

# WHAT IS THE VALUE OF A VALUATION?

ANGUS S. MACDONALD

## ABSTRACT

Life office solvency is usually investigated by carrying out a valuation, on a basis which may be determined by the actuary or by the insurance supervisors. A valuation basis is an extremely simple model of the future, usually modelling interest and inflation as constants. However, the real future is unlikely to resemble that model, quantitatively or qualitatively. An important feature of real life overlooked by the valuation model is the range of strategies which life office managers can use to steer the office in response to events. This paper uses a computer model office to compare the results of a conventional solvency valuation with the results of a simulated run-off of the in-force business under the stochastic investment conditions provided by the Wilkie investment model.

KEY WORDS: Insurance, solvency, valuation, simulation, modelling.

## 1. INTRODUCTION

From time to time, every life office must find out whether or not it is solvent. The tool which actuaries have used for 200 years to test solvency is the life office valuation, although the correct approach to valuation has always been a matter for debate. Should one use a gross premium or a net premium method? Should the valuation basis be the same as the premium basis? What value should be placed on the assets? Should the valuation basis be decided by legislation? The number of different approaches used in the E.C. will ensure a lively discussion for some time yet.

Whatever method may be preferred, and whoever chooses the basis, every conventional valuation basis is a model of the future. That the interest, mortality and expense assumptions are all models tends to be disguised by their simple nature; we do not usually dignify a fixed interest rate with the name "model". They are models nevertheless, and it is legitimate to ask how well they perform their tasks, and whether other models might be better.

To say that a life office is solvent or insolvent because it has passed or failed a solvency valuation is to say that, if the future follows the valuation model, then the office will have assets to spare after meeting all its liabilities and paying its expenses. The future will almost certainly not follow the model, however, so we can expect some errors. Sometimes a solvency valuation will close down an office which is then run off with assets to spare, and at other times it will allow an office which would, if closed, have been unable to meet its liabilities, to remain open to new business. We may say that the solvency valuation is doing a good job if it reduces both types of error to reasonably small proportions.

The aim of this paper is to measure the success of valuations carried out in accordance with the U.K. valuation regulations (2). The test proceeds in three steps.

(1) The first step is to use the Wilkie asset model to produce 1,000 simulated futures for U.K. inflation, fixed interest assets and equities over the next 65 years. A simple model office is subjected to these 1,000 different futures. The office continues to transact new business, and it is valued every year using the U.K. statutory minimum valuation basis. Offices which fail the valuation test are not closed down but are allowed to carry on regardless; the object of this step is to find out which offices fail the valuation test and at what times.

(2) The second step is to take each of the 1,000 futures and to close the office in each of the next 40 years, running off the in force business. Thus, 1,000 simulations are run in which the office is closed after 1 year, 1,000 simulations are run in which the office is closed after 2 years and so on. In some cases, a deficiency will be revealed.

(3) The third step is to compare the results of the previous two steps. If we suppose that an office in (1) would be closed down upon failing the valuation for the first time, we can see from (2) whether the valuation correctly identified offices in difficulties. Moreover, by identifying in (2) all the offices which would ever have shown a deficit had they been closed down, we can see whether the valuation test in (1) missed any offices which it should have caught.

The U.K. valuation regulations, and other aspects of U.K. practice, are described briefly in Section 2. An aspect of U.K. practice which must be discussed at more length is the very wide discretion given to life office actuaries in the management of investments and bonus rates. The effect of this discretion on the modelling of U.K. business is described in Section 3. Section 4 describes the main features of the model office, and Section 5 presents some results.

## 2. SOME FEATURES OF LIFE OFFICE PRACTICE IN THE U.K.

Apart from pension funds, life offices are now the main vehicle for individual investment in equities and property in the U.K.. Other vehicles have been popular from time to time, but none has been as durable as the with-profits endowment. As a result, U.K. life offices invest their with-profits funds substantially in equities and property, at home and overseas, and the actuarial systems of measuring and distributing surplus have had to be adapted to meet the risks presented by these potentially volatile assets.

The key to the working of the U.K. system is its reliance on terminal bonuses. A terminal bonus is declared only when a claim arises, and until then it does not form any part of the guarantees.

A life office will systematically declare lower reversionary bonuses than can be supported by the emerging surplus, diverting the extra surplus into an investment reserve. The build-up of the guaranteed liability is thereby reduced, and the investment reserve is available to absorb fluctuations in the value of the assets without solvency being threatened. The investment reserve gives the office the freedom to invest in equities, and also acts as a reservoir which can be drawn upon or topped up as part of the process of smoothing policyholders' benefits. In this way, asset risks are pooled among different generations of policyholders.

Were the office to pay no more than the guaranteed benefits when a claim arose, it would normally be acting unfairly, since it would have diverted part of the surplus earned by the policy into the investment reserve. The remedy is to return the policyholder's share of the investment reserve in the form of terminal bonus. The scale upon which surplus is directed into investment reserves rather than being distributed as it emerges can be judged from the rates of terminal bonus which have been declared in recent years. After a 25 year term, the terminal bonus may exceed 150% of the sum assured and reversionary bonuses. This means that more than half of the policyholder's money ends up in the investment reserve, with the consequence that its return is not guaranteed.

U.K. life offices, and actuaries, have acquired much more discretion over the policyholder's benefits than would be possible under a system which relied mainly on reversionary bonus. Some may regret that the discipline imposed by the reversionary bonus system has been shaken off, but most U.K. life offices believe that their customers would rather have the benefits of equity investment. They are also aware of the need

to exercise their discretion with care, and recognize that a fair system of determining terminal bonuses is needed. The system which is perhaps most widely used is based on the idea of an asset share. An asset share is simply a retrospective reserve based on the experience, not unlike the accumulation of the unit fund under a unit-linked policy. The office may calculate asset shares using a smoothed version of the experience, and there are several possible treatments of expense, mortality and surrender profits but in essence the asset share is the policyholder's "fair share" of the office's assets. It provides a starting point for the consideration of terminal bonus rates.

Investment in equities has another important consequence, stemming from the way in which equity dividend yields influence the statutory minimum valuation. There is no mandatory valuation basis in the U.K., but there is a minimum basis, laid down in the Insurance Companies Regulations 1981 (2). Any basis which the actuary uses in the official returns must be at least as strong as the minimum basis.

The minimum valuation basis has some odd aspects. It is a net premium valuation, yet the assets must be taken at market value. This juxtaposition of the most active method of valuing the assets with the most passive method of valuing the liabilities has never been fully explained. It raises the disagreeable possibility that an office which is perfectly sound if its assets and liabilities are valued consistently might suffer insolvency of a purely technical nature because of a clash between the two halves of the valuation regulations.

The liability valuation is not entirely passive, however. The maximum interest rate which may be used is linked to the current yields on the assets. Broadly, up to 92.5% of the net redemption yield on gilts may be used, and up to 92.5% of the running net dividend yield on equities. The office must apportion assets to each part of the business which it wishes to value separately; for example it is common to suppose that annuity business is backed by gilts and therefore to use 92.5% of the gilt yield to value annuities. From what has been said already, it is obvious that the running net dividend yield on equities will be a most important factor in the valuation of with-profit business. No allowance can be made for potential growth of dividends or share prices, so during periods when dividend yields are low, offices will be forced to use a very low interest rate to value their with-profits business

Any allowance for future dividend growth in the valuation assumptions would have to be approached with care, but there are many actuaries who argue that no allowance at all is unreasonable. See, for example, Ross (3). Offices may be forced to move funds from equities to gilts for

reasons of solvency rather than of policy; this seems to have happened to more than one office recently. If such switches are genuinely necessary to ensure solvency, then it is right that the valuation regulations should indicate when they must take place, and it is also proper that the regulations should err on the safe side. The point which troubles critics of the statutory minimum valuation is that it has not been shown to be a satisfactory measure of solvency; one whose interventions in office management are well founded. These concerns motivate this paper.

There are two further limits on the valuation interest rate. First, the gross yield which may be assumed on investments to be made more than 3 years in the future is limited to 7.2%. Several methods of calculating net premiums allowing for this provision have been suggested (Elliot (4)). Second, the valuation interest rate may not exceed 92.5% of the yield on certain irredeemable gilts. The actuarial effects of these restrictions are similar; the values placed upon the assets and liabilities may change in different ways following a change in market yields.

### 3. ASPECTS OF MODELLING U.K. LIFE OFFICES

The chief problems facing an actuary wishing to model a U.K. life office are, first, how to model the future course of inflation, interest rates and asset prices, and second, how to allow for the responses of its managers to these events.

In this paper, I use the Wilkie investment model (5) to generate 1,000 suitable futures. The model provides inter-related values for price inflation, the equity dividend yield, the change in the level of dividends, and the yield on irredeemable gilts ("Consols"). The features which make the Wilkie model most valuable for actuarial work are that it provides a consistent model of both the major classes of asset in which life offices typically invest their funds, allowing investment strategies to be modelled; and that it models equity yields as well as prices, allowing the minimum valuation rules to be applied.

Of the many decisions facing life office managers, three may be singled out. These were also discussed by Ross (3).

(1) The investment strategy must be decided, bearing in mind the nature of the liabilities. Most U.K. offices have preferred equity-type assets to fixed interest assets, although departing from this position when short term strategy dictates. A more important reason for moving towards fixed interest investment may be the need to increase the current

yield on the fund in order to meet the minimum valuation standard. We must assume that offices will employ this tactic, however reluctantly, when they would otherwise appear to be statutorily insolvent.

(2) The bonus rates must be decided. The traditional approach of analysing surplus retrospectively, while not irrelevant, is perhaps less important than the need to guard against too great a build-up of the guarantees and any consequent constraints on the investment strategy. We might approach this by considering what margin between the asset share and the guaranteed benefits is desirable, and declare reversionary bonuses which allow this margin to be attained. On maturity, the margin will provide the terminal bonus, so the office is effectively aiming at a target terminal bonus.

(3) The premium rates must be decided. This may be the crucial decision for protection business, but there is less need for active pricing for savings business. In the U.K. it is not uncommon for with-profit premium rates to remain unchanged for long periods - sometimes decades. The terminal bonus system affects this decision too, since premium rates and reversionary bonuses have a reduced role in achieving equity between different generations of policyholders.

The discretion given to life offices to choose bonus and investment strategies has a great impact on the policyholders' reasonable expectations, and on the measurement of solvency. In recent years, the sum assured under a typical 25-year with-profit endowment has been 20% or less of the maturity value; thus the majority of the benefit is at the office's discretion. Further, most with-profits offices could show themselves to be solvent easily, by switching their assets into fixed interest securities and scrapping all reversionary and terminal bonuses. Such actions should be unacceptable, but they would not breach the minimum valuation regulations. Something stronger is needed.

The idea of "policyholders' reasonable expectations" or "PRE" is mentioned in the 1982 Act (1). The supervisor (the Secretary of State at the Department of Trade) can intervene in a company's affairs if it seems that the "reasonable expectations of policyholders" may not be met. This important phrase is not defined by the Act and has never been defined by the courts. Its meaning is clear with respect to non-profits business, less clear with respect to unit-linked business and not at all clear with respect to with-profits business. It must impinge on the way in which managements exercise their discretion, but how is an open question.

Brindley et al (6) examined PRE on behalf of the Institute of

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Actuaries and Faculty of Actuaries, and their conclusions, as far as they affect with-profits business, are summarised below :

- (1) PRE is virtually synonymous with equity, and is most commonly measured by asset share calculations.
- (2) It is not reasonable for policyholders to expect any free assets which the office may possess to be distributed.
- (3) If a major change takes place, such as change of ownership, it should not disadvantage existing policyholders, compared with the option of a closed fund.
- (4) Gradual change is acceptable in the management of with-profits business, sudden change is not.

We may ask two questions which lie at the heart of the problem.

Question 1 : What constraints are placed on investment, bonus and premium rating strategies by PRE?

Question 2 : If "solvency", in the sense of meeting guarantees, is too weak a test in a with-profits office, what else is needed?

These questions are intimately linked, since the level at which the supervisor may intervene is set at failure to meet PRE, which should always anticipate failure to meet the minimum valuation standard. In what follows, I will suggest a broad interpretation of PRE which leads to a definition of "adequacy" rather than solvency. Given assumptions about the future, it will be possible to test whether or not an office is "adequate". If we suppose that offices which are "inadequate" are those which should attract the attention of the supervisors, we will be able to compare the incidence of "inadequacies" and insolvency on the minimum valuation basis.

PRE could be interpreted to mean that the office implements strategies, of which policyholders are made reasonably aware. The strategies may be rigid ("we will always invest 80% of our fund in equities") or flexible ("we will invest our funds as we see fit"). It is reasonable for the office to do anything consistent with the strategies which its policyholders believe it to be following. For example, the office with the rigid investment rule and the office with investment freedom might both, at some time, have 80% of their funds in equities. All else being equal, they would be indistinguishable under the statutory minimum valuation test; both would be solvent, or both insolvent. However, the second office could move away from this investment position when necessary, while the first office could not. The supervisor, who might have views on

the volatility of equities, might not think that both offices were equally adequate.

The test of adequacy is to ask whether or not the office could be closed to new business and continue to implement its intended strategies while its existing business was run off. A closed fund lacks the resilience of a continuing fund, so it would be fair to modify the strategies after closure, to make them more cautious, but it would not be fair to abandon them completely; this would be a sudden change which policyholders would not reasonably expect.

Define an office to be "adequate" at a given time if, upon being closed at that time, and not thereafter departing too far from its intended strategies, it has surplus assets after the last policy has matured. If there is a deficit, the office is "inadequate" at the given time. Adequacy depends on the projected future, and on the time of closure. Given the same projection of future conditions, an office may be adequate at some times and inadequate at other times.

It follows that the most important step in constructing a model is to devise strategies for asset allocation, bonus declarations and possibly premium rating. For testing adequacy, it is also necessary to decide how these strategies may be modified after closure, while meeting PRE. These decisions are subjective, but the effect of different strategies on adequacy and solvency can be very revealing.

#### 4. DESCRIPTION OF THE MODEL OFFICE

Only the main features of the model can be described here. I will concentrate on describing the dynamic strategies.

The office writes 25-year with-profits endowments, and the starting point is the office's in-force business in 1992. Many of the assumptions prior to 1992 follow those of Ross and McWhirter (7).

Since 1950, it has increased its equity investment, so that by 1992, 80% of the fund is in equities and 20% in dated gilts, of terms roughly matching the terms of liabilities. Rates of return have followed the Barclays de Zoete Wedd indices during 1950-1992.

As most U.K. offices did during this period, it has gradually increased its reversionary bonus rates and switched from a compound to a supercompound bonus system (declaring a lower rate of bonus on sums assured and a higher rate of bonus on bonus). By 1992 its bonus rates

are 4% on sums assured and 6.5% on bonus. Terminal bonus is based upon 98% of the asset shares at maturity; the balance of 2% is an ad-hoc allowance for those years when the guaranteed benefits may exceed the asset shares of maturing policies.

New business has increased every year by 2% in real terms, and continues to do so after 1992 (when the rate of inflation is given by the Wilkie asset model).

The office values its liabilities using a basis close to the U.K. statutory minimum basis. The main omission is the restriction of the valuation rate of interest to 92.5% of the yield on consols. The test used here, therefore, is weaker than that used in practice. The liability includes the E.C. solvency margin of 4% of the reserve plus 0.3% of the death strain. At the start of 1992, the market value of the assets is 143.6% of the value of the liabilities.

The office also carries out a "mismatching" test, by verifying that the minimum reserves and solvency margin could still be provided for after a fall of 25% in the price of shares and a change of +3% or -3% in the yields on gilts. Although not laid down by law, this test has been used by the Government Actuary's Department for checking that Regulation 55 ("Nature and term of assets") is being met. The mismatching test matters here because it figures in one of the asset allocation strategies. At the start of 1992 the assets amount to 125.5% of those needed to meet the mismatching test.

Since the office bases terminal bonus on asset shares, the current level of the asset shares indicates the "true" liability; 98% of these assets are earmarked to be returned to the policyholders. At the start of 1992, the assets amount to 102.5% of the total of the asset shares. The difference between this figure and those quoted above shows the level of the investment reserve upon which the office depends for its freedom of action.

I will use two different sets of investment and bonus strategies after 1992. One assumes fixed interest investment and a minimal use of terminal bonus. This may represent practice outside the U.K.. The other assumes investment mainly in equities, tempered by the need to remain solvent on the minimum valuation basis, and higher terminal bonus. This is more representative of U.K. practice.

(Strategy 1) : All the funds are invested in dated gilts. The bonus strategy is based upon a target terminal bonus. The assets underlying the asset shares of the in-force business are valued by discounting future cashflows, using a 5-year geometric moving average of the redemption

yields. The future benefits less future premiums are valued at the same yield, and the supercompound bonus which would result in a terminal bonus of 10% of the guaranteed maturity benefits is found. The ratio between the two tiers of the supercompound bonus is held constant at its 1992 value, i.e. 4:6.5. The bonus declared is a weighted mean of the bonus rates so calculated for policies of each duration in force. The changes in the bonus rates from year to year are limited to reflect the usual practice of changing bonuses gradually; bonus rates may not increase in one year by a proportion greater than 25%, nor decrease by a proportion greater than 20%.

After closure, the bonus strategy is modified in two ways; the terminal bonus target is 20% instead of 10% of the projected guaranteed benefits at maturity, and bonus rates may fall by a proportion of up to 50% in a single year. Thus bonus declarations become more cautious, and larger bonus cuts are tolerated in the absence of marketing considerations.

(Strategy 2) : When possible, the office invests 80% of its funds in equities and 20% in dated gilts. However, if the mismatching test cannot be satisfied, the office switches out of equities and into gilts, to raise the permitted valuation interest rate and to reduce the impact of the 25% fall in share prices assumed in the mismatching test. It switches assets just up to the point when the mismatching test can be satisfied, if that is possible. If subsequent conditions permit, it will return to 80% equity investment. The bonus strategy is the same as in Strategy 1, except that equities are valued using a 5-year geometric moving average of dividend yields, and the terminal bonus target is 50% instead of 10%. After closure, the investment strategy is modified by investing a maximum of 50% of the fund in equities, and the bonus strategy is modified by doubling the terminal bonus target to 100% and allowing greater bonus cuts as in Strategy 1.

In both cases, the nature of the strategies does not change after closure, but the office implements them with more caution.

The same premium rating strategy is used throughout. The default premium rate is calculated assuming 5% interest and a 2.5% compound bonus. This is a fairly typical basis in the U.K.. Each year the office compares the 5% interest assumption with 80% of the net yields implicit in the actuarial valuation of the assets, weighted by the actuarial values of the assets. If the latter is less than 5%, new premium rates are calculated based on that yield, and the same 2.5% bonus assumption. The premium rate is changed if the change would be at least 1.00 per

mille up or down. Thus there is a minimum premium rate but no maximum.

Many simplifications have been made. In particular

- (1) Lapses and surrender profits or losses are neglected.
- (2) Mortality and cost-efficiency are deterministic rather than stochastic. However, fluctuations in mortality matter less than fluctuations of yields and assets prices for endowment business.
- (3) Maturity values are based on unsmoothed asset shares. In practice offices would smooth considerably from year to year.
- (4) Policy terms other than 25 years are not considered. If premium scales typical of those in the U.K. were used, we would expect shorter term business to present much larger financial risks.

## 5. RESULTS

This section gives a selection from the extensive results made available by this approach. Recall that the purpose is to see how effective the minimum valuation may be in detecting offices which are (or are about to become) inadequate on a run-off basis; and also how effective in not closing down offices which are adequate on a run-off basis. We also compare the effect of Strategy 1 based on gilts, and Strategy 2 based mainly on equities.

Section 5.1 describes the pattern of inadequacies. Section 5.2 describes the errors made by the U.K. minimum valuation basis in closing adequate offices or missing inadequate offices. Section 5.3 looks at the timing of the valuation in those cases in which it succeeded in closing down an inadequate office; did it act too soon or too late? Section 5.4 quantifies the degree of inadequacy, in terms of the amount of additional assets which the office would have needed in order to avoid inadequacy (in effect, a solvency margin).

For reasons of space, the question of the relative returns to policyholders under Strategy 1 and Strategy 2, although important, is not addressed here. See, however, Ross ([3]).

### 5.1. THE PATTERN OF INADEQUACIES

Under Strategy 1, 23 of the 1,000 offices (2.3%) were inadequate during at least one year. Under Strategy 2, 138 of the 1,000 offices (13.8%) were inadequate during at least one year. In both cases, some offices were inadequate for a temporary period only, so that the number of inadequate offices at any time was always less than these totals. Table 1 shows the number of inadequate offices at 5-yearly intervals.

**Table 1 – Number of inadequate offices**

Time	Strategy 1	Strategy 2
1997	0	7
2002	4	25
2007	17	49
2012	20	72
2017	22	87
2022	17	99
2027	15	102
2032	12	106

Apart from the striking difference which the investment strategy makes, the number of offices becoming inadequate for the first time rises and then falls. This is partly due to the profile of the in-force in 1992. After the high rates of return enjoyed during the previous 15 years, asset shares are very high, so the bonus algorithm tends to declare high reversionary bonuses. However, such high rates of return have quite a low probability of being sustained according to the Wilkie model, so as older policies mature and are replaced by policies whose asset shares are not so inflated, bonus rates tend to fall. At such times, the offices may suffer from the relatively high declarations which they may have made in the years following 1992; in particular, they may be more likely to be inadequate. We can see this by looking at the bonus rates during the 40 years.

Table 2 shows the lower quartiles of the rate of reversionary bonus on sums assured and the rate of terminal bonus, and in the last column, the cumulative percentage of the offices which had ever, at any time, paid no terminal bonus. (The negative terminal bonus rates are purely theoretical, to show by how much 98% of the asset share fell short of the guaranteed benefits; the minimum terminal bonus actually paid was always nil.)

**Table 2 – Reversionary and terminal bonus rates**

Strategy 1 (no equities, terminal bonus target =10%)			
Time	← 25th percentiles → Bonus on Sums Ass'd	Terminal Bonus	Cumulative percentage ever declared nil terminal bonus
1997	3.78%	81.06%	0.0%
2002	2.07%	27.25%	0.1%
2007	1.66%	-1.50%	34.0%
2012	1.99%	-7.03%	94.1%
2017	2.21%	-5.42%	98.0%
2022	2.41%	7.59%	98.1%
2027	2.33%	12.51%	98.2%
2032	2.17%	9.17%	98.2%
Strategy 2 (high equities, terminal bonus target =10%)			
Time	← 25th percentiles → Bonus on Sums Ass'd	Terminal Bonus	Cumulative percentage ever declared nil terminal bonus
1997	2.12%	96.27%	0.0%
2002	1.40%	33.83%	0.6%
2007	1.02%	2.54%	23.3%
2012	1.00%	-2.00%	44.1%
2017	1.11%	4.86%	52.4%
2022	1.22%	14.41%	60.1%
2027	1.25%	18.51%	65.6%
2032	1.19%	19.47%	71.8%

The most interesting feature is that Strategy 1 has a higher level of guarantees, higher bonuses, and a higher incidence of nil terminal bonuses than Strategy 2, yet has far fewer inadequacies.

## 5.2. THE EFFECTIVENESS OF THE U.K. STATUTORY MINIMUM VALUATION TEST

Under the U.K. statutory minimum valuation basis, the link between the value of assets and value of liabilities may be somewhat tenuous, as described in Section 2. It follows that there is no particular logic in setting the test at the “A/L < 1.0” level - that is, closing the office when assets are valued lower than liabilities. The following table shows the effectiveness of the valuation test applied at different levels. A “correct” closure is defined as an office closed by the valuation test which was inadequate at some time, though not necessarily when closed.

A "wrong" closure is any other office closed by the valuation test. A "missed" closure is an office which was inadequate at least once but which never failed the valuation test.

**Table 3 – Effectiveness of U.K. statutory minimum valuation**

Strategy 1 (no equities, terminal bonus target =10%)					
Level of test (A/L)	1.1	1.0	0.9	0.8	0.7
Inadequate offices	23	23	23	23	23
Total of closures	140	10	2	1	1
Correct closures	22	10	2	1	1
Wrong closures	118	0	0	0	0
Missed closures	1	13	21	22	22
Strategy 2 (high equities, terminal bonus target =50%)					
Level of test (A/L)	1.1	1.0	0.9	0.8	0.7
Inadequate offices	138	138	138	138	138
Total of closures	833	177	27	5	1
Correct closures	138	91	26	5	1
Wrong closures	695	86	1	0	0
Missed closures	0	47	111	133	137

There are two interesting features of this comparison. First, that the same valuation test, applied to offices whose managements use different investment strategies, has such different effects. Furthermore, this is a valuation test with dynamic features which, it might be hoped, would make it adaptable to different strategies. Second, the extreme sensitivity of the results to the level at which the test is set. Between closing offices when the A/L ratio falls below 1.1, to instead closing offices when the A/L ratio falls below 0.9, the pattern of errors made by the valuation test changes completely from missing almost no inadequacies to missing almost all inadequacies.

### 5.3. THE TIMING OF THE U.K. STATUTORY MINIMUM VALUATION

Table 3 does not show how effective the valuation test might be in closing inadequate offices in good time. Ideally, a valuation test should close an office just before it is inadequate for the first time. There is also no merit in closing an office after it has passed unnoticed through a period of inadequacy, but is now in good state again. Table 4 shows the numbers of offices closed early and late, assuming the valuation test is

applied at the "A/L < 1.0" level. "Early" closure is defined as closure before the first year in which the office was inadequate. "Late" closure is defined as closure in or after the first year in which the office was inadequate.

**Table 4 – Timing of U.K. statutory minimum valuation**

Years closed early	← No. of offices →		Years closed late	← No. of offices →	
	Strategy 1	Strategy 2		Strategy 1	Strategy 2
			0	3	11
1	3	19	1	0	3
2	2	6	2	0	4
3	1	1	3	0	6
4	0	0	4	0	3
5	0	0	5	0	7
6-10	1	4	6-10	0	9
11-20	0	2	11-20	0	12
over 20	0	3	over 20	0	1

Under Strategy 1, when the valuation test closes an office down it does so very close to the first spell of inadequacy. Its timing is therefore excellent, although it fails to spot all the inadequacies. The timing of the valuation test under Strategy 2 is much more erratic. The modal time of closure is one year before the first inadequacy, which is good, but there are more late closures than early closures, and there are numbers of closures so distant from the time of the first inadequacy that the valuation test can hardly be called successful in those cases.

It must be borne in mind that these results are incomplete, because some of those offices which were closed despite being adequate during the 40 years of investigation may have become inadequate had the investigation been extended beyond 40 years. If there were any such offices, the time to their first inadequacy has been censored, and they have been counted as "incorrect closures" rather than "early closures".

Under Strategy 1, no offices were closed by the valuation test after the last year in which they were inadequate. Under Strategy 2, one office was closed by the valuation test 1 year after the last year in which it was inadequate. Since adequacy was not tested beyond the time horizon of 40 years, it is not possible to say that this office would have remained adequate, but this result seems satisfactory.

Again, the interest lies in the very different behaviour of the same valuation test, applied to offices managed in different ways.

#### 5.4. CALCULATION OF SOLVENCY MARGINS

This section follows the Faculty of Actuaries Solvency Working Party's approach to the calculation of solvency margins (8). Given a projection of the emerging cashflows, assuming that the office is closed in a given year, the assets remaining after the last policy has matured can be discounted back to the starting point at the rates of return earned on the fund, giving a result  $X$ . The solvency margin is defined as  $-X$ . It is the answer to the question "what extra assets should be held in 1992 in order to close at a specific time after 1992 and run down successfully?" A positive solvency margin means that extra assets are needed; a negative solvency margin means that the assets are more than sufficient.

For each of the 1,000 simulated futures, 40 such solvency margins were calculated, one for each future year in which closure could be assumed to take place. For comparison, these have all been expressed as a percentage of the office's total asset shares in 1992; recall that the office's assets in 1992 amounted to 102.5% of its asset shares. Table 5 shows the means, standard deviations and upper percentiles of (a) the solvency margins on closure in 2002, 2012, 2022 and 2032; (b) the maximum solvency margin needed by each office on closure in any year 1993-2032. The latter indicates the additional assets needed by an ongoing office to ensure adequacy over a time horizon of 40 years, and though the time horizon is very long, it may perhaps be regarded as a more relevant test for this purpose than a valuation of a closed fund.

Under Strategy 2, the solvency margins are only approximate, because had the office possessed additional assets (or fewer assets) in 1992 of the amount of the solvency margin, the investment strategy during the 40 years would have been different.

It is not surprising that Strategy 2, with more volatile assets, appears to require higher solvency margins for a given (small) probability of ruin. What is more interesting is the size of the solvency margins needed under the conservative Strategy 1, if these are compared with the statutory minimum reserves. In 1992, the asset shares were approximately 147% of the statutory minimum reserve excluding the E.C. solvency margin. A solvency margin, calculated as above, of -6.9% (the smallest in the table) of the asset shares means that only 93.3% of the assets are needed to maintain adequacy, or assets of amounting to about 137% of the minimum reserve. This may be compared with the assets of 104% to 105% of the statutory minimum reserve held under current E.C.

regulations. Table 3 suggests, however, that if solvency margins much higher than the current E.C. solvency margins were held, the valuation regulations would be markedly harsher.

**Table 5 - Distribution of solvency margins expressed as percentage of asset shares in 1992**

Strategy 1 (no equities, terminal bonus target = 10%)					
Year	Mean	s.d.	90th ←	95th Percentiles	99th →
2002	-5.51	1.03	-4.54	-3.70	-2.17
2012	-4.87	2.03	-2.67	-1.54	2.96
2022	-5.75	2.27	-3.35	-1.89	2.76
2032	-6.90	2.52	-4.06	-2.60	0.88
(Max)	-4.31	1.79	-2.55	-1.28	3.32
Strategy 2 (high equities, terminal bonus target = 50%)					
Year	Mean	s.d.	90th ←	95th Percentiles	99th →
2002	-5.26	1.75	-3.44	-1.51	2.38
2012	-5.05	3.01	-1.05	1.06	5.73
2022	-5.01	3.58	-0.10	2.06	6.63
2032	-5.08	3.84	0.11	2.44	7.10
(Max)	-3.24	3.23	1.22	3.40	7.45

The solvency margins calculated as above are higher than the current E.C. margins partly because of the way in which the office was managed before 1992, and partly because the definition of adequacy includes some future bonus expectations. It does so, however, in a dynamic way which is related to the office's future style of management, rather than through a static and deterministic assumption in a valuation basis. These results suggest that if the asset shares are to figure prominently in Policyholders' Reasonable Expectations, then minimum solvency reserves, and margins based upon them, may not be the most relevant information for regulatory purposes.

## 6. SUMMARY AND CONCLUSIONS

(1) A traditional valuation basis, even one in which the parameters are related to current conditions, is not a realistic model of a volatile future.

(2) There has been a shift, in the U.K., towards retrospective methods of bonus distribution to cope with volatility of the assets. As a result, life office managements have much greater discretion than before over the level of policyholders' benefits.

(3) The concept of Policyholders' Reasonable Expectations (PRE), which appears in legislation but which is undefined, should ensure that managements exercise their discretion equitably. However, PRE is not allowed for in a strict solvency valuation.

(4) It is suggested that PRE may be modelled, at least for investigative work, by placing limits on the office's freedom to depart too radically from its intended (and, possibly, publicised) bonus and investment strategies.

(5) "Adequacy" may be defined as ability to pursue intended strategies following closure at some future time. Given a stochastic model of the assets, adequacy may be measured over a suitable time horizon in terms of the residual assets after running off the in-force business. This definition does not assume that an office will close to new business at once, so the impact of new business is taken into account.

(6) The effectiveness of a valuation test of solvency may be measured in terms of the numbers of adequate and inadequate offices closed down by the test, and by the times at which it closes down inadequate offices.

(7) A solvency test resembling the U.K. statutory minimum test, plus the E.C. solvency margin, was applied to a simple model office over a 40 year time horizon, based on 1,000 simulations of the Wilkie asset model, with the following results :

(7a) The pattern of emerging bonuses showed that the office's past history (typical of U.K. conditions before 1992) had a considerable effect (Table 2).

(7b) Both the adequacy of the office (Table 1) and the effectiveness of the valuation test (Table 3) varied greatly according to the office's strategies. Under a low equity and low terminal bonus strategy, there were few inadequacies (2.3%) and even fewer closures (1.0%); remarkably all of these were accurate and most were timely (Table 4). Under a high equity and high terminal bonus strategy, there were many more inadequacies (13.8%) and many more closures (17.7%) but both the accuracy (9.1% correct) and the timing (Table 4) were markedly worse.

(7c) The number of closures was extremely sensitive to the level at which the valuation test was assumed to be failed. So too was

the type of errors made (missing inadequate offices or closing adequate offices) (Table 3).

- (7d) The (approximate) solvency margins required in 1992 to ensure adequacy in future were higher under the high equity and high terminal bonus strategy, but not much higher. Even under the no equity and low terminal bonus strategy, the solvency margins so calculated were greatly in excess of the current E.C. solvency margins.

(8) Much more work could be done on the effect of different strategies, different asset models, different valuation tests and different types of business.

#### BIBLIOGRAPHY

- (1) INSURANCE COMPANIES ACT, H.M.S.O., 1982
- (2) THE INSURANCE COMPANIES REGULATIONS, H.M.S.O., 1981
- (3) M.D. ROSS, *Modelling a With-Profits Life Office*, Journal of the Institute of Actuaries Vol.116 1989, p.691.
- (4) S.F. ELLIOTT, *Some Aspects of the Statutory Valuation*, Journal of the Staple Inn Actuarial Society Vol.31, 1988 p.127.
- (5) A.D. WILKIE, *A Stochastic Investment Model for Actuarial Use*, Transactions of the Faculty of Actuaries Vol.39, 1984 p.341.
- (6) B. BRINDLEY, N. DUMBRECK, C. THOMSON, S. THOMPSON, *Policyholders' Reasonable Expectations*, Report of Joint Working Party issued at seminar on Current Issues in Life Assurance, Birmingham, 10 July 1990.
- (7) M.D. ROSS, M. R. MCWHIRTER, *The Impact on Solvency and Policy Results of the Valuation Regulations Restrictions on Equity Yields*, Unpublished paper, 1991.
- (8) THE FACULTY OF ACTUARIES SOLVENCY WORKING PARTY, *The Solvency of Life Assurance Companies*, Transactions of the Faculty of Actuaries Vol.39, 1984 p.251.

