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Dynamic management actions

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INTRODUCTION

Realistic modelling of dynamic management actions (DMA) is critical to many areas of the management of a life insurance company today, although, historically, actuarial models effectively assumed static rules for future management actions.

In real life we would hope that management would react to events in a dynamic way, but arguably what they have been less good at doing in the past is deciding in advance how they would react to the range of circumstances which may arise in the future. In fact, it is the authors' belief that frequently, even today, not enough attention is devoted to the planning, modelling and monitoring of dynamic management actions. There could be a number of reasons for this:

- It can be difficult to express planned DMA in a way which is both meaningful to the management in general and tractable for modelling purposes.
- There can be practical and technical difficulties in modelling management rules which are rich enough to approximate reality, and the results of such modelling can be difficult to interpret.
- The topic involves effective communication across a number of stakeholders who may frequently have quite different perspectives.
- There may be cultural opposition from management not wishing to be constrained by DMA rules or who do not see the value in planning how they will react to hypothetical future situations.

Devoting more attention to this topic can greatly increase the meaningfulness and usefulness of a company's financial models and play a significant role in risk management and the decision-making process.

Our aim in this paper is to give an overview of this topic. We will explain what is meant by dynamic management actions and what the main types of DMA are. We will discuss the issues involved in modelling DMA and how this provides a crucial link between Pillar I and Pillar II of Solvency II and a key role in enterprise risk management. However, we will also draw attention to the limits of quantitative risk management and the challenges of *known* and *unknown* unknowns.

This paper was originally presented at the Staple Inn Actuarial Society in London on 6 March 2012.

WHAT ARE DYNAMIC MANAGEMENT ACTIONS?

In the real world, *management actions* can be considered as essentially any actions taken by the principal decision makers at an insurance company from the time they sit at a desk in morning to the time they leave in the evening.

Those actions that are *dynamic* (in this context) are understood as being taken *a posteriori* by management in direct response/reaction to real-life events (either actual or expected) and experience (in contrast to *a priori* initiatives).

Thus, a decision which is articulated as being *fixed* in that it will be enacted in the same way in the future regardless of actual conditions would not be *dynamic*. A typical example of management actions would be with regard to investment decisions relating to assets backing policyholder liabilities. A decision that says *when assets are required to be sold, sell proportionately across the board* regardless of future circumstances would not be considered a *dynamic* management action as it is known what management will do from the outset.

On the other hand, a decision which says *sell the longest assets first when unrealised gains exist, otherwise sell the shortest assets first* would be a decision that depends on future conditions not known at the outset, and would hence be regarded as *dynamic*.

More particularly, in this context, we are interested in the preplanning of these management actions before a particular scenario has occurred. A management approach which makes decisions only in the light of particular circumstances as they occur may be dynamic, but certainly cannot be modelled and is unsatisfactory from a risk management perspective (although the other extreme of robotically following planned management actions might be almost as bad).

Features of the business over which management has no control would not fall into the category of management actions (and hence DMA). An example at the time of this writing might be policy charges which contractually increase each year according to increases in some defined inflation index. However, if policy conditions allow charges to be increased at any rate up to a defined inflation index each year, this provides management with a range of options within which it can exercise discretion, and hence would fall into the category of management actions and would be considered *dynamic* if the discretion is exercised in response to actual conditions and experience.

In the past, actuarial models were typically liability-only deterministic models where future experience was assumed to be known at the start of the projection period.

In recent years, partly driven by reporting standards such as market-consistent embedded value (MCEV) and Solvency II, models have been developed for which the path of future experience is not assumed to be known at the start of the projection, such as through the use of *stochastic economic scenarios*, where future economic experience in any given scenario cannot be inferred from economic conditions at the start. Another development is that models now typically project assets as well as liabilities, and assets and liabilities are assumed to interact with each other in the future.

With such models it is necessary to consider modelling DMA, whereby management are assumed to make different decisions depending on external information (such as that contained in a particular economic scenario) and/or results generated by the model itself (such as the level of unrealised gains or losses on assets at any point in time).

This paper is mainly concerned with the modelling of DMA, although clearly there should be a direct link between what is or would be done in practice by management and what is modelled. This is a theme developed further later in this paper.

Types of DMA

This section describes some types of DMA which might typically be encountered by a life insurer.

Bonus/crediting rates on participating policies

A typical type of life insurance contract is a savings contract which provides minimum guaranteed benefits (sometimes expressed in terms of an interest rate guarantee), but which also provides bonuses (profit sharing) by way of enhanced benefits to policyholders depending on the performance of underlying assets and (in some countries) other sources of profit. This is typically expressed as a declared percentage bonus, profit sharing, or crediting rate. In some countries there is also the possibility of a *terminal bonus* payable when a policyholder claim is paid.

The extent to which management has discretion in setting crediting rates varies by country. In some countries there is a degree of discretion allowed, whereas in others crediting rates are prescribed by fixed rules related to investment returns achieved in an underlying fund (such rules may be defined by law or by the policy conditions).

Only to the extent that the bonus/crediting rates fall within management discretion would they be considered DMA.

However, even where bonus/crediting rates are based on fixed formulae, such rates are typically based on book value returns on assets; thus the level of bonus could depend on management decisions as to the timing of realisation of investment gains or losses and hence be included within DMA (see discussion on investment strategy below).

A related action could be the application of a discretionary market value adjuster (MVA), which could allow *guaranteed* surrender values to be adjusted downwards if market values of underlying assets have fallen significantly. To the extent that management has discretion over the application of such an MVA, this would be a type of DMA.

A further possibility could be the declaration of a special one-off bonus in order to incentivise or reward customer loyalty, which could have a knock-on effect on policy persistency.

Management discretion in these areas could affect how policyholders will exercise their own options, for instance whether to lapse or continue with their policies.

Investment strategy

Investment strategy can include, amongst other things:

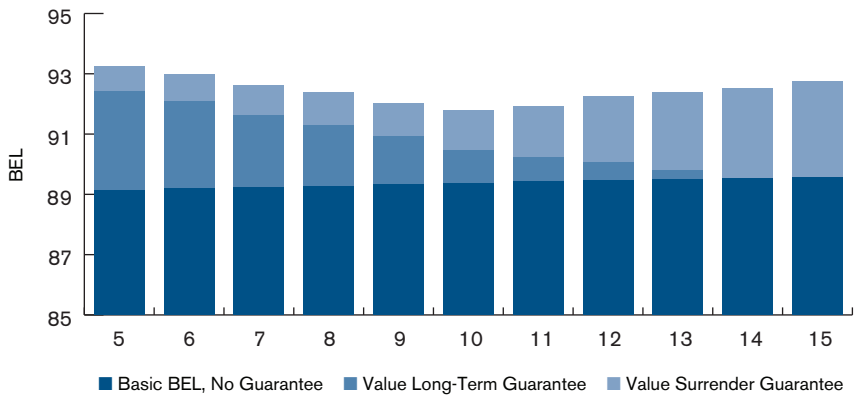
- Asset mix
- Choice of assets to purchase and sell (asset types, durations, etc.)
- Timing of purchases and sales
- Timing of realisation of gains and losses

To the extent that management decisions in respect of investment strategy vary according to conditions, these could be considered DMA.

The management rules in respect of investment strategy can themselves influence the nature of the liabilities. This can be illustrated by considering management actions in respect of a simplified example of a 15-year single premium participating product with a guaranteed long-term return, profit participation based on book value accounting investment returns, and guaranteed surrender/maturity values including the accumulated profit participation at the date of the surrender/maturity.

Assuming all assets are risk-free zero coupon fixed interest investments, and looking at only the dimension of the duration of these assets at the outset (initial investment strategy), we can calculate how the liabilities vary according to this strategy as shown in Figure 1.

FIGURE 1: BEL BY INITIAL ASSET DURATION



Note that this choice of asset duration at the outset would not constitute DMA, as it is the same regardless of how circumstances unfold.

The total size of the bars represents the total best estimate liability (BEL) calculated on a stochastic basis, including allowance for dynamic lapses. Furthermore, the BEL is broken down into three components:

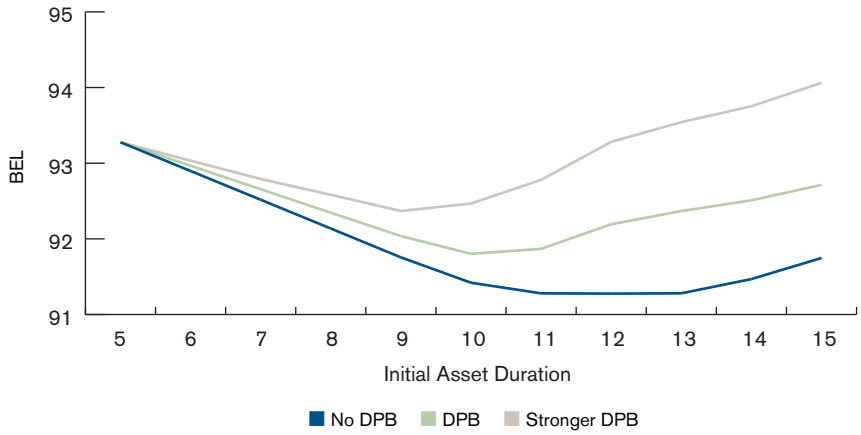
- A basic BEL related to liabilities which would be due even if there were no guarantees
- The liability in respect of the long-term (maturity) guarantee
- The liability in respect of the guaranteed surrender value

The second two items include both intrinsic values and time values; the latter are due to the asymmetries in the outcomes between more and less favourable economic scenarios. The different columns show how both the total liability and its composition vary according to the decision of the management on initial investment strategy. If the company invests short, the risk of having to realise assets at losses to meet surrender outgo when interest rates have risen (which is also assumed to drive additional dynamic lapses) is reduced, whereas if it invests longer, the cost of the long-term guarantee becomes gradually lower as reinvestment risk reduces. Where initial investments are in 15-year zero coupon bonds, the long-term guarantee is exactly matched and its cost therefore becomes zero.

Under these conditions there is an initial investment strategy which is optimal from a shareholders' perspective, under which the liability is minimised, but it should be noted that the optimal investment strategy after outset will vary as underlying market conditions vary, and this can be reflected in a dynamic investment strategy.

Of course this *optimal* initial investment strategy is a function of the assumptions, including those for dynamic policyholder behaviour (DPB), which in this case relate to dynamic lapses. The graph in Figure 2 shows how the BEL varies by initial asset duration with no DPB, the DPB rule as assumed above, and a stronger DPB rule (i.e., policyholders assumed to be more reactive).

FIGURE 2: BEL BY INITIAL ASSET DURATION AND LEVEL OF DPB



These BEL curves show a couple of interesting features:

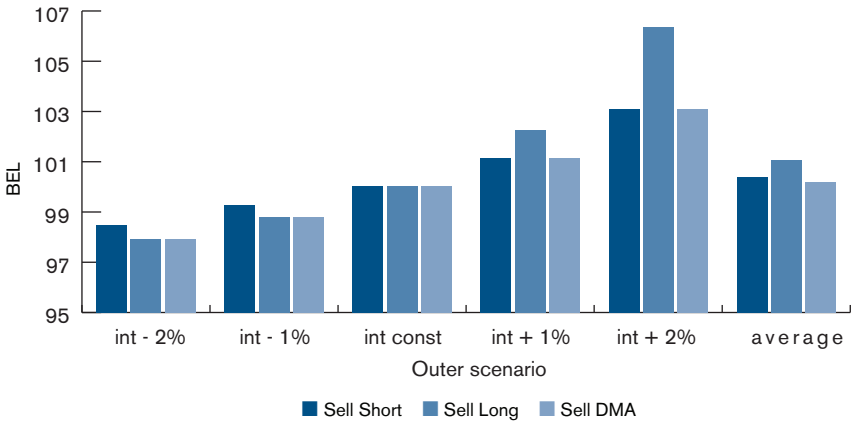
- The impact of DPB generally increases with increased duration of assets, which is as expected because dynamic lapses necessitate additional asset sales at a time when market interest rates have risen; the losses arising from such sales will increase the longer the duration of assets held.
- The stronger the DPB rule, the shorter the *optimal* initial duration of assets, again as expected for the same reason as in the previous point.

In the above example (assuming the original DPB rule), let us now suppose that we wish to determine at time zero a management action plan which will change dynamically depending on market conditions in the future.

We assume that the only element of the investment strategy changed is the choice of whether to sell longer- or shorter-term assets to meet surrender outgo. We can see in the graph in Figure 3 that the *sell DMA* strategy which selects whether to sell longer- or shorter-term assets depending on how interest rates have moved since the outset always does at least as well as the static strategies of always selling longer or shorter assets for each of the five outer stochastic scenarios under consideration in this example, and that on average across these five scenarios the dynamic strategy leads to the lowest BEL.

Of course, this is a very simple one-dimensional example, but the principle of investment strategies which vary according to market conditions is clearly an important one.

FIGURE 3: BEL BY OUTER SCENARIO



Investment decisions and the factors upon which they depend can, in practice, be very complex, and could go beyond what can reasonably be captured in an actuarial model. This point is discussed later in this paper.

Factors upon which investment decisions depend could include:

- External market conditions
- The level of unrealised gains/losses in a pooled fund
- Cash flow and other matching considerations
- Target investment return to be achieved by a pooled fund
- Level of solvency coverage

This is an area where extreme scenarios need to be considered carefully, particularly for economic capital calculations. As we will discuss later in the paper, assumed investment strategies in models (and any DMA) should be based on what management would actually intend to do in each scenario under consideration; this can be a particular challenge where scenarios similar to those envisaged in the model projection have not been experienced in the recent past.

Note that hedging is also a type of investment strategy. Dynamic hedging is a continuous form of DMA.

Future new business

This is an area which is not always considered explicitly in actuarial modelling. However, future new business can be significant in a number of respects:

- The impact on the asset liability management (ALM) position of a fund where new business is pooled with existing business
- Long-term unit costs
- Persistency of existing business (cannibalisation of existing contracts by new ones)
- Capital position of the company (because of new business strain)
- The calculation of franchise value

Clearly, management does not have complete control over the levels or types of new business which it can sell, as these will also be affected by circumstances outside the company's control, but management actions in relation to future new business could conclude:

- Choice of product lines to sell and market
- Product pricing
- Level and nature of guarantees
- Level of marketing effort
- Choice of underlying investment funds to back new business (e.g., pool new business with existing business or open a new fund for new business)
- Level of bonuses/crediting rates (more competitive bonuses can lead to increased new business sales)

To the extent that management has discretion over such actions, these could be considered under DMA. In a model context it may be appropriate to create assumed rules which link such decisions to future assumed levels of new business sales.

The particular decisions assumed to be made by management in a model projection relating to future new business described above could depend on a number of factors, for instance:

- The projected ALM position of a pooled fund
- External market conditions (e.g., interest rate levels)
- Projected crediting rates
- Projected demographic experience

Such management decisions which could impact the volumes and nature of new business sold will themselves feed back into the projection and might create other effects such as those listed at the start of this sub-section.

It is worth noting that a key part of risk management for a company is how new products are priced and structured. Although risk management issues which are suffered by insurers can manifest themselves in many forms, many of these originate in the definition of policy terms, which influence liability structures.

Reviewable charges

For some risk products, such as yearly renewable products or risk riders, there can be reviewable charges where rates are not guaranteed from one year to the next.

Another example is reviewable expense charges on unit-linked policies.

Such reviews would only fall under DMA to the extent that management has discretion. Thus risk charges which are reviewed using a fixed contractual formula based on the experience of a pool of contracts or some external index would not be considered DMA. However, to the extent that management could influence this, such as by improving claims experience via claims underwriting, this could constitute DMA.

Management discretion may take the form of being able to increase premiums or charges from one year to the next up to some contractual maximum; in such a case, management would decide the extent to which increases should be applied based on various criteria, such as the desire to remain competitive.

The exercising of such reviews could have an impact on policyholder behaviour, such as the level of policy renewals or lapse rates.

These types of actions are perhaps most significant when considering the shock or extreme scenarios envisaged by economic capital calculations.

Operational management

Operational management covers a broad range of actions and decisions, from decisions made at the highest (board) level of a company down to decisions made in respect of individual policies, or other everyday decisions made by company staff at various levels in the organisation.

Some decisions could be seen as having clear links to the financial results of a company, such as:

- Initiatives which directly reduce expense levels
- Improvements to underwriting standards, which could lead to improved claims experience but lower new business volumes and/or higher expenses
- Changes in distribution arrangements which might affect new business volumes and persistency experience
- Improvements to customer service standards such as communications and speed of handling policyholder enquiries, which would be expected to have a positive impact on policyholder persistency and new business levels, but could also lead to increased expense levels in the shorter term

Such actions may be considered *dynamic* in that they are likely to be at least partially driven by external conditions, such as competition from other companies or regulatory drivers.

Reaction to economic and other crises

How management chooses to react to crises can have a profound effect on a company.

This area has become particularly pertinent in the current Eurozone sovereign debt crisis, whereby insurers have written contracts giving guaranteed benefits to policyholders, but backed by government bonds which are currently looking somewhat less than *risk-free*. Critical decisions may have to be made by companies highly exposed to such sovereign debt if and when it does default.

By their nature, crises are often not foreseen and hence will quite often fall into the category of unknown unknowns. This is not always the case, however, as, for example, an influenza pandemic might constitute a crisis for an insurer with a lot of risk business, but definitely represents a *known* rather than an *unknown* unknown, and hence management action plans should be in place.

MODELLING DMA: SCOPE AND PRINCIPLES

Financial models

In this section, and those which follow, we will consider the modelling of DMA within financial models for life insurance companies.

We can consider a financial model as being:

> *… designed to represent in mathematical terms the relationships among the variables of a financial problem so that it can be used to answer* what if *questions or make projections.*[1]

In the context of life insurance management, financial models are typically used to project future outcomes for assets and liabilities and their interactions based on a series of assumptions and rules. These would include rules as to how the management will make decisions based on the future outcomes projected by the model or other external data.

Models are necessarily simplified versions of reality, relying on assumptions and/or limited sets of scenarios about future experience, and therefore cannot incorporate all possible future outcomes. As we discuss below, risk management should aim to gain as many insights as possible from financial models but also to realise their limitations, so that risks and circumstances which cannot possibly be reflected in the models are also considered.

The scope of DMA: The *Goldilocks Principle*

Given that a financial model is a simplified version of reality, it is not meaningful for DMA assumptions to be more sophisticated, or to cover a wider range of situations than the model itself. So, for example, if a model includes rules on how the management would react to changes in market volatility, but the underlying economic model being used projects constant volatility, these rules would never come into effect. The rules would be redundant and there would be a risk of misunderstanding which effects the model was actually capturing.

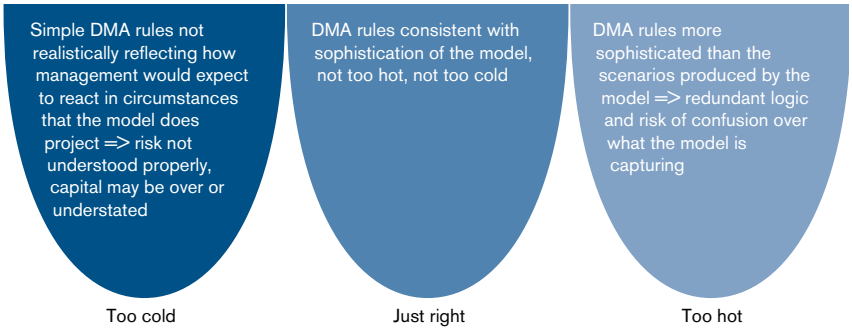
However, the opposite is also true in that a model would be defective if assumed modelled DMA was oversimplified and did not reflect the scenarios being modelled or how management would react to them in practice. For instance, a modelled investment strategy in which the same assets would be bought or sold regardless of economic or other factors could be unrealistic, could materially misrepresent the impact of different situations and hence be of limited use in risk management.

This can be seen as a type of application of a *Goldilocks Principle*. The Goldilocks Principle requires something to fall within certain limits, rather than being on the extremes. It is sometimes applied to the fact that, of all possible conditions on Earth, the actual conditions are *just right* to support life.

[1] Sengupta, C. Financial Analysis and Modeling.

The Goldilocks Principle in relation to models of DMA is illustrated in Figure 4.

FIGURE 4: THE GOLDILOCKS PRINCIPLE AND DMA



Of course, just because a company's model doesn't consider a particular situation doesn't mean that management does not need to consider what it would do in such a situation. It may be appropriate to improve models to incorporate a wider range of scenarios, risks, and management actions.

A limitation of financial models is that they may not adequately consider situations which may occur with significant financial implications, for example the current Eurozone debt crisis or potential government debt defaults.

For situations which would not be feasible to include in the model, either a qualitative approach should be used or ad hoc models constructed (perhaps partially using results from the main model) in order to assess the impact of such a situation, and potential management responses to it.

Certain types of management actions (such as those related to aspects of operational risk) may never be feasibly included in actuarial models (as a dynamic link to the modelled outcomes cannot be established), but should nonetheless be considered as part of risk management.

In addition, different models may also focus on different aspects; thus a model for calculating MCEV results would perhaps be less concerned with extreme scenarios than an economic capital model. Nonetheless attention should be given to making the modelled DMA as realistic as possible in order to avoid material distortions in results or conclusions from the model.

General principles to consider

Models of DMA should:

- Reflect the actual documented intentions of management under the scenarios envisaged by the model
- Be consistent with other management actions and other aspects of the model
- Be comprehensive
- Be capable of being coded into the model
- Consider knock-on effects of actions

Each of these principles is considered in more detail below.

Reflect the actual documented intentions of management under the scenarios envisaged by the model

The DMA modelled should reflect *what management actually intends to do*, and should be appropriately approved and documented.

In particular, *this should not necessarily be assumed to be the actions which would optimise the measure under consideration if this is not what management would actually do in practice*. For instance, it should not be assumed that management would cut bonuses in order to minimise the Solvency II Standard Formula Solvency Capital Requirement (SCR) if this is not management's intention (which, in practice, could be driven by a number of considerations, including the requirement to maintain a competitive position).

Solvency II

The latest Solvency II proposals,[2] in order to ensure that assumptions on future management actions are determined in an objective manner, require that insurers should *establish a comprehensive future management actions plan* approved by management. This plan should cover the identification of relevant future management actions and the specific circumstances in which they would be carried out and in which they might not be able to be carried out. It should specify the order in which actions would be carried out, any governance requirements applicable, and any ongoing work required to ensure that the insurer is in a position to carry out these actions.

The action plan should describe how future management actions have been reflected in the calculations of the best estimate of liabilities and assess their quantitative impact on the best estimate. Regular internal reporting on the management actions included within the best estimate calculations is also required.

The above requirements constitute a key foundation of the risk management and governance of the company and a critical link between Pillars I and II of Solvency II. The requirement for future management actions to be formally stated in a clear and comprehensive way, their impact to be quantified, and all of this to be approved by the management, means–if properly implemented–that the management has to decide what it intends to do in all scenarios foreseen by the models and to ensure that this is consistently reflected in those models. We add the caveat *if properly implemented* because we need to recognise that this requirement is potentially challenging, but is definitely something companies should strive for. In the past, we have seen cases where the management actions assumed in models are not transparent or are oversimplified and seem unlikely to reflect the real intentions of management. We have also seen cases where management intentions are stated in an insufficiently clear way or where the management does not appear to have thought through how it would react under a range of different scenarios.

Solvency II also requires that assumed management actions be *realistic and consistent with the insurer's current business practice and strategy*, including the use of risk mitigation techniques. If there is sufficient evidence that an insurer will change its practices or strategy, the assumed actions should be consistent with the expected future practices or strategy.

A life insurer may use the same or related cash-flow projection models to calculate both the best estimate provisions and the SCR, and generally the requirements for management actions for the calculations of best estimate and the SCR are the same and should be modelled consistently.

[2] The *Draft Implementing Measures Solvency II* dated 31 October 2011 (the *Draft Level 2 Text*) Article 19 TP6 (related to the calculation of Technical Provisions). These requirements also apply to Standard Formula SCR calculations and to full and partial internal models. Note that throughout the document when we refer to Solvency II, this reflects our understanding of the position at the time of writing the paper, but this could be superseded by subsequent developments.

The DMA specifications are essentially the same irrespective of whether the standard formula or a full or partial internal model is being used, but there is an additional requirement for internal models to quantify the impact on the SCR of the assumed future management actions in the model.

There are requirements to disclose assumptions on management actions both for public disclosure and regular supervisory reporting.

Solvency II also requires that account be taken of the time needed and the expenses incurred in the implementation of management actions, and not to assume that large quantities of an asset can be traded without impacting its price.

Note that, for the purposes of calculating the SCR under the standard formula, it must not be assumed that management actions are taken while the stress scenario occurs.[3]

MCEV

The European Insurance CFO Forum Market Consistent Embedded Value Principles[4] (MCEV Principles) contain similar requirements for the approval of management actions and require that management discretion has *passed through an appropriate approval process* and that *any changes from current decision rules (for example regarding flexible crediting rates or policyholder bonuses) must be supported by appropriate approvals*.

In respect of assumptions about future bonus rates and the determination of profit allocation between policyholders and shareholders (which can come into the realm of DMA), the MCEV Principles require assumptions to be *consistent with the underlying projection assumptions, established company practice and local market practice*.[5]

The MCEV Principles point out the need for assumed management discretion to be subject to any contractual guarantees and regulatory or legal constraints. Further, in respect of discretion over bonus allocation, including the realisation of gains, this would include other constraints such as an established bonus philosophy and should *have regard to the past application of discretion, past external communication, the influence of market practice regarding that discretion, any payout smoothing strategy in place and any guidance from the local supervisory*.[6] The Solvency II requirements contain similar points.

The MCEV Principles also require disclosure of assumed management actions.

In conclusion, in setting realistic management actions which management would actually carry out in practice, it is not the case that these are simply *what have been done in the past*. Conditions and circumstances change, and circumstances envisaged by the model may not have occurred in the past. In particular it will be important for actions assumed in scenarios which have not occurred before to be justifiable and properly validated by management.

Assumed actions should reflect practical issues associated with their implementations, such as the time needed and the costs incurred.

The DMA modelled should be consistent with other actual constraints on actions, for instance legal aspects, or expectations deriving from established practice or public announcements.

3 Draft Level 2 Text, Article 75 BSCRx.
4 Copyright© Stichting CFO Forum Foundation 2008
5 MCEV Principles, 16.
6 MCEV Principles, G16.4.

A key implication of the above is that companies should not assume unrealistically aggressive management actions, which they would not carry out in practice and which could therefore distort projected results.

Be consistent with other management actions and other aspects of the model
A particular assumed management action should be consistent with other assumed actions and this is explicitly required under Solvency II.[7]

In fact, the model needs to be consistent as a whole. Thus, for instance:

- DMA should be consistent with other assumptions, including economic conditions. For example, projected bonus rates should be consistent with projected future investment returns.[8]
- DMA should be applied in a consistent way across different product lines, to ensure, for instance, equitable treatment of different types or generations of policyholders. Any assumed level of cross-subsidies should be realistic.
- The level of expenses projected should be consistent with the management actions assumed, e.g., a very active assumed investment strategy should be reflected in projected investment costs.
- Knock-on effects of assumed DMA should be considered (see subsection below).

Be comprehensive
The model should include all management actions that would be expected to be carried out in the scenarios envisaged by the model and which would have a material impact on the model results.

Under some circumstances, not assuming a future management action which would actually be expected to occur is itself a management action assumption, which would render the model unrealistic.

Be capable of being coded into the model
Clearly for any DMA to be modelled it needs to be capable of being coded into the model, and without undue burden in terms of computing resources/run times.[9]

This requires rules linking one or both of the following to the modelled DMA:

- Modelled external conditions (such as economic scenarios)
- Results calculated by the model itself (e.g., the level of unrealised gains or losses in a fund or level of projected solvency)

This could require simplifications to the modelling of DMA compared to what the management expects to do in reality. Nonetheless any simplifications should avoid introducing material distortions into the results and should be consistent with other elements of the model. Limitations should also be understood by management as part of the qualitative risk management framework. Furthermore, entities should monitor how well expected management actions can predict actual management actions and look to improve models when a poor fit is demonstrated (i.e., *back-testing*).

Consider knock-on effects of actions
The knock-on effects of management actions should also be considered in the model, to the extent

7 Draft Level 2 Text, Article 19 TP6.
8 See, for instance, MCEV Principles, 16 and G7.2.
9 For instance, management actions which required nested stochastic valuations at every point in the projection might prove difficult from a practical point of view.

that they could have a material impact on the results. This ties in with the requirement for the model to be consistent as a whole.

Examples of such knock-on effects could include:

- A particular management action leading to a corresponding reaction from policyholders, i.e., dynamic policyholder behaviour (DPB). Considering such reactions is a requirement of both Solvency II and MCEV.

- *Contagion* effects on the business.

  Certain management actions could cause a detrimental (or a positive) impact on other parts of the business.

  For instance, recently in Italy the contract conditions of many index-linked products allowed the insurer not to honour guarantees if an external third-party guarantor defaulted; however, owing to the potential contagion effect and reputational risk, many insurers decided to honour guarantees (sometimes in restructured forms) following the collapse of Lehman Brothers. Not doing this would have likely had a negative effect on the public perception of those businesses.

  It is important not to assume a free lunch (e.g., in the above example a guarantee on index-linked products could seemingly be given without risk to the company, but in practice risks would be involved).

- The level of costs associated with particular decisions.

It may not always be immediate that some knock-on effects have any impact on the values being calculated, but careful consideration should be given as to whether this is realistic.

For instance, a cut in bonus rates could reduce the amount of future new business. It may seem, for a measure which only considers the in-force business (such as the calculation of MCEV or Solvency II Pillar I calculations), that this point is not relevant, but any decrease in future new business may impact the in-force business, for instance via an increase in unit costs or a change in the ALM position of segregated funds.

In a Solvency II context, the impact of DMA on new business may have only a second-order effect on Pillar I calculations, which may be justifiable to ignore but would in any case need to be considered in the context of the Own Risk and Solvency Assessment (ORSA).

Also, the requirement that DMA modelling should reflect what management actually intends to do means that DMA should implicitly allow for the impact on other parts of the business (such as future new business), even if not apparently directly related to the measure being calculated. Thus it may be a company's intention not to cut bonuses in certain adverse situations because of the wish to remain competitive for new business.

What should be modelled as DMA?

The model should aim to include all management actions that would be expected to be carried out in the scenarios envisaged by the model and that could materially impact the model results.

The DMA modelled should not be more sophisticated, or cover a wider range of situations, than the model itself. On the other hand, modelled DMA should not be oversimplified such that it does not reflect the scenarios being modelled or how management would react to those scenarios in practice.

Clearly, the universe of potential management actions is vast, although some would not materially impact the results being covered by the particular model. It may require expert judgement to decide which actions are likely to be materially relevant.

It may be appropriate that the range of scenarios envisaged by the model should be reviewed and expanded if they do not reflect possible future scenarios which can materially impact the company's financial position and for which the management should have defined action plans.

Therefore, the management actions relevant to the calculations being considered should be identified, including circumstances in which such actions could or could not be carried out. If the management has not been used to this type of forward-looking scenario-based planning, the time which will need to be dedicated to this thought process should not be underestimated. For example, if the company's historical modus operandi has been to *meet problems when they come to them*, it may seem artificial to have to consider how they would react under a series of hypothetical future scenarios which may never occur. However, this process is required for both governance/risk management purposes and in order for the Solvency II Pillar I calculations to be robust and realistic.

SETTING UP DMA MODELS

Introduction

Modelling DMA can be contrasted with modelling dynamic policyholder behaviour (DPB). It should—at least in theory—be easier to determine DMA assumptions than DPB assumptions, because the management should know what it intends to do, whereas the company often has no accurate way to predict how policyholders will react to future scenarios. Policyholders are a group of individuals, not always acting in a consistent or rational way, whereas, in theory, management is a single *unit*, thinking consistently.

On the other hand, DMA rules can be quite articulated, as will be seen in the examples below, and thus challenging to model, whereas for DPB the fact that it is not possible for the company to know how policyholders will react in different situations will tend to lead to simple models with necessarily subjective assumptions. Also, the range of options available to policyholders (such as policy surrenders) would generally be much simpler than those available to management.

Because DMA models should be set based on actual management intentions, a monitoring of the difference between actual actions and intended actions should then become part of the control cycle, allowing DMA models to be refined over time.

In this section we will consider:

- The selection of factors driving DMA
- The particular actions to be considered
- The process for determining DMA rules

The selection of factors driving DMA

In very general terms the aim of management actions may be to maximise shareholder value whilst limiting risk/risk capital (although this would be subject to various constraints, such as policyholders' reasonable expectations, and would not be the case for mutual companies). Decisions should be consistent with the risk appetite of the company.

In reality actual management actions (for instance around an area like investment strategy) could be driven by a number of complex interrelated factors.

When we are considering the modelling of DMA the factors we would consider can be divided into one of the following types which can (at least in theory) be derived directly from model inputs or outputs:

- **Economic conditions (e.g., interest rates, shape of yield curve, equity market levels, bond and equity volatilities, inflation, credit spreads, etc.)**
  - Many of these features will be directly observable from the economic scenario generator (ESG) underlying the model, but, depending on the level of sophistication of the underlying economic model, some may not (e.g., variation in future volatility may not be included in an economic model).
  - Of course, we should not forget that ESGs are inevitably simplifications of reality, for instance modelling all equities of a particular currency as one asset, whereas actual investment decisions would usually go into more detail. But our goal should be to determine generic management rules which would apply in the hypothetical case that reality looked exactly like scenarios envisaged by the ESG.
  - There may be other inputs similar to an ESG, such as stochastic mortality rates, which could be key factors driving certain types of DMA.

- **Current and projected future position of assets from the model**

  — This would cover the amounts and nature of the assets held (e.g., type, mix, durations, pattern of future cash flows, credit ratings, currency, level of unrealised gains/losses).

  — Many of these aspects may be observable from asset data at the projection start date and its evolution as projected by the model.

  — However, the degree of sophistication of the modelled asset position in future time periods will depend on how articulated the model is. For example, some models do not project future changes in credit ratings or spreads of bonds (e.g., via transition matrices).

- **Current and projected future position of liabilities from the model**

  — This includes the amounts and nature of the liabilities (e.g., duration, nature, and levels of guarantees and options, pattern of future cash flows).

  — Much of the information may be easily derivable from the model projections both at the projection start date and in the future.

  — However, some aspects of the liabilities may theoretically be derivable from model projections, but not practically obtainable. For instance, calculations related to future time values of guarantees might technically require nested stochastic calculations.

    In such situations, either approximations (e.g., closed formula solutions for guarantees) or proxies (e.g., assuming the value of guarantees is a function of the relationship between the guaranteed interest rate and a market rate) may be required for such items. Such proxies would need to be sufficiently realistic to be meaningful (for example, a fixed percentage of some other measure such as mathematical reserves may not be a suitable approximation for the value of guarantees as it doesn't allow for changes in volatility or interest rates in the future).

  — Key factors are also likely to involve the relationship between assets and liabilities, for instance:

    - The level of solvency
    - Relative durations of assets and liabilities
    - The pattern of net future cash flows arising from assets and liabilities

  — It should of course be noted that various assumptions will impact the liability cash flows, such as lapses, mortality, option take-up rates, expenses, etc. Some of these assumptions which relate to policyholder actions, such as lapses and option take-up rates, will be dynamic in the sense that they themselves are likely to vary as a result of economic conditions and DMA.

    Indeed, projected asset cash flows can also depend on assumptions, for instance levels of expected defaults.

  — Furthermore, in a dynamic ALM model liability and asset cash flows will interact with one another. Investment returns on assets will impact policyholder benefits on profit-sharing business, and requirements to meet policyholder payments will impact purchases and sales of assets and so on.

In addition to the points mentioned above, there are likely to be a number of factors which in practice would drive management decisions, but which would not be directly derivable from model inputs or outputs. Examples of these include:

- Some factors driving investment decisions based on economic or market data beyond the scope of the model's ESG, or that involve a degree of subjectivity on the part of investment managers. For instance:

  — Economic scenarios don't always give the *back story* to a particular economic scenario. Thus an appropriate management (or policyholder) reaction to a particular interest rate level could be very different depending on what is driving interest rates.

  — The purchasing of individual equity stocks which an investment manager considers *cheap* (*tactical asset allocation*). In many models and ESGs, all equities are modelled in the same way (effectively as a single asset), and so would not capture this level of detail. Indeed, the investment manager's view of particular stocks would rely on complex amounts of data and include a degree of subjectivity.

- Actions of competitors, for instance the declaration of particularly aggressive bonus rates to gain a competitive advantage.

In these cases, where factors are not directly derivable from model inputs or outputs, there are two approaches which could be considered:

1. If particular factors are considered more sophisticated than the underlying model, consideration would either be given to improving the sophistication of the underlying model, or such factors would be excluded from the DMA modelling.

   Therefore, for example, in the case of the *back story* to economic scenarios described above, an ESG could perhaps be expanded to include other indicators to fill in some of this detail (such as unemployment or other indicators of the state of the economy), which may help to provide a more realistic picture, particularly when models are being used for planning management reactions to negative scenarios and for risk mitigation strategies.

   In the case of the selection of individual equity stocks this could just be considered to be beyond the sophistication of the underlying model and thus excluded for DMA purposes.

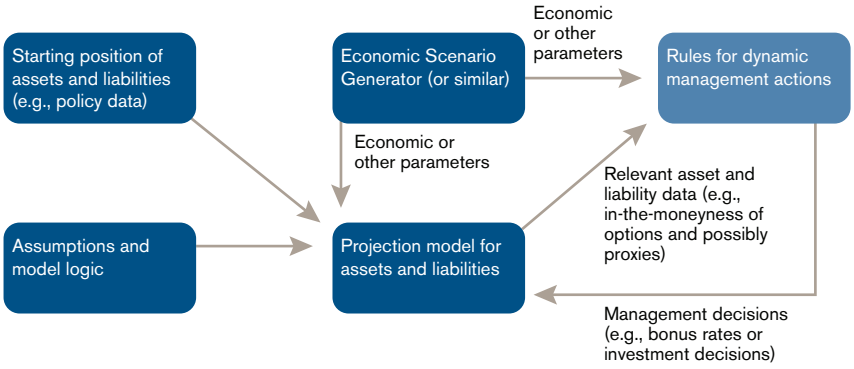
2. Use of proxies which can be determined from model inputs or outputs.

   For example, the requirement to maintain competitive bonuses could be modelled by developing a set of target bonus/profit-sharing rates which are based on a limited number of parameters, such as interest rates, levels of unrealised gains/losses, etc. (Where bonus rates are then determined by a fixed formula based on book-value returns on the underlying assets, the corresponding DMA would relate mainly to choosing when to realise gains and losses.)

   As part of the regular monitoring process the use of such proxies could be reviewed by comparing actual with expected actions.

The way these different elements fit together in the overall logical structure of the process is illustrated in Figure 5.

FIGURE 5: MODEL PROCESS STRUCTURE



It is worth noting that, when models involve two-way interactions, the ordering of events in the time steps may need to be defined to avoid circularity in the logic. Thus, for instance, if assets are sold in order to maintain a target level of assets in the fund relative to liabilities, the resulting realisation of gains and losses could change policyholder profit sharing and hence the level of liabilities, which in turn would change the required target level of assets in the fund. Some form of goal-seeking may be appropriate, or alternatively approximations could be made.

A balance needs to be struck between realism and avoiding too much complexity, which could make calculations difficult to program and interpret, increase the risk of calculation error, and/or require onerous calculation resources.

In practice, DMA rules would normally be set so as to depend on a relatively limited set of indicators that can be derived from model inputs and outputs, either directly or via simple algorithms.

In the example of investment strategy for participating business these might include:

- Current market yields in relation to guarantee rates or bonus rates
- Unrealised gains/losses on key asset classes
- Positive or negative net cash-flow requirements in the current time period
- Discounted mean term of liabilities compared with assets

Each of the above points could, in theory, be derived from model inputs or outputs, and some could act as proxies for other more complex factors such as the value of guarantees. Factors driving DPB could be similar to these, but are likely to be simpler than those driving DMA.

Sometimes factors which can only be derived from the whole model may be important drivers of management actions. For example, investment strategy (e.g., equity backing ratio) might be dependent on the solvency ratio of the company. This can be challenging to reflect within many model architectures. This provides an interesting application of the modern proxy modelling approach of Least-Squares Monte Carlo (LSMC), because the management rule can be made one of the variables when fitting probability distributions for the economic balance sheet.

The particular actions to be considered

The most easily built strategies in models may be fairly simple ones.

For example, for the case of investment strategies this could be something like *buy five-year bonds, sell assets in proportion to holdings at the time of sale*. However, for assumed future investment strategies to be realistic and for the management to declare that these really represent its intentions, we would almost certainly need them to be more sophisticated and comprehensive than this and to vary according to some of the factors outlined above.

This of course has to be balanced against the need to ensure that modelled DMA can be driven via predefined rules from the indicators, which can be obtained from the model inputs or outputs. To make this feasible, some simplification will inevitably be required for certain types of DMA, but this should not introduce material distortions to calculated results.

Intended management actions should be revised regularly, and a comparison of actual and intended actions will help to make modelled actions as realistic as possible.

The process for determining the DMA rules

The process used to come up with the DMA rules should be seen as critical. We have stressed that the DMA model should reflect the management's documented intentions on how they expect to react under the full range of scenarios projected by the model. This is highlighted in the Solvency II requirements to establish a comprehensive future management actions plan.

Determining the DMA rules needs to be a collaborative effort by the relevant management and the actuaries responsible for the model. If only the management is involved in this process it may not come up with actions which can fit into the model and may not consider the breadth of possible model outcomes. If this process is driven too much by the actuaries then the authenticity of the planned actions may be diminished; for instance, actions which seem to optimise results on given measures (e.g., minimise required economic capital) may not be those which management would carry out in practice.

A process for deriving DMA rules might look like this:

1. Initial qualitative debate between management to agree on:

   a. The broad types of DMA which should be modelled, which will be those which can reasonably be captured in the model, are not beyond the level of sophistication of the underlying model, and could be expected to have a material impact on results produced by the model.

      Any appropriate model enhancements should be agreed on.

   b. The factors likely to drive DMA.

      A division is made between those factors which can be captured in the model and those which cannot.

      For those factors which cannot be captured in the model, these are divided into:

      - Those factors genuinely beyond the scope of the model and thus excluded for modelling DMA.
      - Those factors currently beyond the scope of the model, but for which the model could be enhanced to include (i.e., a future model development).
      - Those factors for which it would be reasonable to model DMA via the use of easily obtainable *proxy factors*.

This discussion should also include which particular factors should be assumed to interact for defining DMA (e.g., the level of interest rates and the level of unrealised gains and losses in a fund).

Additionally, this should include considering policyholder reaction to certain scenarios (for example increased lapses at a time when market interest rates have risen, producing unrealised losses in an underlying fund).

2. The actuaries derive a set of discrete scenarios (some extreme, some more normal) described in terms of the factors agreed in (1)(b) above.

   These should:

   - Be representative of the range of scenarios which the model would be expected to cover
   - Include interactions between two or more factors where appropriate

   The management agrees what would be its intended reactions to these scenarios. Some element of *back story* may be useful in presenting these scenarios, although care should be taken that the back story doesn't bias the outcome.

   The types of actions would be those covered by (1)(a) above, but consideration of these scenarios may suggest further actions not included above and thus there may be some degree of iteration in the process.

3. The actuaries propose generic DMA rules for the model based on (2) above.

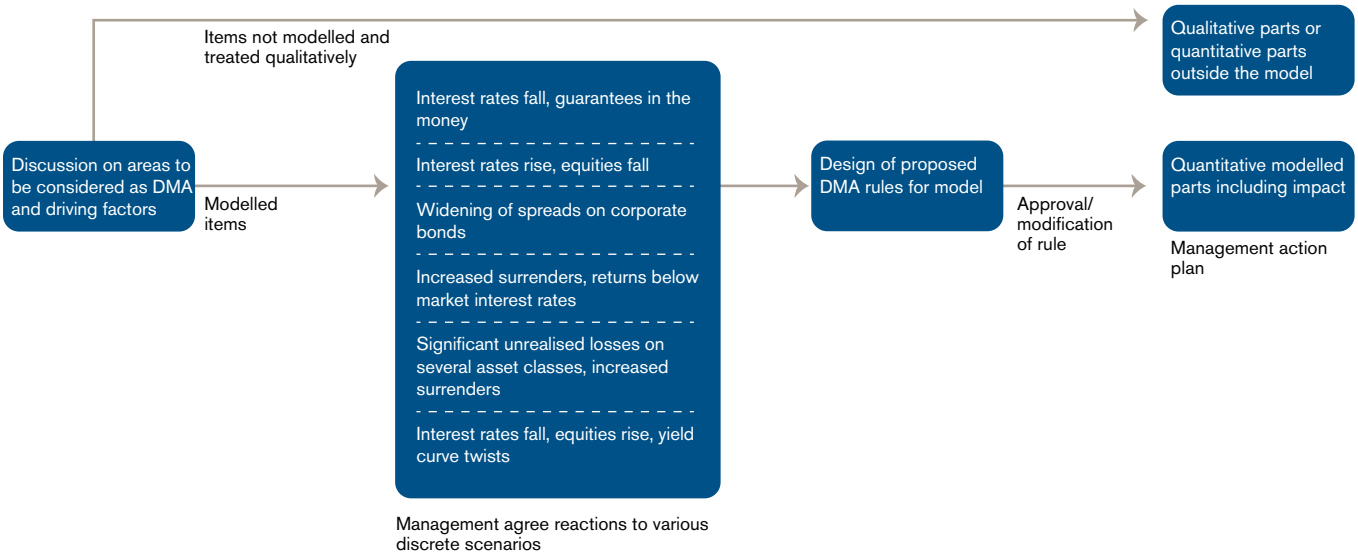
4. These generic rules are debated by the management and signed off or modified.

   Note that the signed-off action plan should also include the actions which go beyond the model identified in (1) above, and which would be treated qualitatively. There may be other actions which are not incorporated into the main model, but considered quantitatively using sub-models or ad hoc calculations.

   For Solvency II this would form a key part of the management actions plan described above.

This process is illustrated in Figure 6.

FIGURE 6: PROCESS FOR DERIVING DMA RULES



Example

In order to illustrate the above process for deriving DMA rules we consider a simplified example of investment strategies for the case of a Continental European single-premium profit-sharing product with the following characteristics:

- A guaranteed minimum return of 3% p.a., with profit sharing expressed as a fixed formula based on book returns above this minimum. There are guaranteed surrender values. Once profit sharing is added it forms part of the accumulated guaranteed benefits available at maturity or surrender.
- Investments are a mix of 90% bonds with different durations and 10% equities giving a broadly *matched* position.
- There are currently no unrealised gains or losses on the assets backing this product and current market (and book) yields are 4.5% p.a for all durations.
- Increased dynamic lapses are assumed to occur if 10-year market yields exceed the current credited rate (i.e., guaranteed rate plus profit sharing rate) plus a margin. Note that the credited rate is also applied to new business.

In this case the goal of management might be defined as:

1. Avoid over- or underpaying policyholder profit sharing to control accumulation of guaranteed benefits whilst still remaining competitive. This would typically be achieved by controlling the timing of the realisation of gains and losses, and could be referred to as meeting a *target yield*.
2. Minimise the risk of not being able to meet long-term interest guarantees by avoiding assets being *too short*, thus exposing the company to falls in interest rates. The importance of this goal might change dynamically depending on the market interest rate level compared to the long-term minimum guarantee rate.

3. Minimise the risk of losses on assets required to be sold in order to meet guaranteed surrender values by avoiding assets being *too long*, thus exposing the company to rises in interest rates. This particular risk would be exacerbated by rising interest rates triggering additional dynamic lapses.

4. Avoid being locked into long-term low interest rates (thus losing the opportunity to reinvest in the future if interest rates rise).

Figure 7 summarises a simplified set of scenarios together with possible management actions.

FIGURE 7: SCENARIOS AND MANAGEMENT ACTIONS

SCENARIO	ACTION	REASON
MARKET INTEREST RATES FALL TO 2.5% P.A., GENERATING UNREALISED GAINS ON BONDS; EQUITIES FALL BY 40%.	IF ASSETS REQUIRED TO BE SOLD, SELL A PROPORTIONAL MIX OF EQUITIES AND BONDS.	AVOID REALISING TOO MANY GAINS (ON BONDS) OR LOSSES (ON EQUITIES) IN ORDER TO MAINTAIN TARGET YIELD.
	IF NO ASSETS REQUIRED TO BE SOLD OR PURCHASED, TURN OVER 10% OF THE EQUITY LOSSES.	TURNING OVER EQUITY LOSSES GRADUALLY ALLOWS THEM TO BE PASSED TO POLICYHOLDERS WITHOUT SQUEEZING MARGINS.
	IF ASSETS REQUIRED TO BE PURCHASED, BUY 2-YEAR BONDS; TURN OVER 10% OF THE EQUITY LOSSES.	AVOID BEING LOCKED INTO LONG-TERM LOWER INTEREST RATES ON BONDS.
MARKET INTEREST RATES RISE TO 6.5% P.A., GENERATING UNREALISED LOSSES ON BONDS AND ADDITIONAL DYNAMIC LAPSES; EQUITIES FALL BY 40%.	IF ASSETS REQUIRED TO BE SOLD, SELL A PROPORTIONAL MIX OF EQUITIES AND BONDS. SELL BONDS FROM THE SHORTEST FIRST.	AVOID REALISING TOO MANY LOSSES ON LONGER BONDS WHICH COULD NOT BE PASSED TO POLICYHOLDERS.
	IF NO ASSETS REQUIRED TO BE SOLD OR PURCHASED, TURN OVER 10% OF THE EQUITY LOSSES.	TURNING OVER EQUITY LOSSES GRADUALLY ALLOWS THEM TO BE PASSED TO POLICYHOLDERS WITHOUT SQUEEZING MARGINS.
	IF ASSETS REQUIRED TO BE PURCHASED, BUY 75% OF BONDS MATCHING THE OUTSTANDING MATURITY OF THE POLICIES, 25% OF 2-YEAR BONDS; TURN OVER 10% OF THE EQUITY LOSSES.	TAKE ADVANTAGE OF BEING LOCKED INTO HIGHER, LONGER-TERM INTEREST RATES, WHILST AVOIDING THE BOND PORTFOLIO BEING TOO LONG.

Based on the analysis in Figure 7 we could then proceed to define a general DMA rule for investment strategy. We can see that management actions here are driven by some combination of economic factors (e.g., interest rate level), asset position (e.g., losses or gains on equities), and liability position (e.g., whether cash flow is positive or negative).

The analysis in Figure 7 is a simplified example, however, which considers only three factors, and only certain discrete levels of those factors (for instance rises in equities are not considered). In practice, more factors and scenarios would be required to be considered in order to inform a general DMA rule.

PARTICULAR ISSUES

This section describes some particular issues relating to the modelling of DMA.

The link with dynamic policyholder behaviour

DMA can have a direct or indirect effect on how policyholders act. Clearly, not considering how policyholders may react to DMA could overstate the benefit derived from DMA.

The MCEV Principles allow the impact of management discretion to be allowed for in the calculation of the time value of financial options and guarantees, but specifies that it should also allow for market and policyholders' reactions to such action.[10]

Solvency II requires that *policyholders' behaviour should not be assumed to be independent of … a firm's treatment of customers* and *appropriate consideration should also be given to an increasing awareness of policy options as well as policyholders' possible reactions to a changed financial position of an undertaking*. It also points out that *some risk-drivers may be heavily influenced by or even determined by several other risk-drivers (interdependence). For example, a fall in market values may influence the (re)insurance undertaking's exercise of discretion in future participation, which in turn affects policyholder behaviour.*[11]

This is another example of where it should not be assumed that DMA represent a *free lunch* for the company.

Policyholder reaction, in turn, can drive further DMA. The proper consideration of the interaction between DMA and DPB is a key feature of a meaningful asset-liability model.

An obvious example is where a cut in bonuses relative to market yields causes a higher level of lapses, as policyholders seek to gain higher market yields elsewhere. If this forces the sale of assets at a loss to meet increased surrender outgo (which could be the case in this scenario if a rise in market yields has caused unrealised losses to appear on fixed interest assets) it could prompt a further reduction in bonuses, as fund yields fall, prompting yet further lapses, and so on.

Another example is reviewable risk premium rates for medical expenses or long-term care insurance; high increases in premium rates could trigger anti-selective lapses by policyholders, leaving less healthy lives in the portfolio, triggering further rate increases, and so on.

The extent to which it would be reasonable to model such a feedback loop would depend, in particular, on the uncertainty over the extent to which such a chain of events would actually happen in a given set of circumstances. In some cases it may be realistic to assume more moderate management actions, which would be less likely to provoke knock-on effects.

Such events which could give rise to a *downward spiral* for a company could ultimately also trigger other events, such as regulator intervention.

Implications of a *going concern* basis

Certain key measures such as Solvency II Pillar I calculations and MCEV focus on the in-force business, but on a *going concern basis*.

For instance, Solvency II requires that insurers *value assets and liabilities based on the assumption that the undertaking will pursue its business as a going concern.*[12]

10 MCEV Principles, G7.2.
11 Solvency II QIS5 technical specification, TP 2.84 and TP 2.4.
12 Draft Level 2 Text, Article 5 V1.

The MCEV Principles require that best estimate noneconomic assumptions should *where appropriate, be based on the covered business being part of a going concern.* The MCEV Basis for Conclusions also notes that *consideration should be given to … whether the going concern approach implicit with the MCEV valuation would mean that new business may defer the release of orphan assets* (in the context of participating business).[13]

The requirement for modelled DMA to be based on what management actually intends to do (and not that which might produce optimal results for the measure under consideration), means that the DMA model should be formulated in the context of a realistic assumption about future new business.

The Solvency II use test for internal models requires that model outputs play an important role in shaping relevant management decisions; this further reinforces the need for realism (including assumptions about future new business) in modelling and DMA. Further, the ORSA requires the consideration of future new business.

It may be appropriate to consider additionally the impact of closing to new business when considering capital requirements; in this case the DMA should reflect what management actually intends to do in such an event.

A particular issue arises in respect of participating business in which different generations of business are pooled together with a common set of underlying assets (e.g., in the form of a *segregated fund*) and together share in the profits or investment results of that fund.

The *going concern* basis implies that assumed investment strategies and bonus rates (and hence DMA in this respect) should be consistent with an assumption of new business being written into the fund (assuming the fund is actually open to new business).

In a segregated participating fund the presence of future new business could materially change the ALM profile of the fund and hence future investment and bonus decisions. New business could completely change the cash-flow profile of the segregated fund (e.g., from a fund where assets are required to be sold in the future as the fund runs off, to a fund where assets are required to be purchased because of new premiums arising from future new business), and future new business could change the level of bonuses which would be declared in respect of the in-force business as in-force and new business cash flows interact with each other and the asset cash flows.

Indeed, the level and type of future new business (including the choice of particular segregated funds into which new business is written) could itself become a component of DMA, which could be driven by various considerations such as economic conditions and competitiveness (possibly a function of bonus rates, itself dependent on DMA).

This presents a particular issue in a dynamic ALM model where the cash flows of in-force and future new business are inextricably linked with the cash flows from the pooled assets.

In the Solvency II Pillar I calculations it is required to calculate a *market value of liabilities* (MVL), generally calculated by considering a *best estimate of liabilities* (BEL), relating to business in force at the valuation date only. To calculate the BEL a flag could be included within the model to identify those liability cash flows which relate to in-force business only, and it is these cash flows only that are discounted in order to calculate the BEL, even though the projection model includes future new business and even though the model will also include projected liability cash flows in respect of future new business.

[13] MCEV Principles, G11.2, G16.5; MCEV Basis for Conclusions, paragraph 158.

Risk-neutral or real-world economic scenario sets

In many actuarial calculations a *risk-neutral* scenario set is considered. The MCEV Principles, for example, explicitly mention this for valuing financial options and guarantees, but do also allow alternative approaches, for example using deflators with real-world scenarios. It is worth saying a little bit about the theory behind risk-neutral scenario sets.

Risk-neutral valuation is an important general principle in option pricing that states that we can assume the world is *risk-neutral* when pricing an option. The price obtained is then correct not just in a risk-neutral world, but also in the real world.

The need for this arises because the correct discount rate to apply to expected option payoffs is not easily derived, given that the risk of an option changes over time and with movements in the underlying assets. Risk-neutral valuation gets around this problem, and works by adjusting probabilities artificially such that the expected return on all assets (and therefore the discount rate for all expected payoffs) is the risk-free rate, and ends up giving the same answer.

In practice, for valuing the complex options arising from blocks of life insurance liabilities, an approach involving Monte Carlo simulations to produce a set of scenarios that is risk-neutral is typically used. The scenario set is calibrated to reproduce the market price of securities. While each scenario has equal probability of occurring, the generation of the scenario set is made such that, on average (over all the scenarios), the expected return on all assets is the risk-free rate, hence the scenario set as a whole is risk-neutral.

Each individual scenario represents a view of the future evolution of certain economic parameters. At the level of individual scenarios, any such scenario can belong equally to either a risk-neutral or a real-world scenario set. It is the relative probability of the scenarios within the set, i.e., taken in the context of all the other scenarios, that determines the risk-neutral or real-world nature of the scenario set. There is therefore no such thing as a *risk-neutral scenario*, only a risk-neutral scenario set.

In other words all individual scenarios are real-world scenarios, and this means that the same DMA rule should be applied irrespective of whether we are modelling using a real-world or a risk-neutral approach.

A real-world scenario set represents a realistic view of what you would actually expect to happen and should be used if you wanted to see the range of likely future outcomes from a model. A risk-neutral scenario set might be used to guide the choice of management actions if the goal of the management is to minimise the market-consistent value of some option. But it will not necessarily be meaningful to look at individual scenarios from a risk-neutral set.

In some cases, the fitting of economic models to observed market calibration data for a risk-neutral set leads to apparently unrealistic scenarios, i.e., scenarios generally expected to be encountered in the real world in only extreme cases, such as negative interest rates. In this case, modelled management actions might be determined to be those which would rule under the closest more realistic scenario (e.g., in the case of negative interest rate, those which would apply for 0% interest rates). However, the relative probability of such scenarios within the set is likely to be so low that the specific assumption regarding management actions under that scenario may not end up affecting the overall results in a material way.

Other issues

Risks and potential rewards which may drive DMA in practice may not be realistically or comprehensively reflected in the measurements under consideration, or even reflected in a counterintuitive way.

An example would be the current Solvency II treatment of low-quality EU sovereign debt, where a lower required capital under Pillar I could be achieved by holding such debt rather than, say, high-

quality corporate debt. This is a particular example of where optimising a particular measure (in this case capital required by Pillar I) would not necessarily be an appropriate driver for management actions. As has been discussed before, the DMA incorporated into the Pillar I model should be what the management intends to do, and this could be suboptimal in respect of the particular measure being considered. However, in many cases management may aim to optimise regulatory capital measures rather than true economic measures when these differ.

Another example is that Solvency II Pillar I Standard Formula models don't fully allow for combinations of risks occurring at the same time, which is due to their modular treatments of stresses.

The Solvency II Pillar I model could potentially be enhanced to better inform the actual planned management actions of the policy, for instance by incorporating a more realistic treatment of sovereign debt risk, even if this particular feature is not used in the calculation of SCR. Alternatively, further sub-models could be built, perhaps using results from the main model, to assist in this. Of course, the ORSA will require companies to identify all the risks it is exposed to.

RISK MANAGEMENT

DMA and models used as part of risk management

An actuarial projection model with no particular DMA functionality built into it implicitly assumes that no specific management actions will be taken in response to the scenarios envisaged by the model.

We believe that the absence of specific DMA functionality within a model does not necessarily represent an implicit *neutral* or base position with regard to DMA, as might perhaps be thought, but in fact can represent an explicit assumption in itself (i.e., management will take no responsive action).

Furthermore, this can be a *strong* assumption, in that the results of the model can be affected significantly. A model that is rich in actuarial functionality except for DMA is therefore incomplete, and possibly significantly so.

It can be argued that ignoring DMA is usually prudent (because presumably management actions will be taken with the aim of improving the company's financial position), but this is not always the situation, and in any case—from a risk management perspective—a goal should be to properly understand expected future outcomes.

Introducing DMA functionality into an otherwise fully developed model might therefore be seen as moving towards *completing the circle*. But it is critical that the level and nature of the DMA functionality be appropriate for the model—too little or too much sophistication (in relation to that of the model itself) can give rise to significantly different results.

The first point to make concerning risk management and DMA is therefore that the starting point be composed of:

1. An actuarial projection model
2. With an appropriate allowance for DMA built in
3. And a proper understanding of the limitations of the model, its applicability, and its results

This means that any model with either too little (or no) DMA functionality or *too much* (i.e., inappropriately complex) DMA functionality is not likely to be an appropriate tool for risk management. In our experience this point is often not well appreciated.

How models incorporating DMA can be used in risk management

With the above in place, DMA can make significant contributions to risk management, with applications such as:

- Implementation of a DMA *control cycle*
- Help in the management of agency risk
- Decision testing of potential management actions

We consider each of these applications of DMA to risk management in more detail below.

The DMA control cycle

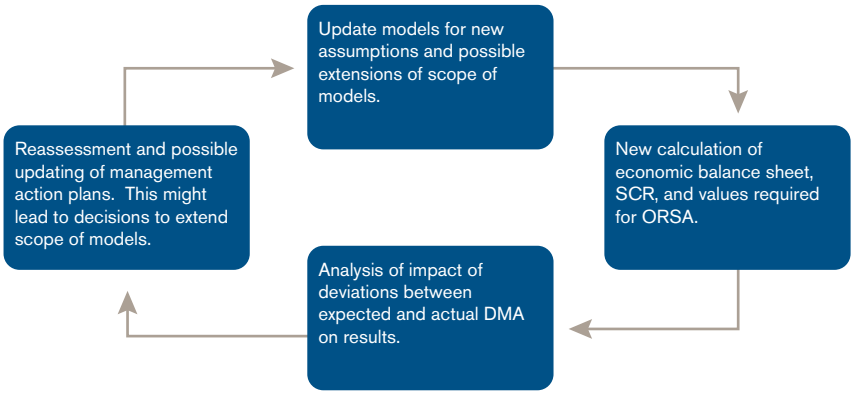
The fact of analysing and documenting clearly what management would be expected to do in specific situations is of value in itself. However, this can then also naturally form the basis for a *control cycle*, in which actual management actions in the face of, for example, past market events, may be compared to those planned and programmed into the model (i.e., back-testing).

We note that Solvency II will require the performance of such DMA control-cycle analyses, requiring, for example, *a comparison of assumed future management actions with management actions taken*

previously, a comparison of future management actions taken into account in the current and past calculations of the internal model, and the ability to *explain any relevant deviations*.[14]

A possible DMA control cycle in the context of Solvency II is illustrated in Figure 8.

FIGURE 8: DMA CONTROL CYCLE



The DMA control cycle implies that actual management actions will be monitored against the DMA that have been assumed within models. Ideally, the prior-year model would be run on a deterministic basis, which represents (as closely as possible) actual experience in the year using each of (1) actual DMA and (2) expected DMA, and the impact of this deviation quantified.

In practice, some of these quantitative analyses can be nontrivial. Care will be needed especially in cases where it is not possible to reconstruct past circumstances fully within the model and key external factors are left out. In fact, as part of the monitoring process a review could be made of how well the DMA-mapping process acts as a proxy for more complex real-life considerations, and how this translates into assumed DMA by comparing with actual historical management actions carried out.

More widely, the DMA control cycle analysis should also attempt to consider management actions occurring along axes lying outside the virtual world of the model, i.e., events and actions that are not amenable to modelling. The monitoring process should therefore look to incorporate a view of how past management actions in the face of actual events can compare to those actions that might have been planned for those circumstances, even if these are unmodelled.

One potential danger of deploying some form of DMA control cycle is that management could end up managing overly *to the model*, i.e., conforming closely to the programmed DMA, either because it fails to consider factors external to the virtual world of the model that should influence the actions to take, or otherwise purely from the knowledge that it is subject to DMA control-cycle scrutiny. It should be stressed that there will be occasions when departures from planned DMA will be the correct management decisions and the risk management processes should ensure that management is not blamed for justified departures.

[14] Draft Level 2 Text, Article TP6.

Management of agency risk

A DMA-enabled model and associated control-cycle analysis can potentially work well in helping the management of agency risks. Actual past management actions may be compared to those which were foreseen by the management action plan, justifications documented for the differences, and a quantitative difference evaluated and presented to the relevant stakeholders.

It is worth noting that observation of a positive variance between actual and expected actions does not in itself automatically mean there is no issue to address (see the second example below). If the management has taken excess risks compared to those which were expected in the management action plan, and these risks have not actually materialised, then a justification for the actions is of course required. Techniques of performance attribution should therefore be applied in this context.

Examples of agency risk

The Costa Concordia shipwreck of January 2012 was, of course, a tragedy in which lives were lost, and it should not be treated lightly. However—at least as reported widely in the press, although it should be noted that investigations are still ongoing at the time of writing this paper—it did illustrate that in a crisis situation, management will not necessarily carry out the planned actions and may ultimately be more concerned with a personal agenda than that of the company and its customers. *Planning, documenting and modelling expected management actions will not of course guarantee that things will not go wrong, but it is nonetheless an essential step towards controlling agency problems.*

Consider also a simple parable of an investment manager who is entrusted with €3.5 billion of clients' funds. On the first day he goes to a roulette wheel at a casino and places a bet totalling €3.5 billion by putting €100 million on each number from 2 to 36 (i.e., except the 0 and the 1). The ball lands on 14, meaning he loses his stake on all other numbers, but he recovers a total of €3.6 billion from number 14, so that he banks an overall return of €100 million. He then invests the proceeds in a deposit account earning a risk-free 2% p.a. After two months he has to report on performance to bosses and shareholders. He is able to tell them he earned 3.2% over this period, a more than respectable return, and the stakeholders are happy.

The next day he goes to the casino and makes the same bet. The ball lands on 29, he puts the proceeds in the deposit account and so on. In this way the manager can create steady returns of over 20% p.a. until something goes wrong. If what he is doing is not understood then he might be able to claim a salary and bonuses based on a share of the results. By the time things go drastically wrong and the ball lands on 1 or 0 he may have safely accumulated several millions in bonuses.

The agency problems revealed by the banking crisis showed that merely linking rewards to performance is not enough, especially if upside and downside risk are not shared equally. Understanding what the management is doing, what it intends to do, and how it will react to crises is equally critical.

Management action decision testing

Faced with a particular decision to make or a strategy to choose, the model can be used by management to test the expected effect of different actions in the face of a particular set of circumstances (as long as the limitations of the model are well understood).

Alternative action plans can be tested using the model to validate whether the proposed action plan is optimal and to justify any differences between the proposed and optimal actions. For example, it is possible to use an iterative process based on running a variety of different management rules to try to determine optimal investment strategies, a technique sometimes referred to as Dynamic ALM.[15]

[15] Balestreri, Kent, & Morgan. Dynamic asset liability management – a method for optimising investment strategy. *European Actuarial Journal.*

But the model represents a *complete*, virtual world in which it is known what management would do in response to the particular axes of uncertainty that are included in that virtual world. Management therefore needs to deploy the model and its associated DMA functionality critically, and ensure that any decision testing includes consideration of significant external factors that might influence the management actions taken in the real world.

In particular, care is needed to avoid management simply *letting the model decide* or using the modelling as justification for having taken an erroneous decision. Similarly, situations where, effectively, the model indicates *do A* but real life suggests *do B*, indicate a potential disconnect, and the reasons for the difference need to be analysed carefully, with consequent improvement in the modelling or a deeper understanding of the model's limitations. An example at the time of this writing might be the potential exit of Greece from the Eurozone, which would have various ramifications and could hence influence management decisions, but which could be beyond the scope of a company's models.

DMA and risk management under Solvency II

Solvency II focuses strongly on risk and places great importance on embedding risk management within companies, their processes, and their governance, as well as requiring a similar focus and modernisation for supervisors.

With reference to DMA and risk management, Solvency II does this by requiring:

- Construction of sophisticated models: Pillar I, Pillar II (the ORSA)
- Internal model(s), where adopted, are to be used in the running of the company, including risk management: Pillar II, the use test
- Limitations of models must be taken into account and wider factors outside the models considered: Pillar II (the ORSA)

The Solvency II use test

The Solvency II use test requires that internal models produce outputs which play an important role in shaping relevant management decisions, and which should be integrated into the company's risk management. This therefore explicitly creates the two-way link between actual and modelled DMA of the DMA control cycle described above.

Insurers using internal models are required to demonstrate that *the outputs of the internal model, including the measurement of diversification effects, are taken into account in formulating risk strategies, including the development of risk tolerance limits and risk mitigation strategies* and furthermore that *the quantifications of risks and the risk ranking produced by the internal model trigger risk management actions where relevant.*[16]

Management's understanding of an internal model should therefore include both the structure of the model and how it is integrated within the risk management system of the insurer.

To satisfy the above requirements it should be expected, for example, that the internal model be used to calculate risk indicators for how external factors might change the risk profile of the insurer and hence to require (dynamic) management reactions. Given that these risk indicators will be used by management in their decision making, these outputs of the model will then also become inputs to the model's own DMA functionality. For a given set of DMA rules incorporated as inputs to the model, the resulting effect on the risk indicators will be a useful model output suggesting how the programmed management actions might in turn affect risk exposures in practice. Inversely, DMA could themselves be an output from the model in the sense that alternative sets or variations of DMA

[16] Draft Level 2 Text, Article 215 TSIM5.

rules can be tested to achieve a given target of risk indicator input values (e.g., based on some view of risk tolerance).

Considerations related to the ORSA

A key element of Solvency II's Pillar II is the *Own Risk and Solvency Assessment* (ORSA), which forms part of the risk management framework. The current guidance focuses more on what is to be achieved by the ORSA than on how it is to be performed, but it seems appropriate that the ORSA should consider both qualitative and quantitative aspects.

In particular, the ORSA will require companies to assess risks which may not be reflected in the Pillar I calculations. In this context it is important to note that the SCR stresses of the Solvency II Standard Formula approach only consider certain specific shocks. Furthermore, these are considered as occurring as at the valuation date (e.g., the equity market value shock) rather than in the future, plus the modular structure of the Standard Formula approach doesn't fully allow for combinations of risks occurring at the same time (e.g., an equity shock together with sustained low interest rates).

The Standard Formula approach therefore clearly does not represent the full range of risks to which a company may be subject, and additional risks which were considered in the setting of the management action policy should therefore be considered qualitatively and/or quantitatively within the ORSA.

Under the ORSA an insurer should also consider *how it can ensure that it stays a going concern. In order to do this successfully, it does not only have to assess its current risks but also the risks it will or could face in the long term.* This will require insurers to take a forward-looking view on risk and solvency, covering each year of the business planning period. From a DMA point of view, for example, this implies that assumptions on the management actions which may impact new business volumes must be formulated and incorporated into models.

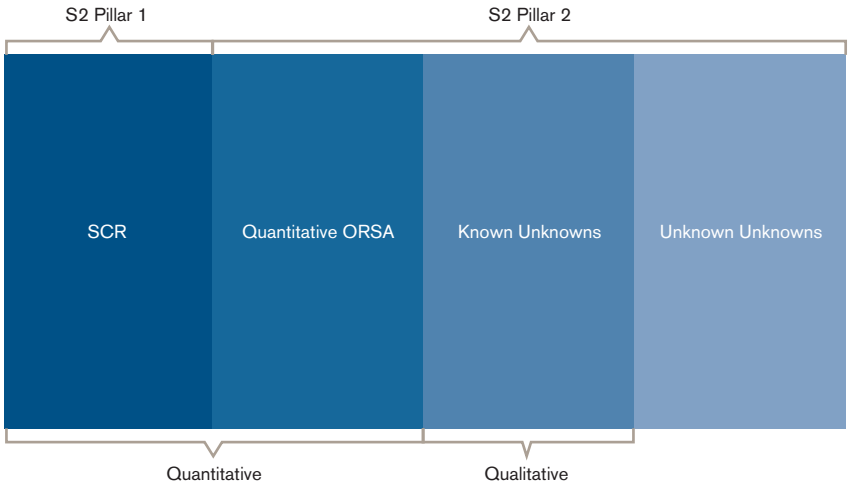
Nonetheless, as we have noted previously, those DMA that are included in a model should be those actions that management actually intends to take. In other words, the fact of using a DMA-enabled model for a particular purpose should not mean that the programmed DMA will be those actions that management would take in order to optimise a particular measure, e.g., Solvency II SCR (although of course this doesn't preclude that actual management actions may seek to minimise SCR). Given that the modelling underlying the ORSA is the broadest in scope within the three Pillars of Solvency II, the ORSA could be used as the basis for setting the context for the definition of DMA rules. These rules are then incorporated within the (more limited) Pillar I modelling used to derive the SCR, even if these DMA rules do not optimise the SCR. This might therefore imply the modelling of *suboptimal* DMA from a Pillar I point of view if these actions are those that management actually intends to take.

CONCLUSION

The context of Solvency II illustrates some of the issues that arise when blending DMA-enabled models and risk management, but it also allows for a convenient generalised structuring of the approach to the modelling and application of DMA.

Figure 9 shows how we might consider a first level of model as one built for the virtual world of the Pillar I SCR, i.e., base balance sheet and SCR stress scenarios. This model would be incomplete without DMA functionality, but DMA functionality only needs to be appropriate for the reduced world that this model represents, i.e., essentially best estimate and SCR stress scenarios.

FIGURE 9: SOLVENCY II PILLAR 1 AND PILLAR 2



The second level then represents an extended model, as we move into Pillar II and address ORSA requirements, whereby future new business and other risk scenarios are incorporated and evaluated. Further DMA functionality is required here but this is also where the boundaries of the model start to become apparent.

The third level notes how there will be known risks and scenarios which are simply not amenable to quantification within the model. Examples might be operational risks such as terrorism or extreme weather. While DMA functionality might be seen as ending where the model ends, considering both the universe of *known unknowns* and associated management actions is clearly fundamental to good risk management and is required by Solvency II. Actions in respect of these items should also be documented in the management action plan and subject to the DMA control cycle, even if the analysis may be done qualitatively rather than quantitatively.

Part of this process, and concomitant with management responsibility, is to be open-minded to as wide a spectrum of *known unknowns* as possible, and to strive to unearth significant *known unknowns* that might lie hidden simply because of blinkered or standardised thinking. In particular, this may mean encouraging (and paying heed to) communications internally on *nonstandard* risk situations and/or other alerts.

We have now moved firmly into qualitative rather than quantitative territory and the fourth level then represents what cannot even be contemplated but could affect the fortunes of the company. Clearly,

DMA disappear altogether from the picture at this point as dynamic management actions are those taken in reaction to an event–but all events at this level are by definition unknown.

While not amenable to either quantitative or qualitative analysis, the existence of *unknown unknowns* means that there is a need for recognising that neither a sophisticated model nor in-depth associated qualitative analysis will ever provide the full story. However, this is precisely where a priori management actions have a key role to play in creating an insurer that can be robust to *unknown unknowns*, for example by incorporating some forms of redundancy (e.g., parallel systems or processes).

In conclusion, we expect that DMA will receive more and more attention in the coming years, particularly as companies gear up for Solvency II and beyond.

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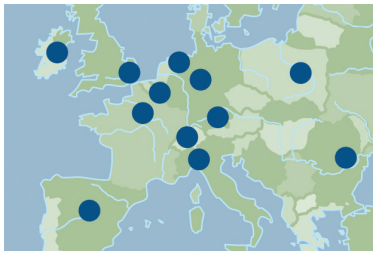

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