are going to be involved in developing anything in this area.

**Professor Cairns** (replying): Some speakers have stated that actuaries should be involved in these products. This is definitely something with which I very much agree, partly because this is a fantastic combination of a wide variety of modern actuarial skills. Part of it involves mortality, which is a traditional skill, which has developed very considerably in its own right in recent years in terms of what we do. There is the field of statistics in terms of the analysis of both mortality and interest rates. There is financial economics, which comes into the issues over pricing, market efficiency and things like that. Then there is stochastic modelling. It is a fantastic combination of different areas in which many actuaries should be interested.

The opener said that the short-term development of the market might be limited. That is probably correct. For example, if you look at the non-life insurance bond market, catastrophe bonds, and so on, that was a market where things did develop relatively slowly, and it is gradually picking up, so that now people understand those contracts much more, and there is a healthy market. If a market in mortality does develop, then I would see it developing at a similar sort of pace over time.

The opener also made some interesting remarks about basis risk and about looking at cross-country improvements. That is a very interesting idea which we have not considered, and it is an area for further work. Within the U.K., if you look at different geographical regions or at different occupation groups, there are relatively little data for us to analyse to get a grip on basis risk. If you look at different countries, then you can start to get a feel for what is going on here. A particular issue on basis risk is to do with the longer-term trends. You may have discrepancies from one year to the next, but do these, in the long run, all balance out, or do they just add up and get bigger and bigger?

Professor Wilkie made some comments about the denominators in the mortality indices, and Mr Richards made some further comments about these. It is definitely correct that there is a degree of unreliability in those indices. What we have tried to do is to weigh up the pros and cons of all of the different approaches. There is certainly no perfectly accurate measure of mortality available, but we felt that, perhaps, the ONS statistics might be described as being the least inaccurate. If that is our published statistic, at least that is something which can be used in the design of financial contracts.

Mr Eastwood made some interesting comments, one about the fact that there are many other things going on to distract people's attention. There were also some comments about risk management. I echo that point, and reiterate that we do not see the use of this type of contract as being the only thing which you do in risk management. This type of contract has to be part of a larger package of risk management within either a life insurance company or within a pension fund. Any company which has good risk management ought to be thinking about trying to hedge this particular risk alongside all of its organisation's other risks, and trying to deal with all of these as a package.

Dr Hare asked: "Why use stochastic mortality models, and why not use epidemiological studies to predict mortality?" That is a good question, about which I have certainly thought. I am not a medical expert, and so I am not well equipped to make these sorts of predictions. The impression which I get when trying to look at particular forms of medical advances, such as cancer cures, is that they are much fraught with difficulty. For example, if you ask a variety of medical experts: "When is the cure for cancer going to come along?" you will get a wide variety of answers. You will also get a wide variety of answers on the likely level of effectiveness of various cancer treatments. So, I suspect that trying to make predictions based on that is perhaps just as difficult as trying to come up with a good stochastic mortality model. The reason why we focus in our other work on the use of the stochastic mortality model is to focus attention on trying to assess how much risk there is in the liabilities which are held. Perhaps the most difficult thing to get is the central projection. These sorts of models can give you a reasonably good feel for how much risk there is around that point estimate.

The closer made some good comments about the fact that these sorts of contracts can contribute to market efficiency and will help people to trade off risks among themselves. He also had some interesting comments about the Government, and there are various issues there for the Government which go beyond the pure financial issue of whether issuing a longevity bond is a good thing, financially, for the Government. There are plenty of other issues for the Government, of which market stability is one, but also the Government might use these sorts of contracts as a way of encouraging longevity. In general terms, we ought to be looking for solutions which allow us to look forward to longevity being a good thing.

**The President (Mr H. W. Brown, F.F.A.):** Thank you very much for a very interesting and thought provoking paper. It has achieved what it set out to aim for, and that was to provoke a great discussion. There has certainly been a good discussion, which has been complemented by

both the introductory remarks by Professor Blake and the closing remarks by Professor Cairns. Will you all join me in thanking the authors for a most excellent paper.

#### WRITTEN CONTRIBUTION

**The authors subsequently wrote:** We thank all of the speakers at the meeting for their interesting contributions. We had the opportunity to respond to many of the remarks made either during or at the end of the discussion. There are a few additional points which we wish to add in this written response.

Many discussants mentioned, in a positive sense, the speculative nature of the paper in the absence of existing traded contracts, and we wish to reiterate the point that the paper is intended to stimulate discussion and to help the future development of new mortality-linked contracts.

A further point which we wish to reiterate is that hedgers, such as pension funds and life offices, should only be using mortality-linked contracts as part of a full package of risk management strategies. Used in isolation these contracts will only scratch the surface.

We can draw parallels with two other contract types when we think of lack of familiarity being one reason for a slow take up. First, there are index-linked bonds. Professor Wilkie drew attention to these contracts, but felt that longevity bonds are more complex in some sense, but we would question whether or not this is really the case. For example, the notion of indexation is essentially the same. Additionally, in many cases investors' liabilities might not be linked exactly to RPI, but to something correlated to that index; for example, an appropriate cost of living index for pensioners would be different from the usual RPI. Professor Wilkie also mentioned that fund managers originally had no mandate to look at index-linked bonds, but that, eventually, that market did become established, and is now a key element of pension fund and life office investments. Second, there are non-life catastrophe bonds, where, again, an initial lack of familiarity has been overcome, and there is now a well-developed market. In both cases, as with the present case with longevity, one key to success is the need for market participants to put the effort into modelling and forecasting the index and measuring the uncertainty in the payments.

Mr Forfar pressed the case for participating annuity contracts to be made more easily available. The implication in his remarks was that such contracts should leave bonus rates fully at the discretion of the board. In a world which has become distrustful of with-profits contracts, we would suggest an approach to participation which is more mechanistic in its approach. For example, annuity payments might be linked solely to the development of a national mortality index over time, rather than to that of the insurer. If mortality improves by more than anticipated (as defined within the terms of the contract), then an annuity which has 3% increases as a target might rise at a lower rate.

Professor Wilkie questioned the need for mortality-linked securities, describing a scenario where individuals and institutions would not require such assets to hedge their longevity risk. We agree that, for some life offices and for some wealthy individuals who have a strong bequest motive, there might be no need for mortality-linked contracts. For life offices, some might wish to carry the risk, but there are clearly circumstances where this certainly might not be the case. For the sponsors of pension funds, managing and speculating on longevity risk is not normally part of their core business. In the current environment there are huge liabilities which are subject to these risks, and one cannot simply switch from this to the ideal world described by Professor Wilkie. At the level of the individual, the majority of individuals are not sufficiently wealthy to be able to live off the income generated by their private investments. For individuals to have suitable index-linked incomes free from the risk of outliving their assets, they need something equivalent to an index-linked perpetuity which gets passed on to their heirs. This would require a substantially larger investment than the cost of an index-linked annuity. For the less wealthy in the population, it is inappropriate, in our minds, to have them rely on the state for support. It is important for them to save for retirement and to maximise their income in retirement through the use of annuities or some equivalent. Equally, wealthy individuals with no heirs or bequest



motives should be able to enhance their incomes substantially through the purchase of equity-linked annuities. So, we do not feel that the demand for annuities or pensions will ever disappear. This, in combination with existing liabilities which are exposed to longevity risk, means that the potential demand for mortality-linked contracts is real and will continue into the future.

One can also consider the potential demand for mortality-linked securities from a purely economic point of view; in a sense what some discussants referred to as improvements in market efficiency. If a new contract is brought into existence, then the worst that can happen is that nobody invests in it and nobody is worse off. However, because all institutions and individuals have different liabilities and work to different time horizons, then it is likely that some investors will choose to go long with others going short (e.g. in the case of the EIB/BNP longevity bond, the EIB, BNP and Partner Re in combination were taking the short position) in the new asset at a price which represents the new equilibrium in the market. The result of this activity should be that the economic welfare of all market participants will be enhanced.

Several of the discussants were correct to remark that even the ONS mortality rates are subject to measurement error, especially in the denominator. This is certainly an issue which might make contracts linked to these statistics less attractive. However, in other markets (e.g. catastrophe bonds) the potential for measurement error is clearly not a bar to successful placement.

Mr Eastwood made some remarks that the involvement of Partner Re in the EIB/BNP bond meant that longevity risk was not really being transferred to new institutions, but really represented a variation on existing reinsurance arrangements. For a market to develop successfully, we need to develop contracts which transfer longevity risk to investors which would not normally take on such risks. We agree with this point, and would argue that this should work for investors which see that longevity risk has a low correlation with their existing assets (so offers a diversification benefit), or if taking on the risk brings with it an adequate risk premium.

Dr Hare raised the issue that potential investors will need to develop good forecasting models before they will be willing to become involved. This is an important issue, and does require institutions to invest time and expertise in understanding bio-medical developments as well as in statistical analysis and stochastic modelling. Fortunately, there is a growing body of research on stochastic modelling in the international actuarial journals as well as in some of the U.K. professional publications, such as some recent CMI reports. Indeed, we have developed our own model of stochastic mortality (Cairns *et al.*, 2006a).