Presented to the Staple Inn Actuarial Society

on 1st February 1994

MULTIPLE STATE MODELLING

by

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1. Introduction

1.1 In recent years the traditional actuarial single state model has been found wanting in a number of areas. Multiple state models have been developed to tackle some of the problems which need to be solved when modelling the newer insurance products, particularly health related products. This paper starts by looking at current actuarial practice and then defines multi-state modelling as an alternative. Section 2 gives a description of multi-state modelling and Section 3 sets out a mathematical specification for such a model. A few of the many potential uses of a multi-state approach are then outlined.

It is hoped by the authors that this paper will act as a discussion document which will stimulate those involved in developing profit testing models to re-examine their approach. It is not the intention to dismiss existing models as obsolete but demonstrate that multi-state modelling is an extension of these techniques.

1.2 Early actuarial modelling was based on books of tables giving look-ups for simple commutation functions. The application to insurance business was limited to areas for which there were tables available. To move beyond the domain of these tables was to roam in the unknown. With the advent of digital computers table look-ups were replaced with formulae and calculation error became a thing of the past. More complicated products could now be modelled and discounted cash flow techniques developed alongside the concept of profit testing. Many actuaries had now to become programmers in addition to their other skills.

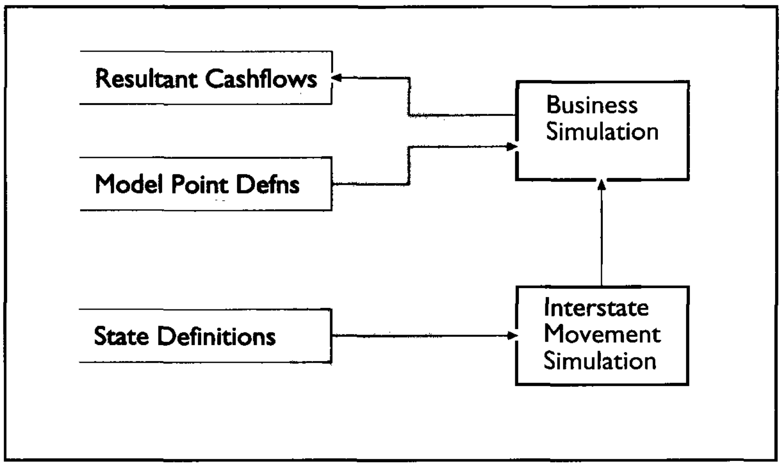
1.3 The current techniques used in profit testing owe as much to the history of actuarial modelling as to the statutory requirements. These techniques tend to suffer from lack of programming imagination as successive waves of actuarial students have approached the problems involved in modelling in similar ways. Even now profit testing models tend to be the domain of student actuaries rather than teams of professional programmers led by actuaries.

1.4 A symptom of this is the bolt-on modular approach to profit testing. Many models will have one module for unit linked and another for conventional business. Recently packages have started to support Permanent Health Insurance (PHI) but only as an additional module. A more fundamental problem is the way profit testing is seen as a separate process to projecting revenues and/or company valuations. In reality all of these are connected and warrant a consistent approach.

1.5 Modern programming has specialised to the point that while anyone can program, only a professional can design and program well. By taking ideas and concepts developed and proven in other industries professional programmers can bring fresh insights into old problems in a way that actuarial students cannot. Multi-state modelling is a case in point.

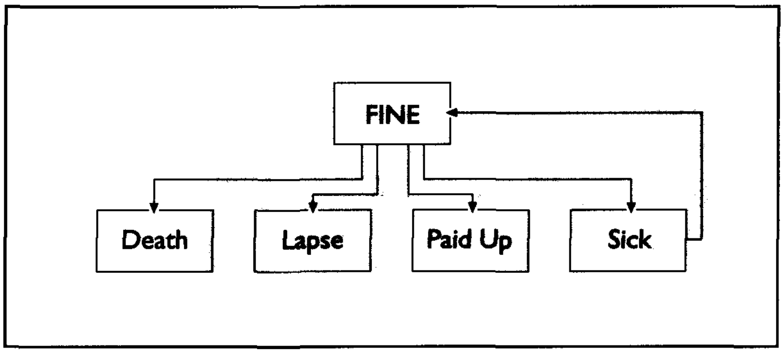
Definition of Multi-State Modelling

1.6 In actuarial parlance, multi-state modelling is "the technique in which the core of the profit testing model is the specification and interconnectedness of relevant states."



1.7 Traditionally the core of a model would be the generation of income and expenditure (discounted and adjusted for the proportion of lives still in force). In multi-state modelling the core is the simulation of the interstate movements. Its input is a data specification of the attributes and interconnections of the states. Its outputs are the proportion of lives in each of the states at each moment during the simulation. In multi-state modelling the output from this process becomes the input for the traditional profit test. Claims may then be modelled as related to the proportion of lives in each state and/or the movement between states.

1.8 Of major importance is the fact that multi-state modelling allows for non-absorbing states. That is to say states that do not end the policy and from which the policyholder may later migrate. Other types of actuarial modelling normally allow only for absorbing (policy ending) states or in the rare event that they cater for non-absorbing states they do so for a maximum of one such state. This shortfall in existing models may require a non-absorbing state such as the P.H.I. claim state to be approximated as an absorbing one using methods such as the annuity inception approach.



1.9 Those accustomed to writing programs to meet their actuarial modelling needs will see the concept of multi-state modelling as an extension of their current programs (if they have not already done so.) The challenge lies in writing a single program that embodies the concept of multi-state modelling so that its connectedness can be configured through data and not through altering the program continually to fit new product design features.

1.10 This last point is an important one. Profit testing requires the assumptions regarding a product to be capable of adjustment with a minimum of work (i.e. without reprogramming). It is a practical long term requirement that the model be data driven. By "data driven" it is meant that the actuaries specify the chart structure of the model in addition to the movement data.

1.11 The configuration of the multi-state model from the extremes of modelling a health care product to that of an investment product is only a matter of supplying different data to configure the states and their interconnections. Therefore within the one model exists the potential for profit testing countless permutations of possible product types. Herein lies the key to the novelty of multi-state modelling.

2. Description of Multi-State Modelling

Terminology

2.1 A description of multi-state modelling must begin with a glossary of terminology which is specific to the context of multi-state modelling.

STATE
A state reflects the current condition a policyholder is in. The attributes that distinguish states are normally things that are relevant to the insurance risk. An actual life assured cannot be in more than one state at one time. Every insurance product has at least two states. At least one state produces a claim and at least one state terminates the policy. For example lapsing a policy puts the policyholder into a "LAPSED" state.

ABSORBING STATE
A state from which the policyholder cannot leave is called an absorbing state. It may also be called "terminating" as the policy will end for the policyholder on entering an absorbing state. Death is an absorbing state!

NON-ABSORBING STATE
Sometimes called a transition state because you can pass from this state into others. By definition it is non-terminating. For example if you have a "no claims bonus" you may be modelled as being in a "NO CLAIMS" state from which you may enter into other states.

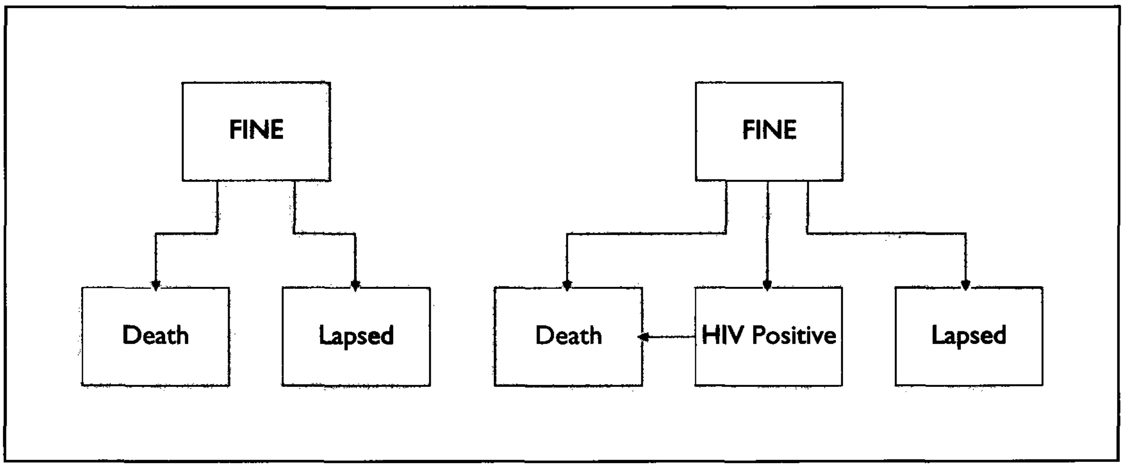
PRODUCT CHART
This is a diagram of the insurance policy's states and the possible movements between states. Those states (boxes) with no movements out of them are absorbing states. The starting state is shown as "FINE." The arrows on the interconnecting lines show the direction of possible movements. The actual movement rates (Inception, mortality etc.) are not shown.

Alternative designs

2.2 When using a multi-state model the user begins by defining the number of states that are applicable and then defines the nature of these states. More than one arrangement may be possible. The goal is to define states in such a way as to accurately model the underlying process.

2.3 By way of example there are two ways of configuring states to model the problem of a claim payable on death with lapses included. The first product chart shown below assumes that lapse is an independent process and its movement rates would reflect the actual population lapse rate.

2.4 With the hindsight of AIDS it is obvious that policyholders who are H.I.V. positive are not going to lapse their policies. This makes the relationship between the death rate and the lapse rate dependant. The adjacent diagram shows an additional state and configures the states differently. This latter configuration is a more accurate description of the insurance problem however with appropriate death and lapse data the former can give an adequate model.



How the process works

2.5 The profit testing process is made up of two components. The traditional business model and the interstate movements model.

The Business Simulation

2.6 Multi-state modelling as implemented by the authors of this paper, uses the model point technique. The data is partitioned cleanly; the policy represents the product specification and the variation represents an instance of business (the model point). This lends itself well to the valuation of inforce business as the variation data is where all the inforce information resides.

2.7 The modelling of cashflows that occurs during a policy term is performed in monthly intervals during which the movements are predicted and their ensuing payments, claims and expenses recorded. However the payments, claims and expenses are a function of the state in which the policyholder is deemed to be in.

The Interstate Movement Simulation

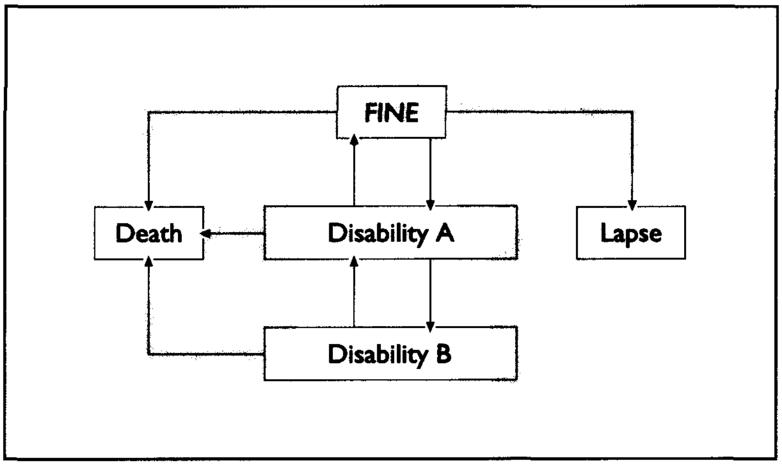
2.8 The distinguishing feature of multi-state modelling is that policyholders are represented as being in configurable claim states. Through the use of claim states, the probabilities of claims are calculated using the probability of movement into states with various claim amounts attached. Each state has one claim state table for reserve and one for experience bases. Because a state table is self contained it may be used by several policies and economise on effort and storage.

2.9 The first stage in designing a policy is to decide upon the various states that exist and the allowable movement between the states. A list of typical states is suggested below.

State name	State Description
Starting state	The starting state with no claims attached.
Death state	A predefined state for death with single claims.
Lapse state	The net lapse state with no claim.
Surrender state	The net surrender state if different from lapse due to claim entitlement. Usually duration based in claim magnitude.
Additional death state	Death resulting from special cases eg. AIDS.
Accident state	Accident or sports related injury state. May be single or annuity claims.
Disability state	Injury or sickness related disabilities. Claims may be single or annuity based.
Sickness state	Medical expenses claims.
Maturity state	A single claim payable because a certain age, term or calendar year is reached.
Pension state	An annuity or single benefit payable because a certain age is reached.
Long Term care state	Medical and nursing home expenses.
No claims bonus state	A state characterised by a reduction in premium.

This list is not exhaustive and merely serves to highlight the range of possibilities.

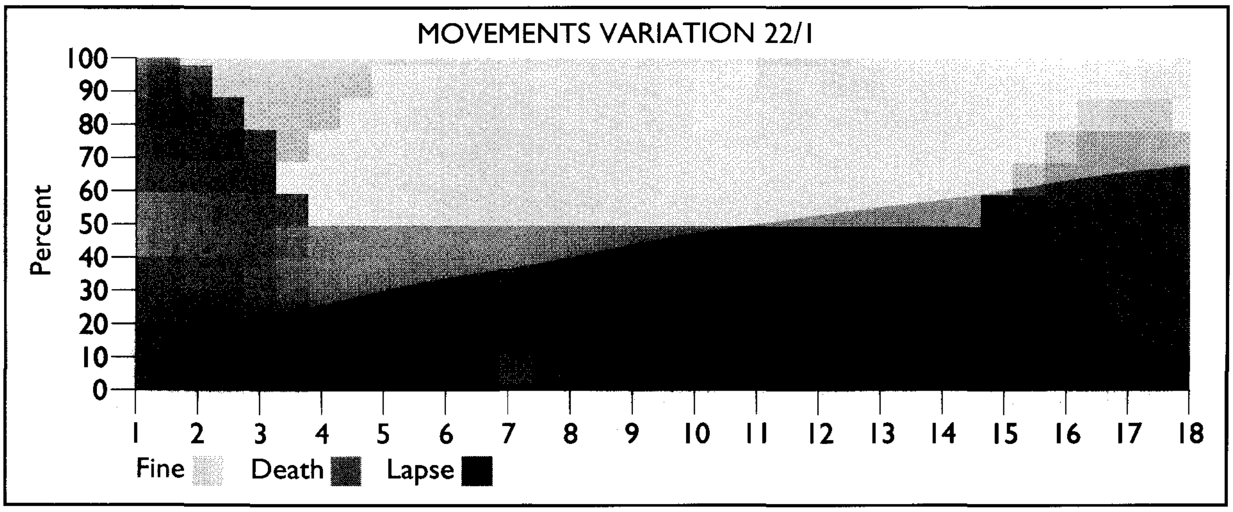
2.10 A diagram of the states and their interdependence is a valuable aid. Such a diagram is shown below.



2.11 It is apparent from the arrows in the figure that DEATH and LAPSE states are absorbing states as no movement out of them is shown. It is assumed in this example that policyholders in the disability states would not choose to lapse their policies as it would not be in their interest to do so.

2.12 It is apparent also that the death state table must include probabilities of movement from the FINE state and from the DISABILITY states (A & B) into the DEATH state. The DISABILITY A state table need only include probabilities regarding the movements to and from the FINE state. The lapse state table need only record probabilities of movements from the FINE state into the LAPSE state.
It should be noted that in the implementation being discussed, although the FINE state exists, it never has a state table associated with it.

2.13 One of the outputs from multi-state modelling should be a graph showing the proportion of people that reside in each of the states. This serves as a check that the states are behaving as you expect them to. Such a graph is shown below.



2.14 When selecting and defining states some questions should be asked.

Is the state absorbing?
By this it is meant that once in this state there is no way of moving on to further states. Death, lapse, surrender and maturity are obvious example of this.

Does entering the state terminate the policy?
An absorbing state must be a terminating state and a terminating state must be absorbing. This serves as a double check on your reasoning.

Are premiums waivered or suspended while in this state?
Applies only to non-absorbing states. Claim states that protect against loss of income are likely candidates for waiver of premium.

What is the claim frequency in that state?
For absorbing states the only valid claim frequency is SINGLE payment. For non absorbing states MONTHLY and/or ANNUAL may also be selected.

What is the lookup key for the state?
Each state has inception rates (and claim amounts) that vary with one of the following parameters.

Age eg. Ultimate mortality, Sickness

Duration into policy term eg. Lapse, Surrender

Age & duration eg. Select mortality

Age & calendar year eg. AIDS mortality

Age & duration in state eg. Permanent Health

A claim state must be declared to be one of these five types.

What is the state's claim related to?
For non terminating claim states the only valid choices are a guaranteed sum assured or a claim amount entered into each row of the state table.

For terminating states a percentage of the total units (or asset share) may also be selected. The claim amount is taken to be the greater of the fixed claim or the percentage claim.

2.15 The core of the multi-state model is the logic that calculates the proportion of policyholders that will (on average) be in each state.

2.16 This simulation aspect of the model generates the probability of state movement events. Rather than assigning the individual to one state or another (as in stochastic modelling), the individual is subdivided in such a way as to reflect the probability of these events. Portions of this individual that move into an absorbing or terminating state (such as death) no longer interest us in the model.

A profit test is deemed to be complete when the subdivisions of the individual, not in absorbing states, falls below a critical amount. This needs to be a user definable limit.

2.17 The model (as implemented) uses a convention whereby people are "Pulled" from one state into another rather than pushed. (The fine state is the only exception.) By this it is meant that in the movement table for state 5 will be all the probabilities of people ENTERING state 5 from the other states.

Appendix A gives an example of table data. This highlights the data requirements of certain table types. Appendix B gives the actual movement data that the model calculates. In Appendix C and D is a typical model point specification. Appendix E shows the complexity that the connectivity can achieve with DEATH, LAPSE and six user defined states.

3. Mathematical Specification

3.1 Describing an insurance product by its states and their interconnections may be thought of as a Markov process. Unfortunately the elegant mathematics of Markov chains require interstate movements to be constant with time. This is usually far from the case as the movement rate varies with policy duration, age, calendar year and duration in state. The movements may be made constant by having separate states for each month of the policy term. However this approach leads to vast numbers of states. Therefore, the mathematics of Markov chains finds little direct application in this problem.

Requirements

3.2 The requirements of an ideal multi-state model are listed below. In practice it is not essential to meet all of these as the absence of some do not result in a significant loss in functionality.

(a) The states shall be user definable and have the following configurable attributes.

Whether state is active,
Whether state is absorbing,
The movement data from other configured states,
The recovery to FINE movement data.

(b) It should be possible to configure for movements from any non absorbing state to any other.

ie. Movement (A,B) = movement from state A to state B

(c) The probability of moving between two states should ideally be a function of any combination of the following factors.

Policyholder age,
Policy duration,
Duration in the "From" state,
Calendar Year.

ie. Movement (A,B) =
fn (Age, Duration, Duration-in-state, Year)

In the authors' implementation the following were achieved in practice.

fn (Age) or
fn (Age, Duration) or
fn (Duration) or
fn (Age, Year) or
fn (Age, Duration-in-state)

(d) An absorbing state should have no outward movements.

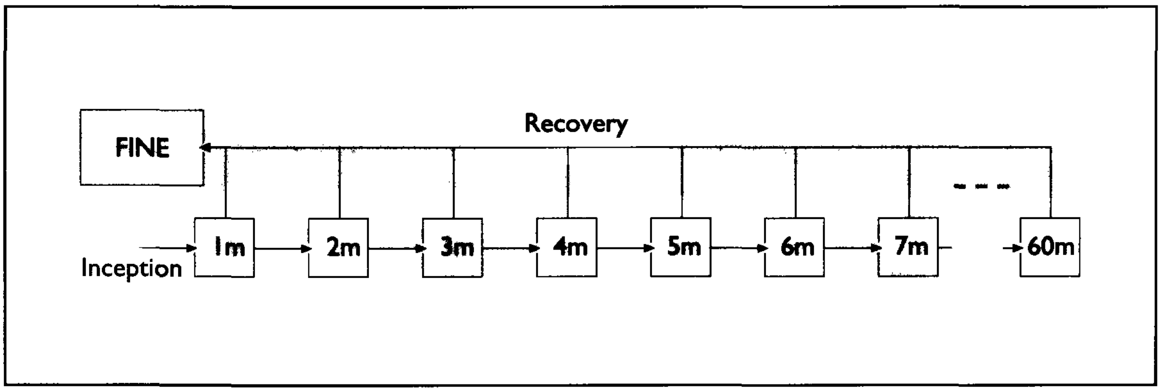
ie. Movement (A,B) = 0 when state A is absorbing

(e) A state should not explicitly refer to movements from itself, to itself.

ie. Movement (A,A) is undefined

Duration-in-state

3.3 The state that models P.H.I. claims (ie recovery which is a function of duration in state) is itself a miniature multi-state model. In the authors' implementation the state embodies a 60 state multi-state sub model of fixed connectedness. Inception (movement into this PHI state) occurs wholly into the sub-state labelled "1m" (month 1). Movements out of the state (eg mortality) are assumed to occur pro rata across all sub-states. However recovery (movement to the FINE state) has a rate that is specific to each sub-state. This adequately emulates the PHI problem while avoiding the need to setup and define 60 user definable states.



Interstate movements

3.4 There are two approaches to the calculation of interstate movements. The first of these is a dependent probability and is computationally efficient. The second of these is an independent probability but is computationally complex.

Dependent Probabilities

3.5 The situation may occur in which by examining all the state tables it is found that 20% of state 5 moves to DEATH, 30% of state 5 moves to LAPSE and 90% of state 5 moves into state 3. The sum of these probabilities comes to 140%. This situation is prevented by adjusting the number of people left in state 5 after each movement takes place so that you can never exceed 100%.

3.6 The previous example would be handled so that 20% move into the DEATH state, 30% of the remainder (24%) would move into the LAPSE state and 90% of the remainder (50.4%) would enter state 6. An analysis of this technique reveals that the calculated movements are order sensitive. It also demands that the tables hold dependent movement data.

3.7 Assuming eight dependent movement probabilities A to H the following effective probabilities apply.

$$A' = A$$
$$B' = B\ (1-A)$$
$$C' = C\ (1-A)\ (1-B)$$
$$D' = D\ (1-A)\ (1-B)\ (1-C)$$
$$E' = E\ (1-A)\ (1-B)\ (1-C)\ (1-D)$$
$$F' = F\ (1-A)\ (1-B)\ (1-C)\ (1-D)\ (1-E)$$
$$G' = G\ (1-A)\ (1-B)\ (1-C)\ (1-D)\ (1-E)\ (1-F)$$
$$H' = H\ (1-A)\ (1-B)\ (1-C)\ (1-D)\ (1-E)\ (1-F)\ (1-G)$$

Independent Probabilities

3.8 In order to get away from dependent movements we need to perform calculations of the independent kind.

In the case of two dependent probabilities A & B the net probability of both occurring may be written as

A + B - AB

Hence we may adopt the independent probabilities

A' + B'

where

A' = A (1-B/2)
B' = B (1-A/2)

This concept may be generalised to the eight independent probability case as shown below for the calculation of A'

```
A' = A X [
I
-I/2 ( B +C +D +E +F +G +H )
+I/3 ( BC +BD +BE +BF +BG +BH +CD +CE +CF +CG +CH +DE +DF +DG
+DH +EF +EG  +EH +FG +FH +GH )
-I/4 ( BCD +BCE +BCF +BCG +BCH +BDE +BDF +BDG +BDH +BEF +BEG
+BEH +BFG +BFH +BGH +CDE +CDF +CDG +CDH +CEF +CEG +CEH +CFG
+CFH +CGH +DEF +DEG +DEH +DFG +EFG +EFH +EGH +FGH )
+I/5 ( BCDE +BCDF +BCDG +BCDH +BCEF +BCEG +BCEH +BCFG +BCFH
+BCGH +BDEF +BDEG +BDEH +BDFG +BDFH +BDGH +BEFG +BEFH +BEGH
+BFGH +CDEF +CDEG +CDEH +CDFG +CDFH +CDGH +CEFG +CEFH
+CEGH +CFGH +DEFG +DEFH +DEGH +DFGH +EFGH )
-I/6 ( BCDEF +BCDEG +BCDEH +BCDFG +BCDFH +BCDGH +BCEFG +BCEFH
+BCEGH +BCFGH +BDEFG +BDEFH +BDEGH +BDFGH +BEFGH +CDEFG
+CDEGH +CDFGH CEFGH +DEFGH )
+I/7 ( BCDEFG +BCDEFH +BCDEGH +BCDFGH +BCEFGH +BDEFGH
+CDEFGH )
-I/8 BCDEFGH ]
```

3.9 The two movement calculation methods have independent advantages. The dependent method is computationally fast although not as rigorous as the independent calculation. A good multi-state model should allow both methods of calculation.

4. Uses Of Multi-State Modelling

4.1 The following three case studies indicate the way in which the multi-state model can be utilised to improve the modelling of PHI business, to allow more complex health products to be developed, and to show how derivation of transition rates can be simplified.

PHI

4.2 The concept of a PHI contract is that lives insured can reside in one of three states, healthy, sick or dead. Using the multi-state approach it is possible to set up a model so that lives move between these states in a well defined manner. Transition probabilities are required for the following:-

(1) Healthy to Sick
(2) Sick to Healthy
(3) Healthy & Sick to Dead

Let us now consider each of these in turn.

4.3 *Healthy to sick*

We require a set of claim inception rates which best reflect the experience, where appropriate, of the office concerned. Where this is not available we can utilise the published reports of the CMI, probably adjusted, to obtain our base rates. We need not concern ourselves here with the underlying period of deferment as this can be allowed for within the sickness state.

4.4 *Sick to healthy*

Here we have what is in essence a multi-state model within a multi-state model where transitions occur based on duration within the sickness state. Hence, at any one point of time the population of the sickness state will be distributed among each durational sub-state, ie. 1 month, 2 months, etc. It is here that we can model the deferment period by specifying that sickness claims are not to be paid until a life has been resident in the sickness state for a specified number of months.

The termination rates needed are those where a life recovers from sickness and returns to the healthy population, we do not need to consider termination by death at this stage. It is also possible to allow for escalation of benefits by first increasing the notional benefit by the required rate and then applying it to those in the sick state but outside the deferment period.

4.5 *Healthy & sick to dead*

Finally, to complete the model, we specify the mortality transitions from both the healthy and sick populations.

4.6 Having created our model we can project forward the population assuming 100% start in the Healthy state and verify that the resulting population distribution mirrors the required experience. In order to extend this model to be able to derive premium rates we also need to add a state to allow for the effects of lapses.

4.7 It is also possible to use the population distributions obtained from the model to produce valuation reserves for both future expected claims and also claims in payment. The latter can be performed by starting the relevant lives in the sickness state and projecting forward.

4.8 The multi-state approach is superior to the traditional methods in that it allows the practitioner to observe the build up of the population over time. For example, consider a life aged 40 at entry whose contract has been inforce for 10 years. Under the inception annuity approach we need the probability of a claim occurring at age 50 and to be able to derive an annuity that will represent the present value of all future liabilities as a result of that claim.

Under the multi-state approach we know the distribution of the population across all states and so can determine the expected amount of claim by multiplying the future benefit payments for those remaining in the claim state and discounting back to provide a present value of future liabilities.

4.9 Another benefit of the multi-state approach is to be able to see how the population in the sickness state has built up from previous periods by analysing according to duration within the state.

Long Term Care

4.10 An important feature of a long term care contract is that the life insured may pass through a number of levels of disability during the life of the policy. Within each level of disability the benefits payable to the life insured may vary. Let us assume that we are able to define three levels of disability, ranging from least to most severe, called Disabled 1, Disabled 2 and Disabled 3. Hence, to model this product it will be necessary to set up a multi-state model where we have the following states defined:

(1) Healthy
(2) Dead
(3) Disabled 1
(4) Disabled 2
(5) Disabled 3

As the severity of disability increases it would be usual for the benefit to increase as well due to the increasing costs of the care that will be required.

4.11 The transition probabilities required for this product could be very complicated if we were to include recovery from all levels of disability. Although this may be possible in real life some of the probabilities will be small and cause unnecessary complication, hence for modelling purposes we assume that recovery only occurs from Disabled 1 back to Healthy. In this case the transitions required can be defined as follows:

Healthy to Dead
Healthy to Disabled 1
Disabled 1 to Healthy
Disabled 1 to Disabled 2
Disabled 1 to Dead
Disabled 2 to Disabled 3
Disabled 2 to Dead

4.12 As for the PHI policy described above the multi-state modelling approach allows the practitioner to observe the build up of the population across the specified states, and after introducing a withdrawal state it is a simple step to derive premium rates, given a suitable set of assumptions.

4.13 If we had to use the inception-annuity approach to model a complicated contract such as this then at each age we would need the probability of a claim commencing and an annuity representing the present value of future liabilities allowing for the probabilities of termination by death, recovery or further deterioration of health. We would also need to be able to allow within this annuity for the increasing levels of benefit as disability becomes more severe. Derivation of appropriate annuity factors would be far more complex than fitting the relevant parameters in a multi-state model.

4.14 Appendices A and B give a snapshot of the data requirements and the results of running the population projection for a long term care contract with two levels of disability.

Derivation Of Transition Probabilities

4.15 The multi-state model can be a useful tool in developing appropriate transition probabilities from the underlying data. In developing a model for pricing long term care the most useful underlying UK data currently available is a set of prevalence rates taken from a disability survey. These rates describe the distribution of a population over various levels of disability.

By making an appropriate mortality assumption for the insured population as a whole and separate assumptions for the mortality of lives in the different disability states it is possible to use the multi-state model to derive transition probabilities between the states using a recursive approach until the population distribution in the model matches the distribution of the underlying prevalence rates.

Alternatively the model may be used to derive the mortality of disabled lives given appropriate transition probabilities.

4.16 A multi-state approach is used by the PHI Sub-Committee of the Continuous Mortality Investigation Bureau in analysing PHI data. The primary reason given by the Sub-Committee for adopting this method was to be able to allow for the probability of recovery to vary by duration in the sickness state. The model allows both the Manchester Unity Sickness Rate approach and the Claim Inception Rate and Disability Annuity approach to be seen as alternative ways of calculating the same functions.

5. Future Developments

5.1 As implemented the model achieves its goal of enabling a vast range of actuarial problems to be within the grasp of a single profit test model.

5.2 It remains to permit the switching from deterministic mode to stochastic mode as a user choice. The stochastic model will enable profit testing of insurance products with limits on the claim amounts. It will also enable the statistical spread of the results to be analysed rather than merely the average result.

5.3 It also remains to better simulate the "joint lives" case where two lives are concurrently (but not independently) moving between states (either deterministically or stochastically).

5.4 Currently the model is implemented with eight user definable states. There are cases (eg paid up policies) when this number of states may not be enough to describe the problem. The difficulty here lies in the fact that the movement data requirements grow with the square of the number of states possible.

6. Conclusions

6.1 Any insurance company which is dealing in health care related products will soon exhaust the capabilities of conventional profit testing packages. Some companies deal with this by relying on their reinsurer to supply the necessary data and results, which begs the question: How do reinsurers manage to profit test health products? The answer lies in the ingenuity of actuaries and programmers to provide specific profit testing solutions to specific products. This is not a cost effective approach compared to the generality of multi-state modelling.

6.2 Arguably there will never be an end to the variations in commission structures or reinsurance treaties, so programming may be with us for some time yet. However a large part of this workload can be replaced by basing the profit test around a number of user definable states.

6.3 The advantages of multi-state modelling are

The technique reflects the process more accurately. It allows non absorbing states to be modelled in their fullness.

The technique is backward compatible with existing non multi-state methods of modelling processes.

The range of problems that can be data driven (as opposed to reprogrammed) is greatly increased.

Reports of the percentages of policyholders in each state enable deeper diagnostics than is normally possible without multi-state modelling.

6.4 The disadvantages of multi-state modelling are

The data driven nature of the model causes it to be slower than models optimised for particular products.

The movement data required for certain products may be published in a form that does not immediately suit multi-state modelling.

The movement data required for certain products may not exist to the level of detail required by a complex model.

APPENDIX A

Sample transition probabilities for a long term care style product.

Mortality Probabilities

Age	From Healthy	From Disabled 1	From Disabled 2
60	0.005428	0.070428	0.165428
61	0.006040	0.071040	0.166040
62	0.006720	0.071720	0.166720
63	0.007475	0.072475	0.167475
64	0.008314	0.073314	0.168314
65	0.009247	0.074247	0.169247

To/From Disability State 1

Age	From Healthy	To Healthy	To Disabled 2
60	0.005297	0.010000	0.400000
61	0.007229	0.010000	0.400000
62	0.009343	0.015000	0.400000
63	0.009350	0.020000	0.400000
64	0.009400	0.025000	0.400000
65	0.009450	0.030000	0.400000

Withdrawal Probability

Duration	From Healthy
0	0.010000
1	0.050000
2	0.050000
3	0.050000
4	0.050000
5	0.050000

APPENDIX B

Sample population distribution for a long term care product assuming policy commences at age 60

Duration	Healthy	Dead	Withdraw	Disabled 1	Disabled 2
1	89.03%	0.53%	9.94%	0.39%	0.11%
2	83.47%	1.12%	14.37%	0.72%	0.32%
3	78.04%	1.81%	18.51%	1.00%	0.64%
4	72.91%	2.60%	22.38%	1.11%	1.00%
5	68.07%	3.48%	25.99%	1.13%	1.33%
6	63.49%	4.44%	29.36%	1.11%	1.60%

APPENDIX C

A Typical Multi-state Policy

Page 1

POLICY DEFINITION

Dated: 16 November 13:42:05 **Policy 1000** **PERMANENT HEALTH EXAMPLE**

Policy Type	CONVENTIONAL	Commission Type	LAUTRO INDEMNITY
Product Class	Permanent Health	Business Type	Permanent Health
Commission Class	Permanent Health	Sterling Reserve Interest	0.0%
Currently Active	YES	Reserve Discount rate	7.20%
Dividend tax rate	30.00%	Reserve Solvency margin	0.00%
Commission method	LAUTRO INDEMNITY	With Profits	None
100% clawback period	NA mths	End of clawback	NA mths
Policy term:	AGE 60	Clawback method	LAUTRO
Initial period	NA mths	Reinsurance table	"Reinsured"
Reinsur. Mnt. expenses (%API)	0.0	Reinsur. init. exp. (%API)	-50.0
Reinsur. Mnt. expenses	£-24.00	Reinsur. init. exp. (% com)	0.0
Reinsur. Mnt. claim exp.	£0.00	Reinsur. init. exp. (£)	£-100.00
Init. Reinsur. comm.	0.0% of LAUTRO	Percentage of inflation	100.0%
Renwal Reinsur. comm.	0.0% of premium		
Rsrv calc. method	2-profit allowance		

	RESERVE		EXPERIENCE	
Initial commission rate	-N/A-	% API	-N/A-	% API
Percentage of LAUTRO comm.	100.0	% LAUTRO	100.0	% LAUTRO
Percentage paid at outset	-N/A-	%	-N/A-	%
Renewal commission rate	2.50	%	2.50	%
Initial fixed expenses	£100.00		£100.00	
Initial variable expenses	50.00	(% API)	50.00	(% API)
Initial variable expenses	0.00	(% COM)	0.00	(% COM)
Maintenance fixed expenses	£24.00		£24.00	
Maintenance variable expenses	0.00	(% API)	0.00	(% API)
Claim expenses	0.00		0.00	
Investment Interest rate	5.00	%	9.00	%
Investment Equity income rate	4.00	%	4.00	%
Investment Equity growth rate	2.50	%	6.00	%
Proportion of investment equity	50.00	%	50.00	%
Estate Interest rate	N/A	%	N/A	%
Estate Equity income rate	N/A	%	N/A	%
Estate Equity growth rate	N/A	%	N/A	%
Proportion of estate equity	N/A	%	N/A	%
Tax on equity income	0.00	%	0.00	%
Tax on fixed interest income	0.00	%	0.00	%
Tax on capital gains	0.00	%	0.00	%
Tax on initial expenses	0.0	%	0.0	%
Tax on normal expenses	0.0	%	0.0	%
Shareholder's dividend	100.00	%	100.00	%
Shareholder's discount rate	15.00	%	15.00	%
Solvency margin based on SAR	0.000	%	0.000	%
Solvency margin interest rate	7.20	%	9.00	%
Unit allocation table "		"		"

POLICY DEFINITION

Dated: 16 November
13:42:05 Policy 1000 PERMANENT HEALTH EXAMPLE

Cancel units	NO	NO
Percent of initial expenses charged	0.0 %	0.0 0.0 % %
Percent of renewal expenses charged	0.0 %	0.0 %
Capital units		
Management fee	0.00 %	0.00 %
Fixed Management fee	£0.00 %	£0.00 %
Gross allocation discount	0.00 %	0.00 %
Net allocation discount	0.00 %	0.00 %
Accumulation units		
Management fee	0.00 %	0.00 %
Fixed Management fee	£0.00 %	£0.00 %
Gross allocation discount	0.00 %	0.00 %
Net allocation discount	0.00 %	0.00 %
Bonus units		
Management fee	0.00 %	0.00 %
Fixed Management fee	£0.00 %	£0.00 %
Gross allocation discount	0.00 %	0.00 %
Net allocation discount	0.00 %	0.00 %

	RESERVE	EXPERIENCE
Death state active YES	"standard mortality	"Reinsure claims YES
State table name	"PHI mortality"	"PHI mortality"
Percentage of movements	100%	90%
Percentage of benefits	100%	100%
Lapse state active YES	"10/5%	"Reinsure claims YES
State table name	" "	"Lapse 10/5"
Percentage of movements	0%	100%
Percentage of benefits	0%	100%
State 1 active YES	"Permanent health state	"Reinsure claims YES
State table name	"PHI EXAMPLE"	"PHI EXAMPLE"
Percentage of movements	110%	100%
Percentage of benefits	100%	100%
Premium type	WAIVED	WAIVED
State 2 active YES	"termination state	"Reinsure claims YES
State table name	" "	" "
Percentage of movements	0%	0%
Percentage of benefits	0%	0%
Premium type	WAIVED	WAIVED
State 3 active NO	"	"Reinsure claims NO
State table name	" "	" "
Percentage of movements	0%	0%
Percentage of benefits	0%	0%
Premium type	REQUIRED	REQUIRED
State 43 active NO	"	"Reinsure claims NO
State table name	" "	" "
Percentage of movements	0%	0%
Percentage of benefits	0%	0%
Premium type	REQUIRED	REQUIRED

POLICY DEFINITION

Dated: 16 November 13:42:05 **Policy 1000** **PERMANENT HEALTH EXAMPLE**

State 5 active NO "		"**Reinsure claims NO**
State table name	" "	" "
Percentage of movements	**0%**	**0%**
Percentage of benefits	**0%**	**0%**
Premium type	**REQUIRED**	**REQUIRED**

State 6 active NO "		"**Reinsure claims NO**
State table name	" "	" "
Percentage of movements	**0%**	**0%**
Percentage of benefits	**100%**	**100%**
Premium type	**REQUIRED**	**REQUIRED**

Policy Notes

This is a reinsured piece of business

APPENDIX D

A Typical Multi-state Variation Definition

VARIATION DEFINITION

Dated: 16 November	Policy 1000	PERMANENT HEALTH EXAMPLE
13:42:32	Variation 1	PERMANENT HEALTH: MALE 45:60

Tax Type (Life/Annuity/Pension)	L	Frequency Premium	£61.81
Entry Date	01/09/1992	Initial Escalation	5.05
Frequency	M	Initial term	999 mths
First Age	45 years	Latter Escalation	0.0%
Second Age	0 years	Escalation Mode	Compounding
First Age Adjustment "	"	Initial policy fee	£2.00
Second Age Adjustment "	"	Latter policy fee	£0.00
Joint Age Adjustment "	"	Rein type	Quota Share
Initial fee term	999 mths	Initial reinsurance	50.00%
Currently Active	Yes	Latter reinsurance	0.00%
Business type:	New Bus.	Reinsurance limit	£0.00
Duration into policy	0 mths	Capital unit value	£0.00
Estate value	£0.00	Accum. unit value	£0.00
Shareholders' loan amount	£0.00	Bonus unit value	£0.00
Goal subject	Nothing	Inforce state	F
Goal method	IRR	Sum Assured	£100,000.00
Goal criteria	0.000%	Commision sacrifice	0.00%
Apply loadings to	Reserve & Exp.	Loading Duration	0 yrs
Premium loading	0.00%		

Death state: Sum Assured 100.0000% ie. £100,000.00
Escalating at 0.00% Compounding
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

Lapse state: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

State 1: Sum Assured 1.5000% ie. £1,500.00
Escalating at 5.00% Compounding
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

State 2: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%
Terminate when AGE equals 60

State 3: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

State 4: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

State 5: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

State 6: Sum Assured 0.0000% ie. £0.00
Escalating at 0.00%
Bonus rate 0.0%
Loadings AGE: 0 yrs FIXED: 0.0000% PERCENTAGE: 0.00%

APPENDIX E

The Most Complex 8 Configurable State Model Possible