EQUILIBRIUM CONDITIONS OF UNIVERSAL LIFE UNDER EXTREME ECONOMIC CIRCUMSTANCES

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I. Introduction

The unsettled economic and social conditions of the last decade or two have undermined the value and extinguished the commercial viability of many traditional life insurance products. During this time, the life industry has seen some of its most basic assumptions called into question. It is now struggling to devise products which are more appropriate for the new conditions. The essence of the need is to provide flexibility, very much more flexibility than traditional products have offered.

The new products will have conditions which can be altered easily according to economic circumstances and the inclinations of the insured. Adjustments might even be automatic according to prescriptions specified by the policyholder. Naturally they will also need to offer adequate safety to the insured, and a margin of profit for the covering firm.

If these needs are to be met, it seems likely that fundamental changes must occur in product structure, as well as in the design and evaluation process. The method of distribution may also change, as Mr. Dinney has discussed in his paper. These changes seem inevitable because they are consequences of forces which are unlikely to diminish.

From the point of view of an individual seeking insurance coverage, almost any realistic financial planning now requires the contemplation of an unprecedentedly broad range of economic climates. These may range from calm to catastrophic. Those alternatives must all be evaluated in relation to a variety of social programs such as those offered by employers and governments, with long-term prospects which are difficult to predict. Perhaps it is not too much to conclude that a company which wishes to allow its clients really meaningful planning freedom must be prepared to provide entirely customized coverage.

From the point of view of the corporate planner, or product designer, the situation is also increasingly daunting. The long-term status of a product will be affected by complex and unknown economic conditions, and also by the competing presence of government agencies. Moreover, there is the increasing consolidation of the financial services marketplace, which is blurring the traditional distinctions between the banking, insurance, and personal investment sectors. Companies which wish not to risk being the odd man out will need to be very nimble about exploiting gaps in other people's offerings, coordinating not only products, but perhaps even computer systems with those of others.

In summary, we can safely say that it is now both feasible and essential to do product planning of a sort which the mere volume of computation would have made quite impossible even a decade ago. The result will be an inevitable shift in emphasis from the traditional actuary's art to interactive modelling of arbitrary, individual, and varied circumstances. This paper examines one approach to this process.

II. A General Model

Our intent is to demonstrate that fairly sophisticated planning questions can be examined, at least qualitatively, from a fairly simple model. The questions we wish to discuss would be fairly standard fare in many manufacturing industries, but are ones which most life companies have preferred to treat as art rather than science.

The ground rules selected for the building of this model reflected what we wished to do with it. They were that it should:

- be utterly flexible in hypotheses,
- be interactive and easy to use,
- consume only insignificant computing resources,
- include macro-economic parameters,
- and deal with certain specific matters.

The idea was to provide a friendly, thrifty computational tool which could be used to experiment with speculative questions about product behaviour under varied and perhaps extreme economic conditions.

This model divides "life insurance" into its two pure constituant parts, life and death insurance, with the components having benefits paid on the occasion of death within a certain time, or life until a certain time. This amounts to supposing that life insurance consists simply of bets against one side or the other of the mortality curve. All real products are effectively linear combinations of the pure constituants, perhaps with some non-risk savings components included. Of course, in general, only pure death insurance, otherwise known as term, is available on its own.

For this paper, we have sometimes described these pure insurance types as "term" and "whole". This does not correspond exactly to customary actuarial usage, but it is perhaps suggestive of the intent of the two types of coverage. The cases which are illustrated here are naturally artificial ones, with no particular relation to specific Great-West Life products.

Populations, or in some cases individuals, are represented in three states, "term", "life", and "uninsured", depending on the resources allocated to death benefits, life benefits, and not buying insurance. The economic climate includes the inflation rate and interest rates, and can be extended as appropriate. Individuals are given inclinations to change their state which are functions of the macro-economic conditions.

The basic mortality figures employed in the examples are illustrated in Figure 1.

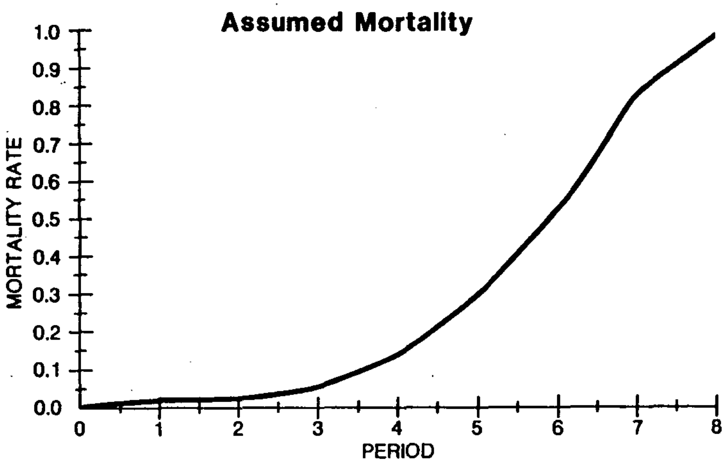


Fig. 1

These figures correspond roughly to the compression of decades into single time periods, beginning from age 20. The accuracy is sufficient to display the trends we wish to illustrate.

Expected mortality results are also part of the parameters and can be altered dynamically to reflect the characteristics of individuals or to examine the consequences of unanticipated mortality levels. One can assume increased risk in variable amounts, for example from smoking, to correspond not merely to whether an individual smokes or not, but also how much. Other increased risk can also be included in whatever degree seems suitable for other deadly sins. This procedure allows one the effect of having infinitely many arbitrarily finely tuned mortality tables.

III. Customized Products

For illustration, we select level premiums of 100 for the life and death components. The corresponding benefit levels are shown in figure 2.

Period	Death Component Premium	Death Benefit	Life Component Premium	Benefit
1	100	677.32	100	0
2	100	677.32	100	0
3	100	677.32	100	0
4	100	677.32	100	0
5	100	677.32	100	0
6	100	677.32	100	0
7	100	677.32	0	2398.43
8	100	677.32	0	2398.43

Premium and Benefit Levels

Fig. 2

These benefits have been calculated to make the life and death components of the insurance separate fair bets, assuming mortality levels of figure 1 and an interest rate of 10%. Given these assumptions, over the insured's expected lifespan, both company and policyholder have expectations of 0.

By calculating these expectations on the spot, rather than taking them from tables, one can produce completely customized coverage. Suppose, for instance, a client wished to spend a year trying to ski down Mount Everest. If one's actuaries estimated that consequently, for that single year, the probability of death was 30%, one could, in a few moments, calculate appropriate price or benefit differentials. For instance, if that were expected in period 2, a level premium surcharge of 9.28 would be sufficient to maintain the benefit levels of fig. 2. The natural increase in mortality means that, from an insurance point of view, it would be cheaper to postpone the skiing expedition to a later period.

In principle, the only conditions on such manipulations are that the insurer's expectations must, at all times, be at least zero, since there is no constraint on the insured to retain coverage. A client might wish to select pricing in such a way as to keep these expectations zero after all intermediate periods, as is often currently done. But one can imagine circumstances of large foreseeable expenses when someone might prefer to give something on the expectation in return for being able to rearrange the schedule of premiums. For example, this might happen to someone who expects short-term expenses from a child at the university.

For the assumptions made above, the expectations of the two components are shown in figure 3. They behave as one would expect, growing when mortality is least, and diminishing when it increases. The term component expectation drops off more rapidly, reflecting the earlier payment of these benefits.

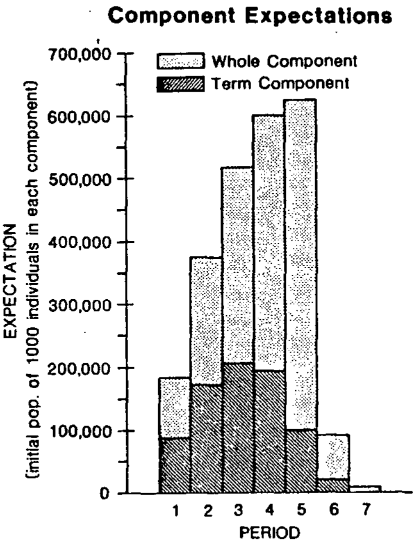


Fig. 3

However, from a product planning point of view, this sort of customization is problematical, for there is no way to determine the precise mortality expectations which should apply to an individual. The approach effectively countermands the traditional one, which is to refuse to acknowledge differences between individuals. By giving individuals more choice, something is lost in predictability and new methods will be required to determine safe bets and corresponding premium levels. Figures 4 and 5 illustrate one way to deal with this difficulty.

Subject to the constraint of maintaining the zero whole-life expectations, they show the regressions of price on mortality and interest rates. Figure 4 shows the price which would be needed to maintain the fair bet if one's mortality expectations were off slightly. It suggests that a 5 per cent change in the price would be sufficient to protect against a 5 per cent unfavorable error in the mortality. It is possible that the market might allow some price increment without a serious loss of market share.

Similarly, figure 5 shows the effect of a change in the interest rates available. If one expected to be able to increase the return available on the reserve funds, one could use that advantage to lower one's prices by amounts which can be approximately specified. That might happen, for example, because of the progressive roll-over of long-term obligations whose return has lagged behind current rates. A difference of about 1% in the return available in investment funds corresponds in this case to a reduction of about 2% in the joint premium level. For this illustration interest rates have been taken as constants, but they may be altered either dynamically or according to a specified pattern to try out various estimates of the possibilities.

Comparing the two curves illustrated in figures 4 and 5, we see also that an increase of about 2 1/2% in the interest rate on investments is sufficient to recover losses from a 5% unfavorable mortality estimate.

Finally, there is the question of protection against normal mortality fluctuations. It is not enough to price in such a way that the long-term expectation is zero, making some allowance for operating expenses and profit. One must also provide a reasonably high probability of avoiding a loss despite normal fluctuations in mortality experience.

Price Stability as a Function of Mortality

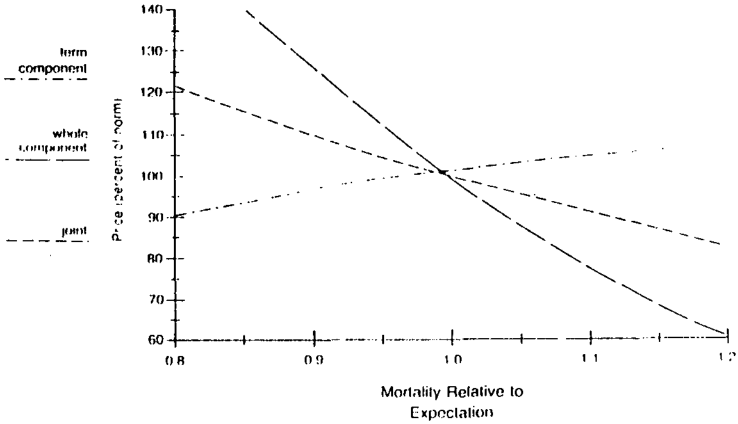


figure 4

Price Stability as a Function of Interest Rate

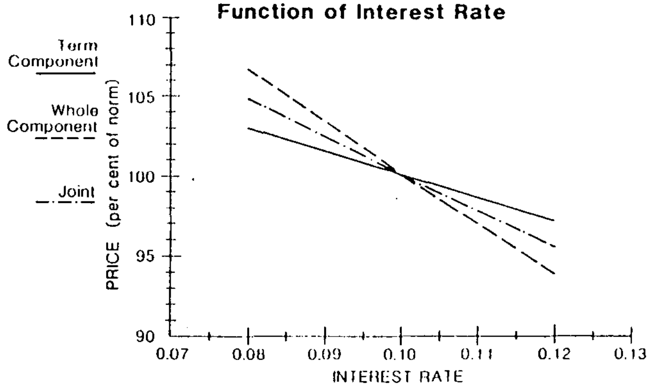
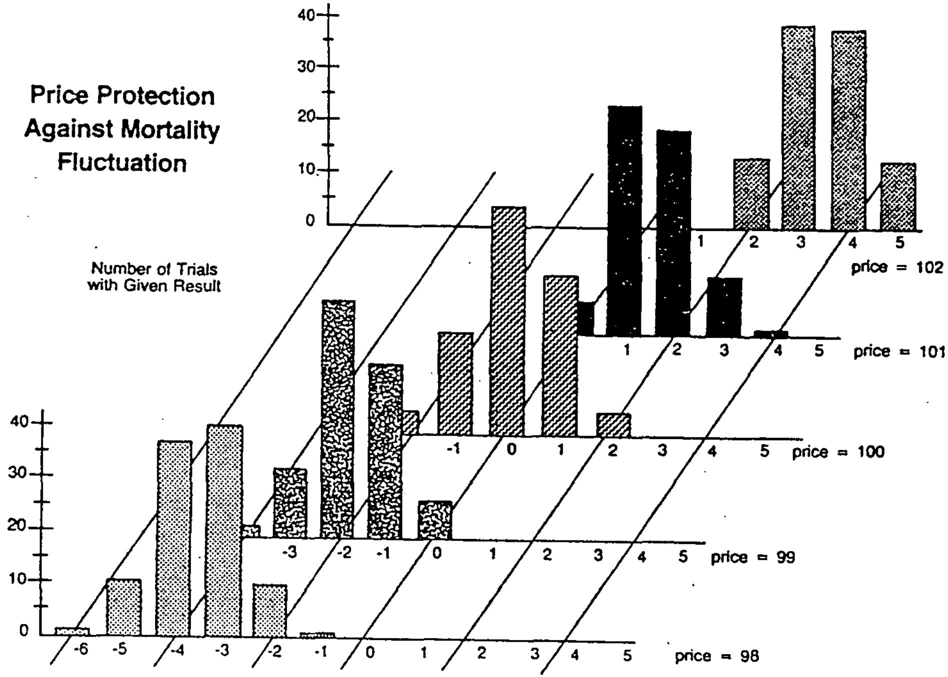


figure 5

Suppose we have a large population of identical individuals in an identical economic climate, but with mortality subject to normal fluctuations. Figure 6 shows the long-term financial position resulting after 100 stochastic trials for each of five prices. The prices correspond to the base of 100, and price increases and decreases of 1 and 2 per cent. The resulting histograms show the results of the five stochastic trial series.

One can see that a change of one per cent in the price is enough to give about a 90% chance of avoiding a loss, and that a two per cent change is enough to make the chance only a few in a hundred. Thus substantial safety can be built into the expectations for only a small change in the pricing. Exactly what probabilities would be acceptable is a question of corporate strategy.

Software to do this sort of analysis could easily be inserted into a program to price customized insurance.



Final Account Balance ($1000's)
100 stochastic trials each price
figure 6

IV. Coverage Equilibrium

Effective insurance coverage consists of some combination of life and death benefits. Since the return on the life part has recently lagged well behind the return available on alternative investments, there has been a trend toward the purchase of pure term insurance. But if inflation were to fall to lower than the return available from life benefits and promise to remain there, this trend might well be reversed. In any case, there is no reason a policyholder should be deprived of the opportunity to rearrange his resource allocation if he wishes. But it is essential for a company which proposes to offer freer choice to try to anticipate the potential effect on their coverage distribution of such client decisions.

In this section, we expand the parameters of the model to allow this reallocation of resources. The reallotment can happen according to any desired function of the macro-economic parameters. Apart from reaction to economic conditions, one could anticipate that such functions should also include a "psychological inertia" factor which describes people's inclinations to remain with what they have despite the economic advantage of change.

Of course, at the moment, no one knows just what these functions are. They depend not only on economic matters, but also on intangibles like the sophistication of the client. In the foreseeable future, it will be an important job for a company's actuaries to try to understand these functions for the company's particular marketplace.

As a first approximation, and to illustrate the application of the model, we will take the propensities to reallocate resources as constant, in particular, as those of figure 7a.

Resource Reallocation Matrices

	Term	Whole
Term	.8	.2
Whole	.3	.7

Figure 7a

	Term	Whole
Term	.8	.2
Whole	.4	.6

Figure 7b

The matrix of figure 7a is to be read that the probability a person retains what term benefits he has is .8, and his probability of moving to life benefits is .2. Similarly, his probability of keeping life benefits is .7 and of changing is .3. The difference between .8 and .7 reflects the fact that in the recent past, whole life benefits have been less attractive than term ones.

To determine the equilibrium distribution of benefits, one assumes no mortality. Of course, as we will see later, one cannot disregard mortality in understanding the effect of resource reallocation of the fairness of the lifetime bet.

Under the specified conditions, the resource allocation balance through the periods is shown in figure 8.

The graph of fig. 8a shows the result if the initial population has purely life benefits; fig. 8b the trend from purely death benefits. Beginning with a population of term clients, it takes about three or four periods for the allocation to come into equilibrium. Anyone familiar with linear algebra will recognize that this balance could also have been derived from the eigenvectors of the reallocation matrix. If one begins with a client whose resources are alloted purely to life benefits, it takes about four or five periods for the allocation to settle to equilibrium, but the equilibrium is the same.

If, through education, or changed economics, or other means, people's inclinations were changed, it would affect this equilibrium. In fact, if the inclinations of figure 7a were changed to those of 7b, the equilibrium resource allocation would be altered by about seven per cent. The progression to equilibrium in the two cases is shown in figure 9.

Component Equilibrium from pure life benefits

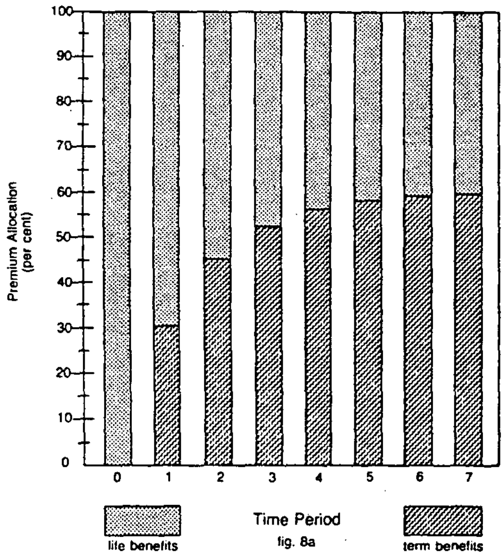


fig. 8a

Component Equilibrium from pure term benefits

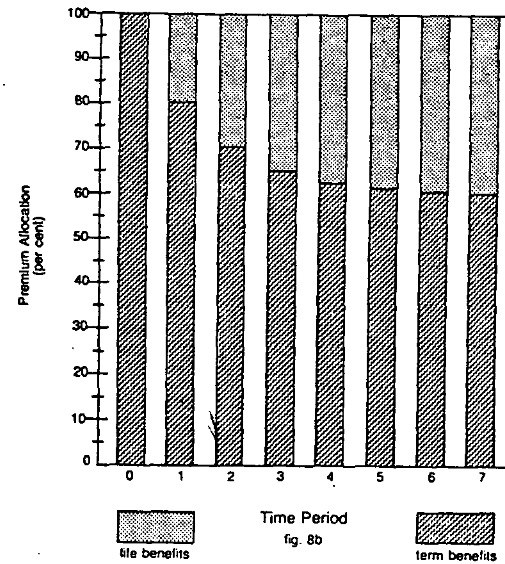


fig. 8b

Premium Resource Allocation
(Various Client Inclinations)

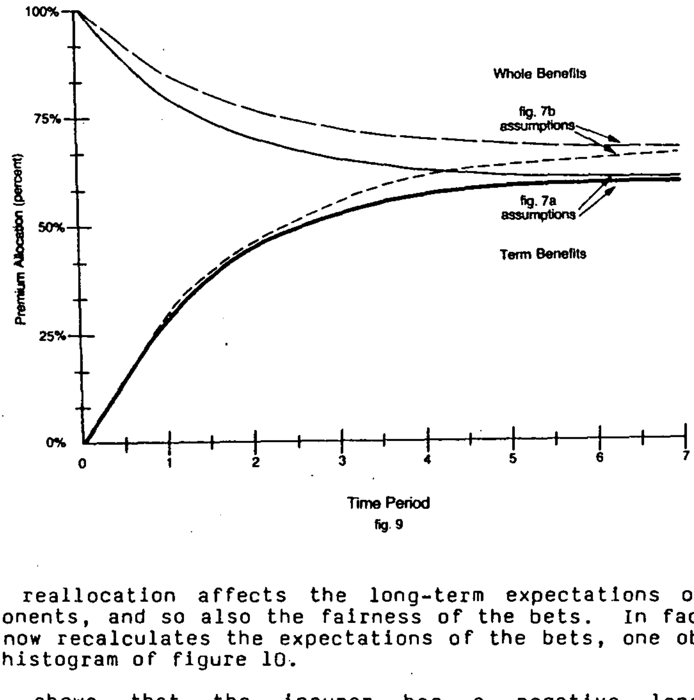
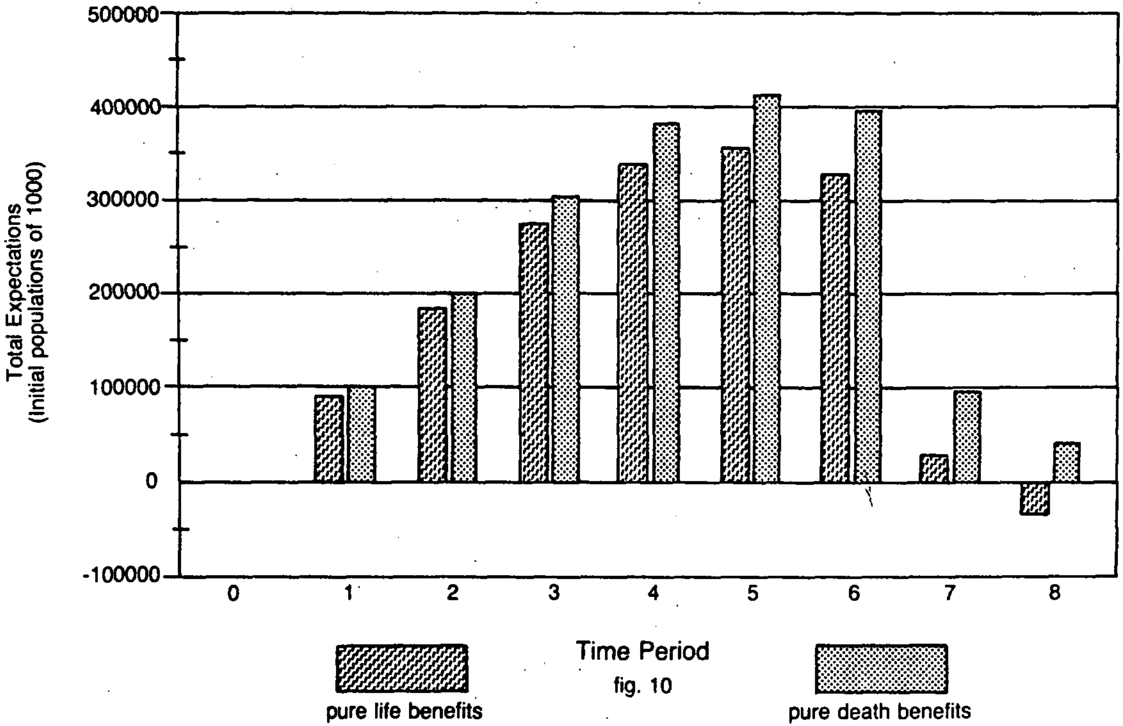


fig. 9

This reallocation affects the long-term expectations of the components, and so also the fairness of the bets. In fact, if one now recalculates the expectations of the bets, one obtains the histogram of figure 10.

This shows that the insurer has a negative long-term expectation from those clients who begin with purely life benefits, while having a positive one from those beginning with pure death benefits. So the insurer will be glad to offer this option to the latter, and could even reduce prices a little to reduce the long-term expectation nearer to zero. On the other hand, in principle, it would be necessary to raise the price slightly in the other case, although a company might wish to accept the slight loss rather than try to explain why a new option means an immediate increase in price.

Expectations from Initial Populations with pure benefits



V. Market Share Equilibrium

To show how the model can be applied to study the effect of varied economic conditions, we again extend the available parameters. Now we allow the population to exist in the three states "uninsured", "term", and "whole". The "uninsured" part of the population allots no resources to either life or death benefits. If the context is an individual, this describes the part of the individual's resources not allocated to life or death benefits. In case of a large population, the ratio of the sum of life and death benefit allocations to total available resources becomes a market share, although our illustration includes no competing companies.

In fact, the model has been designed in such a way that competing products may be compared. But, for the moment, we will take the competition to be simply against the economic environment and psychological resistance.

Within that limitation, we may again allow the inclinations of the population to allot resources to be any functions whatsoever of the various economic and inertia factors. But for simplicity, we continue to assume that these functions are in fact constants, as displayed in figure 11.

Transition Matrices

	Uninsured	Term	Whole
Uninsured	.8	.1	.1
Term	.2	.7	.1
Whole	.3	.2	.5

Fig. 11a

	Uninsured	Term	Whole
Uninsured	.75	.125	.125
Term	.2	.7	.1
Whole	.3	.2	.5

Fig. 11b

The large elements on the diagonal imply an inclination for people to remain in their current state, whatever it may be. The relative sizes of the off-diagonal elements suggest that a switch to term coverage is more probable than a switch from term coverage, and so on.

If one starts with a population entirely uninsured and hypothesizes the propensities of figure 11a, the resulting resource allocations are as shown in figure 12.

Market Share Equilibrium

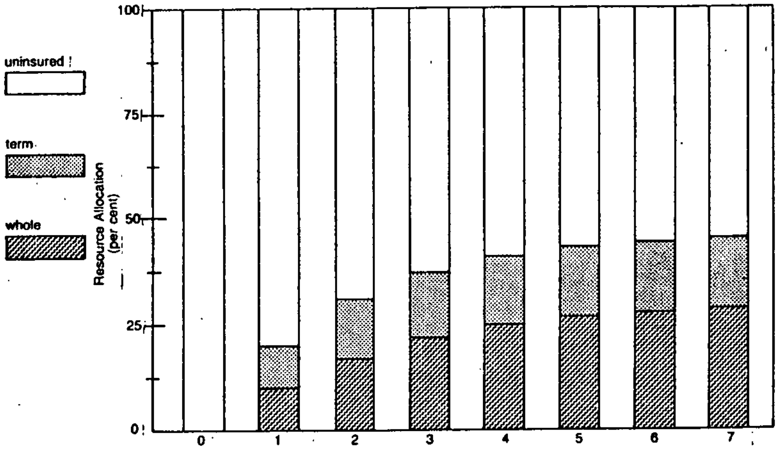


fig. 12

It takes several periods for the situation to come to equilibrium, which it does with about 30% of the resources allocated to death benefits, 15% to life benefits, and 55% opted out. The sum of "term" and "whole" amounts to a sort of "market penetration" which is here about 45%.

According to the 1981 Life Insurance Fact Book, in the U.S. in 1981 the disposable personal income was about $1.8 trillion, while total life insurance coverage was about $3.5 trillion. Using the old rule of thumb that insurance should be about 5 times income, the available market would be about $9.0 trillion. The in-force coverage of $3.5 trillion is about 39% of that. Thus the resistance factors we have included give an approximation to the position of the entire life industry.

It is of interest to see the effect of a change in the economic factors on the "uninsured" population. A reduction of the upper left entry of the matrix corresponds to a reduction of market resistance, which is to say, to better sales results. If we reduce this entry by .05 and rescale the first row to keep the sum of the entries 1, we obtain the matrix of figure 11b.

Figure 13 shows the effect of this change on the "market share".

Total Market Share

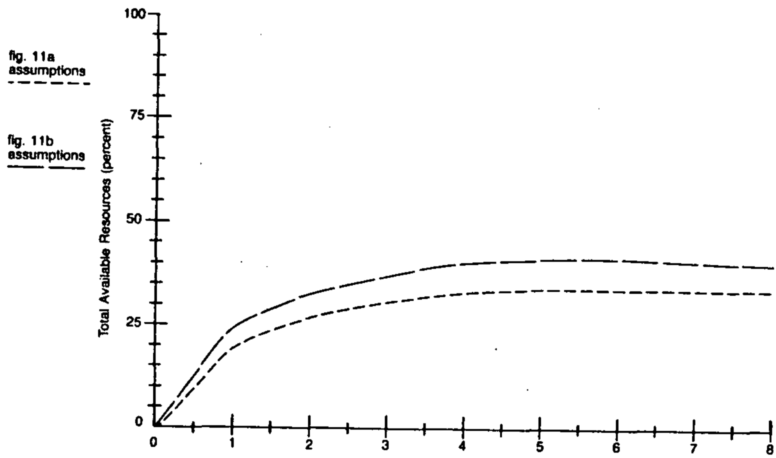


fig. 13

The results suggest that a reduction of 6% in the propensity to allot no resources to either product will result in about an 8% increase in sales. The distribution between product components remains approximately the same.

Put another way, over the whole of the American market, a new product which could diminish customer resistance by about 6% would open up some $290 billion in prospective new coverage.

VI. Long-Term Product Behavior

Finally there is the question of the expected long-term revenue and asset pool from such a product under various conditions. To approach these matters, each period we insert into the population a new cohort of 1000 individuals which is entirely uninsured. All cohorts experience the same economic conditions, but each suffers the mortality experience appropriate for its group. Sales to the cohorts, and terminations, occur with the probabilities specified in figure 11a.

For the product we have been examining, which is a zero bet only in the long run, we would expect that the net revenue is initially positive. This reflects the company's initial positive expectation. But as the first cohorts age, the net revenue would diminish toward zero. Of course, if a real company has not reduced its operating costs to zero, and is reluctant to have no net revenues, the long-term bets would have to be slightly unfair.

Similarly, we would expect the assets, i.e. the excess of revenues over benefits, to grow steeply at first, and then to level out at a certain size. These two curves are shown in figure 14 for the assumptions we have made. The unexpected peak in the asset curve and temporary dip below zero of the net revenue curve reflect the fact that this example has assumed all "uninsured" population begins at a low age with low expected mortality, and that the entire population dies in its eighth period.

The total assets stabilize around $675,000 and the net revenue reaches a maximum at the fourth period. The presence of the large asset pool, even when net revenues have stabilized at zero, is, of course, typical of life insurance companies, and shows why a large asset base cannot necessarily be construed as showing a healthy product line.

We have so far simplified the illustrations with such improbable assumptions as constant interest rates and no inflation. This was unrealistic, but showed what the model could do, without complicating the parameter behavior. We close with two graphs intended to show more unstable, but perhaps more realistic conditions.

Net Revenue and Assets (long term)

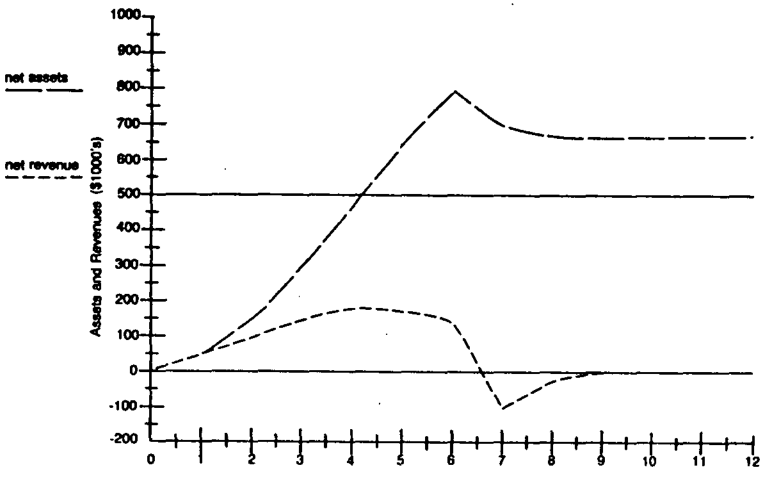


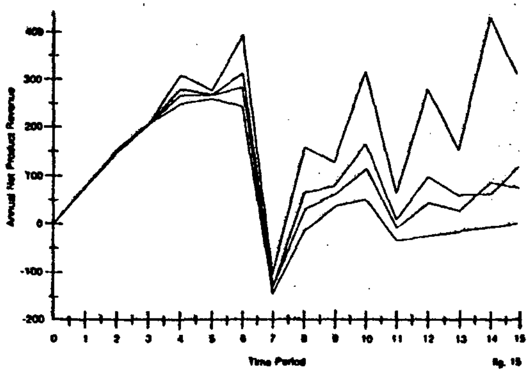
fig. 14

They show the revenue and assets which the product yields under more extreme conditions. We assume that the inflation rate is 11% and increases at 1% per year. We assume further that the interest rate available on the whole life part of the product alternates between the inflation rate and a value 2, 4, 6, and 10 points above the inflation rate in alternate periods. In addition, we suppose that people's inclination to switch from whole coverage to term is proportional to the excess of the interest rate over the inflation rate. Finally we assume the presence of new cohorts of uninsured individuals each term.

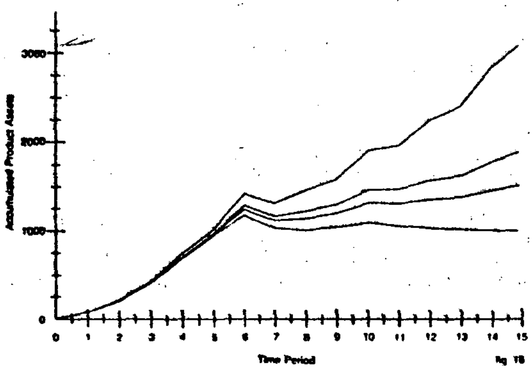
These conditions are rather bizarre. However, the most extreme of them is not utterly dissimilar to those which prevailed in Canada over the period 1979-1981.

Under all these suppositions, we see that, in the long-term, assets increase in a satisfactory way. The annual net revenues, however, exhibit extreme unstability, fluctuating in some instances by more than 100% from period to period.

Revenue in Bizarre Conditions



Assets in Bizarre Conditions



The oscillation of the revenue curve is quite dramatic, as might be anticipated. However, an examination of the surrender rates which Canadian companies have in fact experienced in whole life policies reveals curves which have fluctuated in response to sharp changes in the interest rates scarcely less dramatically than this revenue graph. So perhaps, despite its many limitations, a model such as this can be used for some general planning brainstorms. It is surely worth the little effort required to use it.

While the product illustrated is artificial, and these figures cannot by any means be construed as exact predictions, they show enough to suggest there are some real questions about how "universal life" products will behave if economic conditions as unsettled as those of the last few years continue to prevail.