

## DISCUSSION HELD AT THE INSTITUTE OF ACTUARIES

**Mr A. M. Kaufman, Hon. F.I.A.** (introducing the paper): We discovered, as we boldly set off on this subject, that, firstly, this is a topic everyone likes to talk about. We discovered that simply identifying the issues is a big subject area. When we set off, we hoped that we could solve the problems. However, we discovered that it was going to require much more than a few days or a few weeks of work. We decided that the way we would approach this would be to identify the key actuarial issues involved and to think about the implications of those issues with respect to UK business. This would keep us somewhat focused on a particular set of business problems. We would then look at how we might solve the issues and what research was needed to address those issues.

We decided that it was better to focus on the issues that we identified to be the biggest. Therefore, we will talk through those particular issues as an introduction to the paper.

We discovered that there is a lot of advice available about Solvency II. Everybody has instructions about how to do it: the Directive, the layers of supervision, actuarial organisations around the world, industry organisations, and working parties such as ours. But none of this advice was sufficiently practical.

Among the top five issues — not necessarily in order — we put co-dependency and correlation. Diversification is a good thing but the problem is that sometimes the diversification turns evil.

We considered what would be good practice in identifying correlation co-dependencies in building a Solvency II model. Here are a few suggestions:

- build co-dependencies from mid-range events;
- investigate causal drivers as well as statistics;
- validate new risks by mapping to similar risks;
- ensure consistency of use — RBS, ICA, ECA, and
- stress-test co-dependency part of model.

This shows you the spirit of how the paper works through the issues. We tried to describe what we thought would be good practice and what research will be needed.

The second issue was time horizon: whether time horizon is a matter of a run-off time horizon, where we consider variability until claims are run off, or whether it is a transfer value as the Directive said.

Our Working Party consisted of life actuaries and general insurance actuaries working together. As a general insurance actuary, I think “claim run-off” — and that is hard to do. Then I would hear from my life colleagues that policyholder behaviour is hard to predict. Both of those have run-off aspects that can make run-off quite different from trying to do a transfer value.

There are obviously a number of other issues associated with time horizon that we identified and we have listed what might be good practice in the paper. Hedgeable and non-hedgeable risks, given the definition of transfer value and the cost of capital in the Directive, are two of the issues, as well as policyholder and management behaviour in run-off, looking at the life insurance side. We also think that this issue of terminal value and time horizon will not get settled, so an internal model would need to be able to deal with both types of terminal value.

And now we turn to my part of the introduction: data. The Directive is quite strong on having good data, so we naturally describe good practice as having solid systems for data. But we also discussed in the paper some of the other aspects that might be considered good practice for an internal model in the future. Data could be provided by third parties and would require validation. We discussed the use of expert opinion as data. For much of what we do, expert opinion can be more important than the raw data that comes out of our systems. A research recommendation would be to get the profession, if not the industry, involved in helping to ensure the availability of the robust data needed for an internal model.

**Mr M. B. Chaplin, F.I.A.** (introducing the paper): I have the pleasure of dealing with the last two big issues that we identified. The first of these is extreme events.

What we observe currently in ICAs is that firms tend to rely on a single method for assessing extreme events or, in many cases, no method at all other than the surveys that are run by the industry and a general awareness of what stresses are applied. We felt that good practice, moving forward to Solvency II, would require a far deeper understanding of extreme events, and probably a more structured use of a number of techniques.

In particular, we have seen some problems in the banking industry, and indeed the insurance industry, of over-relying on historical data, calibrating historical models and historical data, and projecting forward, without thinking about the things that might shape or affect the future. Expert judgment has or should have a strong role to play here. You can see the value of this approach in disease-based mortality models, and also in the calibration of some catastrophe models.

This led us to identify particular areas for research. One of them is catastrophe models, although the accuracy of these models has improved significantly in recent years. However, there is always room for improvement, such as learning from events as they occur, and particularly from some of the demand surges you see after a catastrophe; extensions to different perils and geographical regions; and trying to allow for things like global warming and the effect on the frequency of some catastrophe events.

In relation to the use of expert opinion, we identified the need to overcome some of the issues in gathering data from experts and the biases that exist there. This would include the “availability heuristic”, that is, the tendency to overestimate the frequency of events when they are easily recalled, and underestimate the frequency of events when they are not easily recalled. This could be linked to what Andrew Haldane, the Executive Director for Financial Stability of the Bank of England, called in his speech “disaster myopia”. A better appreciation of network externalities is also mentioned in this paper.

The final big issue that we identified was the modelling of groups. Some group issues are really an extension or an exacerbation of the problems that Mr Kaufman mentioned in connection with our first issue, the co-dependency effect.

### **Impact of global economic crisis on economic capital modelling**

Key observations addressed in this section

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- The global economic crisis has raised challenges to some modelling parameters. It is not likely to change fundamentally the methodological frameworks underpinning economic capital models, however companies continue to assess models in light of the crisis
  - 65% of companies will review dependency (correlation) assumptions and 47% expect to increase frequency of scenario testing (currently 43% use quarterly scenario testing)
  - 53% of companies are also considering improvements to EC-modelling of fungibility of capital (currently 49% are not modelling fungibility) and 35% will review treatment of asset liquidity (currently 78% don't include asset liquidity risk in their economic capital calculations, which is in line with the CRO Forum's position on liquidity risk as a risk to be managed rather than capitalised)
  - Some companies are reviewing governance (35%) and reporting frequencies (29%), however these were already on the economic capital agenda before the current downturn
  - Companies intend to continue to base their economic capital frameworks on market-consistent approaches (despite the current challenges to the application of market-consistent methodologies). However the study indicates that there are certain methodological issues where views on the implementation detail vary across companies.

As you build up a wider group, you become more and more reliant on the diversification that exists between business units, geographies and the like, and there can and should be more work done to understand diversification. In support of this, the recent CRO forum paper on

benchmarking internal models: indicated that 65% of the members were looking actively at co-dependencies whilst 53% identified the fungibility or transferability of capital as something they were looking at. Again, there are some lessons to be learnt from the recent financial crisis: the difficulty in transferring money around groups in severely stressed conditions.

Contagion and reputation risk should be considered and an understanding of risk within non-insurance entities should be gained in building up a picture of how the insurance entities are affected by other entities within the group. We did not want to spend too long talking about the issues as we saw them in the paper and preferred to present this paper as a report card on current practice, highlighting some ideas, thoughts and conclusions.

The next steps, where we have identified areas of research, and where the discussion this evening identifies further areas of research, is to hand that over to the practice executive committees' subcommittees dealing with research, to set up the relevant working groups. This working group will close. We recommend that this report card be updated in two or three years' time, not least because we think modelling practice is going to evolve rapidly. As an illustration of this, in between publishing our paper a few weeks ago and this evening, there have been two or three fairly important works also published: the CEIOPS stocktaking report on the internal models [<https://eiopa.europa.eu/fileadmin/tx.dam/files/publications/reports/Stock-taking-report-on-the-use-of-Internal-Models-in-Insurance.pdf>] and the CRO Forum benchmarking study mentioned earlier.

I will conclude by noting that there are a number of fairly radical or controversial statements made in the paper. I am sure not all of you will agree with them. We anticipate that, because we did not all agree with them ourselves. Therefore, I am looking forward to this debate which I hope, when combined with the paper, will provide us with a useful contribution to internal modelling theory and practice.

**Mr C. J. Baron, F.I.A.** (opening the discussion): My thanks to the authors for their paper. It draws together all the different strands that need to be addressed when considering internal models. I should like to add a few comments on the current and future states of companies' financial models.

The paper is quite right when it points out that stochastic financial models are currently being put under significant strain by the requirements of modern risk management and economic capital management. Computing power has struggled to keep pace with calculations that, for example, appear to require nested stochastic calculations to project a company's capital position. The desktop actuarial modelling systems being used were not really designed with the development of such complex models in mind.

So how should financial modelling actuaries react to these challenges, particularly in the light of the internal model requirements of Solvency II? Firstly, it should be recognised that actuarial systems are evolving. True enterprise systems are emerging that provide the connectivity to enterprise technology platforms and the stronger control and audit frameworks that are now being demanded. After all, companies would not implement policy administration or finance systems in Excel and make them available on the network for everyone to make changes. Nor would they allow uncontrolled changes to the general ledger or a batch-processing run from a local hard drive, with results being stored in unprotected locations. Most insurers now recognise that today's fragmented desktop modelling solutions will not meet tomorrow's needs and are probably the major cause of sleepless nights for their heads of IT. Given the importance of internal models in making key business decisions, a more controlled and secure environment seems certain to be best practice by 2012.

Secondly, the new generations of actuarial modelling systems can unlock the power in the latest developments in computing technology, such as 64-bit technology and grid computing. We actuaries should be working closely with our IT colleagues to understand the potential that such high-performance computing solutions to distributive processing can have in making the complex calculations we are being asked to do possible. However, access to high-performance computing will not be enough without sensible use of high-performance actuaries.

Financial modelling actuaries should review their models to ensure that models are fit for

purpose and that we do not fall into the old trap of modelling everything. We also need to embrace the latest actuarial techniques, such as variance reduction and replicating portfolios, when designing our financial models to make sure that they are working smarter as well as harder. Financial modelling actuaries should be considering the benefits of all of these components, and ensuring that they are at the centre of their company's drive to piece together an automated, integrated and controlled end-to-end process, feeding results to the end users who will need them in ever more timely fashion.

**Mr C. D. O'Brien, F.I.A.:** May I thank the authors for this timely paper. It will certainly help actuaries preparing for Solvency II and it links in with a conversation I recently overheard between the actuary of an insurance company and the company's newly-appointed Chief Risk Officer.

The Chief Risk Officer was saying, "I understand you have been developing a new internal model of the company."

The Actuary replied, "Yes, I will be presenting it to the Board next month. It is so much better than we had before."

Chief Risk Officer: "But, are you sure that it is reliable? The global financial crisis has demonstrated the weaknesses in the risk models of banks, and I guess the same is true of insurance companies. A new survey shows that, in a list of concerns about insurers, risk management technique has gone up from 14th to 6th."

Actuary: "It's true that we have some refinements to make; in fact, there is a paper being presented to the Institute of Actuaries on Monday on this subject."

Chief Risk Officer: "That's interesting. However, what concerns me is that people may think that models can produce accurate answers. Even if you refine the model to develop what seems to be a more sensible probability distribution function of future cash flows, you still don't know whether that is right: there is a large element of uncertainty. I recall John Maynard Keynes's comment that it is better to be roughly right rather than precisely wrong. Do you think this is a danger of actuarial models?"

Actuary: "It could be, and indeed I shall be saying to the Board that, while the model is improving, there are many factors that it cannot cover fully. For example, the measure of risk should depend on whether other financial firms have been suffering distress — but that's not something easily incorporated."

Chief Risk Officer: "I suppose I am concerned about what is sometimes called 'disaster myopia', the tendency to underestimate the probability of adverse outcomes. I know that insurance companies have been modelling to find a 1 in 200 year event, and I have heard it said that 2008 was that 1 in 200 year event. Will the next 1 in 200 year event happen in the next 20 years?"

Indeed, the FSA have announced that in setting the liquid assets buffer required for banks, they will be using stress test scenarios rather than probabilistic models. That is because liquidity assessment is concerned with extreme events of low probability. So when you are presenting probabilistic modelling, I think you will have to work hard to persuade the Board to accept it."

Actuary: "Well, the paper at the Institute of Actuaries raises the issue that, if an extreme event has already happened, how should this affect the calibration of a 1 in N event going forward? It says that the accuracy of a model demands a deep understanding of events and can be undermined by shifts in the wider environment. I will be emphasising that to the Board. The paper goes on to refer to contagion and reputation risks being especially difficult to model. There are also group risks, where the paper makes the point that accurate management accounts for holding companies should be made available."

Chief Risk Officer: "I'm afraid I'm not convinced that if there's a problem in a holding company, this will be apparent from the management accounts you see. You need to adopt a critical perspective."

Actuary: "Yes. The paper says we have to be sceptical about 'prevailing wisdom' or 'standard approaches'."

Chief Risk Officer: "I think that's very important. The big risks are not always those where you have done something different from other firms, because that's been a deliberate decision

you've discussed. It is where everyone is doing the same thing: that's when systemic risk can upset all the calculations. I think the internal model is extremely important to the Board in helping it understand the issues facing the company, but the Board's risk decisions have to take a wider view. Can you tell me what the first calculations you have produced from your model are?"

Actuary: "We have been doing some work on Solvency II and the model should enable the company to reduce its capital requirement. In fact, the finance director is very pleased by this, and I think I'm in line for a good bonus. Last year, I had a call from a headhunter about a job with a bank, and I'm glad I didn't pursue that: I certainly wouldn't have had a bonus there. That reminds me, I have a meeting with the HR director next week to discuss incentives within our company."

Chief Risk Officer: "I was wondering whether the Actuarial Profession is developing courses in risk management that it might make available to people other than actuaries. However, those courses would have to recognise that while quantitative risk management is valuable, it has some important limitations."

Actuary: "I'm not sure; I will make some enquiries."

Chief Risk Officer: "That would be good, because I do want to improve the professionalism of staff in the risk function."

**Mr J. P. Ryan, F.I.A.:** I should like to add my congratulations to the authors. It is extremely difficult, in my opinion, to write a paper of this generality covering such a wide range of different topics, and to make it fully comprehensive. I am sure we will be using the paper's cross-references for many years to come to ensure we have not forgotten anything when we are conducting similar exercises. I want to add a few extra points on particular areas that they touch on.

The first is on the justification of the models. Clearly, it is important that they be actuarially sound and need to be demonstrated as such to the FSA, the auditors and whomever. But I think another important aspect is justifying the overall soundness and completeness of the model in respect of all aspects of risk, to non-actuarial experts such as non-executive directors, management, and so on, and getting them to understand how it works and how it picks up the key issues and risks facing an organisation. This is not so much an actuarial exercise but a thorough analysis of what the key issues are, and how they impact on the organisation, as well as ensuring that they are fully comprehensive. This is important, because speakers so far have shown that things can go badly and unexpectedly wrong. This audit of the stability and robustness of the model can come from verification with non-actuarial experts. It is not technically actuarial, but it is important.

This audit in particular would cover tail assumptions and in the broadest possible way and not just from a statistical or actuarial perspective. A good example that we may pick up from the banking industry relates to the past data not picking up all the risks. One reason why the banking data might not have picked everything up is that this is probably the first worldwide global recession that we have ever had. It has affected all the economies in the world. World trade and hence markets are global now in a way that they were not 10 or 15 years ago. Consequently they are all inter-connected and highly correlated. So it is perhaps not surprising the past data has not picked up the current crisis.

It is easy to say this now. It is not anything terribly profound but it is something that a broad-ranging discussion with many experts from different disciplines should have picked up and might have saved a few banks a lot of embarrassment. If you did not use this approach, how else would you have identified that a collapse in the housing market and consequent rise in mortgage failures in the United States would lead to a collapse of Japanese exports, the collapse of the Japanese economy and the collapse of the Japanese balance of payments surplus? I am quite sure there is no data that anybody can produce that would demonstrate that. So it would not be in the data but it is something important. It might, of course, have come out as something with a low probability but nevertheless should have required the banks to hold sufficient capital to meet it.

The other point is risk metrics. The authors talk about this and they throw in VaR and tail VaR. I think it is important to realise that VaR can be a flawed concept. It is not a coherent risk measure. Nevertheless it is widely used in banks and therefore needs to be treated with some respect — or with no respect, perhaps.

The reason for its use is that it is computationally much easier than tail VaR. Therefore, for short-term market risk and day-to-day market movements, it is used because you need to know quickly, that when the market has gone up 50 points or down 50 points, what has it done to your capital? For elliptic risks which, broadly speaking, include day-to-day market movements, it works. However, for most banking risks other than day-to-day market movements and many risk-based insurance operations, especially the skew ones, it does not necessarily rank the risks in the same order. So using VaR instead of tail VaR, you can run into some severe problems. In particular, VaR would have underestimated the capital required for the current crisis even if it had otherwise been modelled correctly.

There is at least one FTSE 100 finance director who is no longer in his job because he used a VaR type approach instead of a tail VaR type approach. So it can be serious. It does not have to be tail VaR, but you do need a coherent risk measure. I think that is important. It seems somewhat esoteric but it can mean the difference between solvency and insolvency and I have seen companies run into trouble by using wrong risk measures.

Also, returns on capital calculated using the VaR approach can be misleading and are probably a significant contributor to the current furore over bank remuneration. Tail VaR will tend to give more capital to skew risks, whereas the required returns for high risk strategies will tend to be underestimated with VaR. This is exactly what the fuss is about with bank remuneration.

I should now like to move on to diversification risks. Models are used for many purposes other than solvency, including returns on capital. It is important to allocate a diversification credit properly if one is looking at the model to allocate capital. In a competitive market, capital levels will be driven down to the lowest level for an efficient company, and returns will be driven down to returns on those levels. Therefore, since the optimal capital will, in general, be a diversified group, if you do not have a diversified company, you are not going to be able to get those returns. You should therefore allocate capital, certainly for the purposes of looking at returns on capital, in proportion to the marginal change in the volume of turnover, or whatever other measure of exposure you are using. It is not an issue for solvency, but it is important for the target returns.

Another point is that the timescale will be important for the treatment of risks. The authors talk about some jurisdictions not allowing for credit for future profits, and fungibility has been used many times. All of that prevents you using that sort of capital for solvency purposes in a stress situation, but if you are planning it in advance, you can use expected future profit. It is possible, even in a jurisdiction where you are not allowed to take credit for future profits, to sell those profits, albeit at a discount and get the capital in a format that you can use. Similarly you can sell subsidiaries and so on.

**Mr J. C. T. Leigh, F.I.A.:** It would not be entirely true to say that this paper was commissioned by the General Insurance Practice Executive Committee. The idea and initiative came from the leader of the Working Party that wrote it, but as a committee we endorsed the project enthusiastically. The remarks I will make concentrate on things that remain to be done or with which I do not entirely agree, but this should not be seen as detracting from my appreciation of what has been achieved.

I had a general sense of unease as I read the paper. Naturally, there is a great deal about models in a paper entitled “Actuarial Aspects of Internal Models for Solvency II”. Nevertheless, the many improvements to modelling practices that the paper hopes for before 2012 would result in models of extreme complexity. They may be very useful tools, but we should remember that banks have had very complex models for some time and have devoted considerable and sophisticated resources to them. These models evidently did not make them recognise that they were lending a lot of money to people who could not pay it back and that this was likely to lead to trouble.



With this in mind, I was greatly pleased to read section 28 of the paper. The general tone of this section showed good sense in appreciating that there are limits to what can be achieved, what can be communicated and what can be reliably parameterised. This sense of humility is entirely appropriate.

The paper identifies a large number of areas that will require research, which might usefully be led by the Profession, if the objectives for 2012 are to be achieved. This Working Party has been an admirable example of co-operation between the life and general insurance wings of the Profession, and this should continue. I believe that the committees, and indeed the ERM Practice Executive Committee, should jointly consider the best way forward. A joint approach will also identify areas where the considerations for life and general business are genuinely and appropriately different and will prepare proposals accordingly. If work is led by one side or the other then there is a danger that such differences will be overlooked and inappropriate measures will be proposed.

When taken together, the recommendations amount to a fearsome workload for firms, their actuaries and their programmers. A working group's first task will be to prioritise the proposals. A second task should be to consider whether each proposal brought a benefit that was commensurate with the cost and effort of achieving it.

In ¶1.3.7 the authors mention a natural tendency to underestimate the likely impact of tail events. We should not be complacent, but I think the record here is better than it might have been. We may not have anticipated exactly the events of 11 September 2001 but, in setting its realistic disaster scenarios, Lloyd's got commendably close. I do believe that scenario testing of this nature is vital even when sophisticated models are used, both in parameterising the distributions and in providing a sense check on results.

In section 2.2, suggestions are made for good practice in 2012 that sound excellent, but I am concerned that the levels of data that can possibly be available can never allow rigorous parameterisation of inter-risk correlations, especially if the form of the correlation is complex. I fear that the most that can be achieved is spurious accuracy. If the authors can prove me wrong by 2012 I shall be delighted. Later in section 2, and also in section 5, I welcome the authors' remarks about fungibility of capital. I noted in the recent collapse of some AIG entities that various local entities and their regulators expressed confidence in their own solvency because they were separately capitalised. There may be groups where capital is freely fungible until it is needed to cover another group entity's losses.

Section 3 discusses the time horizon used in models. Clearly models used to comply with Solvency II must produce results at the required horizon, although we may have strong opinions about a test of solvency that does not run off all liabilities. ¶3.2.2 hopes that "the theory underlying transfer values will be better established by 2012". We can all hope that, but if it remains only a theory, however well established, not a practice, then I fail to see how a model can demonstrate solvency if it does not demonstrate that the insurer can pay all its foreseeable liabilities when they arise. However good the methodology, does it help if insurers cannot actually transfer their liabilities?

The example mentioned in ¶4.4.5 is, I believe, a good one. Here is an imaginable but unprecedented event. The usual criterion by which we now express a required level of solvency is the familiar 1-in-x years probability of failure, although we might perhaps express it more correctly by saying that if we could roll the future forward from now x times we would be prepared to tolerate failure in only one of them. Perhaps we should instead think in terms of imaginable events. Just how extreme an event do we expect insurers to survive? A small atomic bomb being detonated in a major city? This approach is also alluded to in ¶6.4.25, where the authors mention calibrating to the "worst historic event". This may well not be sufficient, but if accompanied by consideration of how much worse it might have been, it will at least provide insights on how robust an insurer's position is.

I was concerned about some of section 11, especially ¶11.2.2. I would not be hasty in disposing of the unearned premium reserve. Indeed, the revenue-recognition paper recently published by the IASB seems to be entirely consistent with the concept of earning of premium.

Point (5) in ¶25.3.1 is well worth making, but I am not sure we always understand the limitations of our own models. The sin of pride is one we do not always avoid.

**Dr L. M. Pryor, F.I.A.:** I should like to thank the authors for an extremely useful paper which obviously took a great deal of hard work. It is especially encouraging to see such productive collaboration between actuaries from different fields.

The opener made the point that there are many different bodies which are, if you like, worrying about Solvency II. The BAS is one of those bodies. We have, over the past few months, published proposals for several generic standards — notably on data and modelling — that will, we think, be especially relevant in the Solvency II regime.

The paper identifies five key issues that the authors think pose substantial challenges to actuaries. I would like to focus on three of them: diversification and co-dependency, extreme events, and group risk, which I think share some important characteristics. I will explain what I mean but I am afraid that it might be a slightly roundabout explanation.

An important thing to realise about models is that they are necessarily limited. A model is inevitably a simplification of the real world, and that is both the source of its power and its downfall. It is the source of its power because it is easier to work with a model than the real world. You cannot rerun the real world to see what would happen if you tried again. Obviously, it is the downfall because you do not know if the model really reflects the real world.

Limitations are especially evident when models are used to investigate phenomena outside the usual range of experience. Unfortunately, it is just these phenomena which are of interest when we are using models to determine the amount of capital that is required. It is what happens in the tail that is important. The three issues that I mentioned earlier all have aspects that increase the difficulty of modelling in the tails.

Let's take extreme events first, as they are obviously completely to do with the tails. The paper covers the difficulties well. It is difficult to know what events should be modelled for any degree of extremeness; and, given an extreme event, to decide exactly how extreme it is. This problem has long been recognised. Although some possible ways forward are suggested in the paper, I do not think that there are any easy answers in this area.

This brings us to the fourth of the three issues that I identified, which is data. A big problem is that, unsurprisingly, there is little data available for the tails. It is worse than that. A paper at GIRO last year (Graham & Glencross (2008)) indicated that even if you have a lot of reliable data, what it says about extreme events, and what it says about what is going on in the tails, is very limited indeed. Of course for most of us, having a lot of reliable data is almost impossible to imagine.

The second of the three issues, diversification effects and co-dependencies, is difficult to model and extremely difficult to quantify, even under normal circumstances. Quantifying correlations between various phenomena in abnormal circumstances is even more difficult. It is increasingly recognised that effects that are normally pretty much uncorrelated may be highly correlated in a disaster scenario.

There are other problems, too. There may be significant agency costs associated with diversification if you are diversifying into areas in which management have little or no experience. Again, it is likely to be in the tough times that the lack of expertise and understanding of the new risks is especially evident. Network effects, such as we saw some years ago in the LMX spiral, and more recently in the credit crunch, may not be evident in normal times, but again quickly balloon when things start to go wrong.

Many of the same problems are relevant to the modelling of group risk — the third area that I highlighted. It is only when things start to go wrong that some of the limitations of governance arrangements, or the relationships between group entities, become evident.

So, where does this leave us? We have models that are at their least reliable when modelling those circumstances that affect the capital requirements most. Moreover, by 2012 sunk costs for internal models are likely to be huge. It would take a great deal of strength of mind to say, "You know that model we spent several million pounds on? I do not think it is telling us anything useful and should be scrapped."

So the temptation to believe the results of internal models will be enormous, but it must be resisted. I am not saying the results will not be of any use at all. I am just saying models can never be the whole answer. They are vital tools but, like other tools, can only do what they are



designed to do and should be used with care. As we suggested in our consultation paper it is important that those making decisions based on the results of models understand both their power and their limitations.

#### REFERENCE

GRAHAM, M. & GLENCROSS, A. (2008). *The case of the credulous actuary; rediscovering the importance of judgement*. [www.actuaries.org.uk/research-and-resources/documents/case-credulous-actuary-rediscovering-importance-judgement-handout](http://www.actuaries.org.uk/research-and-resources/documents/case-credulous-actuary-rediscovering-importance-judgement-handout)

**Mr J. M. Charles, F.I.A.:** I should like to express thanks to the authors, as all the speakers have. I want to focus on section 3 of the paper, which is on the time horizon. I thought the authors set out a useful explanation of the various components and set out a framework that explains some of the thinking behind Solvency II. This area has been less clear and seemed to be understood by only a few Solvency II aficionados. It is quite an important area, particularly for non-life business. I commend that section to you if you have not read the paper.

I should like to make a number of points. In summary, there are two bases used for assessing risk. They are terminal provisions, which I think for non-life actuaries you would see typically as a run-off assessment of risk; or there are transfer values, which are intended to be more consistent with market values, which essentially would be next year's volatility — the change we might see in our reserve estimates over the next year.

I would question the prescribed transfer value basis, particularly for non-life business. I think that if stress non-life liabilities are valued on the prescribed market-consistent basis defined in Solvency II, the result is not necessarily a transfer value.

As we know, non-life liabilities are generally illiquid and it is difficult to transfer risk, particularly after a stress scenario. As we have seen from the recent financial crisis, stress situations often create perverse outcomes for the market, where we see market values that are significantly out of line with economic values on a mark-to-model basis.

Section 3.26 of the paper says that terminal value on a run-off basis is not necessarily higher or lower than terminal value on a transfer basis. I think I can accept this point for some life business, which is dominated by market risks, where, for example, equity markets may fall in the short term but over the longer term there may be a recovery expected.

However, I do not think that is generally true for non-life business, particularly reserve risk, which is a significant component for non-life insurers. The fundamental message is that there is a bias for non-life business. The transfer value is less than the risk measured by the underlying uncertainty. I would suggest that it is imprudent to consider what can change over just one year. One should look at the risk on an underlying basis. That is the best basis that we can do today. By no means is it perfect, but it is still going to be our best shot at what can happen. It is the prudent amount that one should put aside to deal with a risk from a capital perspective.

One point which has been made is that looking at the ultimate can be economically inefficient because there may be situations where capital is not required over the next year but it may be required in future years. Interestingly, Solvency II is quite innovative in terms of the assets that may be considered for capital. There is allowance for contingent capital. Therefore I would suggest that this problem would be addressed via contingent capital if necessary. Just taking the one year view of risk, though, ignores the cost of putting that contingent capital in place.

To sum up, market-consistent values as prescribed in Solvency II are not necessarily market values. Actual market values, I think, for non-life business are much greater than transfer values. I think a literal interpretation of the one-year time horizon is not a sound basis for managing insurance business. Most non-life insurance management would object to it. It potentially compromises the use test, as most companies would not see it as a sensible basis on which to manage their business. Should we just focus on next year's possible variation in the reserve or should we focus on what could actually go wrong in the business that we have just written?

I also think that, if you develop the theory of the transfer value basis, it will ultimately still be a more subjective basis than the underlying risk basis. It is a weaker standard than the current

ICA [Individual Capital Assessment] practice. However, if we look at QIS 4 it is interesting that, in the UK, results for non-life insurance companies' internal ICAs were significantly less than the QIS 4 requirements, which were nearly 150% of the ICA internal model capital.

I think the fear of an increase in the capital requirements, if one were to take a more robust view of the time horizon for measuring risk, for non-life business at least, is somewhat misplaced.

**Mr A. D. Smith (Student):** I should like to add my thanks to those of previous speakers to the authors for this comprehensive paper and to make a few observations about section 2, which looks at diversification and co-dependency of risks. In particular, I should like to encourage a firmer grounding of the way that we discuss these in terms of the underlying mathematics that might be understood by people outside this hall.

So, for example, there are a couple of mentions in ¶2.4.7 and ¶2.4.11 that suggest that the correlation approach to aggregating capital requires normal distributions. Normality is sufficient but it is not necessary. There is actually a wide class of distributions — Mr Ryan has already mentioned elliptical distributions — for which this is valid.

Is this just a quibbling point? I do not think it is because there is a large amount of evidence of distributions not being normal in actual statistics. But that does not necessarily invalidate the correlation approach. It seems to be rather more robust than is often given credit for. I think it would help to have made that point.

What does assume normality is setting your 99.5% confidence at 2.58 standard deviations. If you are using another distribution you might be using 2.8 or 3 standard deviations.

Secondly, I should like to see a clearer articulation of what these correlations are correlations between. I'm referring to the description about life risks being correlated, but mathematically risks are not correlated. Random variables are correlated. So, what are the correlations that we have in mind? If, for example, you assume a correlation of 50% between interest rates and property prices, what are you assuming? Are you assuming that there is a 50% correlation between the change in property prices in the market and the change in interest rates in the market? That would be nice to assume if you were analysing historic data. Alternatively, and in the context of how QIS 4 works, you would actually be assuming that the interest rate component of profit and the property component of profit are 50% correlated in some sort of hypothetical analysis of change.

So, for example, you would have to assume that same correlation for one business that was long in interest rates and long in property and also for another business that was long in interest rates and short in property.

You do not end up with a consistent underlying model if you set common correlation assumptions across different companies. So, I would have welcomed a deeper discussion as to what precisely these correlations are referring to; how might they be historically evidenced?

There is an extreme example of this. I remember when I first encountered the notion that multiplying two negative numbers together gave a positive number; I thought it was some sort of subterfuge, some sort of sleight of hand, that that could possibly happen. As I studied more maths, I began to realise that it was quite sensible to do it that way. Indeed, if you did not do it that way, you would end up with all sorts of inconsistencies.

I think also that negative correlations are fine mathematically. There is nothing in mathematics that stops correlations going negative. They cannot go below minus 1. They certainly could be minus a half, for example. However, there seems to be reluctance on the part of some supervisors to accept that negative correlations could exist inside capital calculations.

Let us be clear about this. Mathematically, the natural thing to do is to use the correct sign of the correlation that you observe. Sticking absolute values all over the place, which is what QIS 4 effectively does, is not a mathematically coherent interpretation of volatility laws. It then becomes a rather arbitrary formula that is like Solvency I but one thousand times more complicated. So I would welcome clearer articulation of what we are assuming about the model and how that relates to the calculation.

I have one last point. Talking about more complicated dependency structures, I should just

like clarification on some of the wording in ¶2.4.8. The authors say, “The co-dependency factors used should in theory be capable of matching... [a number of]... variations. The same complex surface of co-dependency factors should in theory also be used in the assessment of the underlying liability ...”

I should like to know what theory this is. What theory is there of a complex surface of co-dependency factors? In what sense is this a complex surface? In the sense of complex analysis? It seems to me this is just a bit of verbiage. I do not think there is actually any mathematical concept of a complex surface of co-dependency factors. Once again, we end up with a slightly arm-waving description of what one might like to see whereas I would prefer to see a description of something you could implement in mathematics, even if it were at the cost of having some formulas in it.

In conclusion, I should like to thank the authors for this paper. I hope that as it comes up for revision they will be able to build a more substantial bridge between the calculations that people are doing inside insurance companies and mathematics as understood by the rest of the world.

**Mr S. P. Taylor-Gooby, F.I.A.:** I should like to add my congratulations to the authors of this paper. I am sure that, when the dust has settled on Solvency II, this paper will be seen as a valuable building block in what will probably become a vast edifice of literature about internal models. And I am sure it will be a vast edifice. There will be contributions from many professions and from professionals who believe that they can do a great job in the area of internal models.

However, I want to make sure that actuaries maximise their potential in this area. So I am going to comment on a couple of the areas that are not so well developed in the paper.

I believe that actuaries have excellent experience in building insurance models, and in making sure that the data that goes into insurance models is accurate and well-validated. But if we focus just on the technical aspects and get a reputation for being the best technicians in this area, we sell ourselves short. Actuaries also can provide valuable advice on the governance structures around internal models. We read regularly in the newspapers at the moment about how, in investment banks, salesmen were able to influence the modellers, apparently to increase the value of their trades and reduce the risks inherent in their trades. I think we have experience to be able to say something about how that can be prevented and how the use of models should be governed.

I also think that we have great experience in how models should be used, what they can be used for, what their limitations are, when they should and should not be used. I think we can give valuable advice to companies in general, but particularly insurance companies, in this area. I would like to call for the Profession not to be timid and not to limit ourselves to the technical areas, what we might think of as actuarial areas, but to expand the definition of what is actuarial to a wider area and to press for the fact that we are not only well-positioned in these areas but the people who are best-positioned in these areas.

**Dr M. Sales, F.I.A.:** I would like to thank the members of the panel for producing a thoughtful and timely paper. The authors emphasise best practice in 2012 — but that is only 34 months away!

I would echo the previous comments about the need to give more emphasis to the use test. There is not much point in calculating numbers if you are not going to use them.

Having said that, the paper makes some interesting points, and it gets off to a strong start with a good section on dependencies and fungibility. Indeed, what is there to disagree with? Internal models certainly should allow for increased co-dependencies in stress situations, such as high tail dependencies and non-linearity of risks. Otherwise there is a risk that capital may be mis-stated. Of course, many common approaches to capital aggregations, such as the correlation matrix approach, make simplistic assumptions.

I would also like to commend the authors for giving a prominent role to the constraints in moving capital within companies. Fungibility constraints can have a material impact on capital results. As the authors put it in ¶2.2.11, fungibility constraints need to become a core part of an internal model rather than an end-piece adjustment.

The other point I would like to focus on is the need to recognise parameter and model uncertainty. For too long this has been an understated issue. The experience of the banking world, where companies that claimed to be able to withstand a 1-in-2000 year shock were effectively bankrupt 12 months later, means that capital calculations must now address the question, "How sure are we of these results?"

Even worse, the uncertainties in capital modelling have been used in the past as an argument to opt for the simplest possible aggregation models such as those based on simple symmetric distributions. For example, there has been a running argument that since we cannot be sure of the level of tail dependencies, we might as well ignore them or simply model them as higher correlations, which fails to capture the strong dependency of extreme tail events.

The authors rightly bring up the dangers of spurious accuracy. I believe that this calls for more sophisticated modelling, not more simplistic modelling. We need to be able to understand the impact of the assumptions that we are implicitly making in our models. If it happens that results are insensitive to a particular assumption, then it is appropriate to use the simplest reasonable representation. For example, sometimes the linearity assumption may be appropriate. Other times, as in with-profits business, this assumption may give rise to material errors. If it turns out that the results are highly sensitive to some hard-to-quantify factor, then this is also a useful piece of information for management. It allows risk mitigation strategies to be deployed in order to reduce exposure to these hard-to-quantify risks.

I would like to close by going back to the issue of the use test. I do not believe that management will or should rely on the results of an internal model unless they understand the key drivers for these results, what assumptions have been made to derive them, and how the results would vary if the assumptions were different. This is a case where the sensitivities are as important as the actual number.

Relying on the results does not mean that they are 100% exact. We all know that this is impossible with most models, and particularly so when considering the extreme events that drive capital requirements. Instead, reliance on the results means having confidence in the assumptions that have been used to arrive at them, and to be confident of their materiality.

As the authors say with characteristic British understatement, "It is not obvious why life capital assessments should continue to use these simple capital models even though they rely on often complex liability assessment." This reliance on simplistic models is even less appropriate now because the tools to overcome them are in fact available today. There is no need to wait until 2012 to find out which of the assumptions have a material impact on the capital results. In that sense, many aspects of "best practice in 2012" are here now.

**Mr J. B. Orr, F.F.A.:** I had not planned on making a contribution, but as I work for the regulator, I thought it would be worth just emphasising a few points that are on our minds.

We are talking this evening in the context of Solvency II, and considering internal models looking towards 2012, or whenever. It is worth bearing in mind that at the moment we have a regime in place, the Individual Capital Adequacy Standard (ICAS), which in its design sought to anticipate what Solvency II is going to become in due course, because the UK had the view that it wanted to have a risk-based system in place before the European consensus could emerge. This is just to remind you all that the messages that are coming through about capable risk management having an effect on the level of solvency of a business is what we want to see now in terms of ICAS treatment.

I remember talking with bankers a number of years ago about what was going on in risk management and internal models there. You often heard the sentiment, "This is the price that we pay in order to buy off the regulator. If we have, say, a £50 million a year risk management function in our bank, then the regulator will leave us alone." Maybe because I am a supervisor I have not heard those kinds of comments from insurers. However, I am hopeful that the move to internal models will bring genuine value and improved security within the insurance industry.

I also want to support Mr Ryan's point about VaR against tail VaR. Tail VaR is a better measure for many reasons. We would prefer to see businesses using tail VaR in looking through

into the tail of the risk that they take on board. But I think that VaR is the appropriate compromise that we are going to land at in Solvency II.

As a closing comment, I wanted to make a reference to a consultation paper that we recently produced on stress testing. We shied away from referring to a “test to destruction”, but I think that it is important that management do know what it takes to destroy their business. Also, we want firms to look through the underwriting cycle or the economic cycle. We want them to look beyond one year and understand what it takes for those businesses to be viable in the medium term.

**Mr P. D. Smith, F.I.A.:** I have been doing ICAs since the inception of the system. When I first read the draft directive I went through it asking myself, “If all this means literally what it says, what do I have to do that I do not do at the moment?” I found that there were many places where the directive cannot be taken literally. For example, I use a catastrophe model from an external supplier, and articles 119, 123 and 124, taken together, say that I should provide a detailed outline of the theory and assumptions of the mathematical and empirical basis underlying that model. This would be impractical, and nobody would require it since the principle of proportionality applies.

In my remaining comments I am going to restrict myself just to proportionality. I would say I have only just started addressing the subject, am not an expert, and would welcome contributions and corrections from people who know more than I do.

The paper mentions proportionality in ¶6.2.7 where it quotes the BAS data standard definition which is “An improvement in the quality of data is proportionate if the additional effort to achieve that improvement is outweighed by the consequent benefits.” As effort is effectively the same as costs, this means that proportionality is a cost-benefit decision, which is a good, clear philosophical framework. However, it is subjective, and not necessarily what Solvency II requires.

There was an excellent CEIOPS paper on 24 February last year on proportionality, which I will outline briefly. Firstly, it says proportionality is a general principle of the due course of EU law and is therefore not comprehensively defined in the draft directive. Secondly, proportionality applies throughout the directive and has two distinct aspects: it has to be taken into account both when you are building a model, and also when the supervisor is approving it. Thirdly, proportionality is applied regardless of whether it is mentioned in any particular article of the directive. Fourthly, proportionality takes into account the nature, complexity and the scale of the risks inherent in the business.

I would therefore loosely define proportionality as “No word in the directive has to be taken literally in all cases; how you interpret the directive depends on the nature, complexity and scale of the business.” I repeat that I am not an expert in this and I would welcome other contributions.

By way of light relief, I have an FSA document which is a textbook example of how to approach the question of proportionality, and concerns the handling and wholesaling of oysters. I have not gone mad as this is the other FSA the Food Standards Agency. However, please bear with me because it is highly instructive.

There are four points. One, regulations lay down what a company must do. Two, regulations exempt companies with only a small amount of the relevant business. Three, the FSA say the EU regulations use certain terms, like “small quantity”, that are not defined in the EU regulations but nevertheless they have a meaning in terms of those regulations. Therefore, the FSA cannot define them as that would potentially give them a different meaning from that implicit in the regulations! Four, and this is the serious point, the FSA then realised that it had to give guidance on how it intended to implement the directive and went on record with quantitative guidelines, namely that a small quantity of oysters is less than five tonnes a year.

I now return to Solvency II. In a few months I will have to complete a gap analysis identifying the differences between what Solvency II literally requires and what I do at the moment. For each such gap I will then have to decide whether, and to what extent, proportionality means that I do, or do not, have to change my current practice.

There is going to be a need for regular communication between the practitioners and the FSA on practical issues as they arise. I hope the FSA, like the Food Standards Agency, will be prepared to issue guidance on how it intends to apply the principle of proportionality. I believe that proportionality is going to be one of the most difficult and important issues in both the construction and the approval of internal models.

**Mr M. G. White, F.I.A.:** It is well known that if you commission a report from a management consultant, or even an academic for that matter, the conclusion is likely to include a recommendation that further work be done. I do seriously worry whether the enthusiasm for internal models has more to do with employment opportunities than utility to society.

I think the authors have done a decent job of raising questions in respect of internal models and solvency modelling generally. I agree completely with them about the things to focus on, especially time horizon and so-called extreme risks. While the authors took pains to point out in ¶1.3.3 that we should consider the proposed regime in its entirety, I am going to disobey this and focus on a few aspects which concern me.

I will start with the danger of false confidence. In a piece on *The Actuary* magazine's website, dated 1 December 2008, Jesús Huerta de Soto writes on what he calls "the fatal error of Solvency II". He suggests that, given the fact that the behaviour of insurers itself depends upon the confidence the managers have in their environment, and on the future actions of many different sets of individuals, it is not possible to estimate the distribution of probability of failure.

There is a parallel here with derivatives. They were invented to help businesses manage their risks, but in practice we now see, being wise after the event, of course, that the confidence that managers of financial institutions felt as a result caused them to try and work their assets harder and take far more risks than they should have done.

The most interesting disasters, and those that catch us out most easily, are the man-made financial ones. We need continually to ask the question, "What have we forgotten that is important?" I think that scenario testing, worrying about what might conceivably go wrong, is more important than the ability to run complex simulations.

Another thing we should be asking ourselves is, "Are we asking the right questions in the first place?" So let me develop one aspect that is touched on in the paper: time period. The objective for the capital requirement currently set out in the Solvency II is as follows. "Thou shalt not go bust in the next year following the evaluation more than ½% of the time". The period for evaluation is just one year. In my view this is, to put it politely, not wise. My understanding is that the primary motivation for the one-year horizon was to keep the capital requirements down to "affordable levels". But I thought that Solvency II was supposed to be taking a principle-based approach.

I should like to concentrate on the strength of the promise to existing policyholders and take a non-life policyholder with a long-tail risk. Let us assume that the claim, if there is one, will not come to light for ten years and it could take the following five to ten years to be sorted out, and let us assume that the insurer has a host of such policies on its books.

The quality of the promise to the policyholder is surely what solvency is all about and the correct place to start an analysis from first principles. If we were to ask our long-tail policyholder how comfortable he wanted to be that the insurer would pay him out in full if and when needed, what would he say? 90%? More than 90%?

This is where the one-year view completely misses the point. Let us consider the position where there is no new business. That will help us focus on the capital required to support the promise given to existing policyholders. We cannot assume that there will be any new capital subscribed. The existing fund, including all margins and capital present, will have to be enough. So what does our 0.5% probability of failure in one year mean if we look over a two-year horizon? Part of the problem is the difference between VaR and tail VaR, mentioned by Mr Ryan and others, but it goes further than that.

Consider the situation after one year. Some of the time the account will develop well. Some of the time it will develop badly but not actually go bust. So, for the start of year two, many of



our scenarios are already partly impaired. In the really good scenarios the insurer may be permitted to take some capital out. The position at the start of year two is therefore very different from one year earlier, with a range of possibilities rather than our known original starting point.

But what about after two years? If you do the maths and convolute a probability distribution twice, you will find that the chance of going bust within the first two years is materially more than twice our one-year target, 0.5%. This feature becomes more dramatic as you do the compilation many times. That is because of the partial impairment scenarios present at the start of years other than the first. Needless to say, our policyholder with a long-tail policy is likely to be disappointed at the strength of his promise.

Incidentally, doing the maths like this effectively assumes that reserve development from one year to the next is independent. We all know that is not the case. I appreciate the good intentions behind the design of the Solvency II project but I am concerned that false confidence, together with a natural tendency we all have to ignore inconvenient issues, might end up doing more harm than good in the long run. Once again, I should like to congratulate the authors for their achievements and for giving us the opportunity to have this discussion today.

**Dr C. E. Dolby, F.I.A.:** Firstly, I would like to thank the authors of this report for producing a timely document on a topic which I am sure will be high on our collective agendas over the next few years.

Looking at this document, I can see more than 90 pages about properties that internal models will require in order to produce numbers of sufficient robustness and accuracy to meet the requirements of Solvency II. We can expect the main models built around these requirements to be large-scale, substantial models that may be difficult to update more than once or twice a year.

However, as the authors highlight in Section 30, for day-to-day risk management more nimble models are needed to perform the myriad of "what-if" scenario analyses necessary to inform corporate decisions, and to produce accurate *up-to-date* information, so that today's decisions can be based on today's capital position, not last December's.

The authors suggest that by 2012 good practice will involve creating a lightweight proxy of the main valuation model, so that the proxy can be used to produce regular capital updates. They suggest that replicating portfolios could become widespread by that time, as a means of providing such a proxy for those companies for which market risk is important.

I agree with this suggestion. However, let me emphasise that replicating portfolios will not just be good practice in 2012 — they are good practice now. The economic conditions of the last year have highlighted in stark fashion the need for regular, fast and accurate updates of our capital and solvency positions. The FSA has added to these needs recently by requesting monthly solvency updates, along with a series of what-if scenario requests, from a number of UK companies.

Companies are already using replicating portfolios as a way to meet these needs. For instance, replicating portfolios are being used to calculate a weekly realistic balance sheet, including working capital, RCM surplus and ICA surplus. They are also calculating these measures under a range of possible shocks, and investigating the effect that those shocks could have on future balance sheet values.

Other companies are using replicating portfolios to hedge their guarantees actively, based on daily updates of risk-exposure. Replicating portfolios can also be incorporated into a larger risk-aggregator tool, to provide an all-risk solution, addressing issues such as fungibility, co-dependency and tail distributions, all of which are vital issues for internal models.

Tools like these can provide the bridge that we need between the robust but often cumbersome valuation models that may be necessary under Solvency II, and the need, also necessary under Solvency II, for management to make active business decisions based on up-to-date information. Companies may find it difficult to satisfy the use test without such tools.

Finally, let me warn that if replicating portfolios are to be used as a proxy for the main liability model, it is essential to be able to reconcile these portfolios with the full liability results.

Equally important is the requirement to be able to use the portfolio to roll forward the capital position. It should tell you your capital position now, under current economic conditions, not what your capital position would have been last December, if current conditions had prevailed then.

In summary, I agree wholeheartedly that good practice in 2012 will require internal models to be coupled with more nimble proxies, to allow corporate decision-making based on up-to-date capital information. However, I would urge companies not to wait until 2012 to achieve this. We clearly need regular updates of our risk capital position, not because of what the regulator might do in three years' time, but because of what the market might do tomorrow!

**Mr C. G. Lewin, F.I.A.:** The early history of insurance in this country dates back to the 17th-century and earlier, and the people who managed the pioneering insurance companies were very cautious. The first fire insurance companies in the 1680s were looking at not just the risk in their normal business but also the catastrophe risks — perhaps another Great Fire of London. The people who founded the Equitable in 1762 considered the possibility of higher mortality than they were expecting, and made sure the premium basis was robust. The early Victorian actuaries were extremely cautious, building up surpluses in their life offices. That is what enabled the insurance industry to get off the ground successfully in this country — a high degree of caution at a time when the capability of mathematical modelling was limited.

Another historical precedent can be found in capital project appraisal in this country. If you go back 10 or 15 years, there was a distinct tendency to build complicated stochastic models — merchant banks got into this — for projects, and to try to simulate what the outcomes would be. Boards of directors found that they could not understand the results from these models because they could not comprehend the assumptions that were built into the intricacies of them. Therefore stochastic modelling has largely fallen into disuse (except for certain specific aspects of projects), and now scenario analysis has become the way in which the sponsors of projects want to look at them and study the risks.

Quite apart from its use of complex models, I suspect that the solvency standard of Solvency II is quite inadequate. If you went to the man in the street and asked, "What do you think is the chance of insurance companies becoming insolvent in the next 20 years?" and then you told him it was 10%, he would be horrified. That is what Solvency II does, if there is no extra capital. Therefore, Solvency II is only a minimum standard and not what you would use if you were being guided by the much lower chance of insolvency that your policyholders want.

There is also the point that insurance companies may require extra capital from events which cannot be modelled mis-selling, for example. You cannot model that, but if there were to be such an event occurring again, then extra capital would be required. How much extra capital should you put aside for events of that kind? Therefore, my conclusion is that on the one hand there is Solvency II, the need to meet all the regulatory requirements, to do the box ticking, etc, but on the other hand there is the genuine capital that you need to have available, which is probably going to be far, far more than what comes out of Solvency II.

So my feeling is that what will actually happen, as far as real decisions are concerned, is that people will be relying more on scenario analyses, which they can understand, than on complicated models, and that Boards will be largely relying on broad judgment of all the intangibles involved.

**Mrs K. A. Morgan, F.I.A.:** I was not planning to speak tonight; I was relying on my able co-authors. But I wanted to say a few comments about Solvency II, as some people have made some remarks about that, and I feel it is worth responding.

I should like to echo what Mr Lewin said that the solvency capital requirement, 99.5% one year VaR level, is just one measure. Firms will be expected, through the ORSA process and Pillar II of Solvency II, to produce their own risk and solvency assessment; their own assessment of the capital that they require, based on their own risk appetite, which may be higher, than the Solvency II Solvency Capital Requirement (SCR) level. That means that firms may hold more capital than that.

The SCR is a point at which the supervisors will intervene, and it is important that it is consistent for all insurance firms across the whole of the European Union and the EEA. That is the reason why it is calibrated at that level, and that is why we are putting so much emphasis on how assets and liabilities are calculated, and also, how the SCR is calculated. It is one measure in a whole regime of safety measures.

Consider a car: you have brakes, airbags, windscreens and, perhaps most importantly, the driver, the person who is guiding the car along the road. You could think about the SCR as the air bag and then think of the other Pillars of Solvency II as the brakes and the windscreen, and the people running the business as the driver of the car.

So it is one measure of risk. It may not be perfect, and I have heard Mr White's arguments about that. But it is one indication.

In terms of proportionality and the other parts of Solvency II, it is probably worth mentioning that CEIOPS is going to be publishing some consultation papers later this year. I would encourage everybody to read these and to respond to them. The papers are going to set out the draft advice to the European Commission on what the Level II framework will look like. We have the Level I directive, where the 99.5% one year VaR measure is set out. That is not going to change, assuming the framework directive is voted in. The Level II measures are going to put more flesh on the bones about how the rest of the regime will work. For example, in March, there will be a paper on the approval process for internal models. In June there will be papers on the different tests and standards as well as all the other elements of Solvency II, the standard formula, the Pillar II regime and Pillar III, regulatory reporting.

The common theme going through all of those consultation papers will be proportionality. So thank you, Mr Smith, for your comments on that, which we can bear in mind.

**Mr K. Foroughi, F.I.A.:** I would like to add my thanks to the authors for their efforts in identifying the technical actuarial aspects of internal modelling.

There is one further non-technical issue that I would like to encourage the Actuarial Profession and its members to spend more time thinking about, namely the reporting format of the internal models. How will the results get presented to the Board and to the wider business?

Some brief examples of items to consider:

- What will the balance sheet look like? What will the components of the balance sheet look like?
- Which sensitivities should be performed on the balance sheet to highlight the risks?
- What will the analysis of surplus look like? How will this surplus get analysed and, in particular how will the variances be split? There are some good examples within existing supplementary and regulatory reporting that can be considered a starting point. Once we work towards developing the form of the analysis, I think it will be easier within each company to engage with the various stakeholders outside of risk and actuarial, and help them understand how to use the information to make better decisions.

Finally, I encourage some standardisation of the reporting. This would help the Directors, any reviewers and the FSA to judge elements and to approve the internal model.

**Mr A. N. Hitchcox, F.I.A.** (closing the discussion): In respect of the change from the ICAS regime to meeting the requirements of Solvency II, I have heard the FSA often tell the story that the leading companies are those who realise how far behind the curve they are, and the laggards are the ones who think they are not too far behind.

This paper is over 100 pages long, and in the course of the last few months I have read it three or four times in great detail while refereeing it. Each time I read it I have learned something new. That was the value to me and to my day-to-day work. I would say to the audience that the paper has done us a great favour in identifying the top issues that we have to address between now and 2012.

Those of you who have read the paper in great detail will realise how much work still remains to be done, and those of you who have not found time to do more than skim the paper, I

recommend you read it thoroughly over the next six weeks, not just for continuing professional education reasons, but because it will influence your day-to-day jobs.

Turning to tonight's discussion, the authors set out five major topics that they said were the most important, so I kept a record of how many comments we had on each. We had three comments on diversification and correlations; four on time horizons; three on extreme events; three on group risk; and four on data quality. So it sounds like the top five are the top five.

Turning to the details, on diversification and correlations, we heard that correlations are hard to quantify, both in normal circumstances and for rare events. Mr Andrew Smith made a good plea for more mathematical rigour in the study of correlations with which I agree.

On the subject of time horizons, Mr Charles questioned the prescribed transfer value basis, and Mr White reinforced his thoughts on the suitability of that basis. I have read similar material elsewhere round Europe. I am sure that is a topic that will evolve with Solvency II as well as in best practice.

Under extreme events, we heard questions about the suitability of whether the worst historic event is good enough for your modelling. Mr Orr was shy about using the phrase "test to destruction", whereas "test to destruction" as a stress test is a phrase that a Board will understand. So use that phrase more often. Do not be shy of it.

Under group risk we heard about the fungibility constraints in real life. We have seen in the recent events of the financial crisis that many companies found moving capital round the companies to be difficult under stress circumstances. So it is vital, when you take huge amounts of correlation benefits, that you prove to yourself first, shareholders second and the regulators third that you really can realise those events.

Under data quality, we heard from Dr Pryor concern about the level required to justify correlation assumptions and extreme tail events. We also heard that more uncertainty in parameters can be a reason for more sophisticated modelling as long as it is used to focus your priorities on better risk mitigation techniques. If the parameter represents a big risk you should be managing it as much as modelling it.

Then on matters discussed this evening on areas outside the top five we heard from, among others, Mr O'Brien, Mr Taylor-Gooby and Mr Lewin, on governance, structures, model risk and uncertainty, stress events, systemic risk and management incentives. From Mr Ryan and Mr Leigh we heard about understanding the limitations of your stochastic models, explaining the uncertainties to non-actuaries and the need for good risk metrics. Several speakers mentioned the importance of replicating portfolios as a model technique.

Mr White reminded us of the dangers of false confidence and the importance of scenario testing. I liked Mr Peter Smith's comments on proportionality. As I understand the definition from the "other" FSA, a small quantity of oysters is five tonnes a year. So if my maths is any good, that is two stones (28 pounds) a day. That seems quite a lot to me.

My last comment this evening is on governance. We often read comments in the press which go something like, "Oh! The banks have had Basel II, and look at the mess they made of it. Therefore Solvency II is not going to solve any problems in the insurance industry."

We have to push back strongly on those comments. I do have to say, as an outsider, it seems that in banks it was the governance of risk that was at fault in recent years. All the other governance I am sure was perfectly good but the governance of risk modelling was no good. So in insurance companies that is where we have to make a difference, the governance of our models.

Governance is a two-way process. There are the governors, that is, the directors; they have to ask for more information about risk and capital models. Then the governed, which in this case is us, the actuaries, generating internal models. We have to make it easier for outsiders to challenge our calculations and assumptions.

So I join all the other speakers in congratulating the authors on an excellent paper. All of you must read it in great detail in the next few months.

**Mr P. J. Tuley, F.I.A.** (responding): Thank you, Mr Hitchcox, for picking up on the debate we have had. I think the compliment you paid us was that our paper is a bit like QIS 4: it is entirely good for you if you go back and do it properly and read it from start to finish.

I would pick up on two elements of the debate on behalf of the 10 authors; you are merely seeing a small tip of the iceberg on the top table here. Firstly, the topic of communications was picked up by a number of speakers, that is, how to communicate the results of this complicated model to Boards and to fellow executives. That must rank as one of the highest problems we face in modelling, and it seems entirely appropriate that we started the evening with the presentation of a prize for communications. Knowing the limitations of your model and being able to explain it to the Board is very important.

Secondly, Mr Leigh, in particular, set out the case that actuaries had a tendency to overcomplicate models. They build too far into the sky; the models are going to fall down because they are built on spurious accuracy. Again, that is a serious element that we have to face up to. Are we building something that is getting better and better at capturing the risks that we are managing or are we building something that is tending towards complexity for the sake of it?

For me, this comes back to what we are managing the business on. If we are not managing the business on the models that we are sponsoring, then what are we communicating to our Boards, within our Profession and, indeed, to the regulator?

It seems to me that, although John Maynard Keynes had a nice quotation about the accuracy of any result, it is better to have a model that reasonably differentiates between risks than have no model at all. If you rely on expert judgment, as models also do, effectively you are relying on the "internal model" in someone's head. The basis of this paper is to get that out in the open and have it open to challenge, which I think is a powerful and useful thing to do.

So, on behalf of the authors, I thank you all for your kind words, and I will now go away and do QIS 4!

**The President** (Mr N. B. Masters, F.I.A.): My thanks to Mr Orr and to all the contributors tonight. It has been a truly excellent discussion, which is always a sign of an excellent paper. I think also the number of people here, and the fact that we have filled the Council chamber and the balcony is a compliment to all the hard work. So, my thanks again to the authors.

For myself, as somebody who is continuing to struggle with the internal model at my own shop, the one thing I have noticed is how unstable that model is from year to year as I think harder and harder. The numbers whiz about and the diversification becomes much more like an ice rink than a saving grace. I shall indeed go away and read the paper again to see if I can discover stability or instability in the model as well.

There was a call, I think Mr Taylor-Gooby made it, and there are number of others who echoed this, that we should be speaking out on our ability to build, to maintain and to monitor these models. I think that is right. I believe it is our heartland. But we must also do it in the spirit in which Mr Leigh made his comments; namely, we have to do it with common sense, and we have to do it with an element of humility. It is all very well to say, "Oh, the banks didn't get it right." You can be pretty sure that we would not have got it a whole lot better when the system comes quite as under stress as it is at the moment. I want to be sure that we get a balance between some level of confidence in our ability to model and some humility in the fact that we will get only so far before our models are found out, as seems to be always the case.

That said, it is important that we keep this discussion running; that we contribute to the understanding of the financial services world in these areas. I think that we must continue to do that.

A very hearty thanks to all the authors. I ask you to join me in showing that appreciation.

**Dr A. Tsanakas:** The authors present a comprehensive study and flag areas for debate and future research. I would like to contribute some comments on the areas of capital allocation and the use of expert judgement in dependence modelling.

The authors are justified in referring to the somewhat bewildering multitude of capital allocation methods in the literature. To decide which allocation method is appropriate, one has to specify first the purpose of the allocation exercise; indeed if capital allocation gives an answer to a question, it would be helpful to know what the question was.

In Dhaene *et al.* (2009) a unifying framework for capital allocation is presented, which produces most methods proposed in the literature as special cases. There, capital allocation is characterised as an optimisation problem, where the suitably defined distance between a risk and its allocated capital is minimised, with increased weight put on scenarios (states of the world) of particular interest (e.g. states that put the aggregate portfolio under stress). While the problem is dealt with in highly stylised fashion, some interpretation of various ad-hoc allocation rules may be derived from that analysis.

The authors make particular reference to marginal allocations and state that more research is needed on this subject. In fact, such allocations have been extensively studied in the literature (e.g. Overbeck, 2000; Denault, 2001; Tasche, 2004). Marginal allocations generally reflect the impact of changes in exposure to a particular risk on the aggregate position. Hence they tend to involve some measure of dependence of individual risks to the portfolio. Moreover, as larger risks tend to have a higher impact on the aggregate (as they are themselves a large part of it), they also tend to be disproportionately penalised by the capital allocation. This “elephant-in-the-boat” effect, as well as the sensitivity to the (potentially unknown) dependence structure, may not be desirable for particular allocation purposes (e.g. measurement of underwriting performance), for which a pro-rata allocation method may be preferable. Of course using a different allocation method will certainly not make portfolio imbalances and model error go away.

In the most common marginal allocation method, often termed Euler principle or Aumann-Shapley value, the marginal impact is quantified via a partial derivative. This abstract formulation leads to some very tractable formulas, e.g. when the aggregate risk is measured by standard deviation, VaR or TVaR. Such allocations have a clear interpretation in terms of portfolio optimality, performance measurement and benchmarking. The Return on Capital (RoC) calculated for each risk, using thus allocated capital amounts, can be compared to the portfolio return. If the individual risk’s RoC is higher (resp. lower) than the portfolio RoC, we know that an increase (resp. decrease) in the exposure to that risk would yield an improvement to the portfolio RoC. In fact, in an optimal portfolio, all risks will have the same RoC, if capital is allocated using the Euler method. For a mathematical formulation of the above arguments see Tasche (2004), while a less technical discussion can be found in Tsanakas (2009, section 5.11).

A different use of marginal allocations is as a sensitivity testing framework. Since allocated capital is derived by evaluating the impact of infinitesimal changes of exposure on aggregate capital, it provides an indication of the portfolio’s sensitivity to particular risks. Hence if the capital allocated to a particular risk (e.g. credit risk) is much smaller under a marginal allocation, in comparison to a pro-rata one, this shows a low significance of this risk in the portfolio context. Alternatively it can be seen as indication of insufficiently strong dependence assumptions between that risk and the rest of the portfolio, the circularity of this argument being a persistent feature of capital modelling at the extreme tails.

The authors propose the use of formal methods of expert judgement elicitation, with particular reference to the Delphi method (see e.g. Cooke, 1991). I agree that this would be an important improvement in relation to currently followed processes. Nonetheless, even before getting to that stage, a few observations relating to the type of judgement we should be seeking to elicit can be made. These are illustrated by the example of setting dependence assumptions, an area where data scarcity is nearly always a problem.

In any expert judgement elicitation process, we should be asking experts questions that they



can meaningfully answer with recourse to their knowledge and intuition. Hence these questions should be about quantities that can be intuitively grasped and easily interpreted.

For example, when modelling dependence between risks, it would not be good practice to ask questions such as “what do you think is the level of correlation between risks X and Y?” Humans, including the statistically trained, have no intuition on what is a reasonable level of correlation. Moreover, the question is vague. What type of correlation are we enquiring about — Pearson correlation (useful in the context of regression), Spearman correlation (useful for the parameterisation of Gaussian copulas), Kendall correlation (useful for t and Archimedean copulas, such as the Gumbel) or “tail correlation” (a fairly ill-defined term anyway of which no formal definition is available)?

Instead it would be more productive to ask questions about quantities that relate directly to probabilities. Humans have an intuitive (if still generally flawed) understanding of probability via relative frequency. Hence a question could be formulated along the lines of:

*Suppose that risk X has exceeded its  $p^{\text{th}}$  percentile (1 in  $1/(1-p)$  years level). Given this, what is the probability that Y also exceeds its  $p^{\text{th}}$  percentile?*

This approach to elicitation has been proposed in an engineering context by Morales *et al.* (2007).

Questions such as the one above can be asked in relation to a range of possible levels of the probability p, e.g. 50%, 75%, 90%. These elicited values can then be used to select a particular dependence model. If C is a copula function used to model the dependence between X and Y (see e.g. Tsanakas (2009, section 3.9), then the following equation holds:

$$g(p) = P(Y > F_Y^{-1}(p) \mid X > F_X^{-1}(p)) = \frac{C(p, p) - p}{1 - p} + 1.$$

The function g can be plotted for several different models (different correlation values and copula families). For example, the conditional probabilities are plotted in Figure W1 for the Gaussian copula, for different values of the Spearman rank correlation. The values of g(p) that are elicited from experts can then be entered on the same plot, to identify which curve (if any) they seem to lie on. This would enable parameter and model selection, based on expert judgement.

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**Mr M. G. White:** The paper mentions behavioural factors, which arguably come into the category of operational risk. In Solvency II, the principle of embedding risk management into the

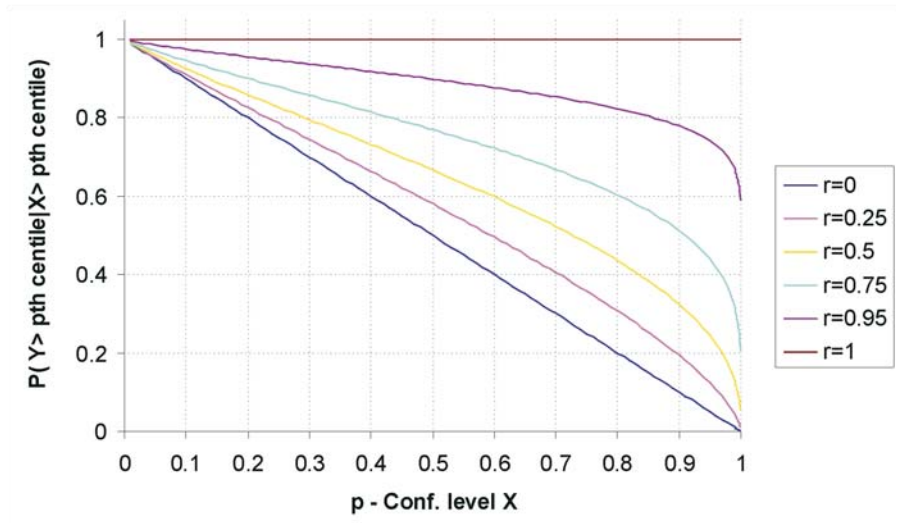


Figure W1. Plot of the function  $g(p) = P(Y > F_Y^{-1}(p) | X > F_X^{-1}(p))$  for the Gaussian copula

business is prominent, so I would like to touch on some issues highlighted by the current financial crisis.

While the situation is improving, I feel that there is not enough attention paid to the motivations behind corporate behaviour, an issue which extends beyond the financial sector to all businesses. Any regulatory framework that misses the impact of the way in which management is rewarded is likely to fail, as the regulation of the banks has undoubtedly failed. If we add to this the natural tendency simply to ignore those things which are “too terrible to contemplate”, even though there might be a non-trivial chance of their happening, the chance of failure grows still further. I suggest that Solvency II itself starts with a behavioural flaw, as some aspects of the policyholder interest have not been considered from first principles.

In the discussion at Staple Inn, there was some mention of counter-cyclical and pro-cyclical regulatory drivers. To be effective, given that some of the biggest disasters to which we subject ourselves result from over-simplistic ideas such as “growth is good” or “we need to help people borrow so that they can spend more” or “rising market values should be recognised as income”, effective measures need to be clever enough to protect us from ourselves. That applies at the macro, national economic, level as well as the more micro level of the company. Politicians too need to be protected from over-confidence. Publicly monitoring potential warning signs such as large adverse balance of payments, high levels of indebtedness, high asset prices might help a little. An equivalent within the insurance industry might be over-reliance on reinsurance, especially by reinsurers themselves. An awareness of these kinds of problem is of course very helpful in the context of internal models and argues for a judgemental adjustment to any conclusions which may come from the models.

Obliquity is a term reflecting the situation where an outcome cannot be achieved by aiming directly at it. A frequently cited example is happiness, but the example most relevant to our discussion is the financial success of businesses. The most successful businesses seem to be led by people who are inspired to do something well, rather than to become rich, though financial success is frequently a consequence. Businesses are complex systems where adjusting one control can have unforeseen consequences and this is a huge challenge to modelling. The experience of

the last few years suggests that managers of financial businesses and also their owners need a deeper understanding of how those systems work and of the dangers of over-simplistic targets.

The most questionable targets in my personal view tend to have long been accepted wisdom. This means that these remarks may be met with some resistance. Managements have been given incentives to achieve growth in earnings per share, or a high return on capital. They have also been given incentives to deliver an increasing share price. The first of these can be manipulated by buying back shares, the second by reducing the capital (which may be one motivation behind the interest in internal models) and the third can lead to self-deception, spin and, ultimately, loss of trust and failure. I would suggest that none of these measures of “success” should be factored directly into financial incentives for management. The remuneration consultants would need to discard their usual set of tools and recommendations and start afresh.

Recent financial developments have caused us to start thinking “how did it all go wrong?” and “what can we do to protect society from animal spirits getting too far out of control?” I think the Actuarial Profession should have some contribution to make here.

While I am arguing that regulators need to think much more about motivators within companies and to understand the implications of obliquity in their work, these remarks are not just aimed at regulators. Regulation is an essential but thankless task. The regulatory environment (and this includes the accounting as well as the tax environment) can aim to enable certain behaviour and to prevent other behaviour, but it can only aim, it cannot actually control. If inappropriately motivated, people will try to find ways around regulations. Many successful careers and businesses are founded on the exploitation of loopholes.

Just as it is necessary for regulators to have a deep understanding of the way in which the businesses they regulate operate, it is arguably even more important that the businesses are intelligently governed in the interests of their owners. If this happened, the regulatory burden could be lighter. This should not be in conflict with the interests of the clients to whom companies have a fiduciary responsibility. It is up to owners to ensure that this is achieved, and I like to think that the Actuarial Profession, with its influence, directly and indirectly, on the fund management industry, will pay greater attention in future to understanding the wealth creation process.

There is enormous scope to consider what the right targets should be in a business. All industries are different, as are the businesses within them. But, for the financial businesses which are subject to prudential regulation to protect the customer, there must be a role for the regulators to ensure the right levels of competence and understanding within boards of companies. That is asking a lot of the regulators, but the indications are that the FSA under Lord Turner is increasingly thinking along these lines.

This situation offers scope for worthwhile research, as well as collaboration with other professions. What advice would you give to an owner when setting the principles that the board should apply for business targets and staff participation and incentives? A different analysis will apply to different segments of the insurance and reinsurance market, so the challenge is not trivial. Crucially, owners, and therefore the managers, should play close attention to the relative competitive strength of the business now and in the years ahead. The important measures of success and indicators for future success are not all immediately reflected in published financial results. This has implications for reporting.

It is all too easy to criticise the conventional measures of corporate success and the way in which their use in setting management incentives has had perverse effects. It is far harder to design sets of objectives and incentives to be adopted by and within an insurance business that have the desired long-term result. This is something to which I believe the Actuarial Profession is in a good position to contribute, and a potentially promising area for research.