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Providing Pensions for U.K. Employees with Varied Working Lives

Deborah R. Cooper*

Abstract

Several different working lives are investigated, including employees with breaks in employment, part-time employment, and temporary employment. The pensions that could be provided to the different employees by final salary, revalued career average, or money purchase pension schemes (plans) are calculated and compared. Some of the weaknesses in a final salary pension scheme (the treatment of deferred pensioners and cross subsidies between different groups of member) are considered. Possible alternative benefit structures are considered to address the problems.

Key words and phrases: *pension scheme, defined benefit, final salary, revalued career average, money purchase*

1 Introduction

Most occupational pension schemes[1] in the U.K. are defined benefit final salary schemes (GAD, 1991). Such schemes aim to provide a pension at retirement based on years of service completed with the sponsoring employer and salary received in the years immediately preceding retirement. Occupational pension schemes were introduced to meet the different needs of employers and employees: employers want

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[1]Pension schemes are called pension plans in the U.S.

a tax-efficient and paternalistic means of controlling their workforce, and employees want a secure pension in retirement that bears some relation to the income they had received while working (Hannah, 1986). In the past employees were expected to stay with one employer throughout most of their working lifetime. Consequently, pension schemes were designed with retirement in mind, often giving no entitlement to benefit on early withdrawal.

1.1 Early Withdrawal Benefits

The benefits occupational pension schemes provide for early withdrawals have improved considerably since pension schemes were introduced. In the private sector the change has arisen largely as a result of legislation. In the U.K. early withdrawals (with more than two years' qualifying service[2]) now can expect a deferred pension increasing between the time of withdrawal and retirement at 5 percent per annum or the rate of increase in the retail prices index over this period, whichever is less. The value of the early withdrawal benefit, however, is still likely to be less than the reserve that would normally be held for an equivalent member remaining in the scheme. The difference between the value of the withdrawal and staying benefits can reduce job mobility.

Because individuals who leave money purchase pension schemes receive the full value of the reserve held (ignoring any surrender penalties), money purchase pension schemes are considered to be more portable. The withdrawal benefit now provided by final salary pension schemes is a substantial improvement over what was available 20 years ago;[3] it is also better than what is available in many other countries with occupational pension schemes (FEE, 1995). Final salary pension schemes therefore have made a significant effort to rectify a major weakness in their retirement benefit provisions; at the same time they often have improved the level of other benefits that they offer.

1.2 Final Salary Pension Schemes

Many pension schemes are designed with the view of providing a target benefit which usually is expressed in terms of an individual's annual salary immediately before retirement, i.e., *final salary*. Final salary pension schemes frequently are criticized for the benefits they

[2]Qualifying service is service that contributes toward the pension that will be paid from the scheme, which may include deferred benefits.

[3]Prior to 1978 members of occupational pension schemes had no statutory right to a withdrawal benefit.

provide to certain types of employees, in particular for the cross subsidies that exist between various categories of members. (For example, see Disney, 1995.) Despite their apparent faults, however, they make an increasingly important contribution to the income of pensioners (Johnson and Stears, 1995). It is necessary to understand the significance of the problems in their design and to discover whether it is possible to amend them.

For those persons who do not have a substantial period of continuous service with one employer up to retirement, final salary pension schemes may not provide the best option. For these persons money purchase provision may offer better value for money. *Value for money*, however, is a difficult concept to judge. For example, money purchase pension schemes may offer employees a better rate of investment return than a defined benefit pension scheme (Disney, 1995), but they also carry the possibility of a worse return.

In a defined benefit pension scheme the investment risk largely is carried by the sponsoring employer. In a money purchase pension scheme, however, the plan participant takes the risk. This makes money purchase pension schemes more or less attractive according to the individual concerned's attitude toward risk. Similarly, there may be greater flexibility within a money purchase pension scheme. For example, an individual member of a money purchase pension scheme normally will be able to choose which benefits the scheme should provide and to select a retirement age. Taking advantage of the flexibility, however, is likely to make the pension scheme more expensive.

1.3 Objectives

Because of the changing nature of employment [with much new employment being of the temporary or part-time variety (CSO, 1996)], it is important to consider the impact of changing workplace dynamics on the accumulation of pension benefits. This paper examines the pension benefits provided by different types of U.K. pension schemes to persons with different working lives and compares them with the benefits provided by a final salary pension scheme. Several categories of working lifetimes are defined,[4] and the retirement benefits accrued in the different pension schemes by each category are calculated and compared under various scenarios. Though the arguments put forward in this paper are based in the situation in the U.K., the problem of providing

[4]Appendix 1 defines terms which may not transcend international boundaries.

pensions for employees with different working histories is not unique to the U.K., and the paper's conclusions can be applied more generally.

Final salary pension schemes are not risk free for all members. For early withdrawals there is the risk that they may be unable to achieve an adequate final salary pension because of the incomplete portability offered by final salary pension schemes compared to money purchase pension schemes. The paper attempts to quantify this risk.

A profound concern in performing this type of comparison is that less than 50 percent of the workforce in the U.K. has occupational pension schemes available to them (GAD, 1991). The past 15 years in the U.K. (and in many other industrialized countries) have seen a shift in the nature of employment from permanent full-time jobs to part-time and temporary work (CSO, 1992; Polivka, 1996). In the European Union there are approximately 14 million part-time and 10 million temporary workers. Table 1 shows the position of the U.K.

Those with part-time or temporary jobs are least likely to have access to occupational pension schemes, even when such pension schemes are provided by their employers (GAD, 1991; Hipple and Stewart, 1996). Even when they are available, final salary pension schemes are considered to provide poor value for money. Those companies that offer pension schemes to their full-time employees but exclude part-time or temporary employees frequently use this argument, together with concerns about administrative costs, to justify exclusion.

Table 1
Temporary and Part-Time Workers
In Great Britain (Excluding Northern Ireland)
As a Percentage of All Employees

	Temporary Work		Part-Time Work	
Males	4.0%	6.0%	4.3%	7.8%
Females	7.8%	8.0%	80.1%	85.7%
Total	6.0%	6.9%	26.3%	32.9%

Source: *Social Trends*, Volumes 17, 25, and 27.

State pension schemes have been ignored throughout the paper for the sake of simplicity.

2 Varied Working Lives

2.1 Definitions of Varied Working Lives

Defined benefit pension schemes have developed assuming that the average employee will have a long period of full-time employment with one employer until retirement. This type of employee is becoming less common in today's workforce. Other patterns of employment are increasingly likely to be the norm.

We will consider examples of different working lifetimes and will look at the benefits possible under different pension arrangements. These examples will encompass persons employed part time; persons who are made redundant and who may or may not return to work; persons who take time from paid employment to look after children or other dependents; persons who change jobs frequently; and persons who change the hours they work. The six basic categories of working lifetimes have been taken from Davies and Ward's pamphlet for the Equal Opportunities Commission (Davies and Ward, 1992). They are:

- No Breaks (that is, in paid full-time employment throughout the working life);
- Break and Part-Time (that is, having time away from full-time paid employment and then returning to part-time employment);
- Break and Full-Time (that is, having time away from full-time paid employment and then returning to full-time employment);
- Break and Mixed (that is, having time away from full-time paid employment and, having returned to employment, experiencing a mixture of part-time and full-time employment) ;
- Late Break (that is, taking a break from full-time employment relatively late in life) ;
- Late Start (that is, starting paid employment later than assumed for the other classes of employee)

These categories were designed primarily to consider the working patterns of women who took time away from paid employment to care for children (for example, break and part-time) or elderly relatives (for example, late break). With little adaptation they can be used to consider the working lifetimes of employees (both male and female) who have been made redundant and not been able to find replacement employment or who have only been able to find short-term or temporary employment. To make the calculations more comprehensive and to deal with these alternatives, some extra histories have been considered. The considerations result in a total of eleven categories. For example, variations of late break are considered, where the break is either short or long. Finally, a cyclical working pattern has been included to portray the experience of many semi-skilled and low-skilled workers whose opportunities for employment tend to vary according to the economic cycle.

Additional calculations have been performed for employees who change jobs regularly throughout their working lifetimes, but are always assumed to be in employment. The labor markets in the U.K. and the U.S. appear to be characterized by high turnover at young ages and increasing tenure as employees age. Some figures are given in Tables 2 and 3. In the U.K. the average tenure has not changed significantly over the past ten years (CSO, 1997); in the U.S. there is some debate about whether average job tenures are falling (Farber, 1995; Swinnerton and Wial, 1995). It is estimated that the probability of an employee in the U.S. remaining in paid employment for longer that four years is approximately 50 percent (Swinnerton and Wial, 1995).

Table 2
Average Job Tenure in the U.K.

	1986	1996
Males	9.4 years	8.9 years
Females	6.5 years	7.1 years

Table 3
Median Job Tenure in U.S.

Age	1993
25-34	3.2 years
35-44	5.8 years
45-54	9.5 years
55-64	12.4 years

Periods of job security increase with age, which is to the relative advantage of a final salary scheme because the value of these schemes is weighted toward employment close to retirement age. In contrast, the value of money purchase schemes is weighted toward employment at younger ages. Full details of the assumptions made about the different categories of employment are given in Appendix 2.

2.2 Measuring Benefits for Different Categories of Employment

A difficulty in dealing with diverse groups of persons is finding a standard of comparison for the benefits provided by the different pension schemes that is appropriate for all concerned. There are several possible choices of benchmark, each one with certain advantages and disadvantages. Two used in this paper are described below.

2.2.1 Total Service Pension

One measure to use as a benchmark is the pension that could be provided from a final salary pension scheme, had all of the employee's service been completed in consecutive years, in a pension scheme that does not distinguish part-time and full-time service. This is called the *total service pension.*

The total service pension is, arguably, the best pension a final salary pension scheme can be expected to provide: it ignores breaks in service as well as changes in type of employment. It does not compensate part-time employees and those taking breaks from employment for the lower rates of salary growth assumed (see Section 4.3.3) and the shorter time spent in paid employment; as expected, these employees do not have a direct opportunity to recoup the earnings they have lost.

2.2.2 Final Salary

For final salary pension schemes, there is a choice of which final salary to use.[5] If we choose the final basic salary of the individual concerned, it becomes difficult to make comparisons across the board. There is also an additional problem: for some groups final salary may have been earned several years prior to retirement, while for others it may not be an annual rate. On the other hand, if a comparison is made

[5] Common definitions of final salary in the U.K. include basic salary earned in the 12 months preceding retirement; the average annual rate of basic salary earned in the 36 months preceding retirement; and the annual rate of salary at retirement, including the average of 'fluctuating emoluments' over the preceding 36 months (GAD, 1991)

with the employee's last earnings before retirement, we can get some idea how well different pension schemes provide replacement income for its members.

The results under final salary are influenced heavily by the total amount of service; that is, the longer the employee has worked, the better the pension scheme appears. With few exceptions the "full-time and bonus" category of employee appears to do best using final salary as a measure of performance, and the "break and mixed" category employees appear to do worst.

Other measures that do not depend on a particular working history demonstrate the force of two commonplace observations: first, the longer the period over which the employee contributes to a money purchase pension scheme, the larger the expected benefit; second, making provision in money purchase pension schemes early in the employee's working lifetime is important. These observations both provide arguments in favor of a state pension, such as the basic state pension in the U.K., which underpins other layers of benefit.[6]

3 The Different Pension Schemes

The different pension schemes considered are deliberately simple. For occupational pension schemes to succeed they must be attractive to both employers and employees. A pension scheme with a relatively simple benefit design will be straightforward to manage and easy to understand and so will be desired by both groups.

3.1 Final Salary Pension Scheme

The final salary pension scheme used provides a pension of 1/60th of final salary for each year of service completed. This is the most common accrual rate among contracted out[7] pension schemes in the U.K. private sector (GAD, 1991); public sector schemes, which provide an accrual rate of 1/80th, provide a lump sum in addition to the pension. For those employees working part time, the pension scheme provides a pension based on the annual rate of salary, with total service aggregated. Someone retiring with a total of n years of service, with an average of h_i ($h_i \leq 40$) hours per week during year i ($i = 1, 2, \ldots, n$), where 40

[6] A comparison with the basic state pension is given in Appendix 3.

[7] That is, contracted out of the state earnings related pension scheme (Appendix 1).

hours is considered full time, would receive an annual pension of:

$$\text{Annual Pension} = \frac{S}{60}\sum_{i=1}^{n}\frac{h_i}{40}$$

where S is the annualized rate of salary received in the 12 months preceding retirement. Thus, someone retiring with a total of 30 years at 20 hours per week part time would receive an annual pension of:

$$\text{Annual Pension} = \frac{S}{60} \times 30 \times \frac{20}{40} = \frac{S}{4}.$$

Those pension scheme members who work different part-time hours at different points in their career will have the appropriate proportion of each year of service used in the calculation.

A further consideration is how members of pension schemes are treated when they move from one category of employment to another. For example, if an employee moves from full-time to part-time status, some pension schemes make the full-time entitlement paid-up[8] and start accrual in the pension scheme afresh as a part-time employee. This may be the case if a separate pension scheme is operated for part-time employees. Other pension schemes may consider the two periods continuous service. Where relevant, results are presented on both bases.

Finally, we consider the position of pension schemes that allow employees to take extended breaks and return to service, counting the periods of employment at either side of the break as one consecutive period for accrual purposes. Several pension schemes, particularly in the public sector, allow past members who rejoin the pension scheme after a break from employment to have service counted as continuous on payment of a small contribution, usually related to pay at previous withdrawal. In effect, this is the total service pension.

3.2 Revalued Career Average Pension Scheme

The revalued career average pension scheme provides a pension of 1/60th of the revalued career average salary for each year of service. Calculations have been made assuming a rate of revaluation in line with price inflation as well as one in line with growth in earnings. The former rate of revaluation will make the pension scheme perform less well

[8]That is, the accrued pension is frozen, receiving only statutory revaluation rather than increasing in line with salaries.

than a final salary pension scheme for a full-time employee. Also, if revaluation is in line with increases in salaries, then, the final salary pension scheme and the revalued career average pension schemes are identical for full-time employees.

In this revalued career average pension scheme there is no difficulty with the treatment of early withdrawals, because the same rate of revaluation is applied to deferred benefits. The different categories of members do not have to be considered separately. The state earnings-related pension scheme operates in this way.

The pension for part-time employees is calculated similarly to the final salary pension scheme.

3.3 Money Purchase Pension Scheme

Two money purchase pension schemes are included in the analysis:

- Employees contribute 5 percent of their salaries throughout their working lifetimes.
- When employees are in full-time paid employment they contribute the maximum amount to the pension scheme, which, for simplicity, is assumed to be 17.5 percent of salary at all ages. For part-time employees, however, they contribute only 5 percent of salary at all ages.

The first arrangement was selected because, on average, the contribution to occupational pension schemes made by members is about 5 percent of their salaries (GAD, 1991). Few employers have chosen to make contributions to the private money purchase pension schemes (or personal pension plans) of their employees. Consequently, it seems reasonable to calculate the amount of pension that could be provided with the contributions saved by opting out of an occupational pension scheme. For simplicity the calculations do not allow explicitly for expenses. Implicit allowances are made instead.

There are several reasons for the two tiers of contribution in the second plan. First, those with low pay have less opportunity to save, so it seems unreasonable to suppose those employees would continue to invest the same proportion of their salaries in a pension scheme if they moved from full-time to part-time employment (Table 4). Second, if an employer were to contribute to a money purchase pension scheme, it seems most likely that they would do so only for full-time employees.[9]

[9]That a low level of contribution will lead to a low level of benefit is not a failure of money purchase schemes. The problems of money purchase schemes that this paper considers are those of volatility and high cost.

Finally, most individual money purchase pension schemes have a fixed charge deducted from each contribution, so the value to the plan participant of the contribution made reduces with the amount. Thus, the lower tier acts partly as an implicit allowance for per policy fees.

Table 4
Distribution of U.K. Annual Household Expenditure On Personal Pensions by Gross Income

	Quintiles				
	5th	4th	3rd	2nd	1st (Top)
Lowest Bound		£117	£223	£367	£556
Avg Wkly Exp	£0.25	£0.84	£2.68	£4.54	£14.92

Source: *Family Spending*, CSO,1995; Avg Wkly Exp = Average Weekly Expenditure.

In addition we consider what level of contribution would be required by a money purchase scheme (given the assumptions made) in order to reproduce the retirement benefit provided by the final salary scheme.

4 Assumptions

The calculations have been performed for an employee starting employment on £16,000. This is close to the average wage for male employees in 1995. In most cases the absolute figure does not matter, as the comparison is done using proportions and percentages. In addition, it is assumed that the basic state pension will continue to increase in line with the Retail Prices Index, as it has since 1979. Other assumptions are specified below.

4.1 Service

The calculations assume a full working lifetime consists of 40 hours paid employment per week from age 20 to 60; the maximum pension in the final salary pension scheme is 2/3rds of salary. Pension payments to retirees start at the normal pensionable age, which is age 60. It could be argued that 65 is a more realistic retirement age because most pension schemes have a normal pension age of 65 for men, and the trend seems to be to equalize pension ages for men and women at age 65 (GAD, 1991). The average age at which pension payments commence, as reported in the Government Actuary's Survey, is about age 61, however. Employees often take early retirement, whether voluntarily or not.

An older normal retirement age would enhance the apparent performance of money purchase pension schemes because of the effect of compound interest and mortality. The calculations assume that employees start contributing to money purchase pension schemes at age 20, however, and the early commencement age partially offsets the effect of the early retirement age, so this apparent unfairness has largely been ignored.

Part-time employees have been included at two levels of service. Over 5 million persons work part time in the U.K., of whom about 80 percent are women. Significant proportions of male part-time employees are those already in retirement from their main occupation (GAD, 1991), and it is difficult to make allowance for this group. Until women have children, those in employment are largely in full-time work (Martin and Roberts, 1984). Of these, 50 percent return to work within nine months of having a baby; about 30 percent return to full-time employment (McRae and Daniel, 1991). Many of the remainder return to part-time work once their children are in school. We can assume that, to some extent, women choose to work part-time because of child care responsibilities.

Part-time employees are assumed to work for either 40 percent (that is, 16 hours) or 75 percent (that is, 30 hours) of a full working week. In addition, the service histories of some part-time employees used in the analysis assume that women are able to choose to work longer hours as their children grow older. There is some evidence to support this pattern (EOCNI, 1993). For example, the "break-and-mixed" category assumes the employee starts by working full-time; stops paid employment to care for young children; returns to paid part-time employment of 16 hours per week; has a further break; and then works until retirement at 30 hours per week.

4.2 Mortality

Except in the calculation of the annuity used for converting the money purchase fund into a pension, mortality is ignored throughout the analysis. This has different implications for the defined benefit pension schemes and for the money purchase pension scheme, although the effect on death benefits is the same. By ignoring mortality the analysis assumes that the death benefits provided are equal in value to the reserve or actuarial liability.

4.2.1 Money Purchase Pension Scheme

By ignoring mortality when accumulating the contributions paid to the money purchase pension scheme the analysis assumes that, on death before retirement, the value of the fund is applied to purchase benefits for any dependent survivor or is paid to the estate of the plan participant.

We assume that the full accumulated fund is used to purchase retirement pension. Death benefits in addition to those provided by the accumulated fund must be purchased with additional contributions. In general this means that unless an additional contribution is paid, the provision for dependents on early death will be inadequate.

4.2.2 Defined Benefit Pension Schemes

The average defined benefit pension scheme provides a lump sum death benefit of nearly three times pensionable salary together with a spouse's pension calculated allowing for some enhancement of service (GAD, 1991). In the private sector this is usually up to full potential service. Except for older employees, the value of these benefits is likely to be greater than the reserve required to fund the retirement benefit.

Ignoring mortality can result in an underestimate of the cost of a money purchase pension scheme and of the value of the benefits from a defined benefit pension scheme. Rather than adjust the calculations to allow for this difference between the two types of pension scheme, we will discuss it in the results section.

The other decrements affecting pension schemes are withdrawal and ill health retirement. These are considered in later sections of this paper.

4.3 Economic Assumptions

Interest rate assumptions are needed to project the accumulated value of the money purchase fund; as a yardstick to measure salary growth and inflation; and to cost the annuity at retirement. These rates are difficult to predict, and the results are sensitive to the assumptions chosen. For this reason, a sensitivity analysis is included as part of the results. The interest rates are assumed to be constant over time as the comparison of results is made only at the end of one period of time. The rates reflect an average of the experience over the period of a person's working lifetime. Each assumption is briefly discussed below.

4.3.1 Inflation

The inflation assumption is used to increase benefits while in deferment and as a basis from which to estimate real rates of salary growth and real interest rates.

It is assumed that the Retail Prices Index will increase 4 percent per annum. This is slightly higher than the current U.K. government's self-imposed maximum inflation target, but lower than the average over the past 20 years.

If inflation is higher than that assumed in the projection, then nominal investment return will improve if the real rate of investment return remains the same. Similarly, if real rates of salary growth remain the same, salaries paid will be higher. Thus, money purchase pension schemes will perform relatively better than otherwise, having higher income from investments and contributions; defined benefit pension schemes will award pensions based on a higher salary figure. The benefit design of the pension schemes will determine which arrangement gives the better value for money.

4.3.2 Real Interest Rates

The assumption for real interest rates is combined with the inflation assumption to accumulate the contributions made to the money purchase fund. A real rate of return of 4 percent per annum has been assumed. This rate reflects what is currently available on longer term index-linked gilts[10] (roughly 3.5 percent on gilts maturing in 2030, as of March 1996) which gives a conservative estimate of the likely investment performance of a fund (Thornton and Wilson, 1992). This approach can be justified for two reasons: first, the rate used is assumed to be net of expenses (to allow implicitly for expenses), and second, most persons included in the categories of employees in this survey will be on fairly low and insecure incomes and probably would want a personal pension plan giving a reasonably secure investment return.

In the U.K. it seems that a small majority of investors in personal pension plans prefer more cautious, with profit, policies to unit-linked policies (ABI, 1996). Some figures are given in Table 5. Some of the linked policies are linked to with-profit or fixed interest unitized funds.

Low interest rates penalize the money purchase pension scheme both by depressing the assumed performance of the pension scheme and by making the annuity more expensive. In order to explore a plau-

[10] *Gilts* is the name given to securities issued by the United Kingdom government.

Table 5
Personal Pensions: New Business
(In £1,000,000s)

	1991	1993	1995
Number of New Policies	2595	2030	1199
Net Premium Income:			
Single Premium-Linked	1719	2393	1675
Single Premium-Non-Linked	2254	2626	1628
Yearly Premium-Linked	600	580	536
Yearly Premium-Non-Linked	519	517	411
DSS* Rebate-Linked	369	207	92
DSS* Rebate-Non-Linked	226	139	53
Total	5688	6462	4395

*The *DSS rebate* is the contribution paid by the Department of Social Security to appropriate personal pension schemes (Appendix 1).

sible range of results, calculations also have been performed assuming real interest rates of 5 percent.

4.3.3 Real Salary Growth

The assumption for real salary growth also can be considered to be low: a real rate of salary growth of 1 percent per annum has been assumed. While average salaries increased faster than this over the 1980s, there is no certainty that they will continue to do so. At present, only senior executive salaries are increasing faster than the rate of inflation, and these employees are unlikely to have part-time contracts. Calculations also are performed assuming 2 percent real growth. This is to be consistent with the 5 percent real growth tested above, as a 4 percent gap between real interest rates and real salary growth may be too large.

The analysis assumes that salaries only increase faster than inflation when an employee is in full-time work. At ages when a working profile imposes part-time work, salaries are increased in line with inflation only. Similarly, after a period of unemployment, the salary at which the employee is assumed to reenter employment will be the salary at the previous date of exit increased in line with inflation only. There is evidence to support these assumptions, as well as the belief that part-time employees are usually paid less than the equivalent full-time employees. This can be shown by comparing hourly rates and by considering measures of productivity (Kremer and Montgomery, 1993). No attempt has been made to allow for different relative levels of pay in the analysis.

A consequence of the assumption that real salary growth only occurs during periods of full-time employment is that those taking breaks from employment will return to work at a relatively lower level of pay than their contemporaries who remained in full-time work.

Just as assuming large real investment returns will result in a better performance for money purchase pension schemes, larger real salary growth will mean defined benefit pension schemes pay a larger pension. In the case of high real investment returns, however, the apparent advantage accrues only to the money purchase pension scheme. In the case of high salary growth, there is an advantage to both types of pension schemes: the money purchase pension scheme benefits from larger contributions. In practice, if investment returns are better than expected over the long term, members of defined benefit pension schemes can expect to receive some advantage. In the past, surplus in occupational pension schemes has been used to make (discretionary) increases to pensions in payment and, less frequently, other benefit improvements.

4.3.4 The Annuity

An interest rate consistent with the inflation and real interest rate assumptions above has been used to calculate the annuity.

The comparison between the money purchase and defined benefit pension schemes has been made assuming that a pension increasing at 4 percent per annum is purchased (that is, in line with limited price increases, given the inflation assumption). According to the Government Actuary's survey (GAD, 1991), occupational pension schemes in the private sector guarantee, on average, increases of about 2 percent per annum. In 1986 they granted increases of 3.5 percent per annum, on average. Public sector pension schemes guarantee increases in line with inflation. Although limited price increases are only a statutory requirement on pensions accrued after April 1997, it seems reasonable to include the cost of increases to make the comparisons consistent.

Allowing for increases to pensions in payment will make money purchase pension schemes appear to perform less well than defined pension schemes.

5 The Results

We begin by considering how well final salary pension schemes perform compared to the total service pension, and by presenting the estimated additional cost required to fund the difference between the final salary pension and the total service pension for each category of member. The benefits provided by a revalued career average pension scheme also are considered. The pensions provided by money purchase pension schemes are compared with the total service pension, and the vulnerability of the plan participant to worse than expected investment and salary experience is investigated.

A comparison of benefits with the basic state pension and with average earnings is presented in Appendix 3 to reinforce some of the results.

5.1 Final Salary Defined Benefit Pension Scheme

Final salary pension schemes are considered to fall short of members' expectations on two counts: (i) because of their treatment of early withdrawals, and (ii) because of cross subsidies between members. We shall first consider early withdrawals.

5.1.1 Deferred Pensioner

The benefit paid to early withdrawals usually has a smaller value than the reserve required for employees who remain with an employer. Deferred benefits normally are increased at rates less than the rate of increase in earnings. The results presented in Table 6 show, however, that (given the set of assumptions used for the calculations) the differences are not exceptional. The calculation of the total service pension effectively assumes that all service is completed contiguously and in the years immediately preceding retirement. This is used as a proxy for a final salary pension scheme that increases deferred pensions in line with earnings. Table A4 in Appendix 2 gives the amount of the total service pension accrued by each category of employee relative to the full-time pension.

We can assess how poorly deferred employees do under the present arrangements by comparing the total service pension with the pension calculated assuming movements between part-time and full-time service do not interrupt pension accrual (called "part/full time continuous"). The difference in the two pensions arises because of the difference between inflation and salary growth. We have calculations assuming a 1 percent and 2 percent real salary growth.

Table 6
Pension Allowing for Periods of Deferment As a Percentage of Total Service Pension

	Real Salary Growth	
	1% Growth	2% Growth
Full-Time	100.0%	100.0%
Break and Mixed	97.3%	94.7%
Late Break	92.5%	86.0%
Break and Part-Time	99.6%	99.2%
Early Break and Full-Time	96.3%	93.5%
Late Break and Full-Time	94.0%	89.1%
Short Break and Full-Time	93.7%	88.8%
Long Break and Full-Time	94.4%	89.7%
Late Start	94.0%	89.1%
Full-Time & Bonus	100.0%	100.0%
Cyclical	93.0%	86.7%

As expected, deferred pensioners do less well when the annual real salary growth rate is large. In addition, they would do less well under current legislation if inflation were high over the deferred period, as the statutory increase in deferment is capped at 5 percent per annum.

Categories (other than the "full-time" and "full-time & bonus" categories) that appear to do relatively well under the present arrangements are those with the smallest proportion of full-time employment. Their earnings do not attract real salary increases; therefore, the difference between deferred benefits and ongoing benefits does not significantly reduce their expectations.

Table 7 gives the additional contributions (paid over a working lifetime) required as a percentage of annual salary to make up the shortfall in pension identified in Table 6.

We also can consider the position of employees who are in full-time paid employment throughout their career, but who change jobs frequently. Some employees choose to change jobs frequently, but employees increasingly are being offered temporary contracts—these employees have no choice about their job mobility. Between 1994 and 1995 the number of employees with temporary contracts increased 10

Table 7
Additional Contribution Required
To Fund the Total Service Pension

	*4/1	5/1	4/2	5/2
Full-Time	0.0%	0.0%	0.0%	0.0%
Break and Mixed	0.2%	0.1%	0.4%	0.3%
Late Break	0.6%	0.4%	1.2%	0.9%
Break and Part-Time	0.0%	0.0%	0.1%	0.0%
Early Break and Full-Time	0.4%	0.3%	0.8%	0.6%
Late Break and Full-Time	0.6%	0.4%	1.2%	0.9%
Short Break and Full-Time	0.6%	0.4%	1.3%	1.0%
Long Break and Full-Time	0.5%	0.4%	1.0%	0.8%
Late Start	0.6%	0.5%	1.3%	1.0%
Full-Time & Bonus	0.0%	0.0%	0.0%	0.0%
Cyclical	0.5%	0.4%	1.1%	0.8%

*4/1, for example, refers to 4 percent real investment growth and 1 percent real salary growth.

percent to 1.5 million. The majority of persons in these jobs would have chosen permanent employment had it been available (CSO, 1996). With each withdrawal, the contribution to pension made by a period of service is effectively downgraded in a typical final salary pension scheme. The results for employees who change jobs frequently are presented in Table 8, and the extra contribution required to meet the shortfall is shown in Table 9.

Table 8
Pension Allowing for Periods of Deferment
As a Percentage of Total Service Pension

	Real Salary Growth	
	1% Growth	2% Growth
Withdraw Every Five Years	84.6%	72.5%
Withdraw Every Ten Years	86.7%	76.1%
Withdraw After Five Years Only	96.3%	93.8%

Tables 8 and 9 show that those employees who change paid employment frequently are disadvantaged in a final salary pension scheme if

Table 9
Additional Contribution Required
To Fund the Total Service Pension

	4/1	5/1	4/2	5/2
Withdraw Every Five Years	1.5%	1.1%	3.2%	2.4%
Withdraw Every Ten Years	1.3%	0.9%	2.8%	2.1%
Withdraw After Five Years Only	0.3%	0.3%	0.7%	0.6%

deferred pensions are increased in line with inflation only. The impact of real salary increases has a more significant effect than the frequency of job change, however, as shown in Table 10.

In certain circumstances, it is possible to redress the balance between early withdrawals and those who remain with an employer. For an employer, the motivation to do so could depend on the reason for leaving employment. Employees leave their jobs for several reasons, e.g.:

- They choose to go to another employer;
- They are made redundant or their contract ends;
- They need time away from employment, for example, for child care and would like longer than their statutory allowance.

Those employers who give employees the right to an extended break without jeopardizing their future employment may have addressed the grounds for complaint of one of the above groups. For example, the employee will be able to count the two periods of service as though they were continuous for the calculation of benefit and frequently will be allowed, for a nominal contribution, to have the break included as part of their pensionable service. Employees seem to support this arrangement, even when they are unlikely to profit directly from it (Gough, 1997).

Similarly, those employees who are made redundant are already entitled to lump sum payments, as established in employment law. Part of the redundancy payment could be directed toward a pension scheme. In addition, if it can be agreed that at least part of the employer's contribution to an occupational pension scheme is in respect of deferred pay, the redundancy payment could be increased to allow for this, and that part of the lump sum could be compulsorily invested in a pension arrangement.

Table 10
Portion of Total Service Pensions Earned By An Employee Who Regularly Changes Employment

Real Salary	Length of Consecutive Employments (in Years)				
Growth	1	2	5	10	20
1%	82.9%	83.0%	84.6%	86.7%	91.0%
2%	69.8%	70.4%	72.5%	76.1%	83.6%

The level of replacement income provided by the different pension schemes for some categories of employee is shown in Table 11. The results suggest that if an employee in a final salary pension scheme must take a break from paid employment, it should be taken early rather than late. The deferred pension will then be in respect of a shorter period of service. This differs from the position of an employee in a money purchase pension scheme, where it is better to take a late break. With the assumption of 1 percent real salary growth, the employee taking an early break loses about 2 percent of the value of the total service pension, and the employee taking a late break loses 3 percent. If there is 2 percent real salary growth, the loss is in the order of 3 percent and 6 percent, respectively. The length of the break in employment also affects the level of replacement income available from a final salary pension scheme, although not substantially. The total service pension is the same percentage of final salary, regardless of the assumption for salary growth.

Table 11
Pensions as a Percentage of Final Salary

		With Deferred Pension	
	Total Service Pensions	1% Real Salary Growth	2% Real Salary Growth
Early Break	50.0%	48.2%	46.7%
Late Break	50.0%	47.0%	44.5%
Short Break	58.3%	54.7%	51.8%
Long Break	41.7%	39.4%	37.4%

Now we turn to the other cross subsidies. Cross subsidies exist in any insurance arrangement, such as a defined benefit retirement pension scheme. An obvious subsidy is from those who die just before reaching retirement to those who survive well beyond pension age. Other subsidies include:

- From employees with no dependents to those with dependents;
- From those who do not have much salary growth, particularly toward the end of their career, to those whose salary grows faster than the average, particularly close to retirement (Wilkie, 1985).

The former problem is discussed in Section 6. The latter issue can be considered by looking at the results for the "full-time-and-bonus" employee.

This paper does not attempt to address the issue of cross subsidies. We just consider the extent of their presence in the different schemes under consideration.

5.1.2 Salary Growth

If we consider "full-time-and-bonus" employees, we can investigate the different benefits available to employees whose salary falls when approaching retirement. It is assumed that this category of employee receives a 20 percent bonus on salary up to age 45 due, for example, to overtime payments. Thereafter, the bonus stops and the employee receives basic salary only. Consequently, the employee's pension will be calculated using the same final salary as other full-time employees, including those who have no history of overtime. The calculation of the final salary pension ignores the bonus earned when the employee was younger. Because of this problem with the formula, many final salary pension schemes ignore so-called fluctuating emoluments (compensation) in the calculation of pensionable salary[11] (GAD, 1991). The employee is able to make other pension provisions, such as additional voluntary contributions. If defined benefit pensions are intended to maintain the level of income just before retirement, this arrangement seems reasonable. A sizable proportion of pension schemes include all pay in the calculation of pensionable salary, however, so it is worth considering the alternatives. The results for the "full-time-and-bonus" category are given in Table 12.

The relative values of the benefits depend heavily on the rate of revaluation assumed to be applied in the revalued career average pension scheme. Even though the employee was assumed to earn 120 percent of the basic salary for 25 years, revaluation in line with inflation is

[11]The salary included in the calculation of pension.

Table 12
Revalued Career Average Pension Received by Full-Time And Bonus Employees as a Proportion of Final Salary

	Revalued in Line With:	
	Inflation	Salaries
1% Real Salary Growth	61.8%	75.0%
2% Real Salary Growth	51.4%	75.0%

Note: Total Service Pension is 66.7% of final salary.

unable to match the benefit from the final salary pension scheme. The position is improved, however, when the pension scheme revalues pensionable salaries in line with salary growth. The employee effectively earns 12.5 percent more pay over a working lifetime than an employee who receives no bonus, and this is reflected in the pension.

Thus, employees with fluctuating emoluments that decrease in size toward retirement may receive a higher pension from a revalued career average pension scheme. It follows that a final salary pension scheme that includes such employees, and incorporates their total pay in the definition of pensionable salary, will incorporate some cross subsidy from these employees to those without fluctuating emoluments. Using similar arguments, it also follows that there is a cross subsidy from those with lower salary growth than the average to those with higher salary growth.

We shall now consider the revalued career average pensions of the other categories of employee.

5.2 Revalued Career Average Pension Schemes

The employees who do relatively well in a revalued career average pension scheme, even when the revaluation is only in line with price inflation, are those who work part time. Because it is assumed that the salaries of part-time employees do not increase any faster than price inflation, this should not be surprising. Even so, the pension scheme is unable to provide a pension as large as the final salary pension scheme. If the rate of revaluation is increased to be in line with salary growth, the position alters. All categories of employee do at least as well (full-time) or better (all other categories) in the revalued career average pension scheme as they would do in a final salary pension scheme. These results are shown in Table 13, assuming 1 percent real salary growth, and they should be compared with those in Table 6.

The revalued career average pension, with revaluation in line with earnings, restores the link to actual years worked that is partly lost in the final salary scheme for those employees with breaks in their working history. As a result, we see that a revalued career average pension scheme can be used to remove the cross subsidy between stayers and withdrawals, as well as between low and high earners. The pension design depends not only on service, but also on how significant a year of service is in terms of income to the employee.

Table 13
Revalued Career Average Pension
As Percentage of Total Service Pension

	Revalued in Line With:	
	Inflation	Salaries
Full-Time	82.9%	100.0%
Break and Mixed	94.1%	118.2%
Late Break	89.0%	111.6%
Break and Part-Time	97.9%	119.9%
Early Break and Full-Time	86.9%	101.7%
Late Break and Full-Time	86.9%	103.5%
Short Break and Full-Time	84.9%	101.5%
Long Break and Full-Time	89.0%	106.4%
Late Start	86.9%	101.7%
Full-Time & Bonus	92.5%	112.5%
Cyclical	91.3%	113.4%

There are difficulties in adopting a sensible and fair level of revaluation. The data in Table 12 show the relative penalties to one category of employee where revaluation is in line with inflation and salaries grow faster than inflation. In addition, if a pension is viewed as deferred compensation, then its value should reflect real levels of salaries when it vests, otherwise part of the salary in each year of work prior to retirement has been devalued. Because a single, average rate of revaluation must be applied to all members in a pension scheme, those employees whose salaries increase faster than the average may feel that they are subsidizing those with flatter salary progression. If the annual rate of revaluation is appropriate for the industry in which the company operates or even linked to actual rates of salary growth within the company, the effect of the revaluation will be to maintain the real value of a year of work. The extent of the cross subsidy will be reduced significantly.

5.3 Money Purchase Pension Schemes

The calculations show that, if the pension purchased under a money purchase scheme is compared with the total service pension, those employees who have breaks in their employment appear to do better than the standard "full-time" employee from money purchase pension schemes (Table 14). For example, assuming a contribution of 5 percent salary to a money purchase pension scheme and 5 percent real investment growth and 2 percent real salary growth, the "break-and-part-time" employee receives 89.4 percent of the total service pension, whereas the "full-time" employee receives a pension of only 56.3 percent. The employees' career profiles assume they all begin their paid employment with a period of full-time service, and the effect of these early contributions is most significant: "break-and-part-time" employees do best because the largest proportion of their contribution is made in the early years.

When replacement income is considered, the position is reversed; full-time employees appear to do better. This apparent contradiction arises because the total service pension is based on the proportion of time worked, whereas the comparison for replacement income is based on final annualized salary. That is, it will be relatively larger than the total service pension for those whose paid employment included part-time work.

The contributions required throughout a working lifetime, as a constant proportion of salary, to reproduce the total service pension in retirement (given the assumptions of the paper) are presented in Table 14. The pension being funded by each category of employee is the same amount in the columns 4/1 and 5/1 and a higher amount in columns 4/2 and 5/2. The different assumptions for real salary growth do not have a significant effect on the contribution required from those employees with part-time service, as they only experience real salary growth for a small proportion of their careers. There is a notable difference for those employees working full time.

We can use Table 14 to form an idea of how vulnerable money purchase pension schemes are to changes in experience. For example, if a full-time employee chose to contribute 8.9 percent of salary to a pension scheme (assuming 5 percent real interest and 2 percent real salary growth) and the experience of the pension scheme turned out to aver-

Table 14
Contributions to a Money Purchase Pension Scheme Required to Fund a Total Service Pension

	4/1	5/1	4/2	5/2
Full-Time	9.4%	7.0%	11.7%	8.9%
Break and Mixed	7.0%	5.1%	7.6%	5.5%
Late Break	7.6%	5.5%	8.7%	6.4%
Break and Part-Time	7.4%	5.4%	7.6%	5.6%
Early Break and Full-Time	10.0%	7.6%	11.8%	9.1%
Late Break and Full-Time	9.2%	6.9%	11.0%	8.3%
Short Break and Full-Time	7.4%	7.1%	11.5%	8.7%
Long Break and Full-Time	8.7%	6.4%	10.1%	7.5%
Late Start	10.1%	7.8%	12.0%	9.3%
Full-Time & Bonus	8.2%	6.1%	10.3%	7.7%
Cyclical	7.6%	5.6%	8.5%	6.2%

age 4 percent real interest and 1 percent real salary growth, the retirement pension provided by the pension scheme would be 5.5 percent less than expected. The "break-and-part-time" employee contributing 5.6 percent would be 24.3 percent lower. These calculations are summarized in Table 15.

The data in Table 15 give an indication of the downside risk of using money purchase arrangement to provide for retirement income. In the U.K. for money purchase pension schemes operated by an employer, there is an obligation for an actuary to recommend a level of contribution for a given target benefit. For individual money purchase pension schemes (personal pension plans) a salesperson normally would provide estimates of the projected level of benefit, given certain levels of contribution. The bases that can be used for the projection are prescribed. Currently the mid-range basis would permit 9 percent interest and 3 percent inflation, which is not too dissimilar from the 5/2 assumption (it is more optimistic).

If the money purchase pension scheme earns interest at 8 percent per annum rather than 9 percent, then its value, accumulated to retirement, will be less than estimated at the start. Similarly, if the employee experiences real salary growth of 1 percent per annum rather than 2 percent, then the fund will receive less income from contributions and will be smaller than originally estimated. Thus, the pension it provides will be smaller. In addition, if interest rates at retirement are lower than anticipated, the cost of the retirement annuity will be more expensive, reducing the pension even further. In a money purchase scheme all these risks are borne by the individual plan participant.

Table 15
Effect of Wrong Contribution Level

	Percentage of Total Service Pension*
Full-Time	94.5%
Break and Mixed	77.5%
Late Break	84.0%
Break and Part-Time	75.8%
Early Break and Full-Time	91.5%
Late Break and Full-Time	89.7%
Short Break and Full-Time	92.5%
Long Break and Full-Time	86.1%
Late Start	92.1%
Full-Time & Bonus	94.6%
Cyclical	82.0%

*Assumes that the contribution required to fund the total service pension, given 5 percent real interest and 2 percent real salary growth is paid and that actual experience is 4 percent real interest and 1 percent real salary growth.

Those persons we are assuming are least able to accept the uncertainty of a money purchase pension scheme (for example, those with some part-time employment) are the most vulnerable.

From Table 14 it should be apparent that if employees contribute the maximum 17.5 percent of salary assumed under the money purchase and variable arrangement, in all cases the pension provided will exceed the total service pension. The comparison for employees with full-time paid employment only is straightforward. Those employees with periods of part-time employment contribute at different rates depending on their status, making the comparison more difficult. Because the two categories concerned both begin paid work in full-time employment, the importance of their early contributions together with their depressed final salary (due to inflation only increases) makes the money purchase pension scheme perform slightly better than the contributions paid would suggest.

5.4 Case Study

We have seen that the employees who appear to do least well in a final salary pension scheme are those who change jobs frequently. The employee who changes jobs regularly, but is always in full-time employment, and the cyclical category of employee both receive pensions of less than 85 percent of their respective total service pensions from the final salary scheme. Consequently, we consider the pension entitlements of these employees in more detail.

Assume an employee wishes to receive a pension equal to the total service pension. This is equivalent to the revalued career average pension the employee would receive, if revaluation were in line with salary growth. Because the revalued career average pension scheme meets the aim, we only need consider money purchase and final salary pension schemes.

There are various possibilities for the employee. For example, the employee could:

- Join an occupational pension scheme and pay additional voluntary contributions;
- Start a money purchase personal pension plan and pay the equivalent of the members' contribution to the pension scheme;
- Start a money purchase personal pension plan and pay the contribution believed necessary to fund 100 percent of the total service pension; or
- Start a money purchase personal pension plan and pay the equivalent of the members' contribution to the pension scheme, with the employer contributing the remainder.

Table 16 shows the contributions required by these employees to fund a total service pension. If the employee joins a final salary pension scheme, then additional voluntary contributions are necessary to increase the scheme's pension to the total service pension. These are given in the first row of figures for each category. Otherwise the employee must join a money purchase pension scheme and fund the total service pension himself or herself, perhaps in conjunction with an employer. The contribution required for this is given in the second row of figures.

We should consider the employee's financial position while in employment, depending on the decision made. Assume members contribute 5 percent of their pay to the occupational pension scheme. Then

Table 16
Contribution to Money Purchase Pension Scheme
Or Additional Contributions Required for Equivalent Pension

Change Jobs	4/1	5/1	4/2	5/2
Every 5 Years				
Final Salary Scheme	1.5%	1.1%	3.2%	2.4%
Money Purchase Scheme	9.4%	7.0%	11.7%	8.9%
Cyclical				
Final Salary Scheme	0.5%	0.4%	1.1%	0.8%
Money Purchase Scheme	7.6%	5.6%	8.5%	6.2%

Source: Tables 9 and 14.

the employee's gross pay will be reduced the amounts shown in Table 17. Categories 1), 2), 3) and 4) in the Table refer to the four options discussed above, respectively.

Table 17
Contribution Required From Employee
Under Each Arrangement

		4/1	5/1	4/2	5/2
5 years	1)	6.5%	6.1%	8.2%	7.4%
	2)	5.0%	5.0%	5.0%	5.0%
	3)	9.4%	7.0%	11.7%	8.9%
	4)	5.0%	5.0%	5.0%	5.0%
Cyclical	1)	5.5%	5.4%	6.1%	5.8%
	2)	5.0%	5.0%	5.0%	5.0%
	3)	7.6%	5.6%	8.5%	6.2%
	4)	5.0%	5.0%	5.0%	5.0%

The financial position of the employee in retirement will be the same, except for the second option where the employee will fare less well. For example, if the money purchase fund experienced 5 percent real growth and the employees receive 1 percent real salary growth, the fund of the employee moving jobs every five years would be able to purchase a pension of 71.4 percent of the total service pension; the cyclical employee's fund would be 89.3 percent of that necessary for the total service pension.

We need only consider the first, third, and fourth options. The third option is the most expensive. The best alternative financially seems to be the fourth option, where the employer contributes to the employee's personal pension plan, because (assuming the assumptions are borne out by experience) the employee receives the target pension and pays the least contribution. The fourth option ignores the cost of other benefits provided by a defined benefit pension scheme (for example, the cost of life insurance and the ill health pension). If these costs are included, the choice between the first and fourth options becomes more difficult. In particular, as the benefit in the first option is provided by a final salary pension scheme, the risk of the pension being lower than expected because of poor investment performance is limited. With the fourth option the risk of underperformance rests solely on the employee.

A revalued career average pension scheme would meet the target benefit of both these categories of employee, provided revaluation was in line with salary growth. If such a scheme is not available, then the best choice for both categories appears to be between:

- Joining a money purchase pension scheme where a reasonable level of contributions are made by the employer and hoping that the benefit of good investment performance will compensate for the additional expenditure on insured benefits that might be necessary; and

- Joining a defined benefit pension scheme final salary with the certainty of a pension (and other benefits) which can be supplemented by additional contributions to compensate for revaluation of deferred benefits at less than the rate of growth of salaries.

Few employers contribute to individual money purchase pension schemes, and when employers have introduced occupational money purchase schemes they have tended to pay lower contributions than they would pay to a final salary pension scheme (NAPF, 1996). In practice, those employees with access to an occupational scheme are likely to be in the second position; those without access to an occupational scheme will have to choose the third option above, assuming they can afford it. Again, the evidence shows that persons choosing to start individual money purchase pension schemes frequently pay a minimum level of contribution and that there is a large proportion of the working population with no pension provision other than that provided by the state.

6 Death in Service and Other Issues

6.1 Death in Service and Other Insurance Benefits

The results of Section 5 have ignored the provision for death and other benefits provided by defined benefit pension schemes. This seems a reasonable approach because, for some categories of employee, a death benefit may not be important and may represent further cross subsidy (from single members to those with dependents). Security for dependents is important for a large percentage of the population, however, and should not be ignored.

The average death in service benefit provided by a defined benefit pension scheme is a lump sum of approximately three times the annual salary at the time of death, together with a spouse's pension of 25 percent pensionable salary. This is unlikely to require a contribution to a money purchase scheme much in excess of 1 percent of salary.[12] The cost of the ill health (disability) pension is harder to estimate, but could be as much as 4 percent of salary.[13] These benefits could cost more than the difference between the costs of the money purchase and final salary pension schemes identified above. An obvious problem is that those employees for whom such insurance is relatively expensive are more likely to choose to join an occupational pension scheme, assuming one is available. This could increase the overall cost of defined benefit pension schemes.

The cost of both these forms of insurance will increase with the age at which contributions begin and also may increase throughout the policy term. Money purchase pension schemes are likely to be relatively more attractive to younger employees, even ignoring the cost of insurance, and this could be a problem for defined benefit pension schemes. Employees could choose to opt out of occupational pension schemes while young, expecting to be able to join their employers pension scheme when older. In the long run this could prove to be a poor strategy because it will increase the average age of the membership of occupational pension schemes, thereby increasing their average cost. Because the provision of occupational pension schemes is voluntary, employers may choose to close the pension schemes as the cost increases, leaving no pension scheme for aging employees to join. If employers were able to make membership of pension schemes com-

[12]This figure was calculated assuming a term assurance for the lump sum necessary to fund the benefit, allowing for the accumulated value of the money purchase fund.

[13]This amount was reached after some telephone inquiries to insurance companies.

pulsory, as was possible in the past, this problem at least could be avoided.[14]

6.2 Administration

Most employers effectively meet the cost of administering occupational defined benefit pension schemes. Sometimes they only do so implicitly, as they usually meet the balance of the cost of the pension scheme. In any case, it is important that administration costs are kept to a minimum.

One problem is in data storage—in final salary pension schemes this is frequently used as a reason for excluding part-time and temporary employees because it can be difficult to record the number of hours worked each week. Data handling software packages are making such advances that this should become less of a problem. The only information that needs to be stored for a revalued career average pension scheme, regardless of category of employee, is the total revalued salary to date. This can be uprated annually, for example when tax statements are produced. Consequently, any additional data handling can be kept to a minimum for all employees.

In individual money purchase schemes the plan participant will have to meet the expenses of the provider. In an occupational money purchase scheme it is usual for the employer to meet the expenses. Because of economies of scale, the expense margins are usually lower for group schemes.

7 Summary and Conclusion

While the assumptions and methodology underlying the calculations can be criticized for their simplicity, they still serve to demonstrate some useful results.

For many working histories, a defined benefit occupational pension scheme can offer good value for money. Revalued career average pension schemes, where revaluation is in line with earnings, meet many of the criticisms of final salary pension schemes.

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[14]Legislation was introduced in the U.K. prohibiting companies from making membership of an occupational pension scheme a condition of employment because of their perceived problems with portability. If the portability problems were addressed, there should be less objection to compulsory membership.

Final salary pension schemes compare poorly with money purchase pension schemes in some circumstances. Their two main weaknesses are:

- When salaries grow significantly faster than inflation and deferred benefits are increased in line with inflation only;
- When interest rates are significantly higher than the rate of salary growth and than assumed in the funding basis and the extra returns are not passed to the members of a defined benefit pension scheme.

The former condition primarily affects employees who change jobs. In some cases employees change employment because they perceive an advantage to a new job. The employer, who meets the balance of cost in most defined benefit pension schemes, may have trained the employee and perceive a significant financial disadvantage to the move. Most employers feel justified in providing a deferred benefit that gives less weight to the years worked with the employer than a retirement benefit would give.

Persons increasingly are leaving employment because they have been employed on a temporary contract or because they have been made redundant. In these situations there may be no financial compensation to the employee (other than a redundancy payment to those entitled under employment law), but presumably there is a perceived benefit to the employer. To penalize these employees further by reducing the amount of the pension they can expect to receive at retirement is less justifiable.

The results show that in certain circumstances the extra cost required to revalue deferred benefits in line with earnings is not great. For an employee changing jobs every five years the cost calculated varies between 1.1 percent and 3.2 percent of salary per annum. If employers do not want to increase the overall cost of an occupational pension scheme, an alternative is to review the target benefit provided at retirement.

This brings us to another cross subsidy: between employees experiencing different rates of salary growth. By comparing the benefits provided by a revalued career average pension scheme and a final salary pension scheme we see that in a final salary pension scheme those employees with flatter salary progression effectively subsidize those with faster salary progression. The problem is one of equity: each employee's pension year should be identified and given a fair weighting in the calculation of the eventual benefit paid which leads to a revalued career average design where the rate of revaluation is linked to increases in earnings. With this design the problem of deferred benefits would disappear.

The second circumstance in which money purchase pension schemes outperform defined benefit pension schemes is also a question of equity. To whom does the surplus in a pension scheme belong if the employer meets the balance of the cost? If the contribution is perceived solely as deferred pay, then the surplus belongs to the members of the pension scheme. As the employer's contribution can fluctuate without any regard to the progression of employees' earnings and, in any case, it is calculated in a way that is not intended to be member specific, it may be unreasonable to assume 100 percent of the contribution is in respect of deferred pay. If this is the case, some mechanism for sharing the surplus between the employer and the members of the pension scheme could be devised. This could depend on the extent to which the employer has a commitment to meet payments where the pension scheme is in deficit and on the normal cost of the pension scheme as reported in the Companies Act accounts.

If some categories of employees are to be paid higher benefits in defined benefit pension schemes without the overall cost increasing, other employees will have to receive lower benefits. A final salary pension scheme could achieve this by reducing the target benefit in a pension scheme by reducing the rate of accrual, while introducing revaluation for deferred benefits in line with salary growth. This leaves the problem of cross subsidy between different rates of salary growth. A revalued career average pension scheme can address both problems by removing the proportionately larger rewards available in final salary pension schemes to those whose salaries increase faster than the average. While probably not removing all of the cross subsidy (because some index of average salary growth will have to be adopted by the pension scheme), the problem is at least controlled. It is also demonstrably equitable and consistent with the idea of pensions representing deferred pay.

Personal pension plans will always have something to offer employees. For example, they can be much more flexible than occupational pension schemes. In particular, the majority of persons in paid employment do not have access to occupational pension schemes. Money purchase pension schemes cannot offer insurance to the same degree as a defined benefit pension scheme. The results of this paper reinforce the work of others (for example, Davies and Ward, 1992) in demonstrating the difficulties of relying on money purchase arrangements, particularly for the less well paid. It is possible to develop a reasonably straightforward pension scheme that can offer a fair level of benefit to many different categories of employee.

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Appendix 1—Glossary of Terms

Additional Voluntary Contributions—In the U.K., members of occupational pension schemes are allowed to make *additional voluntary contributions*, up to certain limits of their salaries, in order to increase their benefits in retirement. The contributions attract the same tax relief as ordinary contributions to a pension scheme.

Appropriate Personal Pension Plan—If an individual chooses to contract out of the state earnings-related scheme through a personal pension plan, the U.K. Department of Social Security pays part of the individual's national insurance contributions to an *appropriate personal pension plan.* This is known as the *contracted out rebate.* The contributions must be accounted for separately from the plan participant's other contributions. More than half of the persons who have personal pension plans only have an appropriate personal pension plan; that is, they do not make any additional contribution beyond the rebate made by the Department of Social Security (Williams and Field, 1993).

Basic State Pension—In the U.K. (and most other developed countries) the government pays a pension to those persons over the state retirement age who satisfy certain eligibility requirements. In the U.K. eligibility depends on the number of national insurance contributions paid. Within European Union countries the level of this pension varies between approximately 15 percent of average salary and 25 percent of average salary.

Limited Price Increases—In the U.K. the 1994 Pensions Act prescribes that for pensions accrued after April 1, 1997, defined benefit pension schemes must increase the pension in payment by *limited price increases.* That is, pensions in payment must be increased by the minimum of 5 percent or the rate of increase in the Retail Prices Index over a year.

Linked and Nonlinked Policies—The value of contributions paid to *linked* policies will change according to an associated investment fund. Depending on the fund chosen, the contributions will be more or less secure. The value of *nonlinked* policies can only increase and will do so at the rate of bonus declared by the insurance company.

National Insurance Contributions—In the U.K. the national insurance contributions are a tax levied on employees and employers for social insurance benefits provided by the state. Employees only pay the tax (which is scaled according to the amount earned) on pay under the upper earnings limit. The insurance cover includes, for example, unemployment benefits and maternity benefits, as well as the basic state pension and the state earnings-related pension.

Occupational Pension Scheme—A pension scheme providing pensions in respect to a period of employment with an employer participating in the pension scheme. The *participating employer* must make regular contributions to the scheme. Employees of participating employers can join the pension scheme, provided they satisfy its eligibility rules. Many occupational pension schemes only cover certain categories of staff; frequently temporary employees or those working part time are excluded (GAD, 1991). Membership cannot be compulsory. Whether employees who choose to join the pension scheme make contributions depends only on the scheme rules. The pension scheme can be defined benefit or defined contribution.

State Earnings-Related Pension—Some governments provide pensions in excess of the basic level described above. This pension is usually salary related, although it is common for the definition of pensionable salary used in the calculation to be capped. In the U.K. the pension is called the state earnings-related pension scheme (SERPS), and it is based on an individual's *upper band earnings* [the salary between the *lower earnings limit* (approximately equal to the basic state pension) and the upper earnings limit (approximately seven times the lower earnings limit)]. SERPS is effectively a revalued career average scheme, with an earnings cap.

Appendix 2—Career Patterns

Using the information provided in studies such as those by Martin and Roberts (1984) and Dex (1984), and after discussion with the Equal Opportunities Commission, Davies and Ward (1992) use the career patterns given below:

1) No Breaks—Employed full-time throughout working life.

2) Break and Part-Time—Employed full-time until a relatively few years are taken from paid employment for child care followed by part-time employment until retirement.

3) Break and Full-Time—Employed full-time until a longer break from paid employment is taken for child care followed by full-time employment.

4) Break and Mixed—Employed full-time until relatively few years are taken from paid employment for child care followed by a mixture of unemployment, part-time and full-time employment, finishing with a gap in the employment record.

5) Late Break—Only two periods away from full-time paid employment, the first for child care, the second over the period up to age 60 for other types of family care. There is also a period of unemployment.

6) Late Start—A gap in paid employment until the mid-20s, followed by full-time paid employment except for a short break for child care.

(Davies and Ward, 1992)

The categories used in this paper are given in Table A1 which summarizes the paid work in different five year periods. Thus, for example, a "break-and-mixed" category employee is assumed to be working part time in paid employment for 75 percent of the week between the ages 45 and 49. The full-time-and-bonus category is assumed to work overtime until age 45 and then to continue basic full-time work.

Table A2 presents the time spent in paid employment by each category as a percentage of the maximum assumed possible of 40 years and the total service pension accrued as a percentage of that accrued by a full-time employee.

If the salary of each category of employee were assumed to grow at the same rate regardless of whether the employee was in full-time or part-time work or employed or unemployed, then the ratios of total service pension to full-time pension would be the same as the ratios of service. The differences occur because it is assumed that salaries grow at different rates, depending on employment status. Table A2 indicates the retirement income lost, relative to the full-time income, due to the different working profiles.

Table A1
Assumed Working Histories of Different Categories of Employee

	Age Range							
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59
Full-Time	1	1	1	1	1	1	1	1
Break and Mixed	1	1	0	0.4	0	0.75	1	0
Late Break	1	1	0	1	1	0	1	0
Break and Part-Time	1	1	0	0.4	0.4	0.75	0.75	0.75
Early Break and Full-Time	1	0	0	1	1	1	1	1
Late Break and Full-Time	1	1	0	0	1	1	1	1
Short Break and Full-Time	1	1	0	1	1	1	1	1
Long Break and Full-Time	1	1	0	0	0	1	1	1
Late Start	0	1	1	0	1	1	1	1
Full-Time & Bonus	1.2	1.2	1.2	1.2	1.2	1	1	1
Cyclical	1	0	1	0	1	0	1	0

Table A2
Comparing Time in Paid Employment
And Total Service Pension

		Total Service Pension: Real Salary Growth of:	
	Service	1%	2%
Full-Time	100.0%	100.0%	100.0%
Break and Mixed	51.9%	40.5%	31.6%
Late Break	62.5%	53.8%	46.4%
Break and Part-Time	63.1%	47.3%	35.5%
Early Break and Full-Time	75.0%	67.9%	61.5%
Late Break and Full-Time	75.0%	67.9%	61.5%
Short Break and Full-Time	87.5%	83.3%	79.3%
Long Break and Full-Time	62.5%	53.8%	46.4%
Late Start	75.0%	67.9%	61.5%
Full-Time & Bonus	112.5%	100.0%	100.0%
Cyclical	50.0%	41.0%	33.6%

Appendix 3—Results for Basic Pension and Average Salaries

Most persons who have enrolled in personal pension schemes have paid only the minimum contribution (that is, the contracted out rebate). For someone earning an average wage in the 1995/96 tax year, this amounted to just less than 5 percent of upper band earnings.[15] Table A3 shows that in many cases this level of contribution would provide a pension not much greater than the basic state pension.

Table A3 also illustrates a potential problem that may arise due to the British government's current policy of uprating the basic state pension in line with prices rather than earnings. In the discussion on money purchase pension schemes, Table 14 demonstrates that the least beneficial experience for a money purchase pension scheme (of the bases considered) was 4 percent real investment return and 2 percent real

[15]Upper band earnings are those earnings between the lower earnings limit (£358 per week in 1995/6) and the upper earnings limit (£440 per week in 1995/6). The state earnings-related pension is based on upper band earnings.

Table A3
Pension Provided by a Contribution of 5 Percent Salary, Expressed as a Proportion of the Basic State Pension

	4/1	5/1	4/2	5/2
Full-Time	184.1%	245.9%	216.6%	286.0%
Break and Mixed	99.2%	138.0%	105.8%	146.6%
Late Break	122.3%	168.3%	134.9%	184.4%
Break and Part-Time	110.9%	151.7%	118.3%	161.5%
Early Break and Full-Time	117.6%	153.6%	132.1%	170.9%
Late Break and Full-Time	127.3%	170.3%	142.5%	188.9%
Short Break and Full-Time	152.7%	203.4%	175.2%	230.7%
Long Break and Full-Time	106.8%	144.8%	116.8%	157.1%
Late Start	115.9%	149.7%	130.6%	167.4%
Full-Time & Bonus	211.5%	284.3%	247.1%	328.5%
Cyclical	93.0%	127.6%	100.3%	136.8%

salary growth. Here it appears that 4/1 is the worst. Similarly it appears 5/2 gives a lower pension than 5/1. This happens because the basic state pension has been assumed to increase in line with prices only. That is, the increase in salaries enters the equation on the asset side (as increased contributions) only and not the liability side (where it can represent increased standard of living).

We can present the pensions in Table A3 as a proportion of average full-time earnings at retirement. The results are given in Table A4.

While the pension provided under the 4/2 assumption is a smaller proportion of average salary than the pension provided under the 4/1 assumption, it is a larger amount. The assumption of 2 percent real salary growth means that more contributions are paid to the scheme, but not to such an extent that the pension can compensate for the larger growth in average earnings.

The basic state pension is currently about 15 percent of average earnings. If real rates of salary increase 1 percent per annum, in 40 years the basic state pension would be only 10 percent of average earnings; if real salaries increase 2 percent, it would be 7 percent. Now we can see the small amount of pension that some employees who contribute only the minimum amount to a money purchase pension scheme can expect to receive at retirement.

Table A4
Pension Provided by a Contribution of 5 Percent Salary, Expressed as a Proportion of Average Earnings

	4/1	5/1	4/2	5/2
Full-Time	35.5%	47.4%	28.4%	37.5%
Break and Mixed	19.1%	26.6%	13.9%	19.2%
Late Break	23.6%	32.4%	17.7%	24.2%
Break and Part-Time	21.4%	29.2%	15.5%	21.2%
Early Break and Full-Time	22.7%	29.6%	17.3%	22.4%
Late Break and Full-Time	24.5%	32.8%	18.7%	24.8%
Short Break and Full-Time	29.4%	39.2%	23.0%	30.3%
Long Break and Full-Time	20.6%	27.9%	15.3%	20.6%
Late Start	22.3%	28.9%	17.1%	22.0%
Full-Time & Bonus	40.8%	54.8%	32.4%	43.1%
Cyclical	17.9%	24.6%	13.2%	18.0%

By gradually devaluing the basic state pension, the British government will find an increasing number of pensioners either accepting increasing levels of poverty or claiming income support.[16]

[16]Income support in the U.K. is a means tested social security benefit paid to those on low income.

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Seeking the Profitability-Risk-Competitiveness Frontier Using a Genetic Algorithm

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Abstract

Monte Carlo simulation is used to develop a flexible framework to measure the profitability, risk, and competitiveness of any insurance product. A genetic algorithm is then used to seek the optimum asset allocations that form the profitability-risk-competitiveness frontier and to examine the profitability, risk, and competitiveness trade-offs. We also show how to select the appropriate asset allocation and crediting strategy in order to position the product at the desired location on the profitability-risk-competitiveness spectrum.

Key words and phrases: *asset allocation, product positioning, risk-based capital, Monte Carlo simulation, capital asset pricing model*

1 Introduction

Monte Carlo[1] simulation has been widely accepted as a valid method of valuing path-dependent cash flows. Hull (1993) applies Monte Carlo simulation techniques to derivatives, Hayre and Lauterbach (1995) apply them to mortgage-backed securities, and Asay, Bouyoucos, and Marciano (1993) apply them to pricing single premium deferred annuities. In recent years, asset-liability management actuaries also have begun

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[1]For an introduction to Monte Carlo simulation in general see, for example, Kalos and Whitlock (1986).

using Monte Carlo simulation to value insurance company liabilities and these liabilities' option-adjusted durations and convexities.[2]

Although asset-liability management actuaries are using Monte Carlo simulation in their work, product development actuaries have yet to widely apply it. This is because Monte Carlo simulation techniques, as they now exist, do not address the needs of the product development actuary. In pricing their products, product development actuaries want to know the following:

- Will the capital invested by the company earn more than the company's cost of capital?
- Will the risk of selling the product be acceptable?
- Will the product be competitive enough to meet the company's sales target?
- How should the company invest in order to balance the above three criteria?

The 1993 paper by Asay, Bouyoucos, and Marciano does not meet the above needs for product development actuaries for the following reasons:

- Product development actuaries are concerned with distributable earnings after considering the surplus required to satisfy both regulators and rating agencies. They are concerned with the liability cash flows only when they impact distributable earnings.
- Profitability, risk, and competitiveness of a product must be considered in pricing. By matching durations and convexities, an attempt is made to minimize the risk component of the product. It may be desirable, however, to take additional risk to enhance the profitability and competitiveness of a product. Asay, Bouyoucos, and Marciano formulated a profitability measure using option-adjusted spreads. Their measure is, however, deficient because it only requires an asset option-adjusted spread that is greater than the liability option-adjusted spread. Though such option-adjusted spreads may result in positive profits, they do not ensure that the profits are sufficient to cover the cost of capital.

[2]For more discussion and detail on the market value of liabilities, see the American Academy of Actuaries Task Force on Fair Valuation of Liabilities (1995), Merfeld (1996), and Reitano (1997).

- The investment allocation likewise must be considered in pricing. While asset-liability management actuaries extensively work to determine the ideal asset allocation to back the liability, their definition of "ideal" has always been that of minimizing risk. A new definition that balances profitability, risk, and competitiveness is needed.

Section 2 introduces a framework through which profitability, risk, and competitiveness of a product can be measured. In calculating profitability and risk, emphasis is placed on distributable earnings.[3] These earnings are not only determined by the profit stream of the product, but are also dependent on the target surplus required by regulators and rating agencies. We use the National Association of Insurance Commissioners (NAIC) risk-based capital formula as a proxy for the target surplus needed to be held.

In Section 3 we provide a brief description of a genetic algorithm and provide references for more detailed information. A genetic algorithm is then used to determine the ideal asset allocation for a single premium deferred annuity. We show that there is no single asset allocation that can be considered ideal. Rather, we have a set of asset allocations forming the profitability-risk-competitiveness frontier. With the genetic algorithm, asset allocations close to the frontier can be found.

Section 4 describes a method to quantify the profitability-risk-competitiveness trade-offs. Once these factors are quantified, decisions on where to position the product on the profitability-risk-competitiveness spectrum can be made by restating the first three concerns of product development actuaries as constraints on each of the three measures defined in Section 2.

2 Profitability-Risk-Competitiveness Framework

For the n-th path of the Monte Carlo simulation, let $r_{y,t,n}$ denote the yield curve path with $y = 0.25, 0.5, 1, 2, \ldots, 30$ denoting the point on the yield curve, $t = 0, 1, 2, \ldots, T$ denoting the time period (be it monthly, quarterly, or annually), and $n = 1, 2, \ldots, N$ denoting the path number. Many models can be used to generate these paths. Under each model, many decisions must be made about the values to be used for parameters. It is beyond the scope of this paper to describe and

[3]Distributable earnings are after tax statutory earnings plus changes in target surplus, i.e., they are net cash flows facing the insurance company. They represent how much the insurance company has to put in and how much it can take out from the project (of selling the product).

evaluate the various models available. The model selected should be arbitrage free, however, and the values used for the parameters in the model should be justifiable. Models that are not arbitrage free will result in mispricing the various asset classes. Hull (1993) describes some of these models.

Once the yield curve paths have been generated, an asset-liability model is used to calculate the distributable earnings of the insurance product. The asset-liability model will consider the asset allocation used, the investment strategy under positive and negative cash flows, the interest-crediting strategy of the product, the required target surplus, competitor rates, and mortality, lapse, and expense assumptions. It is beyond the scope of this paper to detail asset-liability modeling. Asay, Bouyoucos, and Marciano (1993) provide further detail on the topic.

Let $DE_{t,n}$ denote the distributable earnings for time period t and the path number n. The present value of distributable earnings for path n can be calculated as

$$PVDE_n = \sum_{t=0}^{T} \frac{DE_{t,n}}{\prod_{k=0}^{t-1}(1 + r_{0.25,k,n} + s)^{\Delta t}} \tag{1}$$

where Δt is the length of each time period and s is the risk premium that must be added to the risk free rate in order to arrive at the appropriate discount rate for distributable earnings.

From the standard capital asset pricing model (CAPM), the required return on a project or a security, R, is given by

$$R = R_F + \beta(R_M - R_F)$$

where R_F is the risk free rate, β is a measure of the riskiness of the project or security relative to the market, and $R_M - R_F$ is the market risk premium. If we assume that the product being priced has risk similar to that of the insurance company as a whole, and the β of the insurance company can be reasonably estimated, the risk premium in equation (1) can be replaced with:

$$s = \beta(R_M - R_F). \tag{2}$$

The market risk premium $R_M - R_F$ has been estimated by Brealey and Myers (1991, Chapter 8, page 161) to be 8.40 percent, resulting in $s = 0.084\beta$. Clearly s is similar to the option-adjusted spread of mortgage-backed securities as described in Hayre and Lauterbach (1995) and the option-adjusted spread of single premium deferred annuities as described in Asay, Bouyoucos, and Marciano (1993).

The profitability measure now can be defined as the sample mean of *PVDE* (i.e., $\hat{E}[PVDE]$) and the risk measure as its sample standard deviation (i.e., $STD[PVDE]$), i.e.,

$$\text{Profitability Measure} = \frac{1}{N}\sum_{n=1}^{N} PVDE_n \tag{3}$$

$$\text{Risk Measure} = \sqrt{\frac{1}{N-1}\sum_{n=1}^{N}(PVDE_n - E[PVDE])^2}. \tag{4}$$

Finally, the competitiveness measure can be tailored to the type of product. It may be appropriate to look at the credited interest rate for deferred annuities and fund-based life insurance such as universal life. For traditional life insurance we may want to use the annual premium as the competitiveness criterion, while for immediate annuities we may want to examine the periodic payments the policyholder will receive.

3 Genetic Algorithms: Overview and Example

3.1 What is a Genetic Algorithm?[4]

The birth of the genetic algorithm is generally attributed to Holland (1975). Descriptions of the ideas behind these algorithms can be found in Goldberg (1989).

Genetic algorithms are fundamentally different from classical algorithms. The differences are based on four principles (Goldberg, 1989):

1. Genetic algorithms use a coded representation of the parameters, not the parameters themselves;

2. Genetic algorithms search from a population of solution vectors, not a single solution vector;

[4] The description of a genetic algorithm used in this section is taken from Brigger (1995). Brigger's dissertation can be accessed on the World Wide Web at *http://ltswww.epfl.ch/pub_files/brigger/thesis_html/node58.html.* One can also visit genetic algorithm websites such as *http://www.aic.nrl.navy.mil/galist/* for more information. Applications of genetic algorithms to actuarial investments are given in Barber (1995) and Wendt (1995).

3. Genetic algorithms exclusively use values of the function under study and do not consider auxiliary information, such as the derivative; and

4. Genetic algorithms use probabilistic transition rules, not deterministic rules.

The function parameters—or the "living being"—are represented by a structure called a chromosome. Genetic algorithms manipulate chromosomes to profit from and exploit similarities between different performing chromosomes. Genetic algorithms optimize a population of chromosomes, unlike other methods that optimize only a single solution vector. The probability to select a false solution is reduced by considering several solution vectors of high performance. Genetic algorithms remain highly general because their optimization is directly based on the function values. There are no limitations set to continuous and derivable functions. Transition rules of genetic algorithms are stochastic and not deterministic as in many other algorithms. Yet there remains an important difference between genetic algorithms and random search algorithms, where decisions uniquely based on pure chance guide the exploration. Genetic algorithms benefit largely from the available information within the current population and use chance only to guide their exploration.

As in any optimization procedure, three associated objects are characteristic for genetic algorithms:

1. The environment of the system undergoing optimization;

2. The adaptive plan that determines successive structural modifications in response to the environment; and

3. A measure of the performance of different chromosomes in the environment.

The first and third points are given by the problem, and the task of the genetic algorithm is to control the mixture of operators that affect the system undergoing optimization. Thus, the workings of the system are conveyed in the adaptive plan which determines what chromosomes arise in response to its environment. A given chromosome performs differently in different environments, it is more or less fit, and it is the adaptive plan's task to produce chromosomes that perform well (are fit) in the environment confronting it.

The key problem for the adaptive plan is that it has absolutely no information about which chromosomes are most fit. In order to obtain this information, the plan must test and evaluate different chromosomes within the environment. Based on the fitness of each, the adaptive plan draws a selection. The adaptiveness is invoked when different environments cause different chromosomes to be selected. Successive structural modifications dictated by an adaptive plan amount to a sequence or trajectory through the set of all attainable chromosomes. For a plan to be adaptive, the trajectory must depend upon which environment is present.

3.2 An Example Using a Deterministic Genetic Algorithm

Suppose we have a single premium deferred annuity (SPDA) as described in Table 1 and an asset-liability model with assumptions as described in Table 2. Furthermore, we have the ability to invest in the types of assets as shown in Table 3.

Table 1
Description of SPDA

Policy Characteristics	Description
Premium:	$1,000,000;
Average Policy Size:	$50,000;
Guarantee Period:	1 year for both initial and renewal rates;
Minimum Rate:	3.00%;
Surrender Charges:	7% year 1, declining 1% per year;
Free Withdrawal:	10%;
Sales Commissions:	5% of premium;
Issuance Expenses:	0.1% of premium;
Administrative Expenses:	$20 per policy per annum;
Death Benefit:	Fund value.

Given the specifications of the SPDA and the asset-liability model, the goal is to determine the asset allocation that will satisfy the product development actuary in terms of profitability, risk, and competitiveness. With ten different types of assets, however, there is a wide range of possible asset allocations to consider. This is where a genetic algorithm is able to help. Genetic algorithms allow solutions to evolve from one generation to the next, with the new generation of solutions superior to the prior generation.

Table 2
Asset-Liability Model Assumptions

Model Component	Assumption
Projection Period:	25 years;
Target Surplus:	200% of NAIC company action level capital;
Federal Income Tax Rate:	35%;
Company Beta:	1.00;
Mortality:	1975-1980 SOA mortality rate;
Sex Distribution:	50% male, 50% female;
Issue Age:	60;
Base Lapses:	2%, 3%, 4%, 5%, 6%, 7%, 8%, 30%, 10%, 10% ...;
Dynamic Lapses:	Considers difference between competitor rate and credited rate, and surrender charge remaining;
Maximum Lapses:	50%;
Competitor Rate:	Maximum of five year treasury rate and 3.5%;
Crediting Strategy:	Subtract 220 basis points from asset yield;
Investment Strategies Under	
—Positive Cash Flows:	Invest in the same allocation as the initial allocation;
—Negative Cash Flows:	Sell assets in proportion to their market values at the time of sale;
Number of Scenarios:	100, starting with the December 31, 1996 yield curve.

To begin the genetic algorithm process, it is necessary to define the first generation of solutions. One possible way is to define asset allocations that are 100 percent of each of the asset types. Table 4 shows the results of these allocations. We observe the following from Table 4:

- The level of profitability is higher for A bonds, less for commercial mortgages, and least for BB bonds. Based on the NAIC risk-based capital formula, A bonds require the least capital, commercial mortgages more capital, and BB bonds the most capital.
- Investing in longer maturity assets will result in higher risk. In general, the market values of longer maturity assets are more sensitive to changes in the yield curve. Because policyholders have the option to surrender their policies at book value, the insurance company is exposed to most of the fluctuations in the market values of the assets.
- Because of the crediting strategy of deducting a fixed spread from the asset yield to arrive at the credited rate, assets with higher yields will result in a more competitive SPDA. There is no requirement that the spread has to be the same for different asset allocations.

Table 3
Types of Assets Available to Invest

Type	Asset	Spread Over Treasury Curve
1	3 Year Noncallable A Bond	+35 basis points
2	5 Year Noncallable A Bond	+40 basis points
3	7 Year Noncallable A Bond	+45 basis points
4	10 Year Noncallable A Bond	+60 basis points
5	5 Year Noncallable BB Bond	+165 basis points
6	7 Year Noncallable BB Bond	+185 basis points
7	10 Year Noncallable BB Bond	+220 basis points
8	5 Year Commercial Mortgage	+140 basis points
9	7 Year Commercial Mortgage	+145 basis points
10	10 Year Commercial Mortgage	+150 basis points

Note: All commercial mortgages have a 20 year amortization schedule.

Table 4
Generation 1 Results

Asset Allocation: 100% in	Mean	STD	ICR
3 Year Noncallable A Bond	15,654	7,657	4.13%
5 Year Noncallable A Bond	11,346	13,184	4.35%
7 Year Noncallable A Bond	6,391	18,787	4.55%
10 Year Noncallable A Bond	3,377	25,371	4.79%
5 Year Noncallable BB Bond	-11,018	11,340	5.25%
7 Year Noncallable BB Bond	-17,287	16,700	5.59%
10 Year Noncallable BB Bond	-21,132	22,415	6.04%
5 Year Commercial Mortgage	-33	8,765	5.48%
7 Year Commercial Mortgage	-1,496	12,797	5.67%
10 Year Commercial Mortgage	-1,074	17,445	5.81%

Notes: MEAN = Mean of *PVDE*; STD = Standard Deviation of *PVDE*; and ICR = Initial Credited Rate.

To create the second generation of solutions, it is possible to select any two first generation solutions and combine them. Thus, combining a 100% Type 2 (i.e, in 5-year-noncallable-A-bonds) allocation and a 100% Type 8 (i.e., in 5-year-commercial-mortgages) allocation will result in an asset allocation with a 50 percent weight in each of Types 2 and 8 assets. With ten different allocations from which to choose, we are able to create 45 (i.e., $\binom{10}{2}$) new asset allocations to form the second generation of solutions. After the second generation, with 55 different asset allocations in our solution set we can create up to 1,485 (i.e., $\binom{55}{2}$) different asset allocations to form the third generation of solutions. It is impractical, however, to run the asset-liability model for so many different asset allocations. Biased reproduction, based on the fitness of an asset allocation, is imposed to limit the number of solutions we have for the third and later generations.

Let Ω denote the set of all asset allocations that can be formed from the ten asset types shown in Table 3. For an asset allocation $j \in \Omega$, let $F(j)$ denote its fitness score, defined as:

$$F(j) = F^{(P)}(j) + F^{(R)}(j) + F^{(C)}(j) \tag{5}$$

where

$$F^{(P)}(j) = \frac{E[PVDE]_j - E[PVDE]_{\min}}{E[PVDE]_{\max} - E[PVDE]_{\min}} \quad (6)$$

$$F^{(R)}(j) = \frac{STD[PVDE]_{\max} - STD[PVDE]_j}{STD[PVDE]_{\max} - STD[PVDE]_{\min}} \quad (7)$$

$$F^{(C)}(j) = \frac{ICR_j - ICR_{\min}}{ICR_{\max} - ICR_{\min}} \quad (8)$$

$E[PVDE]_j$ = Mean of *PVDE* for allocation j

$STD[PVDE]_j$ = Standard deviation of *PVDE* for allocation j, and

ICR_j = Initial credited rate for allocation j.

From Table 4 we obtain:

$$E[PVDE]_{\max} = 15{,}654$$
$$E[PVDE]_{\min} = -21{,}132$$
$$STD[PVDE]_{\max} = 25{,}371$$
$$STD[PVDE]_{\min} = 7{,}657$$
$$ICR_{\max} = 6.04\%$$
$$ICR_{\min} = 4.13\%.$$

If there are two asset allocations $j, k \in \Omega$ such that $F^{(P)}(j) < F^{(P)}(k)$, $F^{(R)}(j) < F^{(R)}(k)$, and $F^{(C)}(j) < F^{(C)}(k)$, we say that asset allocation k dominates asset allocation j. When this occurs we force asset allocation j to become extinct and eliminate it from our solution set. Asset allocations that are not dominated by other asset allocations will remain in the solution set. Only the fittest asset allocations (i.e., those with the highest fitness scores) of these survivors, however, will combine to produce new asset allocations for the next generation.

A conscious effort is made to ensure that solutions across the profitability-risk-competitiveness spectrum are achieved so that the final solution set is not concentrated in a small part of the spectrum. Also, for diversity purposes, asset allocations representing as many different asset types as possible are selected to reproduce. After six generations, it can be observed that there is no longer much improvement in the fitness scores, implying that the solution set is close to the profitability-risk-competitiveness frontier.

Tables A1 through A8 in the appendix show all the asset allocations in our solution set after generation six, while Figures 1 and 2 show the evolution of our solution set from generation one to generation six. Figures 1 and 2 are similar to the familiar efficient frontier of portfolio theory, except they contain an additional variable. Instead of an efficient frontier in the profitability-risk space, we now have an efficient frontier in the profitability-risk-competitiveness space.

Figures 1 and 2 show that there is no asset allocation that simultaneously yields the highest profitability, the least risk, and the highest credited rate. In order to achieve a higher credited rate for the SPDA, we must reduce the profitability or increase the risk. We will now explore these trade-offs.

4 Profitability-Risk-Competitiveness Trade-Offs

Figure 1 does not allow us to quantify the trade-off between risk and competitiveness because the profitability measure has not been held constant. Similarly, Figure 2 does not allow us to quantify the trade-off between profitability and competitiveness because the risk measure has not been held constant. To view the various trade-offs, we must include all three measures in a single graph. Before we construct such a graph, two points must be made:

- Not all of the asset allocations shown in the appendix are feasible. Although the profitability-risk-competitiveness profiles of these allocations are sufficiently attractive to allow them to survive through all generations, some of these allocations may not be in line with the investment policy of the insurance company. One such policy may be the requirement that the asset allocation cannot be too concentrated in any one asset category to reduce credit and sector risks. Because the model used in this paper does not consider such risks, there is a tendency for these risks to be ignored.

- We have assumed that the credited rate is determined by deducting 220 basis points from the asset yield. The spread of 220 basis points is by no means magical, and the insurance company is not bound to that number. The insurance company may even use a different spread for each policy year. We now assume that the spread can be any number. To simplify matters, however, we continue to assume that a level spread is used. For any given asset allocation, changing the spread will change the profitability-risk-competitiveness profile of that allocation.

Figure 1
Initial Credited Rate Versus *STD*[*PVDE*]

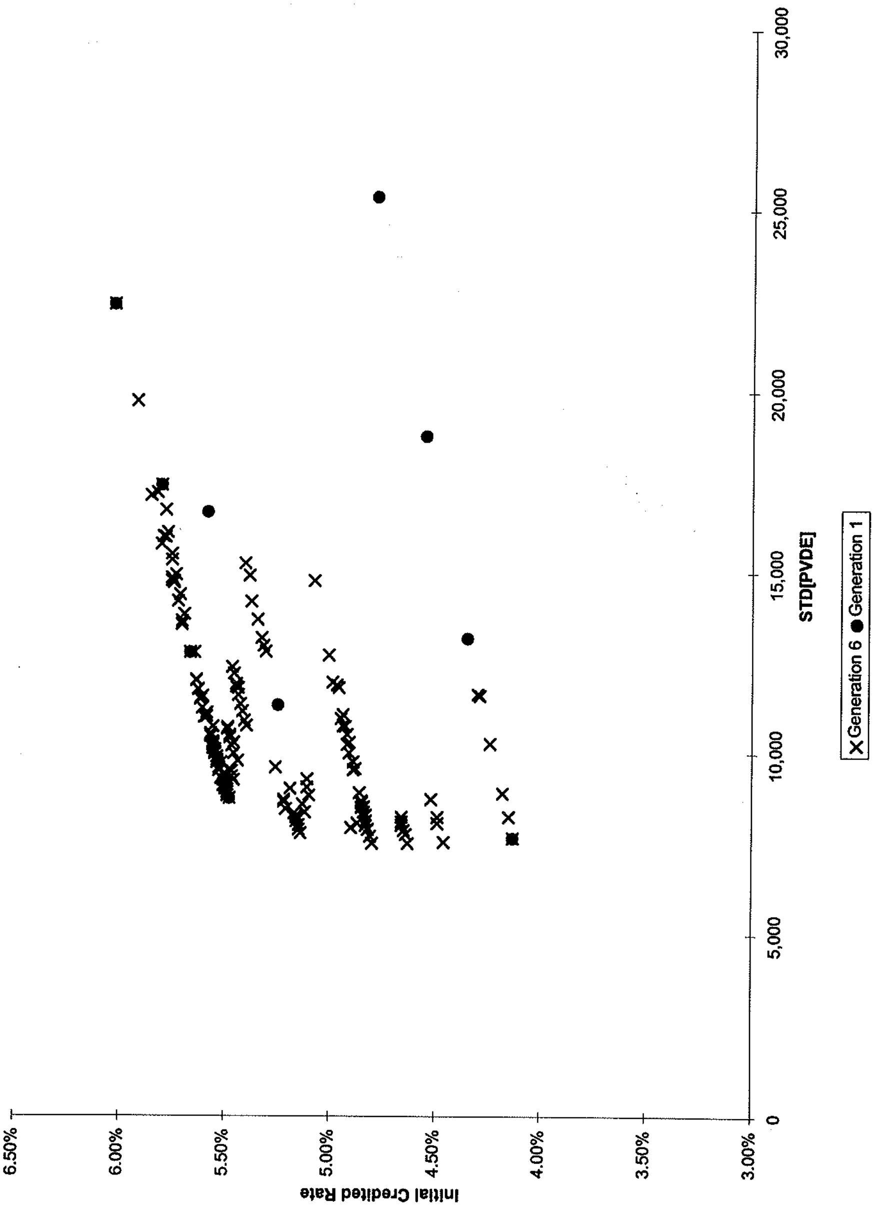


Figure 2
Initial Credited Rate Versus $E[PVDE]$

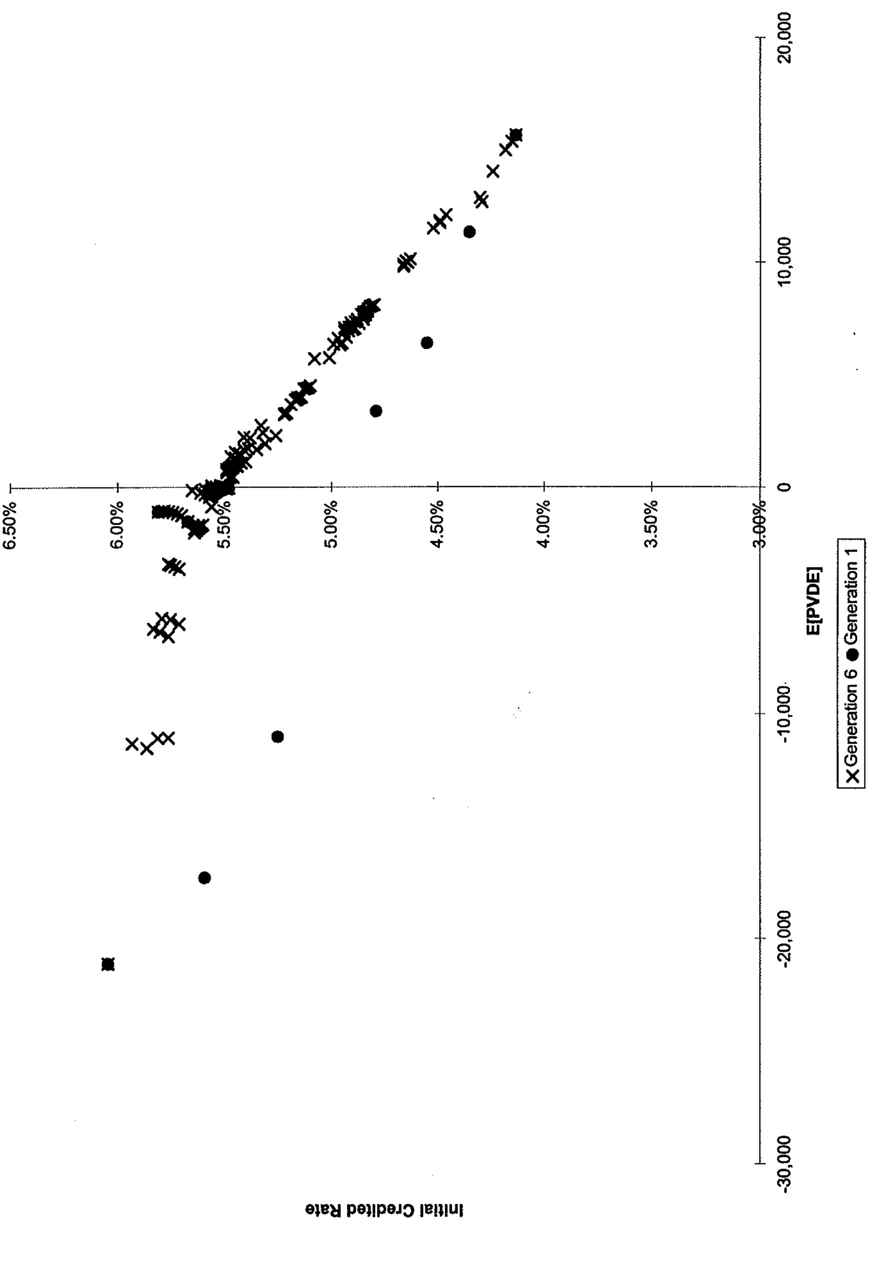


Figure 3 redraws the final solution set shown in Figure 2 with two changes. First, the policy of limiting the combined allocation of BB bonds and commercial mortgages to 50 percent of the asset portfolio is imposed. Second, the spread of 220 basis points is relaxed to range from 20 basis points to 420 basis points.

In Figure 3, points A, B, C, and the four points between them belong to the same asset allocation, with spreads ranging from 20 basis points to 420 basis points. The same case applies to points D, E, F, and the four points between them. Limiting our choice to asset allocations having a combined BB bonds and commercial mortgages allocation of not more than 50 percent reduces our solution set to the line BE while allowing the ability to change the spread to something other than 220 basis points expands our solution set to the area inside ABCFED. Any point within the area ABCFED can be reached by selecting an asset allocation along the line BE and then changing the spread.

Figure 3 shows that when the spread is reduced to increase the credited rate, profitability is adversely impacted. Moving from point B to point A increases the credited rate by 200 basis points from 5.08 percent to 7.08 percent, but reduces $E[PVDE]$ from 5,695 to -55,876. Risk is reduced as well when the credited rate is increased. As shown in Figure 4, $STD[PVDE]$ is reduced from 14,783 at point B to 4,690 at point A. Crediting a high rate will make policyholders less likely to surrender their policies in rising interest rate scenarios, thereby reducing the loss from the sale of assets at low market values and making profits more stable.

From the $STD[PVDE]$ values shown on Figure 4, it is possible to draw rough equivalent risk curves representing the points on the profitability-competitiveness space where the risk level is the same. As expected, these curves have negative slopes which implies that if we keep the risk level constant, the only way to increase profitability is to reduce credited rate. The only way to increase credited rate is to reduce profitability. Also, by increasing the acceptable risk level (shifting to a higher equivalent risk curve), we are able to increase profitability while keeping credited rate the same, increase the credited rate while keeping profitability the same, or even increase both profitability and the credited rate.

Figure 4 allows us to measure the various profitability-risk-competitiveness trade-offs. The trade-off between profitability and competitiveness can be obtained by moving along an equivalent risk curve; the trade-off between profitability and risk can be obtained by moving horizontally; and the trade-off between competitiveness and risk can be obtained by moving vertically.

Figure 3
Investment Policy Imposed and Varying Spread Allowed

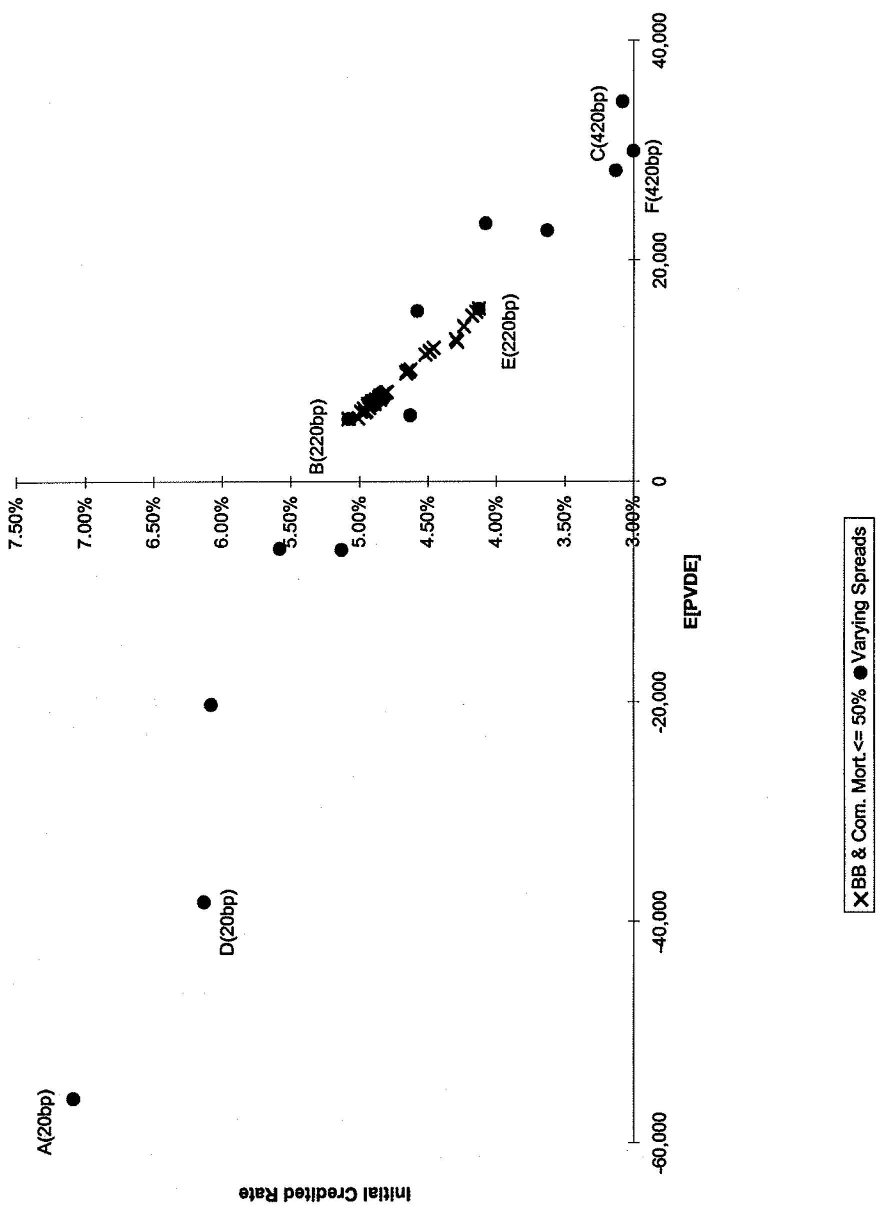
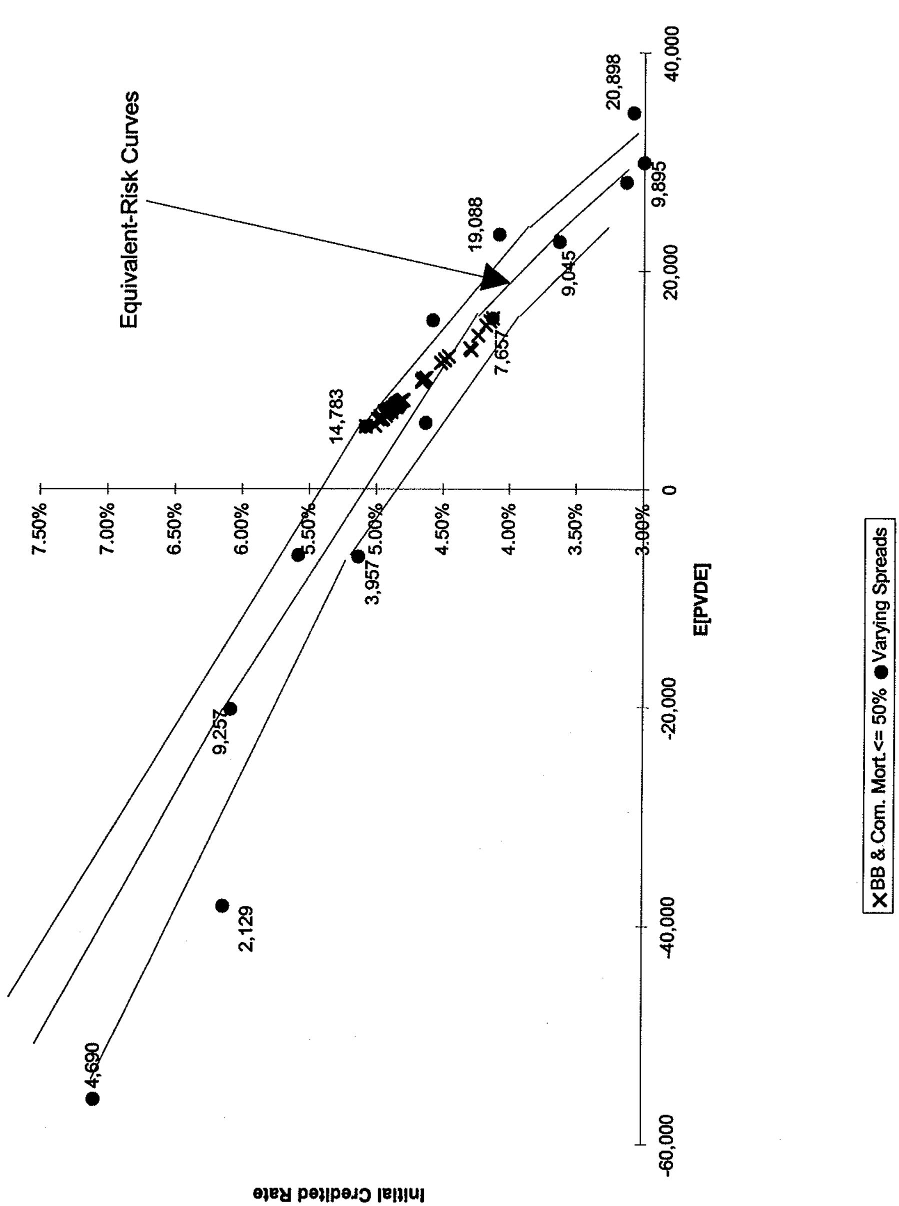


Figure 4
Construction of Equivalent Risk Curves



In Section 1, we introduced four concerns of product development actuaries when doing their pricing work. We can use Figure 4 to address these concerns if we recognize that the first three concerns can be restated as constraints on the three measures we have defined:

- Setting $E[PVDE]$ greater than zero will ensure that the insurance company earn more than its cost of capital;
- Setting $STD[PVDE]$ less than, say, 10,000 (this is just an example, as the actual level will be subjective) will ensure that the risk level is acceptable; and
- Setting the initial credited rate greater than, say, 5.00 percent (again, this is just an example) will make the product sufficiently competitive.

Once these constraints are placed on Figure 4, it will not be difficult to determine the set of asset allocation/spread combinations that will meet these constraints.

It is possible that when the constraints are placed on Figure 4, no possible solution will be found because the area of interest falls outside the area ABCFED. When this occurs, either the constraints must be adjusted to be more realistic or more asset types must be included in the analysis to expand the solution set to an area larger than ABCFED. The search for new asset classes is currently under way at many insurance companies as the competition they face intensifies. Some of these new asset classes include asset-backed securities, credit derivatives, and emerging market debts. If the constraints cannot be adjusted and no new asset classes can be found, the company may want to reconsider the feasibility of selling the product.

A new asset class may be superior to existing asset classes because it is able to take advantage of loopholes in the risk-based capital formula. For example, an asset-backed security may be given an investment grade rating by the NAIC when the assets backing the security are noninvestment grade assets. Thus, the insurance company buying the security will gain from the higher yield without having to put in the extra capital. Such loopholes will not last forever. Once regulators become aware of the loopholes, they will take measures to correct the situation.

Some insurance companies may try to increase profitability by reducing the amount of capital they use to fund their products. For example, they may decide to change the target surplus they use from 200 percent to 150 percent of the NAIC company action level capital.

Such actions eventually will result in downgrades of their ratings. When downgrades occur the cost of capital will increase, and profitability will decrease on a present value basis. Also, downgraded ratings will make their products more difficult to sell. Maintaining the competitiveness of their products will require crediting higher rates, again reducing profitability toward the original level.

5 Summary and Conclusion

This paper presents a flexible methodology that meets the needs of product development actuaries. The methodology can be adapted to any product as long as the distributable earnings for the product can be modeled. Other asset types, including derivatives, can be added as long as the asset cash flows can be modeled. The weighting of the various components of the fitness score also can be adjusted to emphasize one of the three measures.

The methodology is superior to the traditional pricing model in three ways.

- The use of multiple scenarios allows the assessment of the risk of the product. Under the traditional approach where a static economic environment is assumed, the risk of not achieving the required profit objectives due to changing economic environments cannot be measured.
- The use of cost of capital that changes with the yield curve results in a more accurate profit measure. Under the traditional approach, distributable earnings are discounted at a fixed percentage. This ignores the fact that earning 12 percent when the 90 day treasury rate is 5 percent is different from earning 12 percent when the 90 day treasury rate is 15 percent.
- The use of an asset-liability model allows us to determine the appropriate asset allocation to back the product. Under the traditional approach, assets are not modeled. As such, the product development actuaries are not involved in the selection of the asset allocation.

The investment community has long been aware of the first two weaknesses of the traditional approach. This is evident in the pricing of mortgage-backed securities by Hayre and Lauterbach (1995) where

Monte Carlo simulation techniques are used to overcome both the problem of path-dependent cash flows and the problem of discounting cash flows at a fixed rate under different paths.

Asset-liability management actuaries have used the same techniques to value liability cash flows and to calculate their durations and convexities. These models do not serve product development actuaries well because little emphasis is placed on profitability and the competitiveness of the product. This paper combines the strengths of both worlds and presents a general framework that can be adapted to any product.

Despite these strengths, areas exist where further research is needed. Using the simple genetic algorithm described in this paper to seek the profitability-risk-competitiveness frontier is found to be efficient. Genetic algorithms different from the one described in this paper, however, may be more efficient especially since the genetic algorithm we use lacks randomness and mutations.

With the advent of more complicated products such as equity index annuities and life insurance, the need for models to simultaneously generate both equity and interest rate scenarios is compelling. Also, studies on policyholder behavior under various equity/interest rate environments are needed to model the product more accurately.

CAPM is used to find the risk premium in equation (1). With all the controversy surrounding the appropriateness of CAPM, more work is needed to find a better method to calculate the risk premium. For mortgage-backed securities where a broad market exists, the market values can be used to back into the correct option-adjusted spread. Without a market for insurance products, it will be a challenge to create an accurate measure of the risk premium.

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Table A1
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
100.00%								15,654	7,657	4.13%
				100.00%				-21,132	22,415	6.04%
					100.00%			-33	8,765	5.48%
						100.00%		-1,496	12,797	5.67%
							100.00%	-1,074	17,445	5.81%
50.00%	50.00%							14,046	10,264	4.24%
50.00%					50.00%			8,098	7,520	4.80%
50.00%							50.00%	6,605	11,884	4.97%
	50.00%					50.00%		5,749	12,718	5.01%
	50.00%						50.00%	5,695	14,783	5.08%
				50.00%	50.00%			-11,072	14,785	5.76%
				50.00%		50.00%		-11,531	17,157	5.86%
				50.00%			50.00%	-11,344	19,760	5.93%
					50.00%	50.00%		-423	10,483	5.57%
					50.00%		50.00%	-121	12,798	5.65%
						50.00%	50.00%	-1,096	14,953	5.74%
75.00%	25.00%							14,993	8,889	4.18%
50.00%	25.00%	25.00%						12,690	11,593	4.29%
50.00%					25.00%	25.00%		7,442	8,507	4.85%
50.00%					25.00%		25.00%	7,444	9,572	4.88%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A2
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
50.00%						25.00%	25.00%	6,658	10,747	4.93%
25.00%	75.00%							12,878	11,629	4.30%
25.00%	25.00%				25.00%	25.00%		7,101	10,008	4.91%
25.00%	25.00%				25.00%		25.00%	7,063	11,066	4.94%
25.00%	25.00%					50.00%		6,389	10,964	4.95%
25.00%	25.00%					25.00%	25.00%	6,345	11,962	4.99%
	50.00%				25.00%	25.00%		6,317	11,814	4.96%
		25.00%			50.00%		25.00%	2,746	13,194	5.33%
		25.00%			25.00%	25.00%	25.00%	2,181	14,202	5.38%
		25.00%			25.00%		50.00%	2,222	15,268	5.41%
			25.00%		75.00%			1,938	12,822	5.31%
			25.00%		50.00%	25.00%		1,683	13,708	5.35%
			25.00%		50.00%		25.00%	1,724	14,929	5.39%
				50.00%	25.00%	25.00%		-11,081	15,812	5.81%
				25.00%	25.00%	50.00%		-6,029	13,574	5.71%
				25.00%	25.00%	25.00%	25.00%	-5,831	14,728	5.75%
				25.00%	25.00%		50.00%	-5,779	16,005	5.79%
				25.00%		75.00%		-6,578	14,864	5.76%
				25.00%		50.00%	25.00%	-6,371	16,019	5.80%
				25.00%		25.00%	50.00%	-6,251	17,236	5.83%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A3
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
					75.00%	25.00%		-123	9,532	5.53%
					75.00%		25.00%	69	10,745	5.56%
					50.00%	25.00%	25.00%	-230	11,582	5.61%
						75.00%	25.00%	-1,227	13,850	5.70%
						25.00%	75.00%	-1,036	16,132	5.78%
87.50%	12.50%							15,372	8,242	4.15%
75.00%					25.00%			12,114	7,552	4.46%
75.00%					12.50%	12.50%		11,762	8,064	4.49%
62.50%	12.50%				25.00%			11,849	8,234	4.49%
62.50%	12.50%				12.50%	12.50%		11,518	8,728	4.52%
50.00%					37.50%	12.50%		7,800	8,004	4.83%
50.00%					12.50%	25.00%	12.50%	7,034	9,545	4.89%
37.50%	12.50%				50.00%			7,913	8,290	4.83%
37.50%	12.50%				25.00%	12.50%	12.50%	7,324	9,760	4.89%
37.50%	12.50%				25.00%		25.00%	7,297	10,299	4.91%
37.50%	12.50%				12.50%	25.00%	12.50%	6,939	10,246	4.92%
37.50%	12.50%				12.50%	12.50%	25.00%	6,898	10,753	4.94%
25.00%	25.00%				25.00%	12.50%	12.50%	7,098	10,525	4.92%
		12.50%	12.50%		62.50%		12.50%	2,422	12,981	5.32%
		12.50%			75.00%		12.50%	1,681	10,904	5.41%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A4
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
		12.50%			62.50%	12.50%	12.50%	1,509	11,359	5.43%
		12.50%			62.50%		25.00%	1,555	11,916	5.45%
		12.50%			50.00%	25.00%	12.50%	1,302	11,839	5.45%
		12.50%			50.00%	12.50%	25.00%	1,361	12,385	5.47%
			12.50%		87.50%			1,137	10,769	5.40%
			12.50%		75.00%	12.50%		1,083	11,167	5.42%
			12.50%		75.00%		12.50%	1,135	11,805	5.44%
			12.50%		62.50%	25.00%		954	11,615	5.44%
			12.50%		62.50%	12.50%	12.50%	1,016	12,202	5.46%
				12.50%	12.50%	62.50%	12.50%	-3,596	13,663	5.71%
				12.50%	12.50%	50.00%	25.00%	-3,501	14,214	5.73%
				12.50%	12.50%	37.50%	37.50%	-3,429	14,782	5.75%
				12.50%	12.50%	25.00%	50.00%	-3,383	15,369	5.76%
					87.50%	12.50%		-40	9,115	5.51%
					87.50%		12.50%	79	9,747	5.52%
					75.00%	12.50%	12.50%	-17	10,109	5.55%
					62.50%	37.50%		-257	9,992	5.55%
					62.50%	25.00%	12.50%	-146	10,549	5.57%
					62.50%	12.50%	25.00%	-77	11,121	5.59%
					50.00%	37.50%	12.50%	-311	11,027	5.59%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A5
Solution Set After Generation Six

3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
Asset Types*										
						62.50%	37.50%	-1,153	14,393	5.72%
						37.50%	62.50%	-1,056	15,532	5.76%
						12.50%	87.50%	-1,052	16,755	5.79%
62.50%					37.50%			10,149	7,516	4.63%
62.50%					31.25%	6.25%		9,986	7,759	4.64%
62.50%					25.00%	12.50%		9,816	8,011	4.66%
56.25%	6.25%				37.50%			10,043	7,870	4.65%
56.25%	6.25%				31.25%	6.25%		9,884	8,109	4.66%
50.00%	12.50%				37.50%			9,914	8,234	4.66%
50.00%					31.25%	18.75%		7,627	8,252	4.84%
43.75%	6.25%				50.00%			8,017	7,899	4.82%
43.75%	6.25%				43.75%	6.25%		7,880	8,132	4.83%
43.75%	6.25%				37.50%	12.50%		7,738	8,377	4.84%
43.75%	6.25%				31.25%	18.75%		7,573	8,622	4.85%
37.50%	12.50%				43.75%	6.25%		7,786	8,520	4.84%
37.50%			6.25%		56.25%			7,002	7,947	4.90%
31.25%	18.75%				50.00%			7,782	8,690	4.85%
31.25%	18.75%				43.75%	6.25%		7,666	8,914	4.86%
25.00%			6.25%		68.75%			4,497	8,845	5.10%
25.00%			6.25%		62.50%	6.25%		4,412	9,065	5.11%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A6
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
18.75%	6.25%		6.25%		68.75%			4,413	9,286	5.11%
		6.25%			87.50%		6.25%	926	9,800	5.44%
		6.25%			81.25%	6.25%	6.25%	883	10,002	5.46%
		6.25%			81.25%		12.50%	924	10,301	5.46%
		6.25%			75.00%	12.50%	6.25%	821	10,217	5.47%
		6.25%			75.00%	6.25%	12.50%	863	10,506	5.48%
		6.25%			68.75%	18.75%	6.25%	748	10,443	5.48%
		6.25%			68.75%	12.50%	12.50%	791	10,724	5.49%
		6.25%			62.50%	25.00%	6.25%	665	10,675	5.49%
				6.25%	56.25%	31.25%	6.25%	-1,650	11,008	5.60%
				6.25%	50.00%	37.50%	6.25%	-1,724	11,253	5.61%
				6.25%	50.00%	31.25%	12.50%	-1,674	11,532	5.62%
				6.25%	43.75%	43.75%	6.25%	-1,806	11,503	5.62%
				6.25%	43.75%	37.50%	12.50%	-1,753	11,779	5.63%
				6.25%	37.50%	50.00%	6.25%	-1,895	11,757	5.63%
				6.25%	37.50%	43.75%	12.50%	-1,841	12,031	5.64%
				6.25%	31.25%	56.25%	6.25%	-1,993	12,019	5.64%
					93.75%	6.25%		-35	8,925	5.49%
					93.75%		6.25%	40	9,248	5.50%
					87.50%	6.25%	6.25%	13	9,415	5.51%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A7
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
					81.25%	18.75%		-74	9,316	5.52%
					81.25%	12.50%	6.25%	-15	9,610	5.53%
					81.25%	6.25%	12.50%	27	9,912	5.54%
					75.00%	18.75%	6.25%	-66	9,814	5.54%
					68.75%	31.25%		-185	9,759	5.54%
					68.75%	25.00%	6.25%	-125	10,038	5.55%
					68.75%	18.75%	12.50%	-77	10,321	5.56%
					62.50%	31.25%	6.25%	-196	10,269	5.56%
					56.25%	43.75%		-337	10,234	5.56%
					56.25%	37.50%	6.25%	-276	10,509	5.57%
46.88%	3.13%				50.00%			8,061	7,709	4.81%
43.75%			3.13%		53.13%			7,265	8,072	4.87%
25.00%		3.13%			68.75%		3.13%	4,390	8,371	5.12%
25.00%					75.00%			4,002	7,804	5.14%
25.00%					71.88%	3.13%		3,955	7,902	5.15%
25.00%					65.63%	9.38%		3,887	8,127	5.16%
21.88%	3.13%	3.13%			68.75%		3.13%	4,364	8,588	5.13%
21.88%	3.13%				75.00%			3,985	8,028	5.15%
21.88%	3.13%				71.88%		3.13%	3,966	8,278	5.16%
21.88%	3.13%				68.75%	6.25%		3,913	8,232	5.16%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

Table A8
Solution Set After Generation Six

Asset Types*										
3 Year A Bond	5 Year A Bond	7 Year A Bond	10 Year A Bond	10 Year BB Bond	5 Year Comm Mortgage	7 Year Comm Mortgage	10 Year Comm Mortgage	E[PVDE]	STD[PVDE]	Initial Credited Rate
21.88%	3.13%				65.63%	9.38%		3,876	8,343	5.17%
18.75%		3.13%	3.13%		71.88%		3.13%	3,663	9,027	5.19%
18.75%			3.13%	3.13%	56.25%	15.63%	3.13%	2,286	9,619	5.26%
18.75%			3.13%		78.13%			3,281	8,466	5.21%
18.75%			3.13%		75.00%		3.13%	3,265	8,720	5.22%
18.75%			3.13%		71.88%	6.25%		3,220	8,669	5.22%
		3.13%			93.75%		3.13%	459	9,266	5.46%
		3.13%			90.63%	3.13%	3.13%	462	9,362	5.47%
		3.13%			90.63%		6.25%	480	9,510	5.47%
		3.13%			84.38%	9.38%	3.13%	438	9,557	5.48%
				3.13%	68.75%	25.00%	3.13%	-852	10,147	5.56%
					96.88%	3.13%		-48	8,834	5.49%
					96.88%		3.13%	8	9,005	5.49%
					93.75%	3.13%	3.13%	-15	9,076	5.50%
					90.63%	9.38%		-32	9,020	5.50%
					90.63%	6.25%	3.13%	-8	9,169	5.50%
					87.50%	9.38%	3.13%	-9	9,265	5.51%

*No solutions involving five year BB bonds or seven year BB bonds remain after six generations

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Fuzzy Underwriting: An Application of Fuzzy Logic to Medical Underwriting

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Abstract

One of the most difficult issues in the medical underwriting of life insurance applicants is diabetes mellitus. Compiling the prognosticating parameters for diabetic applicants results in a complex system of mutually interacting factors. In addition, neither the prognosticating factors themselves nor their impact on the mortality risk is clear cut.

We show how a fuzzy inference system can be used in underwriting diabetes mellitus. A fuzzy inference system can cope with the imprecise nature of medical parameters by converting them into fuzzy sets and aggregating them

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using mathematical techniques. The fuzzy underwriting system presented goes further than previous applications of fuzzy set theory in insurance, as it is a real life application with contributions from insurance economics, insurance medicine, and computer science.

Key words and phrases: *multiple risk factors, fuzzy inference, life insurance*

1 Introduction

An important challenge in competitive life insurance markets is the accurate underwriting of prospective policyholders. Underwriting in life insurance is designed to determine and evaluate the individual mortality risk of new applicants for insurance, and for current insureds who want to increase their amount of insurance. Underwriting quantifies the potential adverse deviations from "normal" mortality and converts them to higher premiums.

The resulting risk surcharge is justified by subjective factors such as certain recreational and sport activities, professional factors such as miners vs. white collar workers, and specific medical factors. More specifically, medical underwriting is aimed at quantifying the current and future mortality and morbidity risks arising from a health impairment and determining a premium commensurate with the overall risk.

1.1 Insurance Medicine

Since the early 1900s, insurance medicine has formed the scientific basis of medical underwriting in life insurance (Florschütz, 1914). It has established the life-shortening of many medical conditions including obesity and hypertensive diseases. No other medical discipline is involved with prognostic evaluations that span such long periods of time. Long-term prognosis is the most important feature distinguishing insurance medicine from other fields of medicine (Deutsch, 1938). Though this long-term approach is necessary because of the long-term nature of life insurance policies, it may adversely affect the accuracy of estimating a particular individual's life expectancy. Few other scientific studies of human mortality, however, are designed to encompass decades.

The established selection criteria used in the insurance business are riddled with flaws. For example, the mortality and morbidity rates determined decades ago are not applicable today.[1] During the years between the application for a policy and its payout of the benefit, medical advances may significantly influence any predictions. Moreover, the problem is exacerbated by the fact that insurers rarely can identify whether death can be attributed to the disease for which the risk surcharge was once levied. Because of these weaknesses, insurance medicine has increasingly oriented its prognoses on studies developed using mathematical and statistical methods (Lew and Gajewski, 1990).

The disease-related prognostic findings are compiled in manuals for reinsurance companies and provided to direct insurance companies. It is the job of the underwriter to document the individual diseases of an applicant and allocate them to a specific risk surcharge as defined by the manuals. The problem with this task is that the information available on a specific disease is usually not adequate for it to be accurately assigned to a defined group with a known prognosis.

The basic problem can be illustrated with the diagnosis of chest pain. This vague diagnosis applies to a large group. The sole risk surcharge for a mention of the disease would be low, but it is unjustified for most members of the affected group. If chest pain were subclassified further as anterior myocardial infarction with moderate impairment of heart pumping action, this diagnosis would apply to only a small portion of the overall group. Hence, most of the applicants would be accepted with a normal premium; the few with the anterior myocardial infarction diagnosis would be rejected.

1.2 Common Problems in Underwriting

When the quality of information is poor, it is difficult to accurately allocate diseases to rating classes. Obtaining detailed information creates a delay in processing time and an increase in costs. The costs are imposing, when one considers the German experience: only 0.5 percent to 1.0 percent of all life insurance applications are rejected, 2.0 percent to 5.0 percent are accepted with a risk surcharge, and the 94 percent to 97 percent are accepted at the normal premium.[2] To achieve this result (and depending on the insurance company), 15 percent to 25 percent of all applicants are assessed in the underwriting department for extra mortality risks. Most underwriting is superfluous, i.e. the risk is under-

[1] An example is the Medical Impairment Ratings from 1932, edited by the Actuarial Society of America and Association of Life Insurance Medical Directors.

[2] The German experiences are compiled by the Federation of the German Life Insurers, (Verband der Lebensversicherungsunternehmen E.V., Verbandrundschreiben Nr. 31, 1992).

written and the policy issued without any surcharge levied. To reduce this superfluous underwriting, many German insurance companies are developing and installing computer-assisted underwriting systems (Ueberscher et al., 1996).

A problem of quality also exists, a problem that has not been tackled by computer-assisted expert systems. Table 1 shows the distribution of diseases for applicants for life insurance in Germany. Whereas some of the anomalies listed in Table 1 (such as hypertension and obesity) can be assessed automatically during application processing at the insurance company, other medical problems are too complex for immediate assessment. One disease that poses a key problem in underwriting is diabetes mellitus, especially when it is manifested as type I (IDDM). Diabetes mellitus usually affects persons up to 30 years of age. Onset of the disease is prior to the typical age at which most persons apply for life insurance. But the disease is characterized by a multitude of different clinical courses most of which are associated with a markedly lower life expectancy. There are unequivocal indicators for risk groups with a particularly poor prognosis. It is imperative that these indicators be surveyed and assessed within the scope of underwriting.

Table 1
Frequency of Abnormal Applications In Underwriting Life Insurance in Germany

Disease	Frequency
Hypertension	18%
Disorders of lipid metabolism (hypercholesterolemia)	15
Alcohol-related organ changes	13%
Obesity	12%
Diabetes mellitus	10%
Heart disease	10%
Asthma	6%
Other	16%

Source: Hannover Re, Karl-Wiechert-Allee 50, 30625 Hannover, Germany.

1.3 Outline of the Paper

The objective of this paper is to show how a fuzzy inference system can be used in the underwriting of an applicant with diabetes mellitus for a life insurance policy. Fuzzy inference provides mathematical tools for deriving a crisp (i.e., non-fuzzy) output from a multiple fuzzy input space. Fuzzy inference is useful in underwriting life insurance because the risk attributes of medical parameters are not "either/or" variables. An underwriting system based on fuzzy inference can cope with the imprecise nature of medical parameters by converting them into fuzzy sets and aggregating them. The fuzzy underwriting system differs from other risk assessment systems because it allows for gradual shifts in the input variables and allows for compensation between criteria.

In Section 2 we introduce a theoretical framework delineating how fuzzy inference can be used to analyze risks in general and to scrutinize multiple prognostic factors in diabetes mellitus in particular. The paper goes further than previous applications of the fuzzy set theory described in the insurance literature (see, for example, Lemaire, 1990; Cummins and Derrig, 1993; Ostaszewski, 1993; Derrig and Ostaszewski. 1995; and Young, 1996).[3] The underwriting method is one of the first computer-based fuzzy underwriting system being implemented in insurance. In addition, the paper takes an interdisciplinary approach: It integrates the theory of fuzzy inference with the principles of insurance medicine and programming techniques in computer science.

Fuzzy underwriting provides powerful tools for the risk assessment of fuzzy and multiple prognostic factors. We believe that techniques of fuzzy underwriting will become standard tools for underwriters in the future.

2 Basics of Fuzzy Set Theory and Fuzzy Inference

2.1 Identification of Fuzzy Sets Over Membership Functions

To understand what a fuzzy set is, one must first understand what a classical set is. In classical set theory, a set has a crisp (well defined) boundary. For example, in a set of real numbers A, expressed as

$$A = \{x \mid x > 10\}, \tag{1}$$

a clear boundary point exists at 10, i.e., if x is greater than 10 it belongs to set A; otherwise it does not. This membership in a classical subset A of X can also be viewed as a characteristic function μ_A from X to $\{0, 1\}$, i.e.,

---

[3]DeWit (1982) is probably the first to consider underwriting to be a potential area of application of fuzzy set theory to insurance, but his analysis is not detailed.

$$\mu_A(x) = \begin{cases} 1 & \text{iff } x \in A \text{ and } A \subseteq X \\ 0 & \text{iff } x \notin A \text{ and } A \subseteq X. \end{cases} \tag{2}$$

The definition in equation (2) implies that a classical set only allows full membership or no membership. A fuzzy set is, on the other hand, a set without a crisp (well defined) boundary. The transition from belonging to a set and not belonging to a fuzzy set is gradual and not absolute. The membership function for a fuzzy set defines how each point in the input space is mapped to a membership value between 0 and 1. As a result, an element may belong to a set with a certain degree of membership, not necessarily 0 or 1. The closer the value of $\mu_A(x)$ is to 1, the more x belongs to A. A common characterization of a fuzzy set A is

$$A = \{(x, \mu_A) \mid x \in X \text{ and } \mu_A : X \to [0,1]\}, \tag{3}$$

where x is the element of interest, μ_A is the membership function of x in the subset A, and X is the universe of discourse.

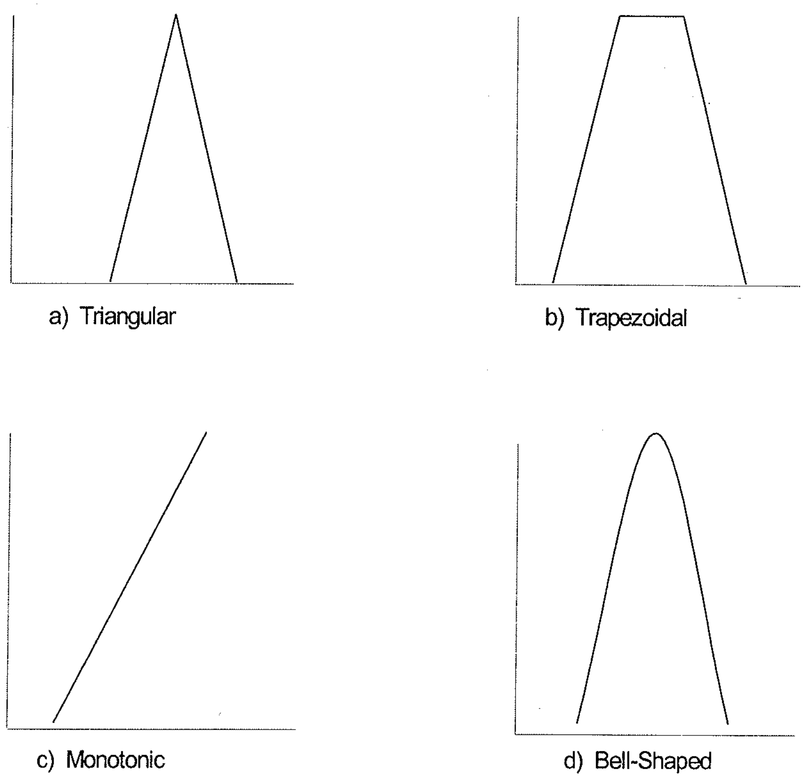
The only condition a membership function for a fuzzy set must satisfy is that it has to vary between 0 and 1. The function itself can assume an arbitrary shape and is defined from the point of view of simplicity, convenience, and efficiency. Most common are monotonic, triangular, trapezoidal, and bell-shaped membership functions; see Figure 1.

Due to their simplicity, both triangular and trapezoidal membership functions are used extensively. As the membership functions are composed of straight lines, however, they are not smooth at the transition points. The Gaussian and the generalized bell-shaped membership functions are smooth and nonzero at all points and are appropriate in cases where crisp transition points are misleading. To specify asymmetrical membership functions, the monotonic or sigmoidal membership functions can be used. An asymmetrical membership function is appropriate for expressing concepts that gradually increase or decrease, such as height or weight.[4]

As the membership function is the essential component of a fuzzy set, it is logical to define operations with fuzzy sets by membership functions. Analogous to ordinary set operations, Zadeh (1965) defines extended operations valid on fuzzy sets. The most important connections of verbal fuzzy expressions are the logical operations *and* and *or*.

[4] The assignment of membership function to the collection of objects X is subjective. Therefore, there must be a rationale behind useful applications. Often the justification of an assignment relies on common sense, expertise, empirical knowledge, and so on. In the fuzzy underwriting system, a medical expert has assigned membership functions to corresponding fuzzy sets.

Figure 1
Membership Functions



Consider the fuzzy subsets A and B of the universal set X. In fuzzy set theory, *and* and *or* operations are defined with respect to the operators $\wedge$ and $\vee$ respectively as follows:

$$\mu_{A\cap B}(x) = \mu_A(x) \wedge \mu_B(x) = \min\{\mu_A(x), \mu_B(x)\} \quad (4)$$

$$\mu_{A\cup B}(x) = \mu_A(x) \vee \mu_B(x) = \max\{\mu_A(x), \mu_B(x)\}. \quad (5)$$

The intersection of A and B refers to the largest fuzzy set that is contained in both A and B. Analogously, the union of A and B refers to the smallest fuzzy set containing both A and B.

The *max* and *min* operators have the disadvantage that the resulting membership value cannot assume a value between the maximal and minimal value, i.e., extreme valuations cannot be offset by moderate ones. The *max* and *min* operators consider only one of the two membership functions. There are other operators with qualities for union and intersection that are different than those of *max* and *min*. These operators vary in their generality and justification of the connections to which they refer. Connectives consistent with the definitions for fuzzy *and* and fuzzy *or* have been proposed in the literature under the names T-norm and T-conorm operators, respectively (Dubois and Prade, 1980, p. 11). By following the basic requirements according to T-norms and T-conorms, the *and/or* operators can be customized as desired. As it is beyond the scope of this paper to investigate T-norm and T-conorm, we refer the interested reader to Zimmermann (1991, pp. 28–43), in Böhme (1993, pp. 43–65), and in Klir and Yuan (1995, pp. 50–93).

2.2 Fuzzy Inference Rules By Generalized Modus Ponens

2.2.1 If-Then Rules

The basic rule of inference is *modus ponens.*[5] Using an "if-then" rule and a premise, one can investigate the truth of a conclusion. Consider the following example:

$$\begin{aligned} \text{Rule}: &\quad \text{if } x \in A \text{ then } y \in B \\ \text{Premise}: &\quad x \in A \\ \text{Conclusion}: &\quad y \in B. \end{aligned}$$

In this case of binary logic, the "if-then" rules are easy to follow. If the premise is true, then the conclusion is true. We normally employ the modus ponens in an approximate manner. The premise does not correspond exactly with the antecedent in the "if-then" rule. To allow for statements that are characterized by fuzzy sets, the modus ponens must be extended for gradual numerical values.

Assume A and B are defined as fuzzy sets on the universes X and Y, respectively, i.e., $A = \{(x, \mu_A) \mid x \in X\}$ and $B = \{(y, \mu_B) \mid y \in Y\}$. Now the modus ponens can be generalized as follows (Mizumoto and Zimmerman, 1982):

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[5] *Modus ponens* means "demarcation inference" and belongs to the set of inference rules in the syllogism

$$\begin{aligned} \text{Rule :} &\quad \text{if } x \in A \text{ then } y \in B \\ \text{Premise :} &\quad x \in A' \\ \text{Conclusion :} &\quad y \in B' \end{aligned}$$

where A' is a fuzzy set.[6] The logic of this fuzzy example should be clear. If the premise is true to some degree of membership, then the conclusion is also true to that same degree. In order to perform this generalized modus ponens, Zadeh (1973) proposes inference methods based on fuzzy logic. In essence, fuzzy inference is based on two concepts: a fuzzy implication (or fuzzy rule) and a composition rule of inference.

The fuzzy rule "if $x \in A$ then $y \in B$" expresses a relation between the objects A and B. Without any loss of generality, we can define the fuzzy "if-then" rule as a binary fuzzy relation; a fuzzy rule is defined as the relation between the antecedent and the conclusion. For this purpose, let R_{xy} denote a fuzzy relation on the product space $X \times Y$, then the fuzzy rule "if $x \in A$ then $y \in B$" is specified by the following membership function:

$$\mu_{R_{xy}}(x, y) = \mu_{A \times B}(x, y) = \mu_A(x) \wedge \mu_B(y) \qquad (6)$$

where $\wedge$ refers to the intersection operator defined in equation (4) as the minimum connective.[7] We can complete the inference method of the generalized modus ponens by applying the compositional rule of inference (Zadeh, 1973).

2.2.2 Compositional Rule

Next we define the compositional rule on inference to be based on *max min* composition. Let A, A', and B be fuzzy sets in the universes X, X, and Y, respectively. Further, let R_{xy} represent the fuzzy relation "if $x \in A$ then $y \in B$". Therefore, we express the generalized modus ponens as

$$\begin{aligned} \mu_{R_{xy}}(x, y) &= \vee_{x \in A'} \{\mu_{A'}(x) \wedge \mu_{R_{xy}}(x, y)\} \\ &= \max_{x \in A'} \min\{\mu_{A'}(x), \mu_{R_{xy}}(x, y)\}. \end{aligned} \qquad (7)$$

[6] Throughout this paper, the prime notation is used to signify that the set is a fuzzy set. Thus A' is a fuzzy set, *not* the complement of A.

[7] The binary fuzzy rule "if $x \in A$ then $y \in B$" can be interpreted as A is coupled with B. This rule is an extension of the classical Cartesian product, where each element $(x, y) \in X \times Y$ is identified with a membership grade denoted by $\mu_{R_{xy}}(x, y)$.

By applying this inference procedure we assign the conclusion a degree of membership from the intersection of the premise and the fuzzy relation. Remember that *max* and *min* are just two of many other composition operators. It is possible to introduce other connectives: for example, an algebraic product or more generally T-norms as *and* operators; and an algebraic sum or more generally T-conorm operators as *or* operators.[8]

As a general form of fuzzy inference, consider n multiple rules with multiple antecedents combined with "else":

Rule 1:	if $x \in A_1$ or $y \in B_1$, then $z \in C_1$ else
Rule 2:	if $x \in A_2$ or $y \in B_2$, then $z \in C_2$ else
$\vdots$	$\vdots$
Rule n:	if $x \in A_n$ or $y \in B_n$, then $z \in C_n$
Premise:	$x \in A^{'}$ and $y \in B^{'}$
Conclusion:	$z \in C^{'}$

When dealing with multiple rules we are faced with a problem: more than one rule can fire (take effect) simultaneously. To decide which consequence should be taken as the result of the simultaneous firing of several rules, we apply the process of conflict resolution (Berenji, 1992).

If A and B are the premise part, i.e., the inputs in a fuzzy inference system, then their corresponding membership functions are represented by $\mu_{A_i}(x)$ and $\mu_{B_i}(y)$ for the i-th rule $i = 1, 2, \ldots$. The firing strength, α_i, of the i-th rule can be calculated by

$$\alpha_i = \mu_{A_i}(x) \wedge \mu_{B_i}(y). \tag{8}$$

The α_i expresses the matching strength of the antecedents for each rule. By applying this strength on respective conclusions, we obtain the inferred fuzzy sets for each rule,

$$\mu_{C_i^{'}}(z) = \alpha_i \wedge \mu_{C_i}(z). \tag{9}$$

As a result of the inputs $A^{'}$ and $B^{'}$, the inference of Rule 1 generates the conclusion $\mu_{C_1^{'}}(z)$, Rule 2 generates $\mu_{C_2^{'}}(z)$, and so on. Thus, each

[8]When a fuzzy rule takes the form "if $x \in A$ or $y \in B$ then $z \in C$," the degree of fulfillment of this fuzzy rule is given as the maximum degree of a match with the antecedent part.

rule suggests a different output. To resolve this dilemma, the conflict-resolution process recommends that the conclusions of respective rules be aggregated by the union operator. We can derive the aggregate output C' as

$$\begin{aligned}\mu_{C'}(z) &= [\alpha_1 \wedge \mu_{C_1}(z)] \vee [\alpha_2 \wedge \mu_{C_2}(z)] \vee \cdots \vee [\alpha_n \wedge \mu_{C_n}(z)] \\ &= \mu_{C_1'}(z) \wedge \mu_{C_2'}(z) \wedge \cdots \wedge \mu_{C_n'}(z). \end{aligned} \quad (10)$$

The connective "else" is interpreted as the logical *or*. The *or* is interpreted as the *max* operator. Hence, the final output is calculated by aggregating results from each rule using the *max* operator.

2.3 Defuzzification Strategies

The implication of equation (10) is characterized by a membership function, i.e., the output of the fuzzy inference is a fuzzy set as well. Often it is necessary to receive an output in crisp terms. Therefore, the membership function of the final output must be translated, i.e., defuzzified, a single crisp value. A *defuzzification strategy* refers to the way a crisp value is extracted from a fuzzy output set. Several defuzzification strategies have been suggested in the literature (see Jager et al., 1994, pp. 179-185). We describe the most popular method called the center of area (coa) method. This defuzzification strategy returns the center of area under the membership curve as

$$Z_{coa} = \frac{\sum_{j=1}^{q} z_j \mu_{C'}(z_j)}{\sum_{j=1}^{q} \mu_{C'}(z_j)} \quad (11)$$

where Z_{coa} is the defuzzified output, q is the number of quantification levels of the output, z_j is the amount of output at the quantification level j, and $\mu_{C'}(z_j)$ is the aggregated output membership function. This defuzzification strategy is simply a weighted average of the z_j's (similar to the expected value of probability theory). A common feature of this method and the computation of expected values is the nondiscrimination of extreme values. The center of area calculation is made on the basis of all aggregated outputs without eliminating endpoints. Other defuzzification strategies (such as mean of maximum, largest of maximum, and smallest of maximum) do not consider the parts of a fuzzy output, the membership values of which are below the maximum. Defuzzification can be performed in several arbitrary ways. Different strategies arise for specific applications. There is no accurate way to analyze them except through experimental studies.

3 A Computer-Based Fuzzy Underwriting System

We provide one description of how expert knowledge about underwriting diabetes mellitus in life insurance is processed for a fuzzy inference system. The system was developed and programmed in MS Excel 5.0 using Visual Basic. The rationale of the system relies on medical knowledge concerning the etiology of diabetes mellitus and underwriting principles in insurance economics.

3.1 Prognosticating Diabetes Mellitus

The list of prognostic parameters for diabetes mellitus is long. There are primary and secondary medical parameters, and an accurate assessment of the prognosis can be made taking into account a limited number of parameters.

Diabetes mellitus is characterized by an elevation in blood sugar values. In type I diabetes mellitus, this blood sugar elevation is caused when the pancreas secretes no insulin. Type II diabetes mellitus, which chiefly affects persons over age 30, has an underlying pathological mechanism, whereby, despite the fact that the pancreas secretes insulin, the activity is suppressed. If not treated successfully either by drugs or insulin replacement, life-threatening conditions will occur within a few days. Renal impairment occurs in type I diabetics, which often leads to kidney failure as early as 10 years to 20 years after onset. In general, the blood vessels in diabetics are damaged; heart attack, stroke, and neural and eye impairment are common complications (Mehnert et al., 1994, pp. 76–78). The prognosis in diabetes mellitus can be based on three primary factors (Rossing et al., 1996, Nathan, 1993): (i) the time factor; (ii) the therapy (adjustment) factor; and (iii) the complication factor.

If complications such as kidney failure, eye disorders, or heart attack are manifest, the underwriting normally ends in rejection of the applicant. While in the past, the insurer chiefly applied the time factor when underwriting a risk, new medical research increasingly has shown the importance of the therapy factor. The time factor ultimately reveals that the insurance company is only willing to accept an application for life insurance with a risk surcharge if the duration of the diabetes plus the applied term insurance do not exceed a specified period of time. In such a case, staggered risk surcharges are assigned for a period of 15 years to 35 years. Numerous case studies have shown, however, that the better the diabetes mellitus can be treated with insulin so that blood sugar levels approximate the level and course of a healthy person, the lower the organ-related complication rate will be. These special forms of therapy cannot be given to every diabetic. Underwriting thus consists of evaluating as accurately as possible the quality of this therapy in terms of the adjustment parameters and excluding any possible complications by achieving a high quality of information (Mehnert et al. 1994, pp. 93, 131).

The quality of therapy can be established by current blood sugar values and the HbA1-values (glycolysated hemoglobin). The HbA1-value can be determined easily in the blood and reflects the blood sugar level over a period of around 90 days. These two parameters of insulin therapy—or other treatment strategies in type II diabetics—define the adjustment by medication or therapy efficiency.

Another important aspect to consider in patients with diabetes mellitus is that the more cardiovascular risk factors are present, the worse is the mortality risk. These factors include elevated blood lipids, high blood pressure, or smoking, These risk factors also must be reviewed within the scope of any prognostic assessment. In addition to these main parameters, several other prognostic factors are important for an adequate risk evaluation of diabetes mellitus.

Table 2 lists the prognostic factors that form the input space in our underwriting system. These prognosticating factors for diabetes mellitus result in a complex system of interdependent variables that mutually interact. All changes can be identified with regard to their effect on the overall prognosis for increased mortality. The prognosticating factors and their impact on the mortality risk is not clear cut.

3.2 Design of the Fuzzy Underwriting System

To depict the knowledge concerning the etiology of diabetes mellitus, the major areas were processed in chronological order:

1. Hierarchical structure of the prognosticating variables;
2. Membership functions of the terms of the prognosticating variables; then
3. Rule base.

Table 2
Prognostic Factors in Diabetes Mellitus

27 Factors
Age of the patient
Age at onset of the disease
Duration of the disease
Type I or type II diabetes
Quality of the therapy (with medication)
Blood sugar level
Blood sugar profile
HbA1
Fructose amine concentration in the blood
Sugar detected in the urine
Compliance with dietary recommendations
Compliance in taking medicine
Insulin dose
Frequency of daily blood sugar checks
Intensified insulin therapy
Intercurrent complications in diabetes
Myocardial infarction
Coronary heart disease
Peripheral vascular disease
Eye disorders
Renal function
Blood pressure
Body weight
Frequency of hospitalization because of coma
Extent of blood sugar fluctuations
Profession
Education

Sources: Rossing et al. (1996), Borch-Johnson (1987), Panzram (1987), Nathan (1993).

First, the three primary factors attributed to diabetes mellitus (therapy factor, time factor, and complication factor) are subdivided into influencing factors on the subordinate level. This process of hierarchical top-down classification was repeated until input factors were present on the first level that either

- showed a continuous dimension (e.g., blood sugar level in milligrams per deciliter) or if such a dimension were lacking; or were
- subject to discrete evaluation by the medical expert (e.g., classification of vascular complications into minor, moderate, marked, or severe).

If a continuous dimension exists, the medical expert determines the values for which terms of language have no membership, i.e., the membership equals 0, and those have complete membership, i.e., the membership equals 1. A linear course of the membership function was defined between the mathematical items for no membership and complete membership defined in this way. If a discrete natural dimension existed for a variable, only complete membership values relating to one of the terms of the linguistic variables could be present. For example, retinopathy can only be present in either stage 1, 2, 3, or 4. In this way, the structure of the fuzzy inference system and all the system's elements are defined.

The next step is connecting these membership values according to a given structure. For this purpose, the expert is required to define rule sets $\{R_1, R_2, \ldots, R_n\}$ for all allocations within the fuzzy inference system.[9] The rule sets must account for all possible combinations from the terms of subordinate variables. For example, the variable "blood sugar level" and "HbA1-value" are defined by five terms each; in other words, 25 rules must be defined.

Each of the individual rules consisted of an antecedent and a conclusion. The antecedent includes the terms of the subordinate variables

[9] The expert knowledge is often referred to as a knowledge base of a fuzzy inference system. Most often the knowledge base also contains a set of rules that specifies the output as a function of a fuzzy input space. In general, there are four methods of rule generation (Sugeno, 1985):

i) Experience and knowledge of an expert;

ii) Modeling the operator's control actions;

iii) Qualitative modeling of a system; and

iv) Self-organization.

The first method is the most widely used, and it is the rule base used in this application. For a review of the other methods, see Sugeno (1985) or Klir and Yuan (1995, pp. 327–356).

and the conclusion includes the terms of the superior variable. In general, a rule takes of the form of: "If {*variable 1*} is {*term set 1*} and {*variable 2*} is {*term set 2*}, then {*consequence 1*} is {*term set 3*}".

An example of a rule is: If the *blood sugar level* is *very low* and the *HbA1-value* is *normal*, then the *blood sugar profile* is to be rated as *medium*. The structure of the total system is illustrated in Figure 2. On the left in Figure 2 we see the final output: the risk-adjusted premium. The lower risk factors extra mortality and age represent actuarial factors to calculate the extra premium for substandard risks. While age is an original input factor, extra mortality is inferred by the three primary factors attributed to diabetes mellitus: therapy factor, complication factor, and time factor. All other medical risk factors are regarded as fuzzy subfactors. To explain the whole fuzzy inference system would not make any sense in this limited space. We make, therefore, an arbitrary demarcation in the presentation and consider only how the therapy factor is inferred.

3.3 Inferring the Therapy Factor

From Figure 2, we see that the therapy factor is inferred by three original input factors (blood sugar value, HbA1-value, and insulin injections) connected in two places. Let us show in more detail how the therapy factor is determined by considering an applicant who has the profile described in Table 3.

Table 3
Applicant Profile

Factors	Level
Blood sugar value	130 mg/dl
HbA1	13.5%
Insulin injections	10 per week

Figure 3 demonstrates how blood sugar value, HbA1, and number of insulin injections are allocated to the terms of the variables (in other words, how the inputs are fuzzified). The blood sugar value of 130 mg/dl has the membership values 0.67 as normal and 0.33 as high. No other terms fire for 130 mg/dl. The HbA1-value of 13.5 percentage has the membership values 0.75 as high and 0.25 as very high. The number of 10 insulin injections per week has the membership values 0.57 as low and 0.43 as medium.

Figure 2
A Fuzzy Inference System for Underwriting Diabetes Mellitus

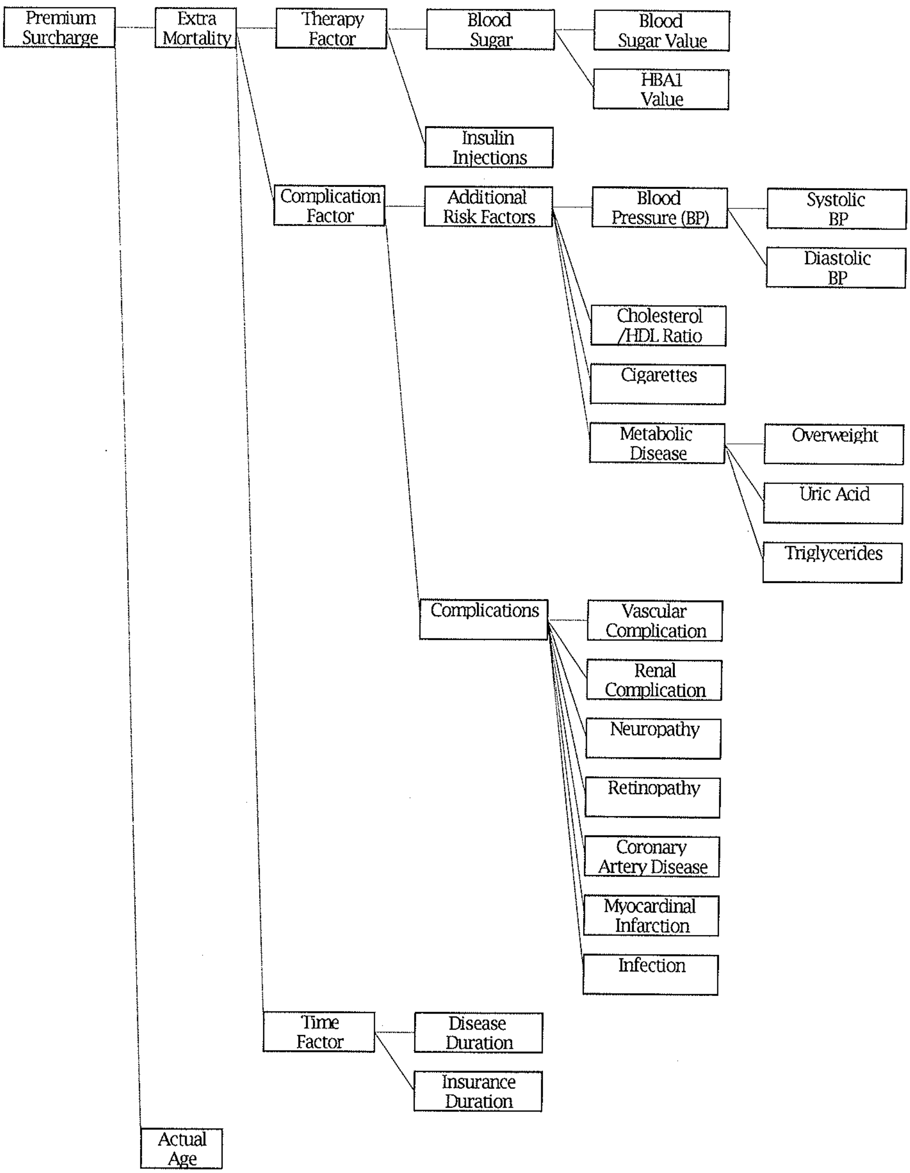
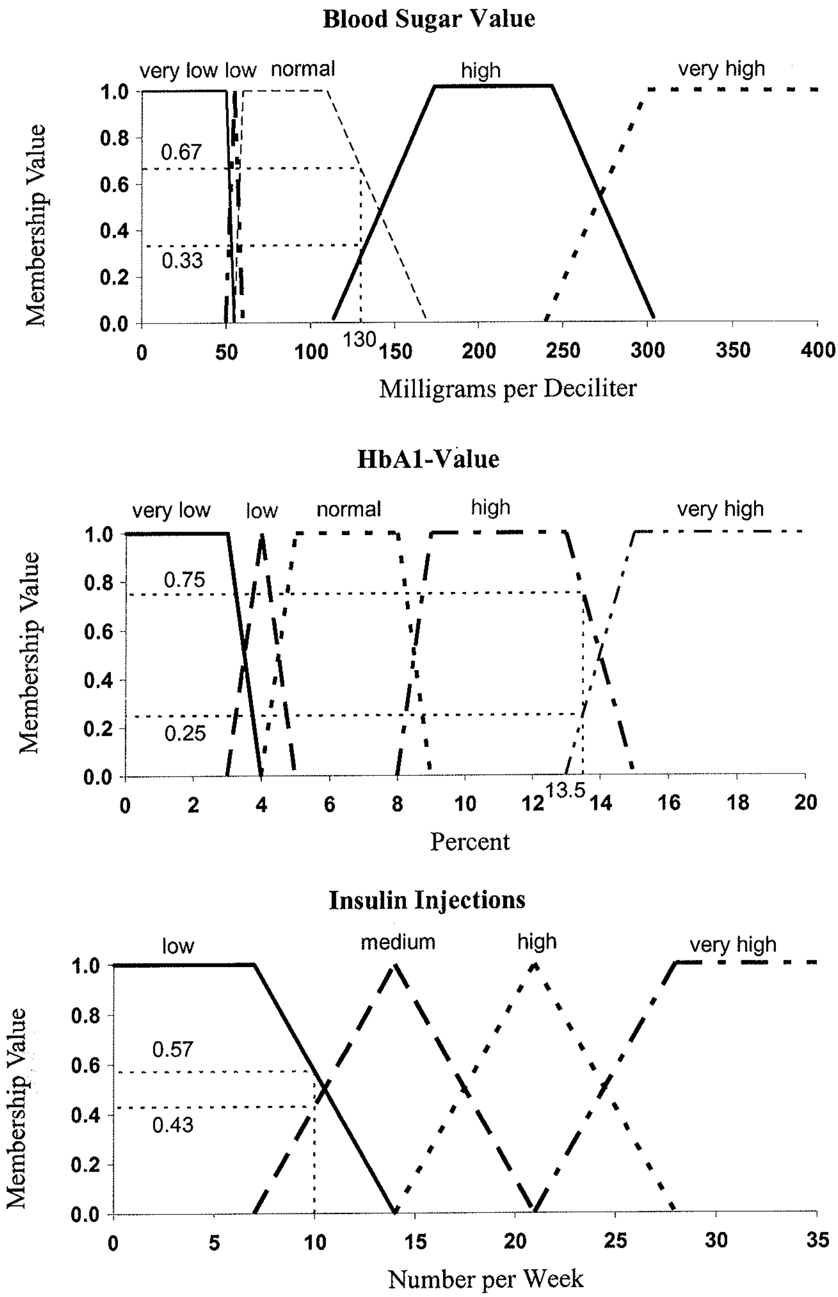


Figure 3
A Pictorial Representation of the Inference Rules



In inferring the therapy factor, we must make two inferences. The first inference is to connect the blood sugar value with the HbA1-value and thereby infer the blood sugar profile. In the second inference, we connect blood sugar profile and insulin injections. This yields the therapy factor, which in turn has to be defuzzified into a premium surcharge. These two inference steps are illustrated in Figure 4.

The rule sets of inference 1 and inference 2 are given in Tables 4 and 5. In our example, we only consider rules that have positive membership values. In rules in which at least one term in the antecedent has a membership value of zero, then a membership of zero results for the conclusion. These rules have no effect on the further processing of information and, therefore, are not represented by numerals in the rule sets.

The operators in the rule base are defined to be the *max* and *min* functions, respectively, similar to the inference system proposed by Mamdami (1976). Such an inference method is called *max-min* inference, because the membership function of the aggregated output is the union (*max*) of the fuzzy sets assigned to that output after cutting their degree of membership values at the degree for the corresponding antecedents by the intersection *min* operator.

After the inference of blood sugar profile and insulin injections we receive the inferred output therapy factor. The last step is to translate, or defuzzify, the therapy factor into a crisp premium surcharge. In Figure 4, we see that the firing strength of the medium premium surcharge rule is 0.57 and 0.25 for the high premium surcharge rule, which means that the membership functions of the medium premium surcharge and high premium surcharge are cut at 0.57 and 0.25, respectively. This is illustrated in Panel B in Figure 5. Thereafter, a total function is produced from both firing rules.

From the resulting fuzzy output set (Panel C in Figure 5) we use the center of area method defined in equation (11) to extract a crisp premium surcharge. This applicant must pay a premium surcharge of 207 percent on top of the class rate. The underwriting is now complete, and the gradual risk of diabetes has been translated into a premium surcharge using fuzzy set theory and fuzzy inference. Allowing for gradual shifts in the input space makes this system flexible and gives a better mapping of individual risk profiles than classical expert systems.

Figure 4
Inferring the Therapy Factor

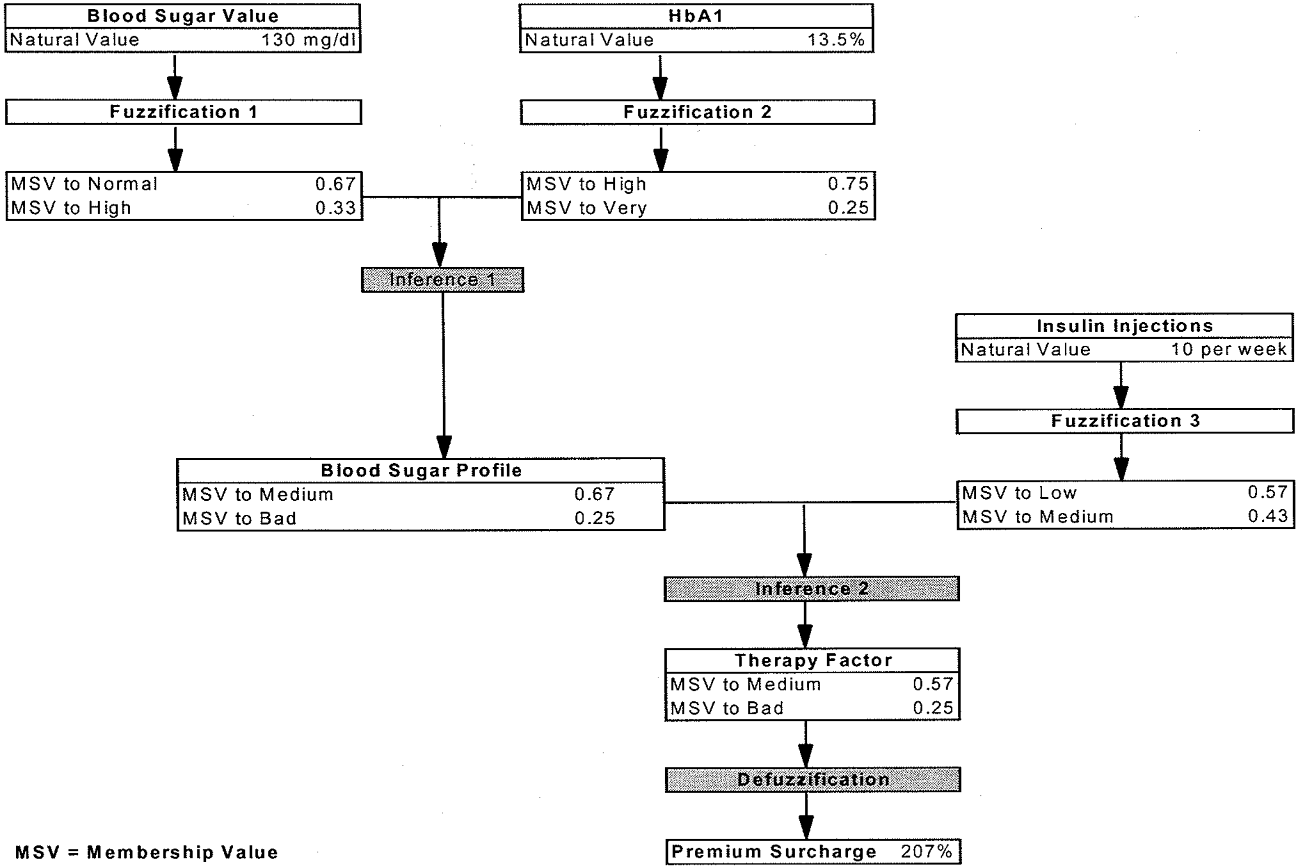


Table 4
Fuzzy Inference of Blood Sugar Values and HbA1

	Antecedents				Conclusions	
Rule	BSV	MV	HBA1	MV	BSP	MV
1	very low		very low		bad	
2	low		very low		bad	
3	normal		very low		bad	
4	high		very low		bad	
5	very high		very low		bad	
6	very low		low		medium	
7	low		low		medium	
8	normal		low		medium	
9	high		low		medium	
10	very high		low		medium	
11	very low		normal		medium	
12	low		normal		normal	
13	normal		normal		normal	
14	high		normal		normal	
15	very high		normal		medium	
16	very low		high		medium	
17	low		high		medium	
18	normal	0.67	high	0.75	medium	0.67
19	high	0.33	high	0.75	medium	0.33
20	very high		high		medium	
21	very low		very high		bad	
22	low		very high		bad	
23	normal	0.67	very high	0.25	bad	0.25
24	high	0.33	very high	0.25	bad	0.25
25	very high		very high		bad	

BSV = Blood Sugar Value; BSP = Blood Sugar Profile; and MV = Membership Value.

4 Summary and Concluding Remarks

We introduce a new inference technique, called fuzzy inference, for underwriting in life insurance. Fuzzy inference systems are well suited for compiling medical facts and can help underwriters cope with the complexity of prognostic decision making. Fuzzy logic presents medical information more realistically than do the classical methods. Medical practice has had to rely on auxiliary constructions for prognostic parameters by forming intervals of demarcation to increase practicability. These intervals in effect convert continuous functions into discontinuous ones.

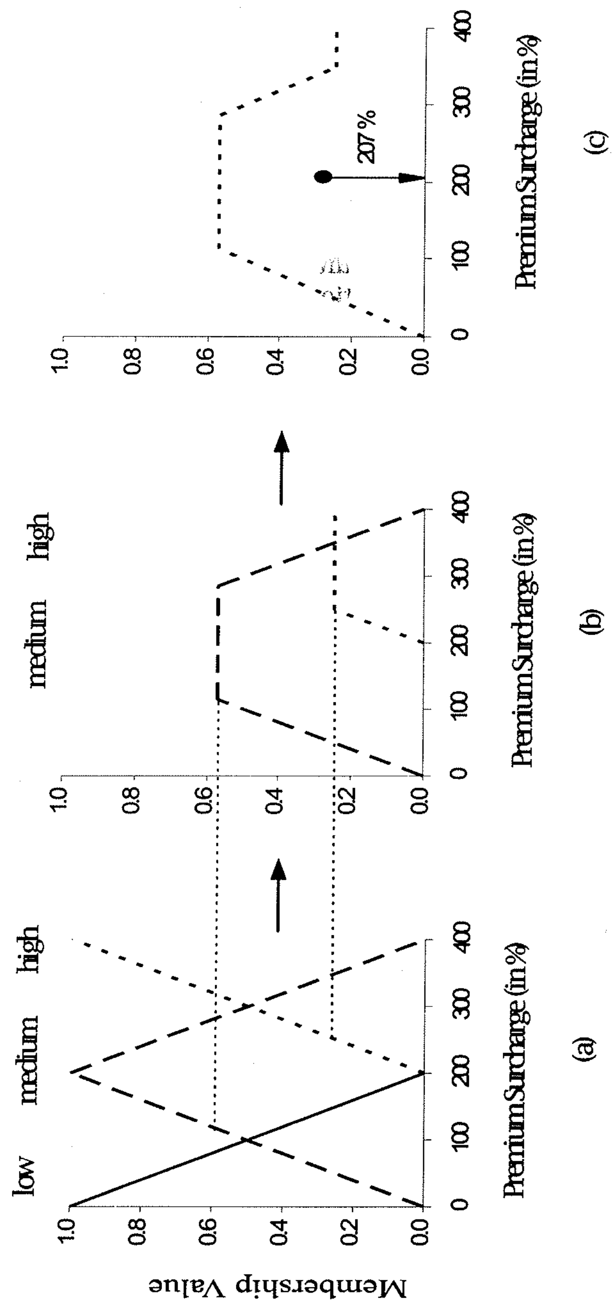
Table 5
Inference of Blood Sugar Profile and Insulin Injections

	Antecedents				Conclusions	
Rule	BSP	MV	INIJ	MV	THEF	MV
1	normal		low		good	
2	normal		medium		good	
3	normal		high		good	
4	normal		very high		good	
5	medium	0.67	low	0.57	medium	0.57
6	medium	0.67	medium	0.43	medium	0.43
7	medium		high		good	
8	medium		very high		good	
9	bad	0.25	low	0.57	bad	0.25
10	bad	0.25	medium	0.43	bad	0.25
11	bad		high		medium	
12	bad		very high		medium	

BSP = Blood Sugar Profile; INIJ = Insulin Injections; THEF = Therapy Factor; and MV = Membership Value.

Another feature of medical descriptions is their fuzziness. It is easy to reach a consensus among physicians that a disease or a symptom is mild, moderate, or severe. A quantitative expression of these fuzzy terms is not normal practice in medicine, but is necessary to be able to make precise prognostic statements. Fuzzy inference systems provide an excellent approach to reaching such solutions.

Figure 5
Defuzzification of the Aggregated Premium Surcharge



The fuzzy underwriting system presented here has been used in practical applications. It shows that the fuzzy language of physicians combined with fuzzy prognostic parameters can be expressed as fuzzy inference rules and, thus, be implemented as crisp decisions. Using fuzzy underwriting, more prognostic factors can be taken into account than are currently possible in underwriting practices of direct insurance companies. The prognosis of disease is generally not determined by one factor alone, but by a combination of factors.

Even in the early versions of the fuzzy underwriting system, practical cases from everyday insurance could be used to show that correct decisions are possible in about 80 percent of all cases. The remaining 20 percent does not result from weakness of the system, but from deficiencies in the information available. The PC-supported system presented also makes decisions when the information available is sparse. Such decisions are naturally less reliable. Prognosis structures can be constructed for many diseases analogously to our example of diabetes mellitus. Fuzzy inference systems can be devised for most diseases. For direct insurance companies, such fuzzy systems would make decision-making process more precise, more transparent, and more free of the subjective errors that have hindered accurate underwriting assessments in the past.

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Accelerated Death Benefits, Viatical Settlements, and Viatical Loans: Options for the Terminally Ill

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Abstract†

There are three options available for terminally ill insureds who are interested in accessing all or part of the face value of their life insurance policies: through the life insurance company (accelerated death benefits), through a viatical company (a viatical settlement), or through a viatical loan company (a viatical loan). This paper explores the definitions and tax regulations, calculations, and the claims process associated with accelerated death benefits and viatical settlements and loans.

Key words and phrases: *life expectancy, claims, taxes, regulations*

1 Introduction

For a person diagnosed with a terminal illness, there are few monetary options available to pay the expenses needed to sustain his or her life. Medical insurance may only cover expenses up to a limit, and their savings and/or possessions may not be enough to cover bills. For the insured terminally ill, however, there are often three other options: accelerated death benefits, viatical settlements, or viatical loans.

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Accelerated death benefits are benefits offered by life insurance companies to terminally ill insureds. The proceeds from an acceleration result from a recalculation of the insured's life expectancy due to the terminal illness and can be excluded from the owner's personal gross income under current tax law. The proceeds consist of a fraction (typically 50 percent, but can vary from 25 percent to 100 percent depending on the company) of the policy's face value, the remainder being paid at the time of death. There is sometimes a waiver of premiums during the period the insured is expected to die. If the insured survives the period, there may be a resumption of premiums. Whether the premium needs to be resumed is company specific and is stated in the policy or rider form that contains the accelerated benefit provision.

The risk insurance companies take when they fund accelerated death benefits differs from the risk insurance companies assume at the sale of a life insurance policy. There is minimal adverse mortality risk involved in accelerated death benefits, if the physician's diagnosis is correct, given the likelihood of death occurring in the near future. Thus, the risk assumed is primarily an investment risk.

A *viatical settlement* is one in which the owner of a life insurance policy sells the policy to a viatical company for an amount less than the face amount. The amount paid is directly related to the amount of time the insured is expected to live, i.e., the longer the life expectancy, the less the amount paid. The viatical company in turn pays the remaining premiums needed to keep the policy in force.

If the person lives longer than expected, viatical settlement companies will suffer a decrease in their investment return. Thus, viaticals risk losing some of their profit. If they are highly leveraged, this could be a large percent of that profit.

A *viatical loan* involves a policyowner giving collateral assignment of his or her life insurance policy to a viatical loan company. The loan is then repaid in full at the time of death of the insured. The premiums are paid by the viatical loan company and are subtracted from the viatical loan amount in the initial computation. Often, a viatical loan allows the policyowner to receive more of the death benefit than an accelerated death benefit or viatical settlement. At the death of the insured, the balance of the death benefit is paid to beneficiaries.

The benefit covered in this paper is the terminal illness-triggered benefit. To be eligible for this benefit, a physician must certify that death is imminent within a specified time period. This time period is usually six months to a year, though 24 months is the requirement in the Internal Revenue Code for a benefit to be treated in a manner similar to life insurance proceeds. Therefore, a terminal illness-triggered benefit is any payment made from a life insurance policy while the insured is alive that results from recalculating the insured's life expectancy due to the terminal illness.

2 Life Insurance Companies

2.1 The Calculation of Accelerated Death Benefits

There are two common methods used to calculate accelerated death benefits: discounting the face value (less any outstanding policy loans) of the policy or by taking a lien against the policy. Other methods are used, but they are not as acceptable to most life insurance companies.

The discounting method requires the face value of the policy to be discounted by a factor related to current market rates (e.g., the U.S. Treasury bill rate) and the length of the acceleration period. The amount paid is subtracted from the face amount of the policy, which results in a lower remaining death benefit. In some cases, companies waive the premium during acceleration. Some life insurance companies charge an administrative fee to cover the expenses of processing the acceleration. Typical fees range from $100 to $300.

A simple example of discounting an accelerated death benefit follows. Assume a policy with a $100,000 face amount, a 60 percent acceleration benefit, no loans, a company-implemented administrative fee of $200, and a Treasury bill rate of 8 percent. The insured is assumed to have a year to live. The amount to cover the interest on the accelerated portion is:

$$\$60,000 - (\$60,000/1.08) = \$4,444.44.$$

Therefore the accelerated payment is:

$$\$60,000 - \$200 - \$4,444.44 = \$55,355.56.$$

The policy would remain in force with a $40,000 death benefit.

In the lien method, the accelerated benefit is treated as a loan secured by the policy. Once death occurs, the loan is reimbursed with interest from the entire death benefit. The difference between the lien method and a straight policy loan is that for the lien method, advances can exceed the contract's cash value. With a loan, however, the policyowner only is able to obtain an amount not higher than the cash value of the policy.

Let us now look at a lien method example using the same scenario as for discounting, with the exception that the 8 percent Treasury bill rate is assumed to be the loan rate and there is a $200 administrative fee. The policyowner would be loaned $59,800 ($60,000 - $200) now. The death benefit remaining, assumed to be paid in one year's time, would be:

$$\$100,000 - (\$60,000 * 1.08) = \$35,200.$$

The difference between the total payments for the two methods is minimal (less than $400). With the discounting method a payment of $55,355.56 could be received now and $40,000 at death. The total payment would be $95,355.56. The lien method offers $59,800 now and $35,200 at death, a total of $95,000. The final deciding factors depend upon the options available from the individual's insurance company. Some companies only offer one of the options. The policyowner also must decide if he or she would benefit from more money at acceleration or at death. These decisions vary for each individual.

2.2 Regulations and Tax Treatment of Life Insurance Proceeds

When an accelerated death benefit is paid to a policyowner, the insurance company must send a statement illustrating the effect of the benefit on the face amount of the policy, the specified amount of the benefit, the accumulation account, the cash value, any loan balance, and what the future premiums (if any) will be (Adam, 1990).

The National Association of Insurance Commissioners (NAIC) formulated model insurance regulations to serve as a guide to accelerated death benefits. A disclosure required by the NAIC guideline[1] is a brief description of the benefit and definitions of the conditions or occurrences that triggered the benefit payment. No further conditions may be placed on the payment of accelerated benefits other than those specified initially in the policy or rider.

Benefit payment options also are covered in the NAIC 1996 guideline. The insured has the option of receiving the accelerated benefit in a lump sum, in periodic payments for a fixed time, or in a fixed amount for an indefinite period of time. Some companies require that the accelerated benefit be taken as a lump sum, but most accommodate policyholder wishes. To receive the accelerated death benefit, the owner often is required by the insurance company to surrender all or part of his or her policyholder rights (Cruise, 1994).

[1]NAIC guidelines can be obtained by writing to the NAIC at: NAIC, 120 West 12th Street, Suite 1100, Kansas City MO 64105-1925, USA.

The introduction of accelerated death benefits in early 1990 resulted in the general public and some insurance companies being concerned about tax uncertainties and terminology. To alleviate these concerns, the Internal Revenue Service (IRS) and the NAIC established tax regulations and model insurance regulations, respectively. On August 21, 1996, President Clinton signed The Health Coverage Availability and Affordability Act of 1996 (HR 3101) clarifying the tax treatment of accelerated death benefits. This act went into effect on January 1, 1997; (see Chodes, 1997). The sections of the Internal Revenue Code (IRC) that affect accelerated death benefits are Sections 72, 101, 7702, and 7702A. The regulations are being amended; more changes may occur in the future.

State-specific regulations are based upon model regulations enacted by the NAIC. The NAIC cannot force states or insurance companies to use model regulations. Because the NAIC is composed of each state's respective insurance commissioner, though, most states have adopted the regulations.

Once the states accept regulations, insurance companies must comply and alter their policies (if needed) in order to do business within each individual state. At first most states allowed accelerated death benefit recipients to be exempt from state income taxes, though recipients may still have had to pay federal taxes (Blake, 1993). Because nobody really knew if taxes were owed or not, the NAIC advised insurance companies to add a disclaimer suggesting the policyholder consult his or her tax advisor about the tax treatment of such a provision (Adam, 1990).

Under Section 7702 of the IRC, a life insurance contract is defined as any contract that is a life insurance contract under applicable law, but only if the contract meets the cash value accumulation test or meets the guideline premium requirement and falls within the cash value corridor. Whichever of these two tests a life insurance contract meets at inception also must be met after a change in the death benefit is recorded (Kraus, 1993). Therefore, a redetermination of values must occur after acceleration.

The tax treatment has always been a concern for those terminally ill and considering such benefits. Current regulations provide that accelerated benefits will be considered as death benefits under Sections 101(a) and 7702. Section 101 states that any amount of a death benefit received in a lump sum or otherwise paid by reason of death of the insured is not included in a person's gross income (Freeman and Marcus, 1993). The Health Insurance Portability and Accountability Act of 1996 redefined Section 101(g). With its passage there are now two types of accelerated death benefits (received after December 31, 1996) that are excludable from gross income. They are amounts received from a life insurance policy or from a viatical settlement company for the sale or assignment of a policy. The determining factor is that the insured is terminally or chronically ill (Wolosky, 1996). The act defines being terminally ill as having 24 months or less to live. To be classed as chronically ill, the insured is not able to perform at least two of six listed daily activities (Christopher, 1997). This paper, however, will not cover chronic illness benefits in any depth.

The definitions and regulations of the IRS and NAIC aim to clarify the treatment of accelerated benefits. Most state insurance departments have adopted similar regulations, so the alterations necessary from state to state tend to be minimal. It is most probable that the tax laws and regulations will continue to change as the insurance industry becomes more experienced in accelerated benefits. For now, the proceeds from a qualifying acceleration can be received free from personal income tax. With this clarification, the insurance industry should notice more terminally ill persons submitting claims for accelerated death benefits.

2.3 The Claims Process for Accelerated Death Benefits

The process for accelerating the payment of benefits on a life policy has many elements. Most companies require a minimum face amount to be carried on a policy, i.e., $100,000, before any claim for acceleration of the death benefit can occur. Fraudulent claims can be reduced by setting a limit to the amount of accelerated benefit a policyholder can receive. A minimum amount also may be set to avoid the relatively excessive administrative expenses in processing small claims.

Specialized claim forms are required for acceleration. These forms must be comprehensive enough to encompass all aspects of the illness and the benefit payout. In addition, these forms should include verification and certification from the insured's physician stating the date of diagnosis of the terminal illness, the extent of the insured's symptoms, the proposed treatments and their efficacy, and the expected life span of the insured. The insured also should be asked to complete a claim form to prevent fraud (Adam, 1990).

When claims are made during the contestable period, special effort must be made to determine whether the illness was present at the inception of the policy (Hitzeman, 1992). If the illness was present, it gives the insurance company a legal reason not to accelerate the death benefit. The insurer must verify that the policy is a valid contract and was issued based upon correct and accurate information before it determines whether the accelerated benefit is payable.

The medical information required by the claim forms should provide adequate data for an initial investigation for the possible contestability of the payment. If the submitted information appears to be legitimate and satisfactory to the insurance company's medical board, the claim is processed and paid (Reimers, 1994).

If the information appears to be false, an extensive investigation usually follows. Certain steps are recommended to protect insurance companies from fraud by policyholders and physicians. First, companies must verify the attending physician's credentials. The next step is to obtain treatment records from any attending physicians and hospitals. It also may be beneficial to interview the insured and/or spouse to determine the extent and severity of the illness and to rule out the possibility of self-inflicted injuries as the cause of the terminal condition. The policyholder must be asked if he or she is mentally competent and be determined as such (Hitzeman, 1992). Anything that seems suspicious should be investigated to safeguard the insurance company.

The insurance company should reserve its right to reaffirm the diagnosis of terminal illness by the company's medical doctor. Most companies also state within their rider or policy that if the insured's physician disagrees with the company's physician on the diagnosis, the company will pay a third impartial physician to perform an evaluation. Both parties should agree the third diagnosis will be the one by which the insured and the company will abide (Hitzeman, 1992).

Because claims only can be made by the policyowner, irrevocable beneficiaries and assignees can complicate the claim process. If a release cannot be obtained from either of these two, payment of the advanced benefit should be refused (Adam, 1990). In most cases the beneficiaries are close to the insured and are aware of the ramifications of acceleration. Irrevocable beneficiaries and assignees commonly play a large role in the decision to accelerate.

Companies offering such riders must be fair to all parties so they are not accused of taking advantage of the insured and the terminal condition. At the same time the company must make correct assumptions about the premiums and/or fees charged so that they do not lose money offering such a benefit. Discrimination must not exist in the underwriting and processing of different types of terminal illnesses (Adam, 1990). The insurance company also must protect the privacy of the insured.

No matter how careful and methodical an insurance company is in investigating claims, problems will arise. One problem is how to deal with an insured who recovers after receiving the accelerated death benefit. A correctly written policy should protect both parties in such an event (Adam, 1990). Some companies require an insured to resume payment of premiums on the face amount remaining after acceleration if the insured survives beyond the acceleration period (Aerts, 1994). Other companies waive the premium.

Another possible problem is an insured who commits suicide after receiving his or her accelerated death benefit. If the suicide occurs within the customary two year contestability period the policy would be terminated; beneficiaries may have to repay the advance (Adam, 1990). If suicide occurs after the contestable period beneficiaries may receive the remaining death benefit. Each company must decide its stand on suicides.

Claims practices of insurance companies are complicated by accelerated death benefits. In the past an insured died and a benefit was paid. Now an insured may have a terminal illness, and a partial benefit may be paid. Insurance companies should expect more claims in a wider variety and greater volume due to terminal conditions.

Accelerated death benefits are consumer friendly and possess a humanitarian appeal that complements traditional life insurance (Wang, 1990). This benefit promises an extra measure of financial security in the event of a catastrophic or terminal illness. Life insurance products have come to offer more while persons are alive instead of after they have died. Accelerated death benefits are one way companies are offering their policyholders additional safeguards and personal benefits. This benefit allows companies a slight marketing advantage. Accelerated benefits give the company's agents a selling point that is visible and desirable for insureds. It is seen by some agents to be a low risk, but a low reward provision.

Although some controversy surrounds accelerated death benefits, most persons familiar with the concept praise it. The benefit may be received as a lump sum, in installments, or as expenses are incurred. Payment depends upon the insurance company and its established practices. The payment can be a way for a dying person to take care of medical bills, visit family in a different part of the world, or do what he or she always has dreamed. The adverse impact of an accelerated death benefit is the decrease in the death benefit of the policy to the insured's survivors.

3 Viatical Companies

3.1 Viatical Settlements

There is a second option available to an insured whose insurance company does not offer accelerated death benefits or to an insured who wants an advance payment sooner than the insurance company offers. This option is to sell the life insurance policy to a viatical company.

A viatical settlement is a private transaction in which a policyowner sells the policy while the insured is living. The owner sells the policy to a viatical company for an amount less than the face value of the policy. Viaticals usually offer a contract under which the company is designated as the sole beneficiary of the life insurance policy. Most of these contracts are made with insureds who are terminally ill or have a catastrophic illness. Viatical companies expect to make their profits by buying life insurance policies from terminally ill insureds.

The factors that determine the purchase price (i.e., the amount of payment offered) are based on the amount of the policy's death benefit, the terminally ill insured's life expectancy, the annual premium, the type of policy, the rating of the insurance company, and the market rate available on a similar investment. Some companies may buy partial benefits in which the policyholder names a co-beneficiary who retains an interest in the death benefit.

The purchase price, however, hinges on life expectancy—the more time a person has to live, the less money the policyowner will receive (Kristof, 1991). The key is evaluating an insured's life expectancy (Barrett, 1992). The sooner the insured dies, the sooner the viatical company receives the death benefit and its profit. This may sound inhumane [some have called viatical settlements death futures (Niedzielski, 1995)], but those selling the policies see the viatical option as a chance to do something with part of the death benefit (Sing, 1990).

The policy sale process starts when the viatical company verifies the life expectancy of the insured and computes a purchase price. The owner can accept or reject the offer. If the policyowner rejects the viatical company's initial purchase price, the viatical company often returns to its investors and tries to improve its offer to one that is more acceptable to the policyowner. Viatical companies are third-party competitors in the free market. They try to offer the best possible price to policyowners (Faig, 1997).

After buying the policy, the viatical company assumes the premium payment and either becomes the sole beneficiary or a co-beneficiary of the policy. At the time of death of the insured the viatical company collects the portion of the death benefit to which it is entitled. Thus viatical companies require a large amount of upfront capital and have no immediate payoff.

3.2 Regulations and Tax Treatment of Viatical Settlement Proceeds

The viatical industry began in 1989 with three companies. Currently there are 54 viatical settlement companies operating nationwide (Connolly, 1995b). The entire viatical industry is estimated to have had a market of $400 million in policies purchased in 1994 and $500 million in 1995, with the potential to reach $6 billion within the next five years (Connolly, 1995a). As an industry they have established themselves as an organized secondary market in the life insurance arena (Faig, 1997).

A growing concern is whether state insurance departments should regulate viatical companies. Although viaticals are not insurance companies, they cross into the realm of the insurance industry. They are purchasing policies involving mortality risk. A viatical company has the option and ability to pay persons who have up to five years to live (which is the void in the insurance industry that viatical companies fill) (Stone, 1993). Only settlements based on two years or less life expectancy, however, could be received tax free.

The Health Insurance Portability and Accountability Act of 1996 now defines terminally ill as having 24 months or less to live. A stipulation in the 1996 act is that in order for a viatical settlement to be considered to be tax-free, the viatical company must be licensed by the state. If that state does not have a licensing system the viatical must pay to the policyowner at least the minimum in purchase price (see Table 1) for policies as set by the NAIC viatical model act. The regulations do allow viaticals to decide the length of life expectancy in which they will invest and if they will pay more than these minimum required prices.

The percentages in Table 1 may be reduced 5 percent for viaticating a policy written by an insurer rated less than the highest four categories by A.M. Best. This percentage reduction could be alleviated by the existence of state guarantee associations which would lessen the bankruptcy risk of the less favorably rated companies.

Though the number of persons wanting to sell their life insurance policies to viaticals is relatively low, it continues to rise each year. Limits to acceleration and the possibility for a high return mean that investors are eager to buy viator policies. Insurance regulators and insurance companies are concerned, however, that viatical companies may become a problem for the insurance industry. Moral risk has been cited

Table 1
NAIC Model Minimum Purchase Price As a Percentage of Policy Face Value

Life Expectancy Months (In Months)	Minimum Percentage
<6	80%
6–12	70%
12–18	65%
18–24	60%
24+	50%

as a major factor in the regulation of viatical companies. It has been considered by some that the viatical industry has been created by companies waiting for a financial reward that is greatly increased by the early death of an insured (Faig, 1997).

Viatical companies tend to believe they are dealing with the sale of a private asset that should not concern the NAIC. The viatical industry also was under attack by the Securities and Exchange Commission (SEC) from August 1995 until July 1996. The SEC considered viatical settlements to be securities and challenged their validity in the U.S. court system (Connolly, 1995a). The SEC wanted viaticals to register the fractionalized shares of life insurance polices they were selling to investors. Many of the viatical settlement companies disliked this because it infringed on the small investors who could only afford to purchase shares of policies and not entire ones.

The District of Columbia Court of Appeals ruled in July 1996 that viatical settlements are not securities and are not to be considered insurance policies either (Connolly, 1996). The court held that "... a viatical settlement is not an insurance policy, and the business of selling fractional interests in insurance policies is no part of the business of insurance" (Connolly, 1996). The court reasoned that profits from such viatical settlements do not come from the efforts of a party other than the investors themselves. The SEC may appeal this ruling.

The viaticals see the legislation and regulations as hindrances to their business. Regulation also may affect the selling price of policies. With increased costs due to registration fees and expenses incurred because of required compliance, the amount an insured would receive would decrease. In the end, legislation and regulations could hurt the persons regulators are trying to help.

companies, viaticals, and the general public) will lead to more stability in the accelerated benefits industry.

Medical advances will be a significant factor in the future of accelerated death benefits for many reasons. First, with further developments and enhancements of DNA and genetic testing, the diagnosis of the possibility of being stricken with a terminal illness at some point of time in the future will become more accurate. Second, the enhanced treatment of and/or cures for current diseases will reduce the severity of terminal illness. These two reasons may make the calculation of life expectancies more difficult, however, as has been the example of AIDS protease inhibitors. These inhibitors have greatly increase the life expectancy of some patients while they have not had much of an effect on others. Even though these are beneficial advances, such new-found methods may cause uncertainty among those calculating life expectancies.

Eventually, increased accuracy in calculating life expectancy and more readily available advanced treatment methods will lead to more exact accelerated death benefit payments. The final payout, however, will be based on who calculates the life expectancy, what formula is used, and who has made the final terminal diagnosis. When the final payout is made because of decisions of a handful of persons, the result can make or break a terminally ill insured and could be construed as morally unjust. Using a simple equation may allow difficult decisions to be minimized by simplistic assumptions for mortality and interest.

If the time between payout and death can be determined, the dollar investment necessary to cover the difference between the accelerated portion and the actual will be more accurately calculated. This is an advantage to all parties and would reduce the risk and profit margins. Not only can the insurance and viatical companies cover any losses while also making a profit, but insureds also should receive the best price for the policy.

The path of accelerated death benefits and viatical settlement companies will continue in the same direction, but the company field will narrow. Only those viaticals that are strong in their investment portfolios and keep up to date with medical advances will remain in the accelerated death benefit market. In the future viaticals also may buy life insurance policies from healthy but old persons.

Steven Arenson, a vice president of Viaticus, Inc., painted a picture of the current viatical market. In *Employee Benefit Plan Review* (1996) Mr. Arenson was quoted as saying, "Only 2% of the terminally ill are AIDS patients, but 95% of those early viatical settlements (mid-1980's) involved AIDS victims. Last year (1995), 23% of our viatical settlements involved cancer patients." This represents the shift in the viatical market from one almost entirely serving AIDS patients to expanding to other illnesses.

Some of the unsettled issues are:

- Whether the use of the accelerated benefit proceeds can be restricted (Pear, 1992); What happens if the insured lives longer than the stipulated length for the acceleration; and
- What effects the accelerated benefits will have on a person's eligibility for governmental assistance (Will it be considered an asset?) (*Employee Benefit Plan Review,* 1990).

Additional questions arise from beneficiaries over estate tax and estate/inheritance tax treatment of the death benefit remaining after acceleration. Because of these and other issues, some insurance companies have been waiting to initiate and introduce accelerated benefits.

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The Right to Underwrite? An Actuarial Perspective With a Difference

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Abstract

For a long time underwriting has been a part of the actuarial canon. With increasing frequency, however, challenges are being issued against the right of insurance companies to underwrite applications for new business, arguing that certain aspects of the practice are undesirably discriminatory.

We explore the role of the actuary in the underwriting process and the challenges that are being set for the profession (as opposed to the life insurance industry) as a result of this role. As the distinction between the interests of the actuarial profession and the interests of the life insurance companies has become increasingly blurred, we consider how the profession can maintain this distinction and so retain its identity as a profession worthy of public trust and respect.

Key words and phrases: *merit goods, fairness, social legitimacy, risk classification, independence, professional status*

1 Introduction

In recent years there have been several papers by actuaries commenting on the broad social debate about what the authors call the

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"right to underwrite" or the "freedom to underwrite."[1] [For example, see Leigh (1996) in the U.K. and de Ravin and Rump (1996) in Australia.] These authors see the role of actuaries as defending the insurance industry against criticism from other interest groups which Leigh (for example) disparages as "the medics, the moralists, and those who are genetically unfit" (Leigh, 1996, p. 19). In this paper we intend to address some of the same issues as these authors, but from a more independent perspective.

We do not mean to imply that life insurance companies should not seek to influence public debate on underwriting practice to protect their commercial interests. The response of life insurance companies as an industry is theirs to make. Such response may include lobbying, public relations, and sponsorship of research that the industry thinks likely to support its case. In this regard, the life insurance industry is no different from any other business group pursuing its own agenda. The issue with which we are concerned, however, is the role of the actuarial profession in the debate on underwriting practice and the need to articulate a separate, professional, actuarial perspective on the matter.

In our view the right to underwrite is not an issue that should be examined solely within our discipline or only from the perspectives of the life insurance industry. It is necessary to look at the nature of insurance and the role that it plays in society. The right to underwrite can be examined accurately only within this broad context.

This paper examines the broad issues first to establish a framework in which insurance practice can be located. We start by outlining the special features of insurance business that may lead public policy makers to impose restrictions on underwriting practices. We then examine alternative concepts of distributive justice and discuss criteria by which a risk classification scheme may be judged. After noting the limitations of the actuarial perspective on these issues, we consider the proper role of the actuarial profession in underwriting and the broader proper role of the actuarial profession in society.

[1] An earlier group of authors, Cummins et al., (1983), produced a study of risk classification in life insurance. Their study concentrated mainly on the economic, statistical, and practical aspects risk classification, and, as such, may not be germane to our discussion.

2 The Nature of Insurance

2.1 Special Features of the Insurance Industry

Insurance companies, like all businesses, operate in a social context. Within this context, however, insurance (particularly insurance of life, health, and disability risks) has a number of special features that distinguish it from other consumer services. Some of these features may lead to a perceived need for special regulation of insurance.

First, the seller of insurance insists on selecting the customers to whom it will sell and on setting different terms for different individual customers; this is not a familiar phenomenon in mass consumer markets.

Second, the cost of providing the service is not known in advance on an individual level. This leads to a fundamental tension in all insurance programs between pooling on the one hand and actuarial rating on the other. This tension between pooling and pricing means that insurance has a dual nature. Insurance is like private savings accounts in its actuarial rating features, but it is like public assistance in that payouts are made selectively to those who suffer loss.

Third, insurance is a collective, communal enterprise; it is redistributive in nature. It redirects resources toward those who suffer loss and away from those who do not. This feature distinguishes insurance both from personal savings for adverse contingencies and from other consumer services. Insurance can be made more or less redistributive, but it is fundamentally different from other products that do not involve pooling and subsequent redistribution according to need.

Fourth, insurance against certain contingencies may be an example of a *merit good* (that is, a good that society considers should be available in certain quantities to all, even to those who do not have the resources to purchase it in a market transaction).

Fifth, insurance may be a *social good* (that is, the supply of such a good generates positive externalities, so that society has an interest in ensuring that the good is supplied as widely as possible). The notion of a positive externality refers to the benefits arising from the supply of the service that accrue to persons other than those to whom the service is supplied. For example, the satisfaction and sense of well-being of the present authors may be increased by the knowledge that we live in a society in which insurance is made available to certain disadvantaged groups. (In this example, the positive externality is relatively intangible in nature, but this need not necessarily be the case.)

Sixth, insurance is unusual because in addition to competing in the usual ways for service industries—price, level of service, product differentiation, recruitment of employees and agents—the insurers also compete in risk selection. An insurer that introduces a new underwriting procedure that facilitates the exclusion of higher risks from its insurance pool gains a competitive advantage over other insurers. This selection competition does not contribute to the aggregate welfare of consumers as obviously as do other types of competition, e.g., competition to reduce expenses. It therefore can be argued that public policy should be directed toward discouraging this bad competition and promoting the good type of competition, e.g. on expense costs and level of service.

2.2 Insurance as a Merit Good

Certain types of insurance are merit goods that society considers should be available in certain quantities to all irrespective of ability to pay. The extent to which particular types of insurance are merit goods depends on the availability of alternatives to the particular insurance in meeting social needs. For example, in a jurisdiction such as the United States where access to adequate medical care is largely dependent on the purchase of private insurance, insurance disabilities may lead to broader social disabilities. In other jurisdictions such as the United Kingdom where a high standard of medical care is guaranteed by the state, it is less clear that insurance disabilities lead to social disabilities. In such a society insurance may not be a merit good; one mainstream political party in the U.K. remains ambivalent about whether it wishes to encourage or discourage private medical insurance.

Medical insurance is not the only form of insurance for which the status of the coverage as a merit good is influenced by state benefits. The existence and level of state-provided death benefit, disability cover, old age pensions, and other welfare benefits also have implications for the extent to which the state expects individuals to be able to find private insurance to meet various contingencies.

Another example where private sector insurance disabilities can create broader social disabilities is the provision of mortgage coverage or home loan business. If lenders generally require such insurance, then uninsurable members of society are effectively precluded from home ownership and its associated benefits. Some governments have recognized the need to remedy this social disability. For example, in France an agreement has been reached between the FFSA (Federation of French Insurers) and the Ministries of Trade and Health to provide loan security policies to HIV-infected individuals to reduce and limit these social disabilities.

The relevance of the above examples and the extent to which insurance can be viewed as a merit good differ from country to country. The trend in recent years in many countries away from state protection and toward private insurance, however, has tended to increase the extent to which insurance is viewed as a merit good. If private insurance continues to play an increasing role in meeting social needs, it seems likely that society's interest in the social legitimacy of risk classification variables will continue to increase.

Insurance has a number of special features that give it the characteristics of a merit good. Increasingly, this characterization has called into question the fairness and social legitimacy of insurance practices. In insurance, however, the concepts of fairness and social legitimacy are not straightforward.

3 Fairness and Social Legitimacy in Insurance

3.1 Notions of Fairness

Actuaries traditionally have argued that underwriting is justifiably unequal. This defense assumes that all forms of cross-subsidization are inherently wrong: "[I]t represents an unfair charge to one individual or group to subsidize another individual or group" (Paddon, 1990, p. 1363).

Many non-actuarial commentators take the opposite stand. They argue that, in reality, society may prefer equality to equity (or, more accurately, society may prefer equality of outcome rather than equality of assessment). Actuarial fairness may be seen as seeking to place the costs of misfortune on the unfortunate, a notion of fairness that non-actuarial commentators may regard as rather eccentric (O'Neill, 1997).

How do we decide between these views? The choice between alternative views of fairness is essentially a question of social philosophy. It is not an actuarial question, and actuarial science is of little assistance in answering the question.

Probably the most influential concept of fairness over the last 25 years has been that proposed by the Canadian philosopher John Rawls (1972). Rawls' seminal book runs more than 600 pages and has spawned an extensive literature; here we can do no more than sketch the central concepts.

There are two aspects to the Rawlsian notion of fairness: the principle of greatest equal freedom and the principle of difference. (There is also a principle of equality of opportunity, but that does not pertain to the issues that we consider here.) The first principle, the principle of greatest equal freedom, says that each person or organization should have the widest possible freedom, but only to the extent that is compatible with the possession of equal freedom by other persons. The second principle, the principle of difference, says that inequalities may be justified, provided that they make even the poorest members of a society better off than they would otherwise have been. Rawls argues that these principles will be acceptable to all if they place themselves behind a veil of ignorance; that is, they assume that when choosing the principles by which society should operate, they do not know what position in society they occupy.

It is not obvious from the Rawlsian perspective that fairness in insurance must mean equal treatment for equal risks. Nor is it obvious that the life insurers' unfettered freedom to underwrite as advocated by Leigh (1996) is consistent with Rawlsian justice. Such freedom for insurance companies may have adverse effects on the freedom of individuals—for example, if this freedom for insurers prevents individuals from obtaining adequate health care. In most societies the sick and disabled include some of the poorest individuals. It is difficult to see how their exclusion from insurance risk pools can make these individuals better off than they otherwise would have been. The freedom-to-underwrite principle may fail to satisfy either facet of Rawlsian justice.

The Rawlsian perspective is only one view of justice, albeit an influential one; there are a number of alternatives. Some views place a higher emphasis on merit or reward consequent upon individual choice, and could be employed in defense of underwriting variables that society perceives are linked to individual choices (e.g., smoking status).

Other ethical theories may offer more support for the paradigm of conventional risk classification—although these theories, unlike many apologists for the insurance industry, generally do not claim to be concerned with fairness.

For example, the principle of utilitarianism—"the greatest good for the greatest number"—can be seen as supporting the exclusion of a minority of persons from insurance pools. Any utilitarian calculus, however, requires weighting the benefit enjoyed by those able to purchase insurance marginally more cheaply against the harm suffered by those excluded from insurance. In jurisdictions where buying insurance is the means for obtaining adequate health care or other merit goods, exclusion from insurance can cause great harm to the individual. It is not obvious that great and fundamental harm to a few is outweighed by a marginal price benefit for many.

It would be easier to defend current practice if the insurance industry took steps to ameliorate the worst harms caused by risk classification; for example, the industry could establish industry-wide pools to cover otherwise uninsurable risks. This approach has been followed in a number of countries, sometimes at the insistence of government and sometimes on a voluntary basis.

3.2 Social Consent to Insurance Practices

Another feature of a merit good is that it is widely perceived as a good thing. This is true of life insurance, and the industry's sales depend on this perception. But what happens if life insurance comes to be seen as undesirable because it is discriminatory? Experience in other markets suggests that consumer perceptions on ethical issues can have a major impact on business. For example, certain U.K. banks suffered considerable loss of business in the 1980s because of consumer boycotts motivated by the banks' perceived continuing involvement in, and implicit support of, the apartheid regime in South Africa. Consumer activism also has had an increasing impact on environmental issues. For example, in 1995 the Shell Oil Company was forced to abandon its plans for sinking its Brent Spar oil rig at sea because of a consumer boycott in several European countries, despite the scientific evidence on the merits of deep sea disposal as opposed to other decommissioning options (such as on-shore dismantling).

In both cases the companies initially disparaged criticism as the work of pressure groups, rather as some underwriters today disparage criticism of their unfettered right to underwrite. Yet in both cases the companies were eventually made to look foolish, being forced to reverse positions in which they had invested financial and political capital because of an increasing flood of public comment.

While these examples do not necessarily imply that the insurance industry will be forced to follow a similar course, they do represent a warning of the possible consequences for any business that fails to respond to changes in social opinion.

3.3 Social Legitimacy of Risk Classification Variables

The fairness of insurance classification procedures is a question extending beyond actuarial science. It is not surprising that many non-actuarial authors have considered the question of what determines the legitimacy of a risk classification variable.

For example, Abraham (1985, p. 442) argues that classification variables may be suspect for any of the following reasons.

- A particular characteristic may be used improperly in other fields and is therefore objectionable on symbolic grounds. For example, women often are discriminated against in an economic context, and, therefore, gender is suspect as a classification variable. Insurers ideally would like to disassociate risk classification from the use of the same variables to stigmatize particular groups, but this can be difficult to achieve—particularly because insurers play many roles (e.g., as employers) outside the context of an insurance contract.

- There may not be enough data to justify the classification.

- Some variables may be used only to the disadvantage of certain groups and never to their advantage. An example in insurance is the underwriting of medically impaired lives for life insurance without a corresponding allowance in annuity prices offered.

Wortham (1986, p. 417) proposes seven criteria for assessing rating factors (with translation into statistical terminology where appropriate):

- Statistical power. The probability of accepting a life on terms that would not be used if all relevant facts were known should be as small as possible.

- Statistical size. The probability of rejecting a life that would be accepted on the terms proposed if all relevant facts were known should be as small as possible.

- Causality. Classification factors for which a causal explanation can be given are preferred to factors for which the link is purely a statistical correlation and there is no apparent causal explanation.

- Incentives to loss reduction. Classification factors that provide incentives for the policyholder to reduce the risk of losses are socially beneficial. For example, if cigarette smoking is viewed as a matter of free choice rather than an addiction, then classification by smoker or nonsmoker status provides such an incentive.

- Controllability. This criterion is a pre-condition for the previous criterion. A classification variable cannot provide an incentive to loss reduction unless it is to some extent controlled by the insured.

- Compatibility with social values. This criterion relates to the use or abuse of the classification variable in other contexts. If a variable is misused or has been misused to disadvantage particular groups, the use of the variable in insurance may be tainted by association. This situation prevails in many countries with regard to racial discrimination in insurance.

- Are alternatives to private insurance available? The existence of such alternatives may result in insurance classifications being of lesser concern for public policy.

Probably only the first two of these criteria (the statistical criteria) normally would be considered in any actuarial analysis to determine an appropriate rating structure. This does not mean that the actuarial approach is wrong, but it does mean that it is incomplete.

3.4 Limitations of the Actuarial Perspective

To illustrate our view that the actuarial perspective on underwriting is incomplete, it is instructive to review how actuaries have defined underwriting.

One such definition of underwriting or risk classification is that it is "the process of grouping risks with similar risk characteristics so as to appropriately recognize differences in cost" (Paddon, 1990, p. 1362).

Implicit in this definition is a concept of how we should *appropriately* recognize differences in cost. What is appropriate depends on the relative merits of equity and equality. The definition implies that—in the market for life insurance, at least—equity is a more desirable outcome than equality. Unlike some other actuaries writing about underwriting, however, Paddon does acknowledge this choice: "As actuaries we do not oppose equality in and of itself. However the means by which [equality] is increased can have unanticipated consequences, and in some cases results quite opposite of those intended" (1990, p. 1365).

But actuaries are not the only persons who have access to determining what is fair and what is not. Lawyers, medical practitioners, underwriters, and policy makers all have their own different interpretations about fairness in insurance.

Another reason why the actuarial perspective on fairness in insurance is incomplete is that actuaries tend to consider fairness only from the point of view of existing policyholders. But the issue of distributive justice can be viewed (Stone, 1990, p. 393) from inside the circle of policyholders or from the vantage point of people who are already ill who are not policyholders. From a societal perspective, the persons who need life insurance most (i.e., those who are already ill) are precisely the individuals whom, from within the circle of policyholders, it is economically necessary and fair to exclude. This conflict between views of fairness from alternative vantage points is the crux of disagreements over fairness in insurance.

4 The Actuarial Profession's Role in Underwriting

Underwriting is not a scientific discipline; underwriters frequently use intuition and experience in making decisions. In principle, the contribution made by actuaries in establishing the statistical justifications for particular underwriting processes can be seen as scientific. In some cases, however, the scientific basis of actuaries' underwriting recommendations is difficult to discern.

The demands of practical work necessitate the use of some approximations. But in South Africa, for example, there has been an alarming trend for risk classification schemes dependent on factors that have not been properly investigated. Truyens (1993, p. 9), referring to the post-April 27, 1994 changes in South Africa, asked whether income-based and education-based rate differentiation would be outlawed as irrational discrimination. He feared that unless the South African insurance industry could produce actuarial statistics to justify such differentiation, that it would be deemed irrational discrimination. Many antidiscrimination laws (for example, in New Zealand, the EU, and the United States) make specific provision for waiver on the grounds of actuarially justifiable statistics. But if actuaries term particular conclusions "actuarially justifiable" when they are based on suspect foundations as alluded to by Truyens, their credibility with public policy makers will be eroded.

The credibility of the profession also depends on our acknowledging legitimate non-actuarial concerns pertaining to underwriting procedures. The policy statements of other actuarial bodies recognize some of the issues associated with the social acceptability of underwriting. For example, the Institute of Actuaries of Australia (1994) has stated that where chosen risk classification factors have been found to be no longer significant or to be socially unacceptable, they have been removed. They also acknowledge that actuaries need to review continually the factors that they choose in order to "reflect the effect of emerging statistics and changing social attitudes."

But the actuarial profession needs to recognize that although actuaries establish the statistical justification for particular underwriting processes, the decision to implement them is a commercial decision taken by life offices in view of other social forces. This distinction between the role of the actuary as a professional and that of the industry is crucial if national actuarial associations wish to be regarded as professions (as opposed to trade unions of life insurance company employees or technicians).

Although our focus has been classification factors that society finds unacceptable, societal preferences also can have the opposite effect. For example, if insurers had chosen not to recognize smoking as an underwriting variable, this position might have been difficult to sustain in light of increasing public recognition (and disapproval) of the effects of smoking on mortality.

5 The Actuarial Profession's Role in Society

The previous section concerns the role of the actuarial profession in underwriting. In this section we broaden the discussion to consider the proper role of the profession in society and the requirements that actuaries must meet if society is to regard the actuarial profession as one worthy of public trust and respect.

Two over-arching requirements for the ongoing social acceptance of professions are those of independence and social beneficiation.

5.1 Independence

It is necessary to distinguish the role of the actuary as a scientist and professional and her (or his) role as a life insurance company employee. As a scientist and as a professional the actuary is constrained by responsibilities more stringent than those that affect life insurance companies. Life insurance companies can be assumed to act in a way that preserves their interests and position in society. If an association of individual actuaries aligns itself too closely with such vested interests, however, the association risks compromising its professional identity and integrity.

One of the key roles of a profession is to be able to articulate both sides of a debate—to observe the pros and cons of any given course of action. According to Paddon (1990, p. 1365): "... we have a responsibility to encourage those who make public policy to understand the impact of a proposal or decision." In recent years the actuarial profession has not played this role well, at least not with respect to underwriting. The contribution of actuaries generally has been to act as partisan defenders of the life insurance industry.

While actuaries may side with life insurers on particular issues, the maintenance of professional status depends on actuaries being perceived as capable of distinguishing a professional viewpoint from the commercial viewpoint of the life insurance industry.

In a number of countries actuaries' status as professionals is questionable because of actuaries' inability or unwillingness to maintain this distinction. In South Africa, for example, the problem is exacerbated by the fact that in recent years the profession has had no input in important social and legal processes, instead choosing to subsume its responses to those of the Life Offices' Association (LOA). In effect, the message is that the views of the South African actuarial profession are identical to those held by the LOA.

This apparent lack of independence is potentially damaging not only to professional status, but also to the profession's prospects for expansion. If actuaries are seen as being uniquely identified with the life insurance industry, in the longer term this perceived lack of independence can only hinder the growth and expansion of the profession.

5.2 Social Beneficiation

Independence is a necessary, but not sufficient, condition for the maintenance of professional status. A second requirement for the long-term survival of a profession is that of social beneficiation. By this we mean that the work that we do as professionals should add value to society.

Some actuaries would argue that performing traditional actuarial roles in life insurance companies and pension funds is sufficient for this purpose. If society decides to reevaluate the way in which the insurance business operates, however, the actuarial profession may come under scrutiny too. If actuaries are seen to be capable only of defending the rights of the life insurance industry and its current policyholders, it is possible that actuaries will be seen as life insurance technicians with no other role than performing prescribed calculations and lobbying for those institutions.

An alternative is to view the social responsibility of the actuary as extending beyond these institutions. Such an approach would not be merely altruistic. By demonstrating its ability to look beyond the short-term interests of its principal employers, the profession could increase the possibility of expanding and developing its professional influence into other areas.

6 Summary and Conclusion

Insurance underwriting, like all business practices, operates in a social context. Insurance has a number of distinguishing features that give it some of the features of a merit good (that is, a good that society considers should be available in certain quantities even to those who do not have the resources to purchase it in a private market transaction) and some of the features of a social good (that is, a good the supply of which generates positive externalities).

The importance of these features depends on the extent to which social needs are met by private insurance. If the insurance industry wants an increasing social role for private insurance and the associated opportunities for profit, it must accept that society will take a greater interest in the social legitimacy of risk classification procedures. The alternative is for the industry to decline this increased social role and retreat into a more limited position in which its risk classification procedures will be of less concern to society.

Actuaries should recognize that the actuarial perspective on fairness in insurance classification has its limitations and that actuaries are not the only arbiters of fairness. The acceptability of underwriting procedures is societally determined, and a profession that fails to recognize and make allowances for this may find itself ostracized and increasingly ignored.

It should be possible for actuaries to take a different position from that of their principal employers in the debate on underwriting and in other debates where corporate and professional views are not necessarily congruent. Unless actuaries are perceived as being capable of holding a different view—whether they do so in practice or not—the professional status of the actuarial profession could come under threat.

If actuaries are to survive as a profession—one that actively engages in debate and the expansion of knowledge and that is aware of its responsibilities to society—actuaries must challenge themselves about what it means to be an actuary, as opposed to an employee of a life insurance company.

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Discussion of T.A. Moultrie and R.G. Thomas's "The Right to Underwrite? An Actuarial Perspective With a Difference"

Charles L. Trowbridge*

This interesting but controversial paper studies a subject I too have seriously considered. Nearly a decade ago I was commissioned to prepare a monograph that appeared in 1989 under the auspices of the Actuarial Education and Research Fund under the title Fundamental Concepts of Actuarial Science.[1] Chapter VII of this work, "Classification, Selection, and Antiselection," claims that the cluster of ideas surrounding these three words form a fundamental actuarial concept.

I have recently reviewed this monograph (hereinafter FCAS) and am struck by the dissimilarities between the two treatments. The authors of "The Right to Underwrite?" (RTU) were unaware of my work, and I mean this in no derogatory sense. FCAS does not appear in the usual literature search, particularly one undertaken from overseas.

This discussion will be an outline of the points at which FCAS and RTU differ. I will paraphrase, avoiding detail and concentrating on the essentials. I highlight the important differences by considering only the three questions stated below.

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[1] Trowbridge, C.L. *Fundamental Concepts of Actuarial Science.* Schaumburg, Ill.: Society of Actuaries, 1989.

Why Do Insurance Companies Underwrite?

Chapter VII of FCAS states that insurance companies underwrite not because of any specific concept of fairness and not because they have a right or freedom to do so, but because they must. If insurance prospects have choices about whether to buy, in what amount, and from whom, they can be expected to act in their perceived self interest and antiselect against the collective. Underwriting has no other purpose than self-protection. (To emphasize this point, FCAS notes that the predominant forms of life insurance protection, at least in North America, are those where such choices are not given, where antiselection is minimal, and where underwriting disappears).

RTU, on the other hand, does not mention antiselection. RTU has no clear answer to the question, though at one point RTU suggests that the purpose of underwriting is the creation of a competitive advantage for the insurer. I am troubled by the antiselection omission. Do the authors of RTU believe that antiselection does not exist or that it can be disregarded?

What Is the Relationship Between Underwriting and the Actuarial Profession?

FCAS treats the cluster of ideas surrounding classification, selection, and antiselection as one of a handful of fundamental actuarial concepts. Sound classification systems have a statistical component, but FCAS recognizes that socially oriented considerations also can be important. While actuaries have no monopoly in the design of classification systems, they do have expertise. This expertise may lie in the ability to examine all aspects of a difficult problem. Classification systems in use today are products of actuarial thinking tempered by actuarial experience.

RTU, on the other hand, views the relationship differently. The actuarial approach is defined only statistically. After defining the term so narrowly, however, RTU says that the actuarial approach is incomplete.

Do Life Company Actuaries Have a Professional Obligation to Speak Out When They Disagree With the Company's Classification System?

RTU seems to answer this question with a resounding yes. The authors of RTU clearly and honestly speak and suggest that others should do the same.

FCAS is silent on this question. If forced, the author of FCAS might reply as follows. The views of the insurance industry and of the actuarial profession on classification are similar. Both realize there are no perfect solutions to this difficult matter, and both are searching for better answers, especially in areas where statistical and social considerations conflict. If any person, actuary or otherwise, has constructive ideas on how classification methods for any financial security system can be improved, these ideas should be well received. These ideas, however, must recognize the world as it is, not as we wish it were.

William R. Lane*

The authors raise a number of issues that are legitimate societal concerns today. Several points, however, are worth noting.

Two Types of Insurance

The authors rightly determine that the distinction between insurance as a merit good and insurance as a social good is important. But they do not differentiate forms of insurance.

Certain types of insurance are largely all-or-none propositions. A person either has or doesn't have medical insurance. While a huge spectrum of provisions to medical insurance (such as deductibles, coinsurance, and restrictions applicable to managed care provider networks) exists, a central question remains: Does the level of benefits available to insureds allow them access to medical care services for all types of injuries and illnesses? Under these circumstances, the issue of whether insurance is a merit good becomes a critical question. If society deems access to medical care services to be a merit good (in other words, available without regard to ability to pay), then medical insurance also must be considered as a merit good. It is important to note that the cost of

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medical insurance with a \$100,000 maximum benefit and the cost of medical insurance with a \$10 million maximum benefit is not significantly different. The preponderance of the cost of medical insurance is determined by the benefits that most persons consider to be basic to the insurance (such as covering most of the cost of hospital and physician services).

Other types of insurance are incremental. For example, a person may have \$10,000 of life insurance, or \$25,000 of insurance, or \$10 million of life insurance. While it may be argued that a minimum level of life insurance is a merit good (at least as long as the individual has dependents who rely on the individual for income), it would be difficult to argue the same point for \$10 million of insurance. In this case the cost for \$10 million of insurance is essentially 1,000 times the cost of a \$10,000 policy. Thus, for life insurance, if one is to argue that it constitutes a merit good, then one also must determine how much coverage is required as a social necessity.

The two concepts, all-or-none and incremental, are not mutually exclusive. For example, disability income replacement is largely an all-or-none proposition with regard to the types of disabilities covered, but the benefit amount is incremental. Life insurance, if offered, rarely excludes specific conditions after the contestable period. Thus, the issue of what causes of death are covered is usually not significant. Given the trend to ever increasing deductibles for medical insurance, it also has an element of incremental benefit levels.

Incremental benefits can be considered a merit good only to the extent that the level of benefits is appropriate. Hence, the debate for such benefits must begin with a question of what level of benefit is under discussion. All-or-none benefits, however, beg the issue of their social necessity; the question of whether the coverage constitutes a merit good is critical. Hence, any discussion of whether society should require insurance products to be available should begin by limiting the discussion to those products that are merit goods, and that will require for some forms of insurance a discussion of how much coverage is a social requirement and how much is a personal decision.

An Actuarial Issue

The authors claim that "the choice between alternative views of fairness ... is not an actuarial question." I strongly disagree. Offering a good as a merit good requires redistribution of revenue. When the good is purchased on a voluntary basis, knowledgeable persons resist the purchase to the extent they perceive the price of the good has been increased by such redistribution to the point that the value of the good to the individual is no longer worth the cost. All forms of insurance require redistribution. That is the chief purpose of insurance. But individuals, when viewing such a voluntary transaction, make a personal determination if the cost of redistribution is worth the value of the benefit obtained by the insurance.

The question then arises: At what point does offering insurance on a voluntary basis become financially impossible (in other words, the product is incapable of statistically providing a profit that at least equals the cost of capital) when legislation or social expectations have required the insurer to consider the product as a merit good?

While the understanding and financial modeling of individual selection of insurance is not an exact science, it is within the province of the actuary. No other profession is as well equipped to understand and evaluate these financial mechanics as the actuary. This issue has been explored in the context of various insurance coverages within the United States. It is professionally challenging, but cannot be considered as strictly a question of social philosophy.

For many years medical insurance in the United States was relatively inexpensive and was offered by many Blue Cross and Blue Shield organizations as essentially a merit good. Individuals and employers were largely not underwritten, and prices were rarely, if ever, related to the individual risk. As the cost of medical coverage rose, however, the willingness of individuals and employers to financially support this redistribution of revenue declined. Providers of medical insurance, including Blue Cross and Blue Shield, were faced with the issue of accepting prospects for coverage and basing the price of coverage on the expected cost of coverage or going out of business due to bankruptcy.

This change in underwriting culminated in a national debate over health care reform. At the crux of that debate was the issue of whether medical insurance was a merit good. (Albeit the term was rarely if ever used by the popular press.) I participated in this debate in several ways. In the United States actuaries vigorously discussed all sides of the question. Those actuaries who strongly favored considering medical insurance as a merit good were forced to bring actuaries into the debate because a merit good loses it value if it can't be financially supported. In other words, the actuarial question of how to financially support a voluntarily purchased merit good had to be answered; public policy resisted legislation that restricted the insurance providers in their ability to underwrite and differentiate in price based on risk.

Simply because society wishes for something to be available at a given price doesn't make it possible. A law requiring luxury cars to be sold for $100 each would not make them more available. It simply would mean that no luxury cars would be sold to anyone. Though insurance is more complex than a luxury car, the result of outlawing underwriting would produce the same result: no insurance, as we know it today, would be sold.

Actuaries have an important role in helping the general public understand the ramifications that such decisions produce. Actuaries also have a critical role in the financial modeling of such restrictions and the development of alternate approaches that balance the financial needs of the insurers with society's desire to make insurance available to all. It has been my experience in this country that many actuaries have contributed to this debate and have reflected all sides of the questions at hand.

Authors' Reply to Discussion

We thank the discussants for their comments and suggestions. We are grateful to Mr. Trowbridge for drawing our attention to his monograph, which contains a broader treatment than is typical in actuarial accounts of underwriting.

Mr. Trowbridge asked if we believed that anti-selection does not exist. That anti-selection can and does occur in voluntary insurance is not in dispute. The extent to which it occurs, and whether its occurrence significantly impairs the viability of private insurance, however, are strictly empirical questions for which the answers will differ according to the class of insurance, the rating factors concerned, and over time. For many classes of insurance, some degree of anti-selection may be regarded as socially optimal according to Rawlsian or other public choice criteria. More prosaically, the occurrence of some degree of anti-selection may maximize public acceptance of the insurance mechanism (as noted by Mr. Lane in the context of medical insurance).

In the light of our brief excursions into social philosophy, both discussants were concerned to reclaim risk classification as a largely if not exclusively actuarial matter. According to Mr. Trowbridge, actuaries' expertise may lie in their ability to examine all aspects of a difficult problem. Actuaries have a statistical and financial training, but they typically have little knowledge of social philosophy or ethics and no professional interest in, or concern for, persons who are harmed by underwriting practice. Even if actuaries might be capable of examining all aspects of the problem, there are other constraints that make them reluctant to do so; as Mr. Trowbridge notes, the views of actuaries on underwriting are usually conveniently aligned to those of their principal employers.

Finally, we were exhorted to recognize the world as it is, not as we wish it were. The world as it is to whom? To actuaries ensconced comfortably in the insurance industry, or to those whom actuaries would exclude from medical insurance in the name of the principle of actuarial fairness? The acceptability of the world as it is depends on from where it is viewed.