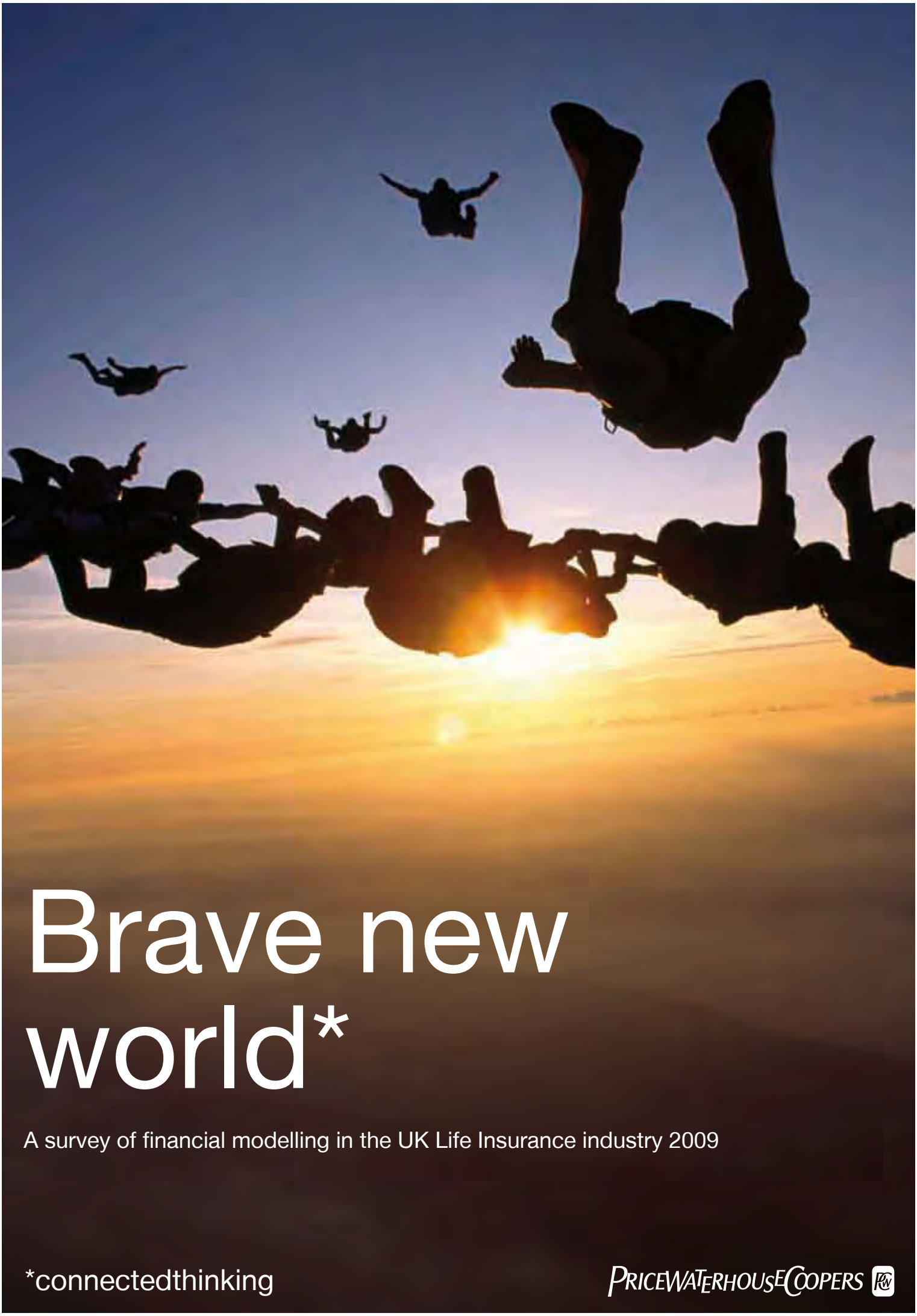

Brave new world*

A survey of financial modelling in the UK Life Insurance industry 2009

*connectedthinking

PricewaterhouseCoopers

Contents

01 Introduction

PricewaterhouseCoopers (PwC) published a survey in 2004 of the emerging adoption of stochastic modelling in the UK life insurance market. The survey was entitled “Weapons of Mass Computation” following a commentary in the Financial Times debating the scale of hardware being employed for the first time by UK insurers and speculating on the computing capacity that would be required by the regulators in order to properly supervise the industry.

The survey highlighted that UK insurers were struggling with the logistical realities of running their statutory valuation models stochastically. Most had adapted their existing deterministic models to meet the Realistic Balance Sheet (RBS) requirement and a few had decided to redesign from scratch. Their processes may have just been sufficient, but would not meet increasing demands. The survey also highlighted that for the larger companies there was a dominance of two providers for liability modelling – Prophet from Deloitte & Touche and MoSes from Towers Perrin. These two products are still active in the market (albeit one of them under new ownership) but there are a number of new competitors seeking to gain market share. The survey also indicated that in the area of economic scenario generators (ESGs), crucial in calculating a market-consistent balance sheet, one company, Barrie & Hibbert, dominated the UK market.

Five years on, and with the European-wide regulatory introduction of a new Solvency regime for the insurance industry (Solvency II), companies across the EU have to embrace the results of stochastic modelling at the heart of their management decision making. UK insurers who may have thought that they'd gone through the hard work in implementing the UK-specific RBS and Internal Capital Assessment (ICA) regimes are finding they have to raise their game to a new level as the European Commission defines the new playing field.

For insurers does this mean they need to discard their existing systems and build completely new models? Are there new tools that they need to add to their armoury and what other drivers, apart from Solvency II, should they allow for in their quest to meet the new regulatory requirements?

What better time to update our original survey and identify the challenges for insurers in this brave new world?

In compiling this report, we interviewed nineteen companies over the summer of 2009, using both face-to-face interviews and web-based survey tools and have supplemented our interviews with additional research and discussions with key figures in the industry.

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02 Executive summary

The challenge is to demonstrate that models are an integral part of the decision making process and that an appropriate governance structure is in place.

Although UK insurers have been preparing balance sheets using stochastic modelling methodologies for 5 years, our survey and research highlights that companies remain unsure as to how they will meet future regulatory and business requirements, in particular Solvency II.

Solvency II requires management to evaluate and take account of risk-capital in managing the company utilising either the so-called "standard" model defined by the regulator or an "internal" model that is tailored to the risks the company faces. The presumption for most insurers is that using an internal model will lead to a lower capital requirement. The calculations themselves are reasonably well-understood by insurers, and in some cases not significantly different from current requirements. The challenge therefore is to demonstrate that the models are an integral part of the decision making processes of the insurer and that an appropriate governance structure is in place – the majority of insurers highlight this as the key area of focus for actuarial systems in the next 5 years.

Alongside Solvency II, companies indicated 2 other key development priorities:

- Rationalisation of existing models and systems in order to reduce costs of maintenance and development particularly entering a period of significant regulatory developments and additional financial disclosures (not only Solvency II but also potential new IFRS standards and Embedded Value (EV) reporting metrics)
- Achieving faster reporting timescales in order to meet an increased demand from the market and regulators for timely financial disclosures following the market turmoil of the last 12 months

Whereas, in the past, the focus was on increasing the amount of hardware in order to perform more complex calculations in a shorter time period, these current business priorities are focussing the development of actuarial models in 2 principal areas:

- Creating a controlled process around the calculations in an appropriate timescale in order to qualify for internal model approval
- Facilitating a step change in the potential frequency of performing these calculations

In order to meet these dual requirements of frequency and governance for their actuarial models, companies are addressing 4 key areas:

1. Understanding the breadth and depth of systems and processes that are impacted by Solvency II

2. Determining whether current systems can be evolved to meet the requirements or if a completely fresh approach is required

3. Developing a capability to use risk-based capital as a management metric – i.e. the ability to report capital requirements on a monthly or more frequent basis and also the ability to quickly report capital requirements on an ad-hoc basis in response to management questions

4. Assessing the level of governance, controls and documentation required to meet the internal model approval requirements of Solvency II

There is a risk that companies will focus on the modelling solutions at the expense of fully understanding and defining the requirements appropriate for their own business needs. In some cases companies are being bombarded with new software solutions that do not necessarily give appropriate business benefits or indeed fully meet their requirements. Experience from the banking world with the introduction of Basel II showed that companies that jumped to "solutions" without defining and validating an appropriate modelling strategy ultimately incurred a greater cost in meeting the requirements.

For many companies, it will be possible to evolve current models and systems although there may be aspects of meeting the requirements that require a fresh look at how particular needs are met. We have seen, for example, the emergence of 2 new types of actuarial modelling tool that are being marketed as essential elements in a company's armoury for Solvency II – aggregators and synopsis tools. Aggregators bring together several risk exposures and, as the name might suggest, aggregate them in order to calculate an overall risk position and capital requirement. It is now crucial that insurers are able to project this economic balance sheet into the future and synopsis tools, such as replicating portfolios or curve-fitting tools, distil complicated risk distributions into easily repeatable calculations to avoid the long runtimes associated with traditional methods of performing these calculations.

The scope of Solvency II and other business priorities and how they impact actuarial models is overwhelming. From our conversations with insurers, there are many different approaches to the way that companies think about their modelling strategy. These range from those who are actively developing a clear and comprehensive strategy to those who are continuing with their current approach and making tactical changes to cope with Solvency II. In order to successfully meet these challenges insurers need to develop an appropriate strategy for actuarial modelling and demonstrate how this strategy will enable the company to deliver actuarial models that are fit for the brave new world.

Sections 3 to 8 look at the challenges insurers face in developing their models and how they perceive their modelling software and priorities.

Section 9 looks at the future requirements and what insurers will need to build over the next few years.

Finally, section 10 sets out a process that we believe insurers should use to define their modelling strategy and the building blocks they need to put in place over the next few years to meet these challenges.

03 Solvency II modelling landscape

When insurers have invested significantly in their modelling systems in the past, there have been typically two drivers for that change:

- Recognition of "pain" in their current systems and processes (e.g. errors identified, excessive runtimes, uncertainty in detailed calculation routines implicit within existing systems)
- Identification of substantial benefit from new features or a step change in functionality provided by the vendors (e.g. the move to stochastic ALM modelling systems enabled companies to perform new analyses)

Regulatory change brings something new into the equation - moving the goal-posts for the business that may mean current modelling systems and processes are unable to cope.

In order to gain the potential capital advantage of using an internal model, companies need to achieve "internal model approval" from their lead regulator. There are 7 tests companies will have to meet.

3.1 The "Use" test

Companies will need to demonstrate that the model is integrated into several core business dimensions. This is highly likely to include, but is not limited to, capital allocation and business planning exercises.

Key issues companies are addressing are:

- Capital allocation - allocating model results to a granular enough level in order to inform business decisions is a serious technical and practical challenge
- Timeliness and accessibility – making model results "real-time" and accessible enough to end-users is viewed by the regulators as a key part of demonstrating that the model is a core component to help run the business
- Integration – ensuring consistency between the internal model and other models used by the business
- Management expertise – model output can be dense and difficult to interpret by the non expert user and education and training will therefore be required. The Board, for example, may not have the required skills to understand and challenge the results

3.2 Governance

The Board and senior management need to take ownership for model approval and model strategy. There needs to be a clear alignment of risk and business strategy with processes for independent review and challenge implemented.

Key issues companies are addressing are:

- Control design and effectiveness – modelling teams often lack experience of working within formal control frameworks. Control reporting and key control indicators can be difficult to design effectively without the appropriate experience
- Model change policy – devising the model change policy to meet the needs of the business whilst satisfying the regulator is a substantial challenge. In particular any major model changes would require resubmission to the regulator for approval
- Consistency of assumptions – achieving consistency of assumptions across the business is likely to be a significant organisational as well as technical challenge

- Levels of management sign-off – finding a suitably qualified senior individual to sign off the operation of controls and governance framework could be difficult

3.3 Statistical quality

Some issues insurers currently face will continue and become even more challenging under Solvency II. For example, data needs to be complete, accurate, appropriate and credible with data processing subject to sound controls. Assumptions should be derived in a robust manner and subject to challenge.

Key issues companies are addressing are:

- Data adjustments – a variety of issues can impact the data. These may require suitable adjustment going forward to ensure the model reflects future business and operating conditions appropriately. Ensuring robust challenge of adjustments by the business can be difficult
- Statistical techniques – validity can be an issue, for example particular cohorts may have low volumes of data. There may be occasions where internal data needs to be supplemented
- Judgement – many elements of modelling are not purely data based, validating judgement is unlikely to be straightforward and may require a number of different approaches
- Dependency – modelling of dependency structures is difficult, and data is limited. This is often a key driver of tail risk and needs to be considered carefully

3.4 Validation

Companies will need to demonstrate that the model is largely transparent and understood by key stakeholders. Validation comes from a variety of sources

Key issues companies are addressing are:

- Analytics – developing and maintaining a suite of analytical tests is time-consuming
- Reference to prior periods – validation is often relative to prior years, which may not appropriately capture the risks to the business going forward
- Expert input – validation from sources outside the modelling team needs to be framed carefully if it is to be robust
- Judgement versus analytical validation – judgemental assumptions can be difficult to validate, particularly when there is divergence from the values indicated by underlying data analysis
- Stress and scenario tests – developing appropriate tests that reflect the key vulnerabilities of the business

3.5 Calibration

The model needs to be calibrated at a range of points on the distribution in order to meet the demands of the use test as well as regulatory capital requirements.

Key issues companies are addressing are:

- Partial models – these will require integration of treatment of risks, and of co-dependencies, between a model and the standard formula. Ensuring that this results in a proper calibration will be part of the debate with the regulator and their comfort the integration has been carried through effectively
- Usability – the discussion on calibration is ongoing and may result in the need to produce separate calibrations for different uses. Reconciliation between different bases is likely to be difficult to determine with any degree of precision

3.6 Attribution

The model must reflect profit sources at a fairly granular level, which is likely to be by major product lines or geographies.

Key issues companies are addressing are:

- Structure – model structure may need to be changed significantly in order to look at economic profit attribution
- Emerging risks – the model structure will evolve with time in order to capture emerging risks appropriately. The temptation may be to view these as isolated one-off incidents, rather than underlying trends
- Granularity and distribution mapping – achieving realistic attribution at a suitably granular level may be challenging. Similarly it may be difficult to ascertain whether the actual experience relates to a 1 in 10 or a 1 in 20 year event; a view on this is required in assessing whether the model has been calibrated appropriately

3.7 Documentation

Documentation of the internal model has to be sufficiently detailed and complete to enable an independent knowledgeable third party to form a sound judgement as to its reliability.

Key issues companies are addressing are:

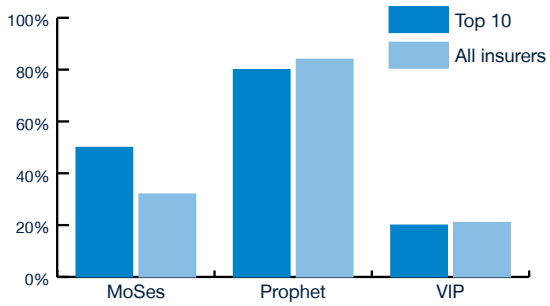
- Standard – although the recent Solvency II Consultation Paper 56 has reduced the level of documentation required and the proposed Board for Actuarial Standards' requirements are under review, the standard required is still likely to be more stringent than that to which existing documentation is developed. The documentation provides evidence for and supports the other model approval tests
- Focus – documentation is regarded as low value within teams, and it therefore tends to receive a low priority and is generally done at the end of the process
- Maintenance – there is a significant ongoing documentation burden that is often overlooked in resource planning
- Clarity – complex, technical issues can be difficult to explain succinctly and clearly, even for expert reviewers

04 Actuarial modelling software employed

The actuarial modelling software market remains dominated by the three longest established providers – iWorks Prophet from SunGard, MoSes from Towers Perrin and VIP/VIPitech from Watson Wyatt. Only five of the companies surveyed use more than one of these packages and the majority of these are looking to consolidate to a single modelling platform. Those companies that use more than one package tend to do so because of previous company consolidations and adoption of existing legacy modelling solutions.

Across all our surveyed companies, Prophet is the dominant package used across more than 80% of the market. MoSes is in second place with a 30% market share with VIP or VIPitech having a 20% market share. Restricting our view to solely the largest companies comprising the top ten surveyed UK life insurers, both Prophet and VIP's market share is consistent with the wider group. However MoSes has a greater penetration and achieves 50% market share with this group showing a greater popularity with the larger insurers.

Figure 4.1: Modelling software used by life insurers

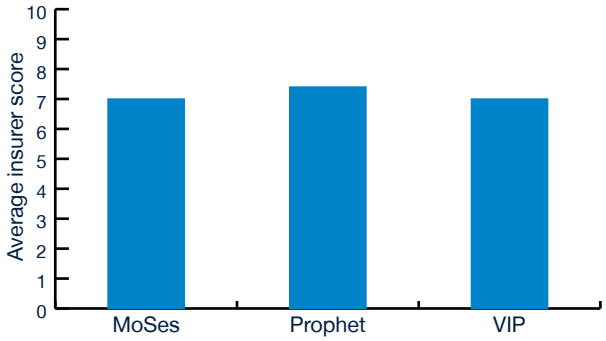


Not surprisingly, a large number of respondents also use Excel as part of their modelling solution across all purposes. Three organisations reported using in-house developed models for business planning purposes of whom two also use it for regulatory and financial reporting purposes.

There are four organisations that rely on a mainframe solution, primarily for their regulatory valuation, although one organisation also uses it for part of their financial reporting.

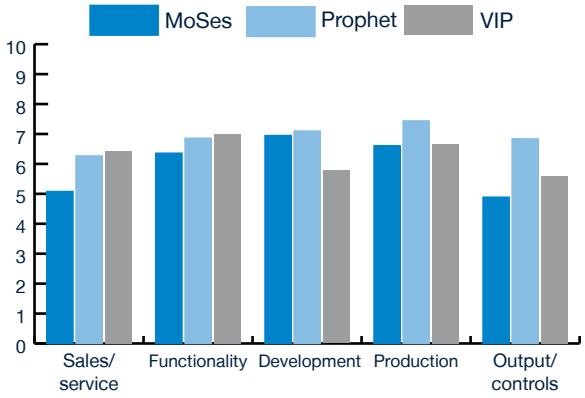
User opinions of the main software packages were compared by asking for an overall opinion of how well the software met their requirements. All three packages scored similarly across the participants with Prophet scoring slightly higher than MoSes and VIP/VIPitech.

Figure 4.2: Match to company requirements



When quizzed on satisfaction rating for particular aspects of the software packages, there was greater disparity in responses with each package scoring well on different aspects. Looking at broad areas, production, functionality and development generally scored highest whereas sales/service and output/controls received lower satisfaction ratings. Overall the satisfaction ratings are lower than the rating given for how well the software matched company requirements.

Figure 4.3: Satisfaction ratings



The following sections highlight the detailed responses for each individual software product.

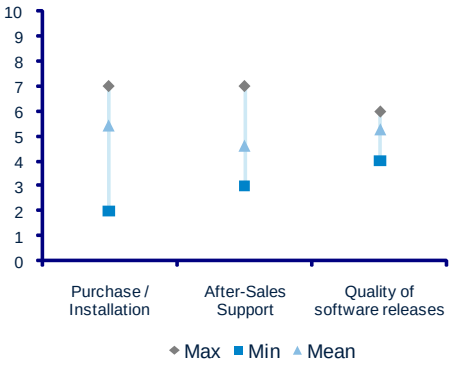
4.1 MoSes

Background

MoSes was originally developed by Australia-based Classic Solutions which merged with Towers Perrin in 2002. MoSes provides a more open and transparent software platform than the other products and has less standard product code, meaning that it can be tailored to the insurer's specific requirements.

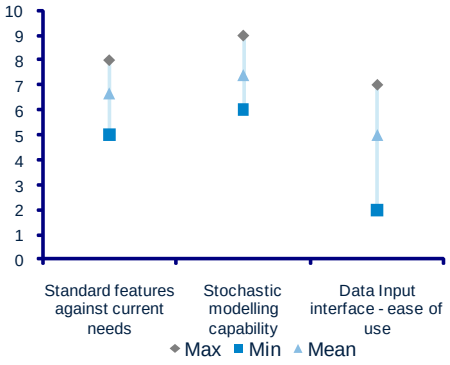
The software is used by six respondents in the survey.

Sales and service



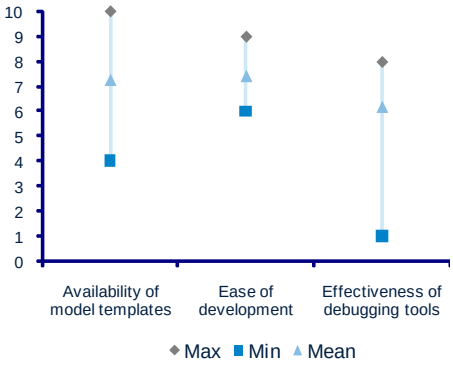
The graph shows a range of scores from 2 to 7. The lowest scores mostly emanated from one insurer, who did not provide detailed explanations. Other companies also gave low scores of 5 or below on after-sales support and quality of software releases. The highest score for each of the three metrics was provided by the same company.

Functionality



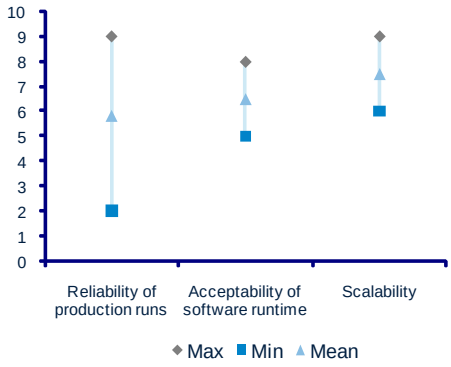
Stochastic modelling capability scored well with the respondents as did the availability of standard features against current needs, where there was only one score below 6. Low scores were provided for the ease of use of the data input interface, where over half of the scores were 5 or less. Respondents did not comment on the rationale behind their scores, although one company did mention some issues in previous releases which removed existing functionality.

Development



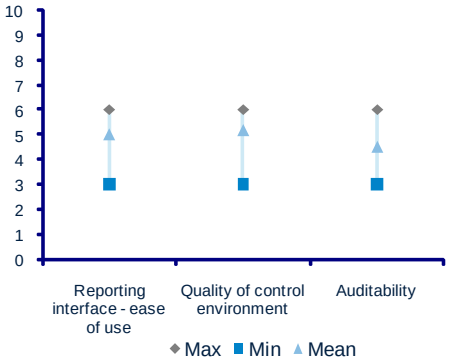
The scores under this category range from 1 to 10. A score of 1 was given by a respondent on debugging tools, with the comment that they could not run the debugger successfully. Only one other score below 6 was recorded, with the remaining scores being mostly 7 or 8. One respondent gave a highest score of 10 on availability of model templates.

Production capability



In this category, scalability scored highest, with all companies indicating satisfaction. Two respondents gave scores under 5 for reliability of production runs, but did not give any reasons why.

Output and controls



The area of output and controls was scored lowly by all respondents with no individual score above 6. One company commented that they had built their own output macro whilst another company said that they had built their own control environment, both because they found the Moses standard version unsuitable.

Overall rating

MoSes was given an average rating of 7 by respondents with a range of scores from 6 to 8. However there were some issues around sales and support and outputs and controls, where average scores were lower than in the other categories.

Priority improvements

Respondents were asked to comment on the priority areas where they felt that the software needed development. The main areas of focus identified were as follows:

- Develop improved processes for the input of data and assumptions, and for general output reporting (including external links)
- Improve controls around MoSes, including automated version control and auditability
- Replace the FoxPro Database
- Improve the scheduling functionality, including Master / Worker reliability
- Improve MoSes product templates
- Increase user friendliness

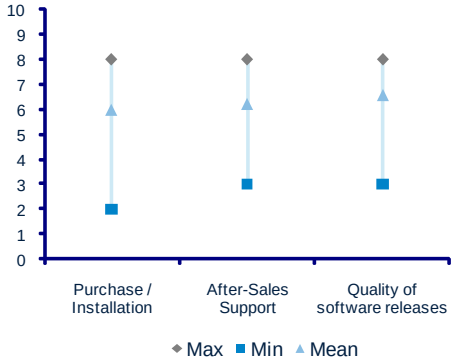
4.2 Prophet

Background

Prophet was originally designed and marketed by Bacon and Woodrow who merged with Deloitte & Touche in 2000. Prophet was sold to SunGard in 2005. It provides a large number of libraries that insurers use as starting blocks for their business, meaning that Prophet is generally easier to start with, but can require more development for complex businesses, for whom the libraries may need significant tailoring. Prophet Enterprise promises a secure and controlled environment for companies in which to run their production models on an enterprise technology platform.

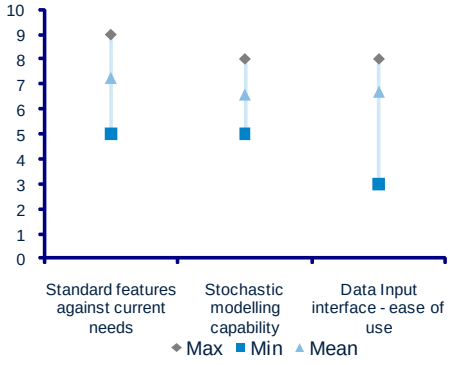
The software is used by sixteen respondents in the survey.

Sales and service



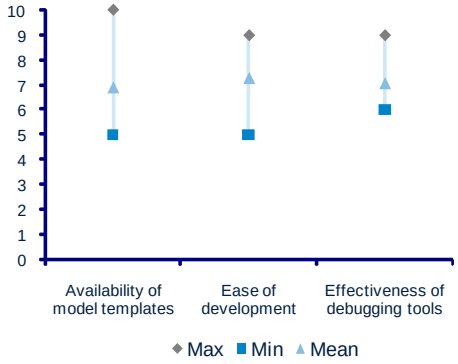
Sales and Service was the lowest area of scoring for Prophet, with scores ranging from 2 to a high of 8. Quality of software releases tended to score better than the other two categories. The lowest scores mostly emanated from one insurer, who wasn't happy about some aspects of software releases and after sales service - this didn't however seem to be the view shared by other respondents. All but one other company provided scores of 5 to 8s. This company suggested that their perception was that technical support had become weaker since the move to SunGard.

Functionality



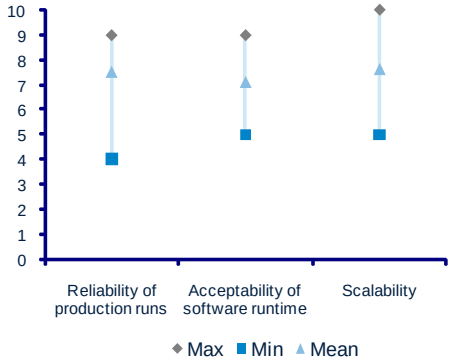
The graph shows a range of scores from 3 to 9. The low score of 3 was provided by a single respondent, who felt that the assumption interface is poor and complex to use. Most of the other individual scores were 7 or 8, although there a number of scores of 5 or 6, particularly in stochastic modelling functionality and data interface – ease of use.

Development



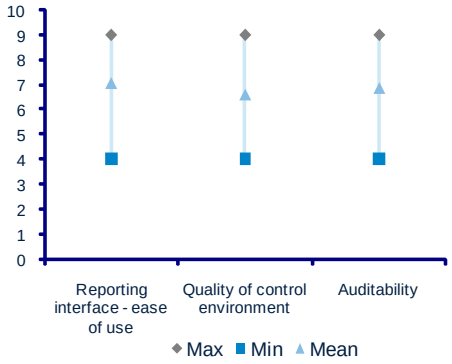
Respondents' scores in this category were higher than those in functionality. This reflects the view that the software is easy to develop, with four companies providing scores of 9 for ease of development. The individual scores ranged from 5 to 10.

Production capability



Reliability of production runs was generally considered good with over half the respondents scoring 8 or 9. Only one other score was less than 6, where the respondent thought that the standard tables tended to have limited functionality and were inefficient to update. Software runtime and scalability receive no adverse comments, with scores ranging between 5 and 10. Scalability in particular received high scores with over half the respondents scoring 8 or more.

Output and controls



The scores provided for these metrics varied considerably with a majority of scores being 7 or more, but also a significant number being 4 or 5, particularly in the areas of quality of control and auditability. Here companies found the control environment too manual and difficult to use, relying too much on the control culture of the organisation. One company commented that they expect the control environment to be improved through the introduction of Prophet Enterprise. Another respondent commented that run logs, particularly on stochastic runs, were unwieldy and difficult to use.

Overall rating

Respondents gave Prophet an average rating of 7.4, which was slightly higher than the other software scores. They were generally happy with the software and in particular liked the ease of development and production capability. The lowest average score was provided for sales and support.

Priority improvements

Insurers were asked about the priority areas where they felt that the software needed development. The main areas of focus identified were as follows:

- Improve controls and simplification of input and output interfaces
- Improve functionality in areas such as reassurance and improvements to the ALS library in relation to asset classes and handling of multi-currencies
- Include a facility to automatically delete and re-scan of input variables to improve development efficiency
- Improve debugging, especially during compilation, and provide more informative error messages
- Have a better diagram view in DFA
- Faster reaction time to industry and regulatory developments

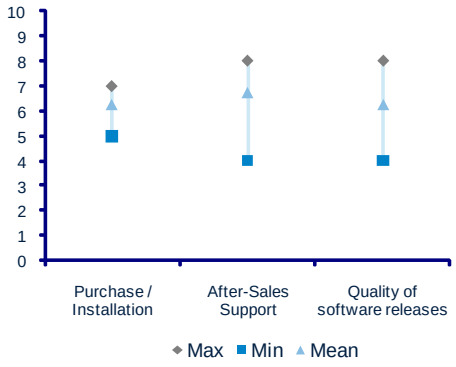
4.3 VIP

Background

VIP is developed and marketed by Watson Wyatt. In April 2006, Watson Wyatt launched VIPitech, which has been designed to be more modular than previous versions. Users of the software also comment favourably on the usability of the interface.

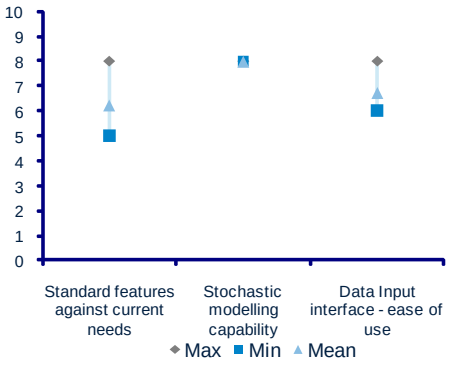
The software is used by four respondents in the survey, most of whom are in the process of moving to VIPitech.

Sales and service



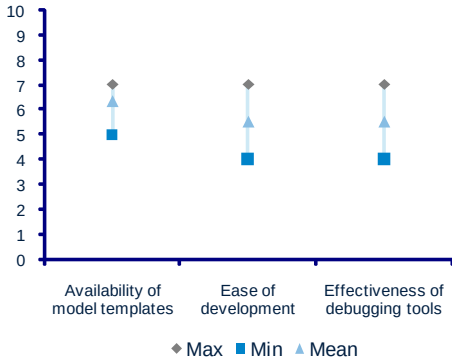
The graph shows a range of scores from 4 to 8. The lower scores all emanated from one insurer. Overall Watson Wyatt scored higher than other software providers, with the other respondents all providing scores between 6 and 8.

Functionality



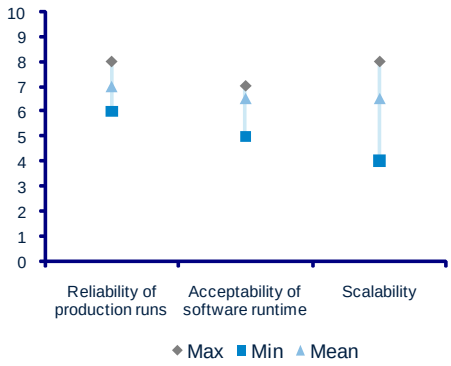
Respondents were generally happy with the functionality within the software, with stochastic modelling capability being universally well thought of. A couple of insurers scored 5 or 6 for the other categories.

Development



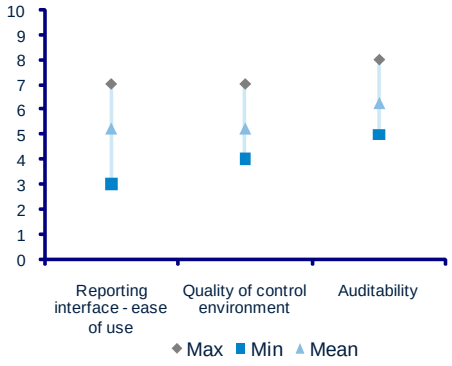
Respondents' scores in this category were lower than those for functionality reflecting their view that the software was not that easy to develop. They also commented that the Analyser was not easy to use, with error messages unhelpful. Most of the highest scores of 7 were from one insurer.

Production capability



Reliability of production runs was considered good, with runtimes generally considered acceptable. There was a significant divergence on the scalability of VIP, with one respondent scoring 4, due to issues with running a large block of business in a single run, with others scoring as high as 8.

Output and controls



Generally VIP users were less happy with the ease of output and controls within the software, with 2 of the respondents giving scores of 5 or less across all measures. One respondent gave scores of 7, with the final respondent giving scores ranging from 5 to 8.

Overall rating

VIP was given an average rating of 7 by respondents who use the software indicating that clients are generally happy with the software, although there are some areas where insurers would like to see improvement.

Priority improvements

We also asked insurers for the priority areas where they felt that the software needed development. The main areas of focus identified were as follows:

- Improve standard functionality, e.g. to better include areas such as reinsurance
- Building an enterprise version, including improved controls and auditability
- Improve debugging tools, including more helpful error messages
- Allow deterministic runs within a stochastic run
- Continued improvement in reliability and robustness
- Ensure future scale / presence in the UK market

05 Development priorities

Over the last few years insurers have continued to develop and enhance their actuarial models for regulatory reasons (such as ICA), producing MCEV results for investors, adding in new products or coping with mergers and other model rationalisation.

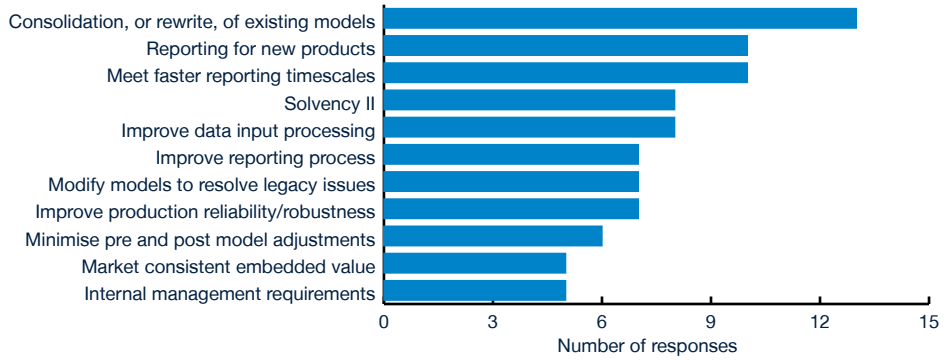
The pace of change is unlikely to slow, with Solvency II on the horizon. This featured on everyone's list of top five developments that they need to undertake in the next five years, but more surprisingly only on eight insurers' priorities over the next year. This may reflect the fact that the survey was carried out over the summer and most responses were received before the consultation period for the second wave of CEIOPS papers on Solvency II level 2 requirements had passed. In any event it is clear that it is a priority for all insurers over the next few years.

When asked to rank their development priorities, consolidation or rewrite of existing legacy models is high on a lot of insurers' lists, reflecting the level of company consolidation over the last few years and the need to streamline legacy actuarial models as part of their Solvency II activity. Another closely-linked issue is that of meeting faster reporting times. Whilst many companies can now produce embedded value and regulatory results much quicker than a few years ago, this is generally at the expense of some long hours and less analysis than they would like, especially at year-end. However, when it comes to ICA numbers, many organisations take up to 2 months to produce these figures, and at a different time to their reported numbers. Current timescales are unlikely to be acceptable to senior management or external parties in a Solvency II world.

Investment may therefore be needed to produce hard close results on a quarterly basis and to develop simplified "ready reckoner" tools, such as a roll forward basis or synopsis tools such as replicating portfolios or curve-fitting tools, for monthly or "what-if" analyses.

The other main development priority highlighted by a large number of insurers is to improve the reporting process. Many organisations produce their results and then use a multitude of spreadsheets and analysis tools to review the numbers and put them into a format suitable for onward transmission to senior management. This process tends to be labour intensive, slow and has little automated control around it. Companies have been improving their reporting processes almost constantly for the last 5 years and yet it still remains a high priority for them.

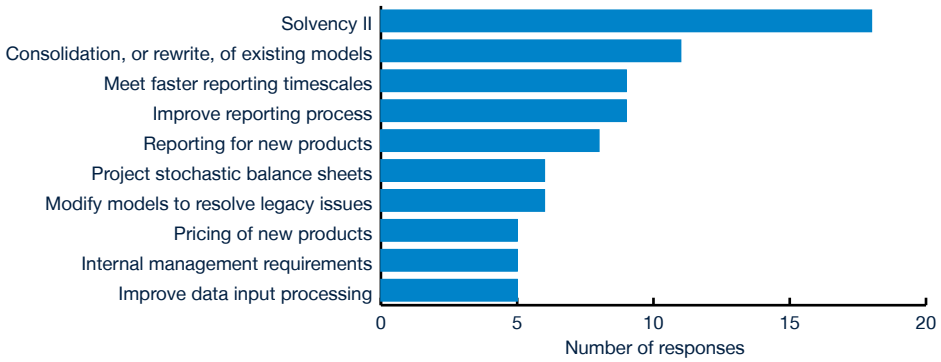
Figure 5.1: Insurers' development priorities over next year



Developing reporting processes and outputs for new products is mentioned by a large number of insurers, over both the 1 year (2nd) and 5 year (5th) time horizons. Pricing model developments figure lower down their priority list probably because models are tailored to the requirements of the product design in a more fluid manner and it is normally carried out in areas away from the core modelling team.

When asked the question, "What modelling issues are you tackling today?", insurers highlighted a number of different areas. Their main focus was on improving the reporting processes, with several commenting that this was as much around accuracy and validation as it was about speed. On a similar vein, a number of insurers are looking to minimise, or eliminate, pre- and post-model adjustments. Whilst a number of themes from the development priorities emerged, there was also some focus on non development activities, such as resolving issues with hardware capacity, the relationship with the software supplier or auditability. One insurer highlighted that a lack of skilled resource was one of their current issues, another that changing regulation was something they were tackling and a third that they wanted to improve the quality of their scenario testing.

Figure 5.2: Insurers' development priorities over next 5 years

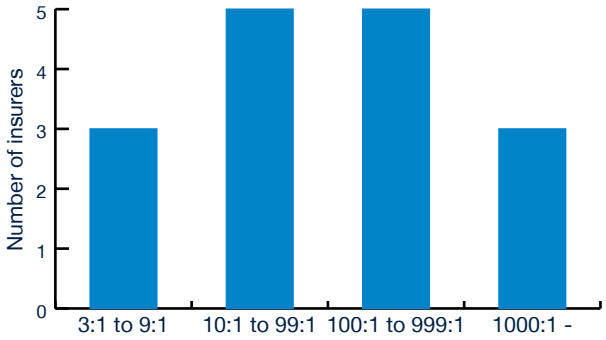


06 Stochastic issues

Not surprisingly, most companies in our survey use stochastic models, with 89% using them for either regulatory returns or production of economic capital results. Whereas in the past, some companies used Prophet for deterministic purposes and MoSes for stochastic purposes, most companies now use the same software for both types of projection.

All insurers use grouped model-points in their stochastic models, unlike for deterministic models, where all but two insurers use full policy data.

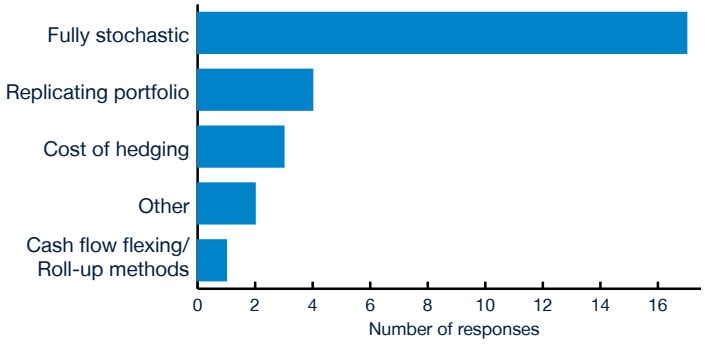
Figure 6.1: Ratio of full policy data to grouped model-points



The ratio of full policy data to model-points appears to be independent of size of organisation, and is more likely to be linked to the types of business sold by the individual insurer.

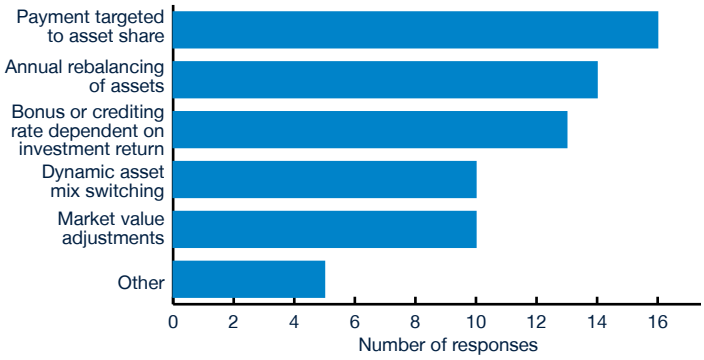
Whilst all of the respondents who perform stochastic valuations use fully stochastic models, there are a variety of approaches that they take to valuing specific liabilities. All but two of the companies use a mixture of closed form solutions, such as Black Scholes, and/or dynamic decision rules, for example to allow for the impact of guarantees or for lapse assumptions. Of the others, one organisation uses a fully stochastic model with no approximations and the other uses a cashflow flexing approach.

Figure 6.2: Valuation approaches for options and guarantees



Four organisations use a replicating portfolio approach with mixed success. Two companies have been happy with its effectiveness in both normal and changing market conditions, whilst one has found it ineffective in changing market conditions and one company is currently finding it ineffective in both normal and changing market conditions.

Figure 6.3: Management actions allowed for in stochastic models



Part of the increasing sophistication with stochastic models is the inclusion of more appropriate management actions in projecting the balance sheet. These are now generally approved at board level and reflect the actions that management expect to take in different scenarios, particularly those that are more extreme. This is shown in the extent to which insurers have a number of different management actions in their armoury, with all respondents using at least 1 type of management action and eleven using at least 4 different types of management actions in their stochastic models.

Other management actions mentioned by respondents included dynamic rates of deduction from asset shares, management of fund surplus and the use of a guarantee charge.

Whereas every insurer in this survey allowed for management actions in their stochastic valuation, only thirteen of the seventeen respondents included the consequent policyholder behaviours in their modelling. Policyholder behaviour can have a significant impact on the balance sheet, as their reaction to changes in the values of their investments can change the underlying dynamics of the portfolio.

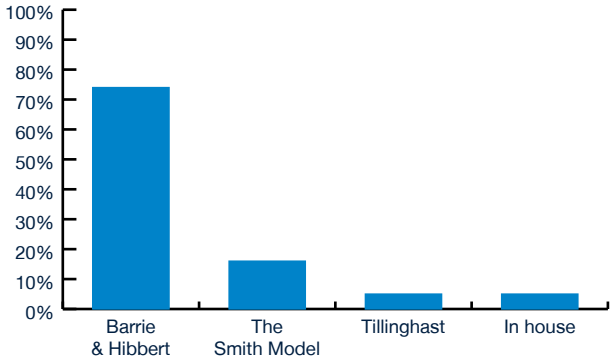
A policyholder reaction which increases or reduces lapse experience can impact insurer profits and the impact of guarantees, as was seen in the UK in the 1990's with personal pensions vesting guarantees, can encourage policyholders to take the most beneficial option for them. Whilst it is unlikely that policyholders have enough knowledge and experience to always take the most advantageous option, regulators can intervene and ensure that they are more likely to do so. Understanding and modelling policyholder behaviour is therefore likely to become more prevalent and sophisticated over the next few years.

07 Economic scenario generators

Whereas there are a number of actuarial software packages in use across the life insurance industry, the Economic Scenario Generator (ESG) software market is dominated by one company, Barrie & Hibbert. Seventeen of the nineteen participants in the survey reported that they used an ESG in their business.

There are two organisations that have more than one ESG package. One of these is planning to consolidate to one package and the other uses one ESG for their statutory returns and another for EV results reported to their Group Head Office.

Figure 7.1: ESG model used by life insurers



Most of the life insurers use a mixture of the software supplier and their own staff to calibrate their ESG scenarios, although three only use their internal staff and two rely solely on their software supplier.

The majority of scenarios used by companies are on a market consistent basis. In fact, seven of the respondents use market consistent scenarios for all of their bases. However, two of the respondents use a "Real World" basis for both their RBS and ICA calculations.

Figure 7.2: Market consistent or real world

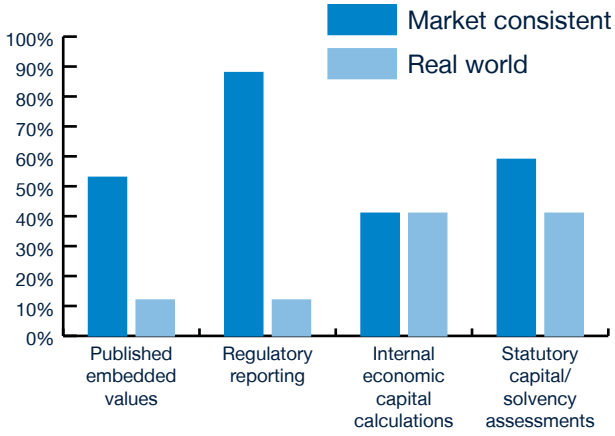
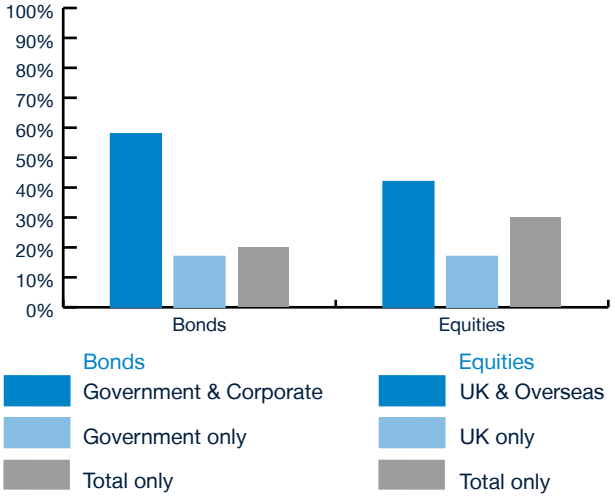


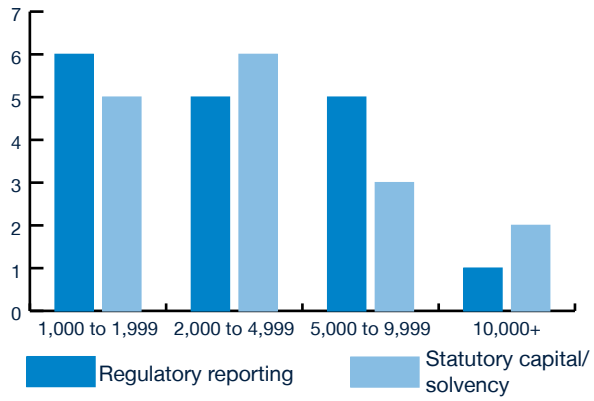
Figure 7.3: Modelling of asset classes – Bonds and Equities



All respondents modelled equity, bond, cash and property classes. Figure 7.3 shows that, whilst most companies modelled government and corporate bonds separately, a number modelled only total bonds. A similar position was found with equities. Very few other asset classes are modelled separately, with only four companies modelling derivatives, one modelling hedge funds and one separately modelling index linked gilts.

All bar one of the respondents used variance reduction techniques to reduce the number of scenarios, with most relying on antithetic variance techniques and a couple using control variates in addition. The respondents using The Smith Model tended to rely on the variance reduction techniques within that model.

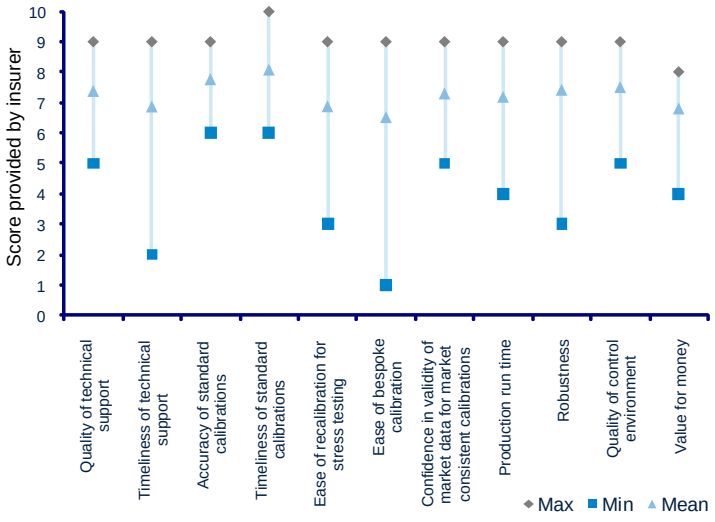
Figure 7.4: Number of simulations used in stochastic models



Most organisations used the same number of simulations for many of their stochastic projections, although there is some evidence of a higher number of simulations being used for insurers' own internal economic calculations compared to those they use for embedded value, regulatory reporting or statutory solvency capital purposes.

Figure 7.5 shows how the insurers rated their ESG software across a range of measures. We have not broken the analysis down by provider.

Figure 7.5 Insurer's ratings on their ESG software



Generally insurers are happy with their ESG provider and the calibrations that they use in their scenarios, with the majority of scores being 7 or more. In fact there were only seven individual scores of 4 or less, which appear to have been caused by individual issues rather than particular concerns with the software.

When asked for the three areas they would like to see improved or developed in their ESG, a long list of different requirements emerged. There were a few common themes, in particular around half of the respondents commented on wanting more robust and stable calibration tools or more bespoke / specific calibration tools for users of the software. There was also a request for independent assessments of the providers' calibrations. Whilst no other feature rated more than three or four comments, the following points were raised by two or more respondents:

- improvement in credit modelling which was felt to have some deficiencies
- a desire for improved speed of the tools used
- individual comments about the distribution of different asset classes or their fit across the volatility surface
- improved stability of results in stressed scenarios
- greater transparency of the model's calculations
- better output analysis tools
- lower price, or more standard functionality

There were also individual comments about including tax modelling, developing better internal understanding of the ESG tool and improved run log reporting.

Overall, clients rated their ESG software at 7.67 out of 10 which suggests that, whilst there are some areas for development, there are not any serious issues either with the software or the relationship the clients have with their ESG software provider.

08 Production pressures

The respondents to the survey cover a wide range of organisations in the UK, from the largest insurers to some who are relatively small. Not surprisingly this translated particularly into the responses to questions on the production environment. The most noticeable is in the number of processors that respondents have available for their modelling production environment, which ranged from 4 processors at the lower end to 1,000 for the largest insurer.

Figure 8.1: Number of processors employed in insurers' production environment

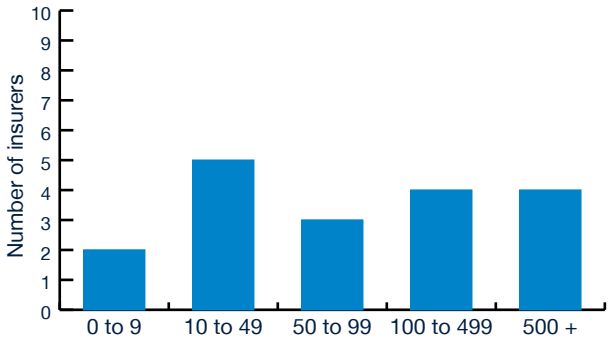


Figure 8.1 shows the diversity of results across insurers. Whilst the number of processors has increased from the previous survey carried out by PricewaterhouseCoopers in 2004, it has not increased significantly over the past 2 or 3 years, as greater processing requirements have been met by increased processing power and greater use of tailored hardware such as blade servers, which take up a fraction of the space of personal computers or servers but provide a higher capacity. We are, however, aware of at least one insurer that expects to add a further 1,000 processors to their capability in the next 3 years to meet the additional pressure from Solvency II production requirements.

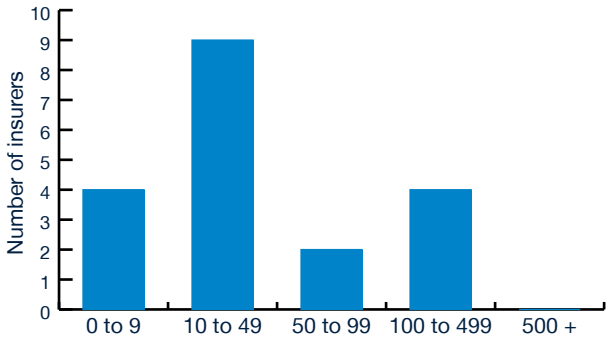
The leading actuarial modelling software providers include a distributed processing (master / worker) capability within their software package, where policy data can be split into a number of separate data parcels and processed in parallel amongst "worker" machines. This reduces the elapsed time needed to run the entire block of policy data and can allow re-runs of only those parts of the data that did not process correctly or where changes, e.g. in assumptions, are required.

Whilst seven of the respondents have no job handling middleware, eleven of the remaining insurers use the master / worker job handling capability in their actuarial software.

Two of the largest insurers who currently use the master / worker functionality also have additional processing middleware to handle their large volumes of policy data. One of these has developed an in-house automation and scheduling system that sits around their actuarial software. The system uses an intranet to schedule monthly, year-end and other runs and will manage the production run schedules based on run priority and availability of policy data and assumptions. The other uses an external GRID to manage the production runs and the actuarial software's own results aggregation functionality to pull together the results from all of the individual runs. The main advantage of using a GRID over the normal master / worker solution within the actuarial software is that any hardware or network related run failures can be taken up by another machine rather than causing a fatal run error, thus avoiding a re-run from scratch.

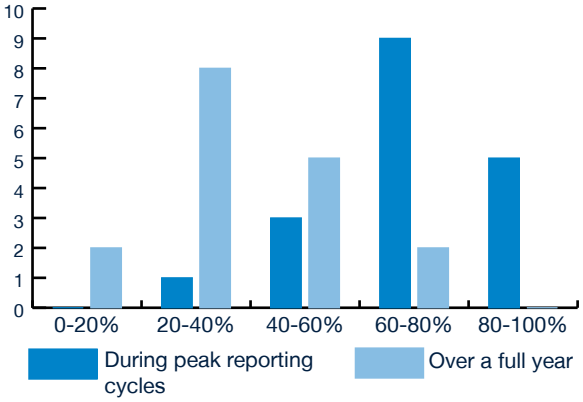
Whilst all this hardware is available, most companies only use a proportion of it for any individual run. Insurers were asked how many processors they used for each production run. Whilst there was still a wide range of responses, as can be seen in Figure 8.2, there is more commonality than in Figure 8.1 above.

Figure 8.2: Number of processors employed in individual production runs



The reason for all this hardware is to meet the timescales that management demands, either for their internal purposes or for external reporting timescales. This is particularly evident at year end, where companies need to provide audited results for regulatory reasons and for meeting investor and market requirements for IFRS and EV results. Figure 8.3 shows that at this time of year, even with the large volume of computers at their disposal, many companies are running their hardware at between 80% to 100% capacity on a 24/7 basis. Over the year, however, the software is used much less intensively, with nearly half the companies reporting hardware usage between 20% and 40% of capacity. There is therefore a major disconnect between the capacity necessary to meet reporting timescales in peak periods and the capacity needed for the rest of the year. Solutions, such as cloud computing, are now starting to become available and may help manage this capacity issue without relying on a large computer infrastructure being left idle for much of the year.

Figure 8.3: Hardware capacity used



There has been an increasing move towards having more formal IT support for the actuarial modelling team and, in our survey, six companies confirmed they had dedicated IT support. Whilst for most companies, this was equivalent to one or two people, one company has a full time team of 5 IT professionals to support their actuarial infrastructure and software.

The time it takes for an insurer to run their models varied significantly, from insurers who said their deterministic models took 15 or 20 minutes to run to those that said it took up to 20 hours to run their deterministic models. Many large insurers will typically target a deterministic run to complete within a 7 to 8 hour window, which means that they can start a run when they leave the office and it is finished the next morning.

From discussions with insurers and from the information they provided in the survey, it is clear that there are a number of factors that are affecting the run times that insurers experience. The most significant of these is the number of policies that they value. All but two companies use full policy data for their deterministic runs, rather than grouped model-points. The number of policies valued varies in size from 400,000 to 8 million policy records.

However, there are a number of other factors that will affect the runtime:

- the quality of the hardware - updating hardware can deliver a 20% – 30% improvement in run time
- the number of processors available - the more processors that a model run can be spread over, the shorter the elapsed run time
- the level of optimisation in the modelling software - it is possible to reduce runtimes by a factor of 2 or 3 by ensuring that code is not called unless necessary and by eliminating calculations for items not needed for reporting
- the level of functionality that is included in the model - some companies will adopt a simple broad brush approach to modelling on the basis that there are so many assumptions built into a model that the objective is to get a materially accurate answer, whereas other companies want to ensure the functionality is as accurate as possible, with a consequent impact on runtime
- the use of annual or monthly steps in projections - clearly annual steps will run quicker

The survey also highlighted a wide range of runtimes for stochastic models, with a minimum of 15 minutes for a company who used the ALS (previously Life DFA) library in Prophet to a company that took 30 hours. The same factors arise as for deterministic runs, although in addition the number of scenarios and the use of grouped model-points also affect the runtime.

Although many companies' stochastic models took longer to run than their deterministic models, some companies actually improved their stochastic runtime compared to their deterministic runtime. This is mainly due to the effect of using grouped model-points having a more beneficial impact on runtime than the adverse impact of the number of scenarios, but may also be due to the use of stochastic models containing less functionality and therefore running quicker per scenario.

We also asked insurers how their production runtimes had changed over the last 12 months. This provided a mixed response with six insurers saying they had improved, three saying they had deteriorated and ten saying they had broadly stayed the same. When asked what had impacted runtimes, improvements tended to be as a result of new hardware or an upgrade in the software version supplied. Deterioration in runtime tended to be the result of adding in more functionality, putting more business through the system or increased reporting requirements. One company who had maintained their runtimes reported that increased functionality had been offset by improving the existing code elsewhere. None of

the other companies maintaining runtimes had made significant changes to their models or the underlying hardware over the last year.

The software packages that have been available to insurers over the last few years have not kept pace with the increasing requirements for robustness, auditability and control that insurers need to meet more demanding regulatory controls, such as Sarbanes-Oxley and, looking forward, Solvency II. All the leading actuarial software suppliers have recognised this and have made available new versions which contain a greater level of control. Watson Wyatt has introduced VIPitech, a new version of VIP, which has improved controls within the actuarial software package, including access through VIPitech Enterprise to a secure web based server environment. SunGard with Prophet Enterprise and more recently Towers Perrin with RiskAgility, have both introduced new enterprise versions to support the growing demand for industrial strength systems.

These systems are wraps around the actuarial software, giving 64bit technology, greater controls and providing audit trails through the production process encompassed within the system. The controls focus solely on the calculations within their own tool and will still need to be integrated into a wider controls environment covering items such as data extraction, manipulation and any additional analysis commonly performed in Excel.

Eight of the respondents to the survey have indicated that they are planning to take on the enterprise version from their software provider, of which two are planning to do so within the next 12 months and the others within the next 3 years. We are aware of a number of companies who have progressed this more quickly than they indicated within the survey and are looking at these solutions to help them meet the Solvency II production control requirements.

09 Brave new world

Companies have been trying to envisage their future modelling architecture – they are being swayed by grand visionary promises from IT companies which come attached with grand price tags. Some clarity, however, is starting to emerge and a life insurer's modelling toolbox is starting to compartmentalise into 4 clear areas:

- Tools that create detailed risk distributions (at an individual product level)
- Tools to allow companies to parameterise the risk models
- Tools to summarise detailed risk distributions into a form that can be easily recalculated for a shift in parameterisation
- Tools that aggregate different risk distributions to create an overall risk distribution for the entity

Layering on top of these is the need to have a control and governance framework in place. Some tools promise to cover more than one of these elements (including the control and governance framework) but it is useful to think of each of these elements separately. The control and governance framework will also need to be extended to the entire end-to-end process so will need to include the assumption and data gathering through to results reporting – both of which sit outside the model kernel so thought needs to be applied as to how this is achieved.

9.1 Risk distribution tools

These are typically the traditional actuarial modelling tools – they perform detailed calculations at a policy level to project the cash-flows for each product in the portfolio including interactions with assets. They generate the required market and insurance risk distributions though can be cumbersome and time-consuming to run following a re-parameterisation. Run-times are typically many hours, even employing large amounts of computing resource, so for companies looking to calculate their risk capital position on a high frequency basis (as implied by the internal model approval process) they are not the only solution required.

They are not, however, redundant as they are needed to calibrate other tools that can be used more frequently. The challenge though for companies is to put them into the appropriate control and governance framework.

For most companies they have both pre- and post-model adjustments in spreadsheets that will also need to be combined into this framework and with some companies running many different models this could be a large amount of work. Alongside this they will need to demonstrate the appropriate documentation standards.

For insurers today, the key question they need to answer is how much work is required to bring their existing models up to the standards required. The options typically fall into one of three camps, all of which should be evaluated in order for a conclusion to be reached:

1. Use existing models updating for new calculation methodology and documentation standards; identifying process improvements to be made and embedding in a suitable governance- and control-wrapper
2. Standardise onto a single model platform (potentially a distinct product from those already used by the company) and in building from scratch ensure that the appropriate documentation and control/ governance standards are met and that the process is stream-lined

3. Build a fully bespoke system using development languages (e.g. C++). This traditionally has been seen as prohibitively expensive although for the largest insurers this is now viable given the potential costs of either of the first two options.

All of these require a clear vision of what these models need to achieve in terms of functionality, speed of process and fit within a wider reporting process.

9.2 Risk parameterisation tools

This covers most obviously the ESG, although the increased focus on "ownership" of assumptions and clearly denoted derivation of assumptions means that areas such as experience analysis that have previously not had much attention now need to be brought into the rigours of the core model kernel.

One upside from the turbulent financial markets of the last year has been the heightened awareness of parameterisation of the ESG and the impact on company balance sheets. The key question companies will need to answer in evaluating their strategy in this area is how consistent is their use of the ESG in both the methods employed and the parameterisation chosen with their management strategy and underlying product portfolio. Management also need to consider how they get comfort in the assumptions used in the ESG (and understand the impact).

9.3 Risk synopsis tools

This, together with aggregator tools, is the emerging area. Companies need to be able to calculate their risk capital with high frequency and their traditional models are unlikely to fulfil this requirement. This has led to the development of so-called "synopsis" tools that tend to follow one of two methodologies – replicating portfolios and curve-fitting, both of which have been used by insurers to varying degrees for a number of years but are only now entering the mainstream and being "industrialised".

These methodologies represent a way of approximately calculating the liabilities. This approximation allows the user to avoid the use of stochastic simulations where an approximate valuation is sufficient.

We include some discussion here of these two methods but companies need to understand:

1. whether such a synopsis tool is required in their processes
2. whether a sophisticated technique such as replicating portfolios or curve-fitting is required or can something less sophisticated such as closed-form solutions be suitable
3. the advantages and disadvantages of each approach in the context of their own portfolio

Replicating portfolios

The replicating portfolio technique involves constructing a portfolio of assets which replicate the liability cash flows profile as closely as possible under a large number of economic scenarios. The market-consistent value of options and guarantees is expressed as the price of a portfolio of a large number of derivative instruments (typically long-dated options, swaptions, swaps, futures, etc). The portfolio is chosen by performing a complex optimisation exercise, where the payoff profile of various financial instruments is matched against the liability cash flow profile and the portfolio of assets that best matches the liabilities' cash flows (according to a specified criterion) is selected.

This portfolio is then used as a proxy for the liabilities and the market-consistent value of liabilities at each point in time can, in theory, be calculated simply by evaluating the value of the replicating portfolio. It should be noted that the composition of the replicating portfolio is determined at the valuation date and is fixed for the period for which the liabilities are projected. The replicating-portfolio method is computationally efficient provided the instruments comprising the replicating portfolio are simple and can be priced using closed-form formulae.

Some liability items for with-profit products are difficult to replicate using financial derivatives. For example, items like cost of smoothing often depend on the modelling of bonus decisions and on the assumed long-term bonus rate. The value of those liability items may not respond to simulated changes in market conditions in the same way as the value of any financial derivative (apart from the most complex ones which can only be valued using Monte-Carlo methods). To the extent that the cost of smoothing forms a significant part of the with-profit liability, this may present difficulties with using replicating-portfolio techniques.

Additionally, the value of a replicating portfolio does not respond to changing demographic assumptions since they are portfolios of financial derivatives and not of insurance contracts. It is therefore not possible to simulate the impact of different demographic scenarios using a replicating portfolio.

Curve-fitting

This technique involves producing a model where the market-consistent value of liabilities is expressed as a function of economic variables.

Several deterministic stress scenarios are run up to the point in time where the simulation of future liability values is required. Full stochastic simulations are then run starting from that point using each stress scenario as a starting point. A multi-variate surface of liabilities as a function of market variables is fit to the liability values calculated on those scenarios.

Typically, around 13-15 scenarios are required, depending on the complexity of the ESG and the number of economic variables simulated. The technique can also be extended to include non-market variables such as asset share, claim value, declared bonuses, etc. In addition, stress scenarios including changes in demographic assumptions can be added (such as mortality and lapses). With a greater number of stress variables a greater number of fitting scenarios will be required.

The systems requirements for this methodology are substantially less onerous that those of the replicating-portfolio methodology. The curve-fitting methodology does not require any proprietary software (the calculations can potentially be performed using a Solver Add-in in Excel). The approach is transparent and allows flexibility in setting the functional form of the model. The mathematical complexity of the regression model is also fairly moderate. The only source of computational burden is the requirement to generate fitting and testing scenarios, for each of which a full stochastic valuation of liabilities is required.

How methodology is employed

These approximations have typically been employed for one or more of the following applications:

- VAR/TVAR analysis. This would otherwise require the use of nested stochastic simulations.
- Calculation of liability in advance of the valuation date. This may be done when the valuation team of a life office expects to run into time constraints at the year-end valuation. The base valuation and sensitivity tests may be performed say, as at 30 November (one month prior to the year end). The fitted approximate function (in the case of curve-fitting) or calculated replicating portfolio can then be used to calculate the value of liabilities as at year-end based on the market movements over December.
- Provision of instantly available management information. Using these approximations, liability calculations can be provided at very short notice. "What-if" scenario analysis can also be performed easily.
- Hedging movements in liability over a short time horizon. Expressing the value of liabilities as a function of economic variables can help the user in setting up an asset portfolio that responds to economic shocks in the same way as the liability does (ie a replicating portfolio).

9.4 Risk aggregation tools

Risk aggregators sit at the top of the tree and pull together the different elements of risk distributions into an overall calculation of risk-capital encompassing the whole enterprise.

Whilst aggregating different risk categories is a familiar subject to actuaries, having a dedicated tool to do so is relatively new and the development is being driven from a desire to have an industrial strength robust tool that fits within the control/governance framework. It is also an area of considerable technical development and whereas in the past companies have typically deployed reasonably simplistic correlation matrix based approaches (also known as variance/co-variance approaches) they are now investigating alternative methodologies such as copulas that give a better representation of risk.

Risk aggregators will also need to project the balance sheet and the revenue account – given the technical demands that this requires it additionally points to externally developed tools rather than in-house developed spreadsheet-based solutions.

Companies need to understand the methods for aggregating risk and evaluate each of these against their own portfolio and requirements. They will need to demonstrate that the key elements of risk are adequately captured and that items such as tax are appropriately allowed for. We would expect for most insurers that, as part of developing their system strategy, they would have carried out a full review of aggregation techniques and documented the choices made and solution implemented.

9.5 Control and governance framework

Whilst the main actuarial modelling tools now build in a number of features that aid control and governance, companies are looking to specialist control/governance tools that enable them to demonstrate that the framework applies across the whole process from end to end rather than just specific elements in the process. This so-called “middleware” is sometimes described as the glue that sticks together the different elements in the process from data processing through calculations to reporting. It gives a common interface to users and documents sign-offs and logs the audit trail. Typically these tools are highly customised and give a slick, web-based interface to end-users, streamlining the processes and only presenting choices or required information to the end-user. The tools have been borne out of workflow management tools and in some cases are already used by insurers for tasks such as claims management and processing.

The key element for insurers is understanding their end to end process and then designing a workflow solution around that. This is not trivial but the design of the “to-be” processes is a fundamental aspect of planning for actuarial modelling strategy.

10 Conclusion

In order to ensure that their organisations have the actuarial modelling capability to meet the requirements of this new world, insurers need to define their modelling strategy and the business case for a new systems landscape. Typically such a process should cover the following steps:

1. Identify key stakeholders for actuarial systems within the organisation, including:
    a. end-users
    b. production team
    c. assumption / data owners
2. Review current actuarial systems architecture highlighting links to other key systems and processes and the extent to which it supports the new world requirements
3. Define proposed actuarial systems architecture highlighting links to other key systems and processes
4. Document main requirements for future actuarial systems architecture through interviews with key stakeholders and with reference to both Solvency II and other business requirements
5. Identify main areas of development required and key areas for systems development / transformation.
6. Identify main options for both individual aspects of the architecture but additionally overall design. Develop understanding of pros and cons of each approach
7. Working with key stakeholders, develop criteria for decisions required for finalising overall systems design and build business case for delivery
    a. Ensure this materially captures the key decision drivers
    b. Validate baseline assumptions regarding cost and benefits
    c. Benchmark to determine how the proposal stacks up against peers' response to Solvency II related system development
8. Develop RFP and criteria for individual technology aspects, in conjunction with key stakeholders, and identify possible vendors
9. Manage RFP process, contacting vendors, managing questions and summarising against criteria
10. Develop business specification for each element of landscape. Develop detailed technical specification with chosen vendors and management

Appendix I: Participating companies

PricewaterhouseCoopers would like to thank the following companies for participating in the survey on which this report is based:

Aviva UK Life
AXA Sun Life Services
Co-operative Financial Services
Engage Mutual Assurance
Equitable Life
Friends Provident
HBOS
Legal & General
Liverpool Victoria
Pearl Group
Prudential
Royal Liver Assurance
Royal London Group
Scottish Equitable plc
Scottish Widows
St. James's Place Wealth Management
Standard Life
Wesleyan Assurance Society
Zurich Financial Services

Appendix II: Software vendors by category

Liability modelling

Advise by DFA inc

ALS Life by Ortec Finance

AXIS by GGY

iWorks Prophet by SunGard

MG-Alfa by Milliman

MoSes by Towers Perrin

Mo.net by OAC

Pillar One by Munich Re

The Risk Framework by QRM

VIPitech by Watson Wyatt

Economic scenario generators

Barrie & Hibbert ESG by Barrie & Hibbert

CAPlink by Towers Perrin

GEMS by DFA inc

Ortec ESG by Ortec

The Smith Model by Deloitte

Aggregators

Algo-Risk by Algorithmics

Fermat Solvency II by Moodys

RiskAgility by Towers Perrin

RiskPro by FRS Global

The Risk Framework by QRM

Replicating portfolios

Algo-Risk by Algorithmics

Replica by Watson Wyatt

Smart by Towers Perrin

The Risk Framework by QRM

Curve-fitting

MatLab by MathWorks

RiskAgility by Towers Perrin

Risk++ by EVMTech

Experience analysis

Pretium by Watson Wyatt

Prophet Glean by SunGard

Specialist workflow and process management/ governance

SecondFloor

Sharepoint by Microsoft

Solvexia

Tibco

Appendix III: References

CEIOPS	The Committee of European Insurance and Occupational Pensions Supervisors (www.ceiops.org) is responsible for providing advice to the European Commission on drafting of implementation measures for Solvency II framework directives and regulations on insurance and occupational pensions ("Level 2 activities") and issuing supervisory standards, recommendations and guidelines to enhance convergent and effective application of the regulations and to facilitate cooperation between national supervisors ("Level 3 activities"). CEIOPS has issued a number of consultation papers to develop its "Level 2" advice. These include a number of papers on internal model approval, in particular CP37 (which sets out the internal model approval process) and CP56 (which sets out the tests and standards expected for internal model approval).
CFO Forum	The European Insurance CFO Forum (www.cfoforum.nl) is a high-level discussion group formed by the Chief Financial Officers of major European listed, and some non-listed, insurance companies. Its aim is to bring greater consistency and improved disclosure to the European insurance industry's Embedded Value disclosures. To support this, it has developed and published standards for embedded value reporting, most recently publishing market consistent embedded value (MCEV) principles.
BAS	The Board for Actuarial Standards (www.frc.org.uk/bas/) is a board of the Financial Reporting Council, the UK's independent regulator responsible for promoting confidence in corporate governance and reporting. BAS develops and maintains actuarial technical standards for the Actuarial Profession in the UK. It has recently ended a consultation period on exposure drafts of generic standards for Data and Modelling.

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