A SYSTEMIC APPROACH TO THE FINANCIAL MANAGEMENT AND RISK CONTROL OF EMPLOYEE BENEFIT FUNDS

MARK S. CLAASSEN

1. INTRODUCTION

1.1. BACKGROUND

The subject of asset/liability modelling has come to the fore in South Africa only recently, and challenges for the actuarial and consultancy communities abound. These challenges exist across a spectrum from the purely technical, to the pure marketing. Technical debate revolves around the construction of investment and simulation models, and interpretation of the outputs. Further challenges arise in combining deterministic output of traditional actuarial methods with the probabilistic output of stochastic methods. At the marketing level, consultants are challenged by methods of communicating and promoting a service that provides benefits in a new and largely intangible form.

The purpose of this paper is to provide an insight into the development and application of asset/liability modelling, as it has been applied in the South African context.

1.2. STRUCTURE OF THE PAPER

This paper has 5 main sections.

Section 2 sketches briefly the South African Employee Benefits and Investments scene as a backdrop to the rest of the paper.

Section 3 elaborates briefly on the asset/liability modelling techniques that we have employed.

Section 4 explains our "system view" of the process.
Section 5 briefly examines a practical example undertaken by a South African sponsor.

Section 6 contains the conclusion.

2. THE SOUTH AFRICAN ENVIRONMENT

2.1. BRIEF DESCRIPTION OF EMPLOYEE BENEFIT PLANS

Asset/liability modelling in SA was initiated to assist in the financial and investment management of pension plans, although applications in other areas, most notably, health care management are increasing. SA pension plans are primarily of the final salary type; typically offering a benefit of 2% of salary earned close to retirement for each year of pensionable service. The pensioner may generally commute one-third of this pension. Many funds implicitly or expressly commit to increasing pensions in payment in line with a percentage (0% to 75%; rarely 100%) of the increase in the Consumer Price Index. Lump sum benefits on death and withdrawal, and dependant’s pensions on death are generally provided. Accrued pension rights are rarely preserved on withdrawal (there are steady improvements in this regard).

Recently moves towards defined contribution pension and provident funds (these latter being instruments for providing lump sum payments on retirement) have gained momentum, due to influences as indicated below.

Until recently health care arrangements tended to pay benefits out of current investment and contribution income. Most employers however pay a significant portion of the health-care costs of their pensioners, a substantial long-term liability. This problem is exacerbated by a sharp rise in health care costs. There is pressure for sponsors to fully fund these liabilities.

2.2. SOCIO-POLITICAL INFLUENCES

SA is currently undergoing profound social and political change. Allied with an enduring economic recession the background environment is one of great uncertainty. A number of tensions arise from the above, for example

- Demands for reallocation/redistribution of financial and material resources,
- Conflicts between different political and economic ideologies (free market vs. socialist/centrally planned views),
- Attacks on economic power blocks, and threats of large scale nationalisation of industry.
- Powerful, and sometimes militant labour movements, are increasingly devoting attention to employee benefits issues.

This background exposes the employee benefits industry itself to significant pressures. Fundamental questions such as: "What form will future capital markets take?", "What will be the enduring economic consequences of politically expedient economic decisions?", "What impact could these have on my ability to underwrite my employee benefit commitments?", are frequently asked.

In our view asset/liability modelling plays a valuable role within such a background, in particularly in providing insight into fund realities, and the potential impact of influences external to the fund.

2.3. LEGISLATIVE ENVIRONMENT

Recent 1989 (and later) legislative changes added impetus to the actuarial need for practical asset/liability management tools. Previous legislation inhibited flexibility in making asset allocation decisions, funds being forced to invest 53% of cash-flows in "prescribed" assets. These prescribed assets consisted of certain money market instruments as well as gilts and semi-gilts. While justified as an attempt to foster prudent investment, it served as cheap financing for the state, parastatals and the banking sector. The economic consequences are discussed later.

Fund managers concentrated on the remaining 47%, no meaningful asset allocation strategy for the fund being possible. These requirements were abolished in 1989, and we replaced by more flexible legislation. Funds could invest as follows (all figures by market value):

<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Percentage</th>
<th>Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equities</td>
<td>65%</td>
<td>(max 10% in one counter)</td>
</tr>
<tr>
<td>Property</td>
<td>30%</td>
<td>(max 5% in one property asset)</td>
</tr>
<tr>
<td>Corporate</td>
<td></td>
<td>(maximum equity and property 85%)</td>
</tr>
<tr>
<td>Property debt instruments</td>
<td>25%</td>
<td>(maximum 5% in one venture)</td>
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<tr>
<td></td>
<td></td>
<td>(maximum 90% in the sum of the above)</td>
</tr>
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</table>
This implied funds were required to invest less than 10% in prescribed asset investments. These limits were later changed (equity 75%, property 25%, sum of these 90%, sum of the items above: 95%).

The practical consequence of these legislative changes was to introduce the asset allocation decision as a real problem.

Regulators simultaneously introduced a further provision that fund valuators, when doing the actuarial assessment, were to certify that the fund's investments were appropriate given the nature of it's liabilities. If such certificate was withheld, certain actions could be prescribed to the trustees. This duty raised the question of how the actuary should go about issuing such certificate.

In summary therefore, much of our modelling work has been motivated by a need to resolve the asset allocation and certification issues.

Other legislative influences

Further legislative changes are under consideration, which may have serious cost or benefit design consequences for funds. The first concerns their tax status. Presently investment build-up of funds is tax free, and contributions of employer and employees are an allowable expense for tax purposes. Benefits are taxed in the hands of the recipient.

With pressure on state revenues (declining tax revenues and social spending demands) proposals were made for the status quo to be broken. The issue is still subject to debate, but the impact of the recommendations, if implemented, will raise the cost of benefits, or alternatively result in benefits reductions.

Another factor that may have an impact, are recommendations arising out the Mouton Committee. This body, addressing inter alia pension benefits, may recommend minimum benefits (particularly on withdrawal, and post retirement pension increases).

The potential effect of these factors, will change the financial status of employee benefit funds, highlighting the need for asset allocation strategy, methods for assessing fund solvency and benefit redesign implications, and techniques for evaluating alternative courses of action.

2.4. South African capital markets and inflation

This section provides historical background to offer insight into local conditions.
Inflation

No index of salary or wage inflation is published locally. The Consumer Price Index (CPI) has been used for modelling purposes, as it is invariably used for wage, salary and pension adjustments.

Graph 1 depicts the rate of increase in the CPI. Salient features are the shift in level of inflation to +/- 14% from the mid 70's, and its persistence at this level.

Equity markets

SA has one formal equity exchange viz., the Johannesburg Stock Exchange. Shares traded fall into 2 broad categories, industrial and financial shares or mining and mining related equities. The market capitalisation of listed equities is currently approximately R500Bn, or +/-165 Billion $ US. This is split approximately 67/33 in favour of industrials: a trend away from minings towards industrials being clearly in evidence.

A feature of the JSE is the low level of turnover, +/- 6% of the market capitalisation is traded each year. Causal factors include fears that realised gains will be taxed as income, inability by local investors to invest off-shore, shortages of blue-chip counters, and shares being tightly held by large conglomerates.

Mining counters have a distinct behaviour, and for purposes of modelling this was important enough to model the industrial and mining entities separately. Table 1 below shows returns (capital and income) on the Mining Producer and Industrial Indices of the JSE over the recent past. Graph 2 depicts the trend of the indices themselves.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MINING EQUITIES</td>
<td>19.3%</td>
<td>22.4%</td>
<td>19.2%</td>
</tr>
<tr>
<td>INDUSTRIAL EQUITIES</td>
<td>19.3%</td>
<td>23.2%</td>
<td>34.7%</td>
</tr>
<tr>
<td>INFLATION</td>
<td>11.4%</td>
<td>13.4%</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

Equities have historically provided substantial nominal and real returns.
Property

SA has no long-term representative property index: only recently has this problem received attention. Property investment in some form is popular for most funds.

For modelling purposes we relied on the Property Trust index of the JSE, for which data is regrettably available from 1977 only: returns on this index are indicated in Table 2 below: the trend in graph 2.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>PROPERTY TRUST</td>
<td>20.9%</td>
<td>18.3%</td>
</tr>
<tr>
<td>INFLATION</td>
<td>14.5%</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

The index has under performed the directly managed property portfolios of reputable financial institutions (due to churning and poorer management): yet it has meaningfully out-performed inflation.

Capital and money markets

This market has been distorted historically by the prescribed asset legislation, Government interference in monetary policy, and large scale Government borrowing via bonds (frequently to finance current expenditure). This caused past interest rates to be low in nominal terms and often negative in real terms, and also a secular increasing trend in bond yields: long-term investment in bonds has been disastrous as can be seen from the trend of yields as displayed in graph 3.

Two recent developments may improve matters, firstly the abolition of prescribed asset regulations (the threat exists of a re-introduction if politically expedient) and secondly a trend towards allowing monetary authorities greater autonomy, allied with greater co-operation between fiscal and monetary authorities.

Graph 3 displays the past trend of the 90 day Bankers Acceptance rate; the political expediency of low real interest rates is clearly seen.

The difficulty these features caused in the modelling, was gauging the extent to which such distortions might continue into the future.
3. ASSET/LIABILITY MODELLING

3.1. BACKGROUND

In developing an asset/liability model we had the following objectives:

i) The model was to reflect local realities, particularly the investment simulations. We found that models developed in the UK and elsewhere were unsuitable.

ii) The model was to have the ability both to select asset allocations given the liabilities, as well as to project the consequences of investing in a particular portfolio. Both of these approaches were to be possible under a number of alternative scenarios.

Where portfolio selection was the desired object, both asset and liability flows were to be used, rather than the assets only.

iii) The model was to be technically sound. Stringent statistical tests were applied in deriving key predictive parameters of the investment model, and the soundness of the model was audited by an outside academic statistical authority.

iv) A generic approach was adopted to the projection of future liability cash-flows as input to the model. As such the user tailors the liability flows of the benefit fund he is dealing with, and can apply his own definitions of liability classes, contingent benefit generating events, the form of the benefit and the quantum to be paid. It is possible also to base calculations on alternative new entrant scenarios (a major current issue with the fluidity of the employment situation).

v) Because of the difficulty of displaying to the end consumer the internal mechanics of the model, the model was to produce intermediate output, which would help in accepting the validity of the model at an intuitive level.

3.2. LIABILITY PROJECTION

The techniques for undertaking liability cash-flow projections are well known and we will not repeat them here.
3.3. THE STOCHASTIC INVESTMENT MODEL

Output

The stochastic investment model projects the future price of industrial and mining equities, future property prices, as well as dividends and rental income produced by these asset classes. The model calculates future short-term interest yields, and the future income yields and prices of long-bonds. Furthermore the model is to calculate future rates of inflation.

Technical development

In brief the model was developed as follows:
Step 1: Initially univariate analysis was applied (via a Box-Jenkins ARIMA modelling technique) to historical series of capital and income items (with the data suitably manipulated). Predictive parameters contained in the individual time series were then identified.
Step 2: Thereafter cross-correlation analysis was employed on each of the series (using Transfer Function Analysis) to identify the existence and degree of interaction between the individual series.
Step 3: The model was integrated into a whole, by designing a State-space Model of the equity and property series, which would be used as input via transfer functions to generate the long bond, money market and inflation time series.

Inputs

In order to run the stochastic model the following initialising inputs (at least) are required:
- Initial values for each of the price indices (equity and property).
- Growth trend parameters for each of these indices.
- Initial values for each of the dividend and rental indices.
- Growth trend parameters for each of these income indices.
- Initial long bond yield.
- Initial short-term interest rate.
- A co-variance matrix setting out initial variability factors for each of the input items, and
- Co-variability factors between each of the input items.
Broad description

In several UK models, inflation "drives" the return components on equities and interest rates, and the "initialisation" problem tends to revolve around setting an initial input value for inflation: generally using figures from the recent past.

In some ways our model had a reverse structure. We found that equity trends tended to influence interest rates, and these in tandem tended to drive the inflation rate. This was consistent with some Australian research, and can be explained somewhat by the nature of the SA economy. With a significant focus on export of primary products (agricultural and mining) the performance of the SA economy is very dependant on the market price for such commodities. As this price is set by demand factors outside the SA economy, the economy is very exposed to external influences.

An increase in external prices feeds quickly through to mining equity prices and dividends, which in turn influence industrial equity and property prices and (with a lag) the income on these assets. A surge tends to lead to a fall in short and long-term interest rates (with various lags), and consequently a rise in the inflation trend.

Impact on setting inputs

With the above model structure, the initialisation values are important because of the influence the initial equity and property parameters will have. To use equity values reflecting the recent past, may distort projected returns in the early years, if these recent returns are unusual in some way. To use long-term averages, implies altering initialisation values for interest rates and inflation also. In practice this is an area where judgement, experience and "playing" with the model are essential. Because we frequently use the model to evaluate alternative scenarios, where different initialisation values are required, this problem is to some extent contained.

The above is a summary of the technical aspects of the model. The ensuing section elaborate briefly on how it has been employed in practice.
4. The "systems" view

Earlier mental models

Because of historical distortions, the asset-liability problem has until recently been addressed largely mechanically, if at all. The actuary was responsible for liability management and advice and the investment manager for generating a decent return on fund assets.

An holistic view of the fund was seldom taken, nor was one needed given the environmental background. This has all changed, and the issue today is one of containing and/or eliminating financial risks and using effectively the fund's and its sponsor's financial resources.

The systems view

The view that we are increasingly adopting in advising trustees and sponsors is that employee benefit arrangements should be treated as important business entities in themselves, and that the principles of business planning as practised in other spheres, can equally be applied in this context.

The "systems view" is an abstract concept, with a philosophical backdrop and practical orientation that contain certain key elements. Philosophically, systems thinking implies that in managing an entity that consists of clearly identifiable components, optimum management of these components, does not imply optimum management of the entire entity. Furthermore it implies that the interrelationships between the component parts of the system, as well as the system to its environment, need to be taken into account in planning and decision making. It is easy to see an employee benefit fund as a system, and that optimum management of the assets and liabilities separately does not imply optimum management of the system.

A difficulty with the systems view is that existing management and mental models have been essentially reductionistic, focusing on analysis rather than synthesis, and that attempts to understand the whole have arisen through an understanding of its components parts. A primary theme in the development of the asset/liability computer system, was that it be a user-friendly system model. As such it aims to allow trustees and sponsors to educate themselves about the realities of their particular fund and its behaviour under different influences.

We believe that in the rapidly changing and volatile domestic environment, a systems approach to fund decision-making and planning, is
a valuable, possibly even essential, method for complementing existing actuarial and investment management methods.

Implications of the systems view

The systems view implies a focus on longer-term planning and setting strategic objectives. In effect the starting question is: “Where do we want to be in (say) 2002?” For the fund this means defining the planning horizon and specific objectives. Concerning the former, a 10 year time horizon is advised for most clients (exceptions occur). A longer period is problematic, because the output numbers become difficult to interpret and because the mind has difficulties casting that far forward. Additionally, the technical validity of the model weakens where longer periods are concerned (because of the short period of historical data (+/- 30 yrs) available for developing the investment model).

Shorter periods (less than 10 yrs) imply a shift away from strategic imperatives, but are coped with by showing key output values for the intermediate years, where a longer view is taken. This helps identify problems that may inhibit achieving the long-term objective, e.g. cash-flow difficulties in earlier years could eliminate and otherwise suitable investment strategy. Intermediate values are useful also in displaying how the long-term objective has been achieved.

Strategic objectives may be anything from very simple to very complex. We prefer a clear strategic objective, adding qualifications as constraints or performance standards, as required. An example of a strategic objective may be: “Maintain the real value of benefits, while ensuring fund solvency.” Qualifications with regard to contribution rates, investment returns, exposure limits etc. would then be added.

The environment

Systems are generally integral to, or operate within, a specific environment. We need therefore to be able to describe the environment in which our fund is to operate. Environment can generally be divided into macro and micro elements, the former concerns the economic and legislative environment, and the latter more fund specific items. An example of macro elements are likely market structures and socio-economic policies, and micro issues could address recruitment policy, fund specific contingent factors and so on. Constraints will be addressed in a following section.
In formulating the future environment assumed for modelling purposes, our point of departure is that it is impossible to predict the long-term future with reliability. The approach we have adopted therefore, is that alternative scenarios be developed, and their impact evaluated against the long-term objectives, constraints and performance standards. Where such comprehensive work is not required, one scenario is applied, in effect a standard "base-case". Valuation bases used by actuaries, although deterministic, are really in effect examples of such base case scenarios.

Development of alternative scenarios is difficult: the approach is often to apply 2 or 3 "stock" alternatives, to show the effects of these, and then (together with the client) to customise them further after analysis, interpretation and discussion. A good starting point is to assume that the situation of the immediate past will continue into the future. This has the advantage that users are generally well informed about the recent past, and that from interpreting the results of this initial scenario, alternatives will often evolve naturally. Interaction is important in developing scenarios, and much of the value of the exercise is derived from this process because it gives insight into the thinking and concerns of the participants.

**Alternative strategies**

In the simplest case, the strategies that will be considered for attaining fund objectives are the alternative long-term (strategic) asset allocations that could be employed. We will concentrate on this aspect, but there is no reason why alternative benefit enhancement strategies for example, or some combination of the two, could not be tested.

Once the strategies have been articulated our approach is to input these into the forecast suite of the model, to test the implications thereof under alternative scenarios. In undertaking a modelling exercise, one may be in a position of having to search for alternative strategies to evaluate, or alternatively a strategy may already be articulated.

There are several approaches to searching for the range of worthwhile strategies to pursue. In our case we will tend to produce as initial model output, that range of portfolios which meets a key asset/liability objective in the most secure way. Generally this is the risk/reward curve of fund surplus, or the risk/reward curve of the fund contribution rate. This method is not perfect, but can be defended on the basis that the strategies derived are merely a starting point for subsequent testing and re-evaluation.
The process is repeated per scenario, and the plainly unsuitable strategies can be eliminated at this stage. The remaining range of portfolios, is then divided into a set of discrete alternatives which are then used for strategy evaluation.

The hope is to identify that strategy, which on balance produces desirable results for as many (or all) of the principal scenarios. The above phase, while reliant on patience, interpretation and judgement, will often go a long way towards identifying the strategies that are worth pursuing to achieve this aim.

**Constraints and performance criteria**

Constraints are normally defined as specific limits to be applied, and performance criteria the minimum standard of the solutions, although the distinction between the two is frequently blurred. The former will tend to be explicit inputs to the modelling whereas the latter will tend to arise as outputs. Constraints will tend to be quantitative and performance criteria qualitative e.g. we may have a constraint on the amount of cash in a fund (quantitative) or a performance criterion which limits the probability of a deficit at the end of 10 years to 5% (qualitative). Performance criteria are applied against outputs: this interpretative phase may add considerably to the understanding and credibility of the process.

Some example of constraints are:

- Limiting exposures to specific asset classes,
- Preventing negative exposure to asset classes (i.e. short sales or borrowings),
- Consider only portfolios where the expected future net cash-flow is positive, and so on.

Performance criteria are more subjective and frequently need revision because they are unrealistic given the modelling results. Examples are:

- Consider portfolios only where the expected prospective future funding ratio (assets to liabilities) is greater than one (say). This may be a requirement after a specific period, or for each year,
- Consider only portfolios where the expected prospective future total contribution rate remains at or below the current level,
- Consider only those strategies that minimise the probability of a deficit,
- Consider only those strategies that have a limited downside.

In selecting a strategy a combination of constraints and performance criteria is generally implied.

A difficulty where stringent qualitative criteria are set initially, is that these may be impossible to achieve in the absence of a large initial fund surplus (i.e. the price of certainty is high, either through adopting a conservative investment approach concerned with capital preservation or through added financing). However this does create awareness that the risks being faced are by no means insignificant.

5. Practical example

Fund type and benefit description

The fund is a large tax-exempt entity, concerned entirely with payment of pensions. Considerations are paid into the fund in respect of each annuitant, such consideration containing a significant loading for generating pensioner increases. The fund desires to annually increase pensions by at least 75% of the rate of increase in the Consumer Price Index.

Fund objective

To fully secure “vested” pension benefits, to prospectively increase such benefits by 75% of the annual increase in CPI, and to remain financially sound at all times.

Constraints

- The fund has no initial surplus, and no external source of recapitalising in the event of loss. In event of loss a moratorium will be imposed on prospective pension increases.
- The fund has to adhere to the investment guidelines in respect of asset allocation as expressed in section 2.
- No more than 15% of assets may be invested in (non-debt) property related entities.
- The fund wishes to be solvent over the entire time horizon of the exercise.
- The fund is concerned that sufficient income on assets be generated in order to pay benefits.

Performance standard

The fund wishes to minimise the probability of a shortfall. However within this the fund finds an increased probability of a minor shortfall more acceptable than a low probability of a major shortfall.

Alternative scenarios

The initialisation scenario was that inflation and the investment performance of assets will display the same trend and behavioural characteristics in the immediate future (the time horizon of the exercise i.e. 9 years) as the decade of the 80's, with some modifications. (We will not go into these here, but they concern the maintenance of a secular declining trend in dividend yields as well as a secular increasing trend in bond yields as indentified in our modelling research).

Two further scenarios were developed based on modifying the expectations of returns from equities and property, while maintaining the original interest rate and inflation scenarios.

These scenarios are generated by modifying the model inputs (frequently a hit and miss affair). A first step was to show the investment model outputs to the user, so as to gain his endorsement or otherwise of the scenarios being modelled. Graph 4 provides an example of such output (for the initialisation scenario). Graph 5 indicates the expected return figures for growth assets for all three scenarios (labelled as follows: initialisation (H), intermediate (I) and low (L)).

The nature of the liabilities

Before addressing the issue of defining strategies, a preliminary assessment is made of the liabilities. The following calculations are done.

- As a check, cash-flows are calculated for the liabilities on the actuarial basis, and discounted using the actuarial valuation interest rate. The result should equal the actuarial valuation result, and is used as a global check.
- Cash-flow modelling of the benefits over the modelling time horizon, applying the inflation scenario (s) that have been decided. This is
done to identify salient features, to educate the client with regard
to what he needs to achieve, to get an insight into the order of
magnitude of benefit flows, as well as their range (or predictability).
Graph 6 indicates the flows for the fund under investigation.

Periodic future actuarial valuations on the basis of the inflation
scenarios. This is to give an insight into the trend and range of
"capital" growth of the liabilities. The format of the output of this
analysis is similar to that of the benefit flows.

The strategies

The set of possible asset allocations is developed for each scenario
(taking account of several of the constraints). This set of alternatives
is generally a continuum, and is shown for the intermediate scenario in
Graph 7 (optimised with regard to future expected surplus).

A few salient points are:

i) The greater the expected surplus, the greater the tendency to be in
cash rather than bonds. This reflects this powerful historical reality
in the South African context, and is of course also a function of
the scenarios themselves. The fixed interest allocation tends to be
fairly sensitive to small differences in assumptions (see fixed interest
adjustments) below.

ii) A dominant exposure to bonds is likely to lead to a deficit. Gener-
ally that set of portfolios to the left of the $E(S)=0$ figure, can be
discarded.

iii) The general tendency for the model to "like" property.

iv) A general preference for industrials over mining counters (except at
the extreme right of the graph).

This continuum of portfolios is merely a starting point. It is now
divided into a number of discrete alternatives which are tested against
the constraints. The amount of computation is generally enormous, as
these strategies then need to be tested against each of the scenarios. Ac-
cordingly we will developed the process using the intermediate scenario
only.

The strategies

The asset allocation strategies investigated were as in table 3 below:
A systemic approach to the financial, ecc.

Table 3

<table>
<thead>
<tr>
<th>PORTFOLIO</th>
<th>IND</th>
<th>MIN</th>
<th>PROP</th>
<th>BONDS</th>
<th>CASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7%</td>
<td>4%</td>
<td>10%</td>
<td>45%</td>
<td>34%</td>
</tr>
<tr>
<td>2</td>
<td>11%</td>
<td>4%</td>
<td>15%</td>
<td>23%</td>
<td>47%</td>
</tr>
<tr>
<td>3</td>
<td>16%</td>
<td>5%</td>
<td>15%</td>
<td>3%</td>
<td>61%</td>
</tr>
<tr>
<td>4</td>
<td>21%</td>
<td>7%</td>
<td>15%</td>
<td>0%</td>
<td>57%</td>
</tr>
<tr>
<td>5</td>
<td>27%</td>
<td>9%</td>
<td>15%</td>
<td>0%</td>
<td>49%</td>
</tr>
<tr>
<td>6</td>
<td>33%</td>
<td>12%</td>
<td>13%</td>
<td>0%</td>
<td>42%</td>
</tr>
<tr>
<td>7</td>
<td>38%</td>
<td>14%</td>
<td>11%</td>
<td>13%</td>
<td>36%</td>
</tr>
<tr>
<td>8</td>
<td>44%</td>
<td>17%</td>
<td>9%</td>
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<td>9</td>
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<td>7%</td>
<td>0%</td>
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<td>54%</td>
<td>21%</td>
<td>9%</td>
<td>0%</td>
<td>16%</td>
</tr>
<tr>
<td>11</td>
<td>54%</td>
<td>21%</td>
<td>15%</td>
<td>0%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Solvency testing

These portfolios were tested against the likely long-term solvency implications thereof. Although each was originally selected as leading to an expected solvency position, the solvency ratios will themselves have a probability distribution. Probability of insolvency on the basis of each of the above scenarios is shown in the second column of table 4, below.

Table 4

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>INSOLVENCY PROBABILITY</th>
<th>BADNESS INDICATOR (5% LEVEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48%</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>42%</td>
<td>61</td>
</tr>
<tr>
<td>3</td>
<td>38%</td>
<td>62</td>
</tr>
<tr>
<td>4</td>
<td>35%</td>
<td>62</td>
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<tr>
<td>5</td>
<td>33%</td>
<td>55</td>
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<tr>
<td>6</td>
<td>32%</td>
<td>53</td>
</tr>
<tr>
<td>7</td>
<td>31%</td>
<td>51</td>
</tr>
<tr>
<td>8</td>
<td>30%</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>29%</td>
<td>41</td>
</tr>
<tr>
<td>10</td>
<td>29%</td>
<td>36</td>
</tr>
<tr>
<td>11</td>
<td>20%</td>
<td>29</td>
</tr>
</tbody>
</table>

There is initially a tendency for the probability of insolvency to decline quite sharply, whereafter it decelerates and remains quite flat. The insolvency probability (this of course assumes no intermediate action) is quite significant (generally more than people assume at an intuitive level). This is of course one of the virtues of modelling, in that it shows what the likely risks could be.
Shortfall analysis

Risk is both a function of the probability of "shortfall" and the consequences of such shortfall. The above probabilities need to be tempered against how badly things might go wrong.

While there are several ways of addressing this issue, for purposes of this exercise, a gauge of the potential "badness" of each strategy was taken to be the 5th percentile of the funding ratio of the fund i.e. the value above which 95% of the funding ratio figures lie. These figures are shown (as an index) in the third column of table 4 above: the smaller the figure the more potentially disastrous the strategy. The indicator is fairly stable for portfolios 1-7 and thereafter shows a deteriorating trend.

Combining the above

By empirical, as well as mathematical methods is can be shown that portfolios 6 and 7 bast satisfy the overall requirements of the fund. The above analysis is applied also to the alternative scenarios, to test whether the strategies that satisfy the various criteria best are fairly similar. If so the strategy to choose is quite obvious. If not judgement will need to be applied to decide which scenario should be given most weight in making the decision. This is of course frequently reflective of the attitudes and views of the end user.

Cash-flow testing

Cash-flow tests were then applied to the selected portfolios (6 and 7). No constraints arose out of this analysis (this test was applied to all the strategies-it easily eliminates portfolios 9, 10, 11 because of their bias in favour of equities with current very low dividend yields).

The fixed interest assumptions

It is important to stress that the process is both an iterative and interactive one. The scenarios were subsequently modified to reflect higher returns on bonds than on cash (the more classical view). The impact of this change was mainly to alter the fixed interest allocations of portfolios 6 and 7.
Recommendation

The asset allocation finally recommended was as follows:

<table>
<thead>
<tr>
<th>Table 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDUSTRIAL EQUITIES</td>
</tr>
<tr>
<td>MINING EQUITIES</td>
</tr>
<tr>
<td>PROPERTY</td>
</tr>
<tr>
<td>BONDS</td>
</tr>
<tr>
<td>CASH</td>
</tr>
</tbody>
</table>

6. Conclusion

This application of modelling techniques in the South African employee benefits scene is still in its infancy. The approach that we have outlined, and the model itself, will no doubt yet undergo major evolution. Where we have found the process of model development and application extremely useful is in clarifying our approach to planning for employee benefit funds, and enriching our understanding of the economic and business systems that we deal with.

In conclusion we feel that both asset-liability modelling and the systems approach outlined, are valuable tools for resolving the asset allocation and fund certification problem. Even more importantly is makes the process both understandable and beneficial to the end user.
GRAPH 1

ANNUAL RATE OF INCREASE IN CPI

GRAPH 2

INDUSTRIAL, MINING PRODUCER AND PROPERTY TRUST INDICES (Log Scale)
GRAPH 3

INTEREST RATES AND INFLATION

GRAPH 4

SIMULATED COMPOUND RETURNS (5TH, 25TH, 50TH, 75TH AND 95TH PERCENTILES)
GRAPH 5

EXPECTED GROWTH ASSET PERFORMANCE: ALTERNATIVE SCENARIOS

GRAPH 6

FUTURE BENEFIT PAYMENTS (5TH, 50TH AND 95TH PERCENTILES): INCREASES OF 75% OF INFLATION