JIA 117 (1990) 533-595

WORK TIME LOST TO SICKNESS, UNEMPLOYMENT AND STOPPAGES: MEASUREMENT AND APPLICATION

BY S. HABERMAN, M.A., Ph.D., F.I.A., A.S.A., F.S.S., A.F.I.M.A.
AND D. S. F. BLOOMFIELD, B.Sc.

[Presented to the Institute of Actuaries, 23 April 1990]

ABSTRACT

The paper considers a number of methods of estimating the work time lost due to sickness, unemployment and stoppages. The most satisfactory approach suggested is based on a multiple state working life table. Numerical examples of the measurement of work time lost are provided for particular application to the actuarial assessment of damages (arising out of personal injury or fatal accident). Other applications, including the pricing of unemployment insurance, are also discussed.

KEYWORDS

Multiple State Models: Damages: Sickness: Unemployment

1. INTRODUCTION

1.1 We begin with a problem arising in the area of the actuarial assessment of damages. When the assessment of damages arising out of personal injury or fatal accident litigation is made, it is appropriate to take into account a number of contingencies other than mortality. These contingencies are considered to affect the probability that an injured plaintiff would have received the earnings or pension for the loss of which he/she is being compensated.

1.2 One of the aims of this paper is to consider the modifications needed to the conventional actuarial calculations to incorporate such 'other contingencies'. The paper looks at this problem from different theoretical viewpoints, comments on the data which are routinely available and makes recommendations regarding data which should be available. The paper attempts to quantify the effect of incorporating these 'other contingencies' into the actuarial assessment of damages.

1.3 The paper explains that the most satisfactory approach to the above problem is based on a multi-state working life table, based on the methodology of the Markov chain as applied to labour force status. This model enables unbiased estimates of the work time lost due to sickness, unemployment and industrial stoppages to be made, providing that adequate data are available for the key parameters to be estimated.

1.4 The paper also examines wider applications of this multi-state model, including the pricing of unemployment insurance.

1.5 A preliminary version of this paper has been published by the authors.[1] This provides more detail about the applications of the above techniques to the problem arising in the area of assessment of damages.

2. ASSESSMENT OF DAMAGES AND OTHER CONTINGENCIES

2.1 *What are these Other Contingencies?*

2.1.1 As Owen and Shier[2] have noted in their interesting overview of current practice in damage assessments, the most important contingencies (other than mortality) are the probabilities of future redundancy and subsequent unemployment, temporary ill health, permanent disability and early retirement. Strikes and industrial disputes should also be allowed for. With respect to a self-employed plaintiff, it may be appropriate to make an allowance for the possibility that his business will fail in the future.

2.1.2 The same contingencies also apply to a plaintiff unemployed at the time of the injury or accident.

2.1.3 Clearly, these contingencies reflect processes with a number of different states and the possibility of transitions back and forth. Mortality is much simpler—there is a one-way transition from 'alive' to 'dead'! We return to this important point in a later section.

2.1.4 Thus, an individual may, in the future, have interspersed periods of gainful employment and unemployment, disability and activity (as a particular condition improves, is cured, deteriorates, recurs and so on). What is important, from an assessment viewpoint, is the time spent in these transient states. The comparison with a situation where only mortality is important is of value—here, we are interested in the time spent in the 'alive' state before the (once and for all) transition to the 'dead' state.

2.1.5 As noted in § 2.1.3, the process underlying mortality is straightforward. The definitions, 'alive' or 'dead', are obvious too. The nature of the other contingencies under consideration here are not subject to such precise definition. The evidence on which a claim for sickness, invalidity or unemployment benefit may be based is not subject to simple certification. Terms like 'sick', 'disabled' or 'unemployed' are susceptible to different interpretations.

2.1.6 Consider the term, 'unemployed', for a moment. It is widely agreed that a person without a job and looking for work should be counted as unemployed, but such a definition is not precise. For example, how active should people be in search of a job? Should other conditions such as being immediately available for work be added? And should those not looking for work be included if they no longer believe jobs are available? These complexities, in particular relating to entitlement for different benefits, mean that there is no unique measure of unemployment that would be universally accepted for all purposes. Haberman[3] provides a similar discussion in respect of disability and invalidity.

2.1.7 A further complication that arises in respect of unemployment in the United Kingdom is the frequent changes in the basis by which monthly statistics of these unemployed are produced. For example, six changes of this nature have taken place between October 1979 and March 1986 (discussed further in § 7.7).

2.1.8 A final point on the comparison with mortality concerns the stability and rate of change of the underlying flow rates. Mortality rates do vary between years but, in developed countries, are seldom subject to violent fluctuations (if we discount the effect of AIDS). However, as a result of economic conditions within a country and elsewhere, unemployment rates (and sickness or disability rates) are liable to violent and unpredictable fluctuations.

2.1.9 All of these influences conspire to make statistical measurement of the contingencies of sickness and unemployment highly problematic.

2.1.10 It should be noted that, in the event of certain of the contingencies that we are considering here, the individual may receive statutory or other benefits. Thus, the employer has to provide a statutory benefit in the event of redundancy or sickness, and the payment of social security benefits (including, for example, means-tested assistance benefits like income-support or supplementary benefits) would also reduce the plaintiff's prospective loss. In the case of early retirement or retirement on grounds of ill health, credit should be given for any pension which would be received. The provision of unemployment benefit from the social security system would also reduce the loss related to such periods of inactivity. (Any deduction to allow for the payment of statutory benefit would be further affected by the provisions of the 1989 Social Security Act, Clause 23 of which requires injured persons, who successfully sue for damages, to repay to the Government all social security benefits which they have received as a result of their injuries.) Allowance for such payments would need to be made in an actual actuarial assessment of damages.

2.1.11 Although changes in circumstances could rightly lead to an improvement or a worsening in the level of damages, it tends to be only those factors which lead to a worsening that are considered in the courts.

2.2 *Current Practice on Contingencies*

2.2.1 Prevett[4] noted that it is the practice of the courts to make a percentage deduction for contingencies resulting in a temporary loss of earnings. This view is supported by the more recent paper by Owen and Shier.[2]

2.2.2 Traversi[5] described contingencies such as sickness and disability as 'of almost negligible importance in dealing with damages cases' when allowance is made for the payment of social security benefits leading to only a partial loss of earnings. Traversi investigated the rates of sickness and unemployment using data from the United States of America and Australia and concluded that a 2% deduction would be appropriate.

2.2.3 Street[6] estimated that the average number of days lost per annum from strikes, unemployment, sickness and disability was 17·85, which he reduced to 12 to allow for social security benefits which the plaintiff may receive. This led him to suggest a deduction of 3·5%, with a possible range of variation of 2% to 6%, allowing for different occupations and geographical areas.

2.2.4 Craighead, in the discussion of Prevett's paper, suggested that a deduction of 1% to 3% was then common in South Africa.

2.2.5 Prevett[4] indicated that at that time, viz. 1966, he used a deduction of 'not more than 2%'.

2.2.6 A number of writers have referred to the practice among judges of using a deduction of 10% or more for 'other contingencies' where these 'other contingencies' have incorrectly included the possibility of death prior to the attainment of the expectation of life!

2.2.7 Kemp[7] doubted whether, in the ordinary case, a discount exceeding 5% should be made for 'other chances'. He quoted examples of discounts that have been used in practice. In *Mitchell* v. *Mulholland*, in 1972, Lord Justice Edmund-Davies described a 2% discount for contingencies as 'both haphazard and too little', although he did not say what level of deduction he favoured and why. The Law Commission, in a working paper in 1970, suggested a deduction of between 2% and 4%. Kemp also quoted two cases from overseas (one from Canada and one from Australia) where the courts had accepted a discount of about 10%. Examples from other jurisdictions are, of course, of only limited value, given that economic and other relevant factors are likely to be different.

2.2.8 Luntz[8] in a careful analysis using unemployment, sickness and industrial dispute statistics for Australia relating to the 1960s suggested that a 'maximum possible allowance in the average case for contingencies causing loss of income' is 4%, made up as follows:

Sickness	0·2%
Industrial accidents	0·3%
Other accidents	1·0%
Unemployment	2·0%
Strikes	0·5%
TOTAL	4·0%

2.2.9 A number of features of the economic environment within the U.K. have changed since many of these earlier papers were written. Thus, in the U.K., unemployment rates have risen, stabilised and now are falling, long-term disability rates have risen, early retirement rates have risen. Also, any offset for social security benefits should now reflect the introduction of earnings-related retirement pensions and invalidity benefits in 1978 and the subsequent modifications to these earnings-related benefits instituted in the Social Security Act 1986, as well as the effects of Clause 23 of the 1989 Social Security Act (see §2.1.10).

2.2.10 These earlier estimates do not recognise the entry and re-entry feature of many of these contingencies, nor do they recognise the possible effect of timing of a future transition from employment to unemployment (say) on the present value calculations that the actuary ultimately makes in his/her assessment of damages.

2.2.11 Kemp[7] and Luntz[8] hinted that important evidence that should be taken into account is the particular circumstance of the plaintiff, e.g. past absence from work through illness, etc. In particular, the plaintiff's status just before the injury or accident occurred in terms of economic activity and morbidity is important and should be allowed for in a numerical way.

3. WORK TIME LOST: OTHER APPLICATIONS

3.0.1 We consider, in this brief section, other potential areas of application for unbiased estimates of the work time lost due to sickness, unemployment and industrial stoppages. Further details will be given in Section 10.

3.1 *Unemployment Insurance*

3.1.1 Unemployment insurance is provided in many developed countries by what amounts to a public system, a feature that makes it similar to other public redistributive schemes which provide income support. Thus, in the U.K., National Insurance contributions, which give entitlement to unemployment benefit, are both compulsory and flat-rated (although dependent on earnings). This implies that the premium that an individual pays does not fairly reflect the unemployment risks that are being 'underwritten' by the State.

3.1.2 It is possible that the multi-state methodology suggested in subsequent sections for the measurement of work time lost to unemployment, could be applied to setting up a theoretical basis for an unemployment insurance scheme which would be on the same footing as other types of insurance (e.g. life or motor insurance), with the premium reflecting directly the risks that are being underwritten. Such a scheme could be operated by the state or by the private sector: it is not our purpose to discuss the relative merits of these two approaches.

3.2 *Other Applications*

3.2.1 It is worth noting that the multi-state model, which will be advocated in Section 8, is indeed the basis being used by the C.M.I. Bureau in its analysis of sickness experience under permanent health insurance policies and has been proposed by Haberman(3) for the analysis of long-term social security invalidity experience. It is understood that the C.M.I. Bureau will suggest that premiums and reserves be calculated using a multi-state methodology.

3.2.2 If we turn our attention to employers, it is possible that the multi-state methodology could be used for the pricing of group-based insurance, which would provide indemnity against losses caused by industrial stoppages and strikes, or worktime lost through sickness among the workforce. Employers contemplating the alternative of self insurance might be able to adapt the methodology to facilitate the calculation of internal reserves for these contingencies. These other applications are not pursued further in this paper.

4. METHODS OF MEASUREMENT OF WORK TIME LOST

4.1 In this paper, we present three different approaches to the measurement of the effect of the contingencies of sickness, unemployment and so on, on the estimates of average working lifetime. Each approach arises from a distinct methodological basis and requires different data for its implementation. These three approaches are compared, using numerical illustrative examples of current relevance to the U.K., where these are available.

4.2 The first method is that of the conventional working life table. It uses the methodology of the decrement table to model labour force transitions.

4.3 The second method recognises the deficiencies in this first approach and attempts to utilise data routinely published on the average time spent in the sick or unemployed states. These estimates are then combined, in a way similar to that for the first method, with published mortality rates, in an attempt to calculate a joint probability of being alive and active or working or, as here, in an attempt to calculate the reduction to apply to the probability of being alive to allow for the probability of *not being active*.

4.4 The third method improves on both of the first two approaches. It recognises fully the nature of the underlying stochastic process of labour force transitions and requires the setting up of a multi-state life table (or increment-decrement table as some commentators would call it) based on the methodology of the Markov chain.

5. THE WORKING LIFE TABLE: INTRODUCTION

5.1 The working life table is a basic tool for estimating the expected duration of a man's productive life. This tool is modelled on the ordinary (single decrement) life table and it is a fundamental instrument in the scientific analysis of labour force structure and mobility (entries and exits), as well as for the projection of labour force participation.

5.2 Hoem[(9)] describes the usefulness of working life tables and notes, in particular, the analysis of work-force progression and trends of retirement, educational planning and the calculation of the money-value of an individual. The resulting summary indices, for example work life expectancy, facilitate the comparisons of different levels of economic and social development both over time and across populations.

5.3 There are two principal approaches to the methodology and construction of working life tables. We shall describe both and compare their effectiveness, paying particular emphasis to the data that are currently available for the U.K.

5.4 Historically, the first approach was that proposed by Wolfbein,[(10)] which uses the classical, conventional life table methodology to construct a working life table (Section 6). More recently, Hoem[(9)] and Becker & Alter[(11)] have used Markov chain methodology to construct a multi-state (or increment-decrement) working life table (Section 8).

5.5 A full discussion is provided by Hoem & Fong's working paper.[(12)]

6. THE WORKING LIFE TABLE: CLASSICAL APPROACH

6.1 *Methodology*

6.1.1 Consider the construction of a working life table for males.

Let w_x be a set of age-specific labour force participation rates for males (for single years of age). Suppose a corresponding life table is available for which l_x is the number of males aged x out of l_0 born alive. If the population were stationary, the number of males aged x to $x+1$ at the current time would be proportional to L_x where:

$$L_x \doteqdot \tfrac{1}{2}(l_x + l_{x+1})$$

in the usual way.

Let $Lw_x = L_x w_x$ be the corresponding life-table population in the labour force.

6.1.2 A graduated set of w_x would have the appearance of the curve in Figure 1 (showing the labour force participation rates for males based on the 1985 Labour Force Survey for Great Britain).[13] The rates rise sharply from age 16 to the early 20s, when most young men enter the labour force. They continue to rise to a peak

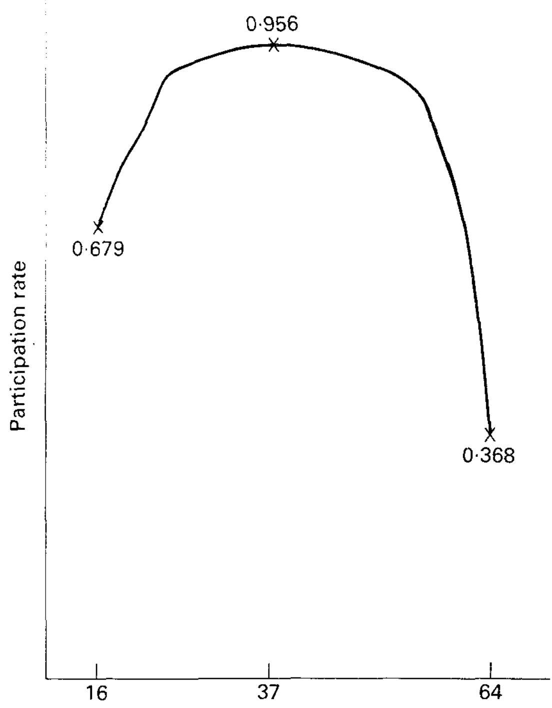

Figure 1. Graph of labour force participation rates. Labour Force Survey, Great Britain, 1985: males

at some age x_0 in the 30s (in Figure 1, $x_0 = 37$). The curve drops slowly from age x_0 to the mid 50s, but then declines rapidly due to the effect of retirements of various types.

It is assumed in the classical approach that, for $x < x_0$, separations from the labour force are due to death only.

6.1.3 Let $q_x^d = (1 - L_{x+1}/L_x)$ be the independent mortality rate between successive years of age (from age x last birthday to $x + 1$ last birthday).

Let $(aq)_x$ be the corresponding dependent rate of labour force separations from all causes for persons in the labour force in a given year of age. Let $(aq)_x^d$ and $(aq)_x^r$ denote the corresponding dependent rates of death and retirement.

Then, for $x < x_0$, $(aq)_x = (aq)_x^d = q_x^d$ and $(aq)_x^r = 0$.

For $x > x_0$,
$$(aq)_x = \left(1 - \frac{Lw_{x+1}}{Lw_x}\right)$$
$$(aq)_x^r + (aq)_x^d = (aq)_x$$

and it can be proved, using classical multiple decrement theory algebra, that:

$$(aq)_x^d = q_x^d(1 - \tfrac{1}{2}q_x^r) = q_x^d\left(1 - \frac{\tfrac{1}{2}(aq)_x^r}{1 - \tfrac{1}{2}q_x^d}\right)$$
$$\doteqdot \frac{q_x^d(1 - \tfrac{1}{2}(aq)_x)}{(1 - \tfrac{1}{2}q_x^d)},$$

(which requires the usual assumptions about a uniform distribution of decrements in the underlying single decrement tables).

For $x < x_0$, additions to the life table labour force between successive years of age would be $A_x L_x$ where:

$$A_x = (w_{x+1} - w_x)(1 - (aq)_x^d).$$

6.1.4 To obtain estimates of working life expectancy, we adapt the classical life table approach to $\mathring{e}_x$.

For $x > x_0$, the average number of years remaining in the labour force is given by

$$\mathring{e}_x^w = \sum_{y \geqslant x} \frac{Lw_y}{lw_x}$$

where $lw_x = \tfrac{1}{2}(Lw_{x-1} + Lw_x)$.

This has the interpretation of the average number of years of working life remaining to a group of individuals in the labour force at age x. Adjustments are hence needed for $x < x_0$, to eliminate the effect of entries into the labour force in the following years. A hypothetical set of values of the stationary labour force, Lw'_x, and of the corresponding members alive at exact age x, lw'_x, are calculated as follows:

for $x < x_0$

$$Lw'_x = L_x \cdot w_{x_0}$$

$$lw'_x = \frac{l_x}{l_{x_0}} \cdot lw_{x_0}$$

and then $\mathring{e}^w_x$ is estimated according to the following formula:

$$\mathring{e}^w_x = \frac{\sum_{y=x}^{x_0-1} Lw'_y + \sum_{y \geqslant x_0} Lw_y}{lw'_x}.$$

6.2 *Application to Current Data for Great Britain*

6.2.1 Working life tables have been constructed using this conventional method with the following data:

(a) l_x from English Life Tables (1980–82) No. 14 for males,[14] and
(b) w_x from Labour Force Surveys for 1973, 1977, 1981 and 1985 for males for Great Britain.[13]

The definition of labour force and hence of the participation rates as used in this report is given in Appendix 1.

6.2.2 The choice of w_x has been made to illustrate typical levels and shapes of labour force participation rates from the recent socio-economic experience (cross-sectional) of this country. The purpose is to investigate the magnitude of $\mathring{e}^w_x$ in relation to these differing levels of participation rates and it seems a reasonable expedient to employ the same (mortality) life table throughout. The values of w_x for single years of age have been derived from the grouped data by a process of graphical smoothing.

6.2.3 The $\mathring{e}^w_x$ figures are all truncated at age 65, so that $y = 64$ is the maximum age in the respective summations. They may be interpreted, under the assumptions described earlier, as the average number of years remaining in the labour force between ages x and 65. Table 1 shows the respective values based on the four sets of labour force participation rates and the ratios of the average number of years remaining in the labour force between ages x and 65 to the average number of years remaining alive between ages x and 65, i.e:

$$k_x = \frac{\mathring{e}^w_{x:\overline{65-x}|}}{\mathring{e}_{x:\overline{65-x}|}}.$$

6.2.4 Examination of these rates gives some idea of the deductions needed in estimates of the average remaining lifetime (up to age 65) to allow for the average time spent *outside* of the labour force:

			%
age:	16	deduction:	1·5– 5·8
	20		1·7– 6·3
	25		1·9– 7·2
	30		2·3– 8·3
	35		2·6– 9·8
	40		3·1–11·7
	45		3·5–13·8
	50		4·6–16·8
	55		6·6–22·6
	60		4·1–25·0

6.2.5 These deductions taken from Table 1 are lowest for the calculations based on the 1973 Labour Force Survey and highest for the calculations based on the 1985 Labour Force Survey. These features are not unexpected, given that labour force participation rates for men were falling during this period of time, particularly at ages 16–17 and at ages over 60. The main influences were the high levels of unemployment, the difficulties of finding re-employment, the effects of youth training schemes and the trend towards earlier retirement.

6.2.6 The increase in the deductions listed in § 6.2.4 with increasing age can be attributed to the particular shape of the underlying labour force participation rates, w_x. Each of the four sets of w_x is unimodal with a peak at age x_0. The approximate values of x_0 are:

39·5 for 1973
41·0 for 1977
34·0 for 1981
37·0 for 1985.

Table 1. *Average number of years remaining in the labour force up to age 65 (Labour Force Surveys and English Life Tables No. 14)*

Truncated = $\mathring{e}^{w}_{x:\overline{65-x}|}$

Year of survey

Age x	1973	1977	1981	1985
16	45·73 (98·5%)*	45·40 (97·8%)*	44·51 (95·8%)*	43·75 (94·2%)*
20	41·89 (98·3%)	41·56 (97·5%)	40·66 (95·4%)	39·90 (93·7%)
25	37·06 (98·1%)	36·72 (97·2%)	35·83 (94·8%)	35·06 (92·8%)
30	32·20 (97·7%)	31·86 (96·8%)	30·96 (94·0%)	30·20 (91·7%)
35	27·34 (97·4%)	27·00 (96·2%)	26·18 (93·3%)	25·33 (90·2%)
40	22·51 (96·9%)	22·16 (95·4%)	21·70 (93·3%)	20·53 (88·3%)
45	17·83 (96·5%)	17·47 (94·5%)	16·98 (91·9%)	15·93 (86·2%)
50	13·19 (95·4%)	12·84 (92·8%)	12·40 (89·6%)	11·50 (83·2%)
55	8·67 (93·4%)	8·33 (89·8%)	7·91 (85·3%)	7·18 (77·4%)
60	4·55 (95·9%)	4·32 (90·9%)	4·00 (84·3%)	3·56 (75·0%)

* The figures in parentheses denote the ratios

$$k_x = \frac{\mathring{e}^{w}_{x:\overline{65-x}|}}{\mathring{e}_{x:\overline{65-x}|}},$$

where the term in the denominator is based on E.L.T. No. 14.

6.2.7 The monotonic decreasing trend of w_x with age for $x > x_0$ explains the decreasing trend in k_x as x increases and hence the increasing trend in the deductions, $(1-k_x)$, quoted in §6.2.4: this point is discussed further by Bloomfield & Haberman.[1]

6.2.8 Percentage reductions in this form would not be appropriate for application in the assessment of damages and for related estimates, because it is usual in such estimates to discount the anticipated future stream of earnings using an expected *real* rate of interest.

6.2.9 Instead of considering the ratio

$$k_x = \frac{\mathring{e}^{w}_{x:\overline{65-x}|}}{\mathring{e}_{x:\overline{65-x}|}}$$

and its progression with x, we now consider the ratio:

$$k(x,i) = \frac{\ddot{a}^{w}_{x:\overline{65-x}|}}{\ddot{a}_{x:\overline{65-x}|}} = \frac{l_x \sum_{y=x}^{64} v^y lw_y}{lw_x \sum_{y=x}^{64} v^y l_y}$$

where $v=(1+i)^{-1}$, and i is an appropriate *real* rate of interest.

6.2.10 Values of $k(x,i)$ for quinquennial ages and $i=1\%$, 3% and 5% are given in Table 2, using the Labour Force Survey data for 1973, 1977, 1981 and 1985 and English Life Tables No. 14 as before. The case $i=0$ would be similar to the presentation of Table 1. For convenience, we have considered annuities with payments made annually in advance (rather than continuous annuities), in the above formulation and in the presentation in Table 2.

6.2.11 Table 2 indicates that the ratios, $k(x,i)$, are less sensitive to the level of the real rate of interest than to attained age.

6.2.12 If we consider the ratios in Table 2 corresponding to $i=3\%$ with those in Table 1 which (approximately) correspond to $i=0$, we discover that the former ratios are higher in absolute terms by about:

1·0% at ages 20–50
1·3% at ages 55–60,

based on the 1973 labour force participation rates.

6.2.13 A comparison based on the 1985 labour force participation rates shows that the ratios for $i=3\%$ are higher than those for $i=0$ in absolute terms by about:

2·4% at ages 20–30
2·8% at age 35
3·5% at ages 40–50
4·3% at age 55
5·9% at age 60.

Table 2. *Comparison of annuity values paid while alive and active and those paid while alive, using the conventional working life table approach*

Ratios of annuity values $k(x,i)$

Age	Real rate of interest	Year of Labour Force Survey 1973	1977	1981	1985
x	i p.a.	%	%	%	%
20	1%	98·8	98·1	96·5	95·2
	3%	99·2	98·8	97·6	96·8
	5%	99·5	99·2	98·3	98·0
25	1%	98·5	97·8	95·9	94·4
	3%	99·0	98·5	97·0	96·1
	5%	99·3	99·0	97·8	97·3
30	1%	98·3	97·4	95·1	93·4
	3%	98·7	98·1	96·2	95·1
	5%	99·1	98·6	97·0	96·4
35	1%	97·9	96·9	94·4	91·4
	3%	98·4	97·6	95·4	93·0
	5%	98·7	98·1	96·2	94·4
40	1%	97·4	96·1	94·6	90·3
	3%	97·8	96·8	95·5	91·8
	5%	98·2	97·4	96·3	93·2
45	1%	97·1	95·4	93·3	88·0
	3%	97·5	96·0	94·2	89·5
	5%	97·8	96·6	95·0	90·7
50	1%	96·1	93·9	91·3	85·7
	3%	96·5	94·4	92·1	86·9
	5%	96·8	95·0	92·8	88·1
55	1%	94·4	91·2	87·5	80·7
	3%	94·7	91·6	88·1	81·7
	5%	94·9	92·0	88·7	82·5
60	1%	97·2	92·8	87·7	80·5
	3%	97·3	92·9	88·0	80·9
	5%	97·4	93·1	88·2	81·3

6.2.14 As with the ratios in Table 1, the ratios shown in Table 2 decrease with increasing age. Hence, any deductions based on $(1-k(x,i))$ would increase with increasing age. A brief mathematical note in Bloomfield & Haberman[(1)] considers this phenomenon.

6.2.15 As already noted the ratios $k(x,i)$ increase with increases in the real rate of interest. This phenomenon is considered in Appendix 2. There, it is shown that the decreasing nature of the labour-force participation rates with increasing age (beyond x_0) explains the increase in $k(x,i)$ with increases in the rate of interest and hence the *decrease* in $(1-k(x,i))$.

6.2.16 The numerical results in Table 2 give some clue to the order of magnitude of deductions to apply to present values, using the framework of the classical working life table. For example, on the basis of a real rate of interest of 3% and the labour force participation rates of the 1973 and 1985 Labour Force Surveys, deductions of the following magnitude would be advocated:

	Labour Force Survey 1973	1985
age 20	0·8%	3·2%
30	1·3%	4·9%
40	2·2%	8·2%
50	3·5%	13·1%
60	2·7%	19·1%

Clearly there is a wide range in these figures which would make application problematic.

6.2.17 In Section 6.3 we consider the methodological problems associated with this approach to the estimation of average working lifetime and related indices.

6.3 *Critique of the Method*

6.3.1 The classical approach to the construction of working life tables has been described in Sections 6.1 and 6.2. This approach is based on a number of important assumptions which we discuss later with particular reference to their validity in the real world. These assumptions include a unimodal curve of age-specific labour force participation, a single lifetime entry transition into the labour force and a single lifetime exit from the labour force.

6.3.2 A unimodal curve of labour force participation is the customary form for males, but bimodality is common in female work patterns. Although modifications (for example, subdividing the population by marital or family status[15]) might enable bimodality to be incorporated into the classical approach, the application of different techniques for the two sexes would make the comparison of results difficult. Further such modifications would still require the single entry and exit age assumption.

6.3.3 The classical method is geared to a situation where all males who ever enter the labour force do so before some age, x_0, of 'maximum participation' and then stay on at least beyond that age (given survival) and never return to the labour force once they have left it. In reality, there can be multiple entries and exits for an individual, all first entries are not necessarily before age x_0 and all final exits are not necessarily after age x_0.

6.3.4 The classical method cannot use information on current labour force status—for example, a male currently aged x inside the labour force and a male aged x outside the labour force would be treated in the same way, so that this method would lead to the same estimate of the expectation of working life in these two cases.

6.3.5 To calculate labour force mobility rates solely on the basis of the work rates and a life table, involves stationarity assumptions which are rarely justifiable. The approach is similar to estimating a male life table from the age structure of males at a particular date (or a nuptiality table from the age and marital status structure of a population at a particular date). Even if the parameters describing labour force transitions were constant over time, the labour force participation rates, which they imply, may be different from the labour force participation rates of any one point of time of observation.

6.3.6 Conventionally, the data on labour force participation are collected from a single time point, for example from a census or an isolated (*unlinked*) labour force survey. It is more satisfactory to recognise the dynamic nature of labour force participation and use data that relate to flows into and out of the labour force collected, for example, from a series of *linked* periodic labour force surveys.

6.3.7 The distinction between stock and flow data is important not only in numerical terms but also in *compositional* terms. Thus, in recent research, Hughes & Hutchinson[16] consider the stock of male unemployed in Great Britain and the monthly flows in and out of unemployment each month. Most of this flow enter and leave quickly, but some remain unemployed for reasons of age, lack of skill or other unfavourable qualities, which make them less attractive to employers. The process that converts the flow of new entrants to unemployment into a stock with differing durations may be called a 'sorting' process. This process, whereby those with more favourable labour market characteristics find employment at a faster rate than those with poorer characteristics, operates continuously, so that those with poorer prospects make up the preponderant part of the stock, even though, over a relevant period, they comprise a minor part of the flow.

6.3.8 Thus, we see that there is a fundamental methodological problem with this classical approach, in that labour-force participation rates are used as the building block for the model when mobility data should be used to analyse what is a mobility phenomenon.

6.3.9 Finally, it should be mentioned that, like all life tables, a working life table is a synthetic device. It summarizes the labour-force participation behaviour of all age groups in the population in a given period. The table does not trace the history or experience of any group (or cohort) through its own specific lifetime. Thus, a particular table necessarily gives an artificial view of the underlying decrements and is likely to give a misleading impression of the trends in the underlying labour force participation rates, or is likely to become out-of-date in the presence of marked trends in these underlying labour force participation rates.

7. USING THE AVERAGE TIME SPENT SICK OR UNEMPLOYED

7.1 *Introduction*

7.1.1 In the second approach, described in this section, we utilise the data routinely collected and published on the average time spent sick or unemployed for males in Great Britain. These estimates are then combined with a life table in a similar manner to that described in Section 6 for the working life table.

7.1.2 We are concerned here with the amount of working time which the male workforce of Great Britain loses to various causes, viz. sickness, unemployment, industrial disputes.

7.1.3 Time lost through sickness is considered in Section 7.2. Until 1974, estimates for the majority of the civilian labour force could be obtained simply from social security statistics. After that year, the discontinuation of one series of figures increased the difficulty of making such estimates. Two alternative sources of statistics are discussed. There is also consideration of the possible effects of the exclusion, from the sickness benefit statistics, of two large groups within the civilian labour force.

7.1.4 Sections 7.3, 7.4 and 7.5 are concerned with the incidence of unemployment and its relationship with age, region of residence and type of industry. The calculation of estimates that we attempt in Sections 7.3 and 7.4 has been frequently hampered by changes in the recording and processing of unemployment statistics. The significant changes are listed in Section 7.7. The published statistics have been more detailed since the computerisation of unemployment records, enabling more complex estimates to be obtained from 1983/84 onwards than was possible previously.

7.1.5 Working time lost during industrial disputes is discussed briefly in Section 7.6. Compared with sickness or unemployment these losses are very minor.

7.2 *Statistics on Average Working Time Lost Through Sickness*

7.2.1 Social Security statistics have, in the past (up to 1973/74), included tables of the number of days sickness benefit claimed per year in eleven age groups.[17] The average population at risk during each statistical year has also been tabulated for men in the same age groups. It is then possible to calculate an estimate of the average number of working days lost per year by each member of the male workforce, subdivided by age. This has been done for the years between 1962/63 and 1973/74, and the results are tabulated in Table 3. The 65 and over group has been discarded, since men of this age who suffer ill-health are likely to

Table 3. *Number of days sickness benefit claimed per man. DHSS Statistics, Great Britain*

Age group	1962/3	1963/4	1964/5	1965/6	1966/7	1967/8	1968/9	1969/70	1970/1	1971/2	1972/3	1973/4
Under 20	5·1	5·3	5·7	6·2	6·0	6·5	6·6	6·9	6·2	6·0	6·7	6·6
20–24	6·0	6·1	6·2	6·6	6·4	7·1	7·4	8·1	7·2	6·3	7·5	7·3
25–29	6·3	6·4	6·6	7·1	7·2	8·0	8·1	8·6	7·8	8·1	7·9	7·6
30–34	7·6	7·6	8·1	8·5	8·3	9·3	9·7	10·4	9·2	8·6	9·2	9·2
35–39	8·8	9·0	9·4	10·2	9·7	9·7	10·8	11·5	10·2	10·2	10·7	10·9
40–44	10·5	10·5	10·8	11·3	11·3	11·6	12·8	13·5	11·9	11·3	12·3	12·6
45–49	11·8	12·1	12·6	13·6	13·3	14·8	15·4	16·3	14·7	14·2	15·1	15·2
50–54	16·0	16·0	16·4	17·5	17·1	18·9	19·0	20·3	18·6	19·3	19·8	20·2
55–59	23·8	23·1	24·2	25·4	24·4	26·9	27·8	28·5	26·3	25·0	26·9	27·6
60–64	40·3	39·4	41·4	43·0	41·4	45·5	45·8	46·9	44·8	44·5	46·6	47·7

Table 4. *Number of days lost to sickness per man. Comparison of Table 3 with estimates calculated using the Labour Force Survey*

Age group	1971/72 Table 3	1971/72 Labour Force Survey	1972/73 Table 3	1972/73 Labour Force Survey	1973/74 Table 3	1973/74 Labour Force Survey
16–19	6·0	5·6	6·7	6·1	6·6	5·6
20–24	6·3	6·3	7·5	7·1	7·3	6·9
25–29	8·1	7·9	7·9	8·2	7·6	8·0
30–34	8·6		9·2		9·2	
35–39	10·2	10·5	10·7	11·1	10·9	11·3
40–44	11·3		12·3		12·6	
45–49	14·2	16·2	15·1	17·1	15·2	17·2
50–54	19·3		19·8		20·2	
55–59	25·0	25·5	26·9	26·7	27·6	27·2
60–64	44·5	51·7	46·6	52·7	47·7	53·4

retire rather than retain their jobs and claim sickness benefits. These statistics exclude the armed forces, Post Office employees and most non-industrial Civil Servants.

7.2.2 After the statistical year 1973/74, information on the average population at risk was discontinued and thus an alternative denominator is required. Two sources are possible: the General Household Survey and the Labour Force Survey. It was decided to utilise the Labour Force Survey to estimate the denominator, because of its larger sample size.

7.2.3 The Labour Force Survey estimates the number of economically active men in Great Britain for seven age groups below age 64, from a sample of over 26,000 males living in private households. Calculations were made of the number of days lost per man per year due to sickness. The figures obtained are presented in Table 4 and are seen to be close to the first series (Table 3), except for ages 60–64 which are too high.

7.2.4 The Labour Force Survey excludes the permanently sick from the labour force. Adding this group to the denominator and using Social Security statistics for the number of people claiming invalidity benefit greatly improves the match between this series and that based entirely on Society Security statistics, particularly at ages 60–64 (Table 5). This adjustment is anomalous, since invalidity benefit claimants are not at risk of claiming sickness benefit because they are already ill.

7.2.5 The two series based on the Labour Force Survey have been continued up to 1982/83, the last year for which information is available on the total number of days sickness benefit claimed. Table 6 presents the estimates of the number of days of sickness per man on this basis.

7.2.6 From 1962/63 to 1973/74, Table 3 shows that, in each of the age groups, the number of days benefit claimed per man each year increased. From 1974/75

Table 5. *Number of days lost to sickness per man. Comparison of Table 3 with estimates calculated using the Labour Force Survey and the number of men claiming invalidity benefit*

	1972/73		1973/74	
Age group	Table 3	Labour Force Survey + permanently sick	Table 3	Labour Force Survey + permanently sick
16–19	6·7	6·1	6·6	5·6
20–24	7·5	7·1	7·3	6·9
25–29	7·9	8·2	7·6	8·0
30–34	9·2		9·2	
35–39	10·7	11·0	10·9	11·1
40–44	12·3		12·6	
45–49	15·1	16·7	15·2	16·8
50–54	19·8		20·2	
55–59	26·9	25·5	27·6	25·9
60–64	46·6	47·2	47·7	47·6

to 1982/83, Table 6 shows that in the three age groups below age 35 the number of days claimed rose slightly and then fell again, finishing below the 1962/63 figures. The same pattern can be discerned in the 35–44 age group, although the fall at the end of the period is not so great. The number of days benefit claimed by people in the three age groups from 45 to 64 increases almost every year, finishing well above the 1962/63 levels, particularly in the oldest age group (i.e. 60–64).

7.2.7 The series which includes the long-term sick in the estimate of the workforce is identical, below age 25, to that which does not. It is lower than the simpler estimate from age 25 upwards, the difference initially being small and increasing to 15·9 days in 1982/83 for the oldest age group.

7.2.8 Over the period studied, the amount of work time lost through sickness varies between 1·0% and 2·2% for the youngest age group. This rises with age, until between 12·6% and 27·7% of work time is lost in the 60–64 age range.

7.2.9 The sickness benefit statistics after 1974 continue to exclude the armed forces, Post Office employees and non-industrial Civil Servants. The workforce estimates used after 1974 refer to the civilian population, including Post Office employees and non-industrial Civil Servants. Thus, the amount of work time lost per man per year is understated in Tables 4 to 6. It was not possible to adjust each workforce estimate, since the relevant statistics are not published. However, figures have been made available for January 1986 (Personal Communications, The Post Office and Treasury Chambers). Table 7 indicates the percentage of the civilian workforce (Labour Force Survey estimate) which is employed in the two named occupational groups. These percentages suggest that an increase of around 1% in the figures of Tables 4 to 6 may be appropriate.

Table 6. *Number of days lost to sickness per man, estimates of the civilian work force based firstly on the Labour Force Survey and secondly, on that survey plus the numbers claiming invalidity benefit*

Age group	1974/75 Labour Force Survey	1974/75 Labour Force Survey + invalids	* 1976/77 Labour Force Survey	1976/77 Labour Force Survey + invalids	1977/78 Labour Force Survey	1977/78 Labour Force Survey + invalids	1978/79 Labour Force Survey	1978/79 Labour Force Survey + invalids	1979/80 Labour Force Survey	1979/80 Labour Force Survey + invalids	1980/81 Labour Force Survey	1980/81 Labour Force Survey + invalids	1981/82 Labour Force Survey	1981/82 Labour Force Survey + invalids	1982/83 Labour Force Survey	1982/83 Labour Force Survey + invalids
16–19	5·3	5·3	5·2	5·2	5·5	5·5	5·5	5·5	4·7	4·7	3·6	3·6	3·5	3·5	3·1	3·1
20–24	6·9	6·9	7·3	7·3	7·9	7·9	8·3	8·3	7·1	7·1	6·1	6·1	6·0	6·0	5·2	5·2
25–34	7·8	7·8	8·1	8·1	8·8	8·7	8·7	8·6	7·9	7·9	7·2	7·2	6·9	6·8	6·3	6·2
35–44	11·1	10·9	11·8	11·7	12·5	12·3	12·5	12·3	11·8	11·6	10·8	10·7	11·0	10·9	10·4	10·2
45–54	16·3	15·9	17·6	17·2	18·7	18·2	19·4	18·8	18·4	17·8	17·6	17·0	18·6	18·0	18·8	18·1
55–59	27·1	25·8	30·5	27·1	30·9	29·2	35·1	32·9	32·7	30·4	32·1	29·9	34·4	31·9	36·9	33·9
60–64	51·2	45·7	55·9	49·3	61·2	53·2	69·6	59·4	71·6	60·4	71·5	60·2	78·2	65·1	86·5	70·6

* Statistics not available for 1975–76 due to industrial dispute.

Table 7. *January 1986: The percentage of the civilian labour force (Labour Force Survey estimate) classified as Post Office employees or non-industrial Civil Servants*

Age	%
Under 20	1·4
20–24	2·4
25–34	2·6
35–44	2·8
45–54	3·2
55–59	3·8
60–64	2·7

7.2.10 The General Household Survey for 1982(18) does provide some limited information on sickness absence in the form we require. Taking the number of days on which employees were off sick in the week before the interview multiplied by 52 to derive an annual figure of sickness absence per person per year, we find that male employees were off sick for an average of 8·3 days in 1982. These days of sickness absence accounted for 3·2% of the usual working days of the male employees.

7.3 *Statistics on Average Working Time Lost Through Unemployment*

7.3.1 Attempts were made to quantify the working time lost through unemployment in a similar manner to the information obtained on sickness. However, this proved extremely difficult, due to the form in which unemployment statistics are published and the frequent changes in the way in which they are collected and published.

7.3.2 Quarterly figures are available from the Department of Employment in twelve age groups subdivided by duration of unemployment. The age groups were combined to match the sickness data. The number of weeks unemployment experienced by the workforce, in each age group, for each quarter, was obtained and the quarters were combined into statistical years. Labour Force Survey estimates of the age composition of the civilian workforce were used to calculate the amount of working time lost due to unemployment.

7.3.3 However, these quarterly 'snapshots' of the unemployment situation do not include individuals who have ceased to be unemployed during the previous quarter. An estimate of their experience may be obtained for recent years from quarterly tables giving the number of completed spells of unemployment during the previous quarter and their median duration.(19) This information refers to computerised records only and is rather inaccurate for the 60 and over age group, since many of these claims are handled manually, such claimants being required to register less frequently than younger people. Unfortunately, the first complete

Table 8. *Estimated percentage of working weeks lost to unemployment by age. Great Britain, males*

Age group	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
16–19	14·1	18·2	20·4	21·5	20·3	19·2
20–24	14·9	19·3	20·3	18·9	18·3	17·6
25–34	8·7	11·6	12·2	12·8	12·8	12·8
35–44	6·4	8·2	8·7	9·4	9·3	9·5
45–54	6·1	8·0	8·7	9·7	9·8	10·2
55–59	7·6	10·7	12·7	14·8	15·1	16·3
60–64	31·0	43·4	16·2	9·9	8·6	7·7
All ages	10·2	13·5	12·8	12·9	12·7	12·7

statistical year of computerised records, separated by sex was 1983/84. Thus, only three years of accurate estimates of working time lost to unemployment could be (and hence have been) calculated. The details are given in Table 8.

7.3.4 In order to produce estimates for years prior to 1983, the ratio of the amount of unemployment from completed spells to the total amount of unemployment, was calculated in each age group for 1983/84, 1984/85 and 1985/86. The averages of these ratios were then used to supplement the information available on the duration of unemployment at each quarter date, for the three years back to 1980/81. The results of these calculations are presented in the remainder of Table 8. It is apparent that the percentage of working time lost in the age group 60 to 64 is unstable. The underlying errors are probably due to the number of manual records which are missing from the estimates for 1983 to 1986. In recent years, the amount of unemployment experienced by those in the 16–19 age group has decreased. The Youth Training Scheme has been influential here, in September 1985 providing 31,143 training places and thus absorbing 26·2% of the teenage labour force. These features would explain the slight downward trend at these ages in Table 8.

7.3.5 A further source of data is the DHSS cohort study of men joining the unemployment register during the autumn of 1978, which follows their experience over two years.(20) Their average durations of unemployment were used, with estimates of the inflow to unemployment as a percentage of the labour force, to calculate the percentage of time lost to unemployment during the autumn quarter of 1978.(21) These levels of time loss were assumed to apply throughout the statistical year 1978/79. It was then necessary to add on the percentage of work time lost in each age group, over the year in question, by those who were already unemployed at the beginning of the autumn quarter. This was done using tables of unemployment duration and the combined results are shown in Table 9.(19) The inflow figures are based on General Household Survey estimates of the labour force and so these were used throughout the calculations, rather than the Labour Force Survey figures used in later years. A result of this discrepancy is that the age groups in Table 9 differ from those in Table 8.

7.3.6 Some further, albeit limited, information comes from an analysis of

Table 9. *Estimated percentage of working weeks lost to unemployment by age. DHSS Cohort Study. Great Britain, males*

Age group	1978/79
25–29	3·99
30–34	3·53
35–44	5·20
45–49	3·12
50–54	3·51
55–59	4·20
60–64	9·12
All ages	4·55

unemployment duration carried out by the Department of Employment.[22] This study examines trends in the average duration of time spent on the unemployment register over the 1973–78 period. These indicate that the average duration rises and falls with the level of unemployment, but tends to lag behind the unemployment rate as it changes direction; that males experience longer unemployment durations than females; that the duration of unemployment increases rapidly with age; and that the duration of unemployment tends to be higher in regions with higher unemployment rates.

7.4 *Statistics on Regional Differences in Time Lost Through Unemployment*

7.4.1 The amount of time lost through unemployment is not distributed equally throughout the country. Figure 2 illustrates regional differences in unemployment rates from 1978 to 1985, as presented in Table 10. (Changes in the method of recording these statistics cause discontinuities between 1978 and 1979

Table 10. *Unemployment rates (%) by region. Great Britain, males*

Region	1978 *	1979	1980	1981	1982 †	1983	1984	1985
South East	5·0	4·3	5·4	9·1	10·8	11·4	11·3	11·7
East Anglia	5·9	5·2	6·5	10·4	12·0	12·2	11·7	11·9
South West	7·6	6·6	7·7	11·5	13·1	13·2	13·0	13·6
West Midlands	6·2	6·1	8·5	15·4	17·9	18·7	18·0	18·0
East Midlands	5·8	5·4	7·4	12·0	13·6	14·4	14·6	14·9
Yorkshire and Humberside	6·9	6·5	8·7	14·1	16·2	17·0	17·1	17·7
North West	8·6	8·1	10·3	15·7	18·4	19·6	19·7	19·9
North	10·1	9·9	12·3	17·9	20·3	21·8	22·5	23·0
Wales	9·2	8·5	10·9	16·4	18·8	19·4	19·8	20·5
Scotland	9·1	7·4	9·1	12·6	17·1	17·9	18·4	19·1

* Change to fortnightly recording.
† Some boundary changes made.

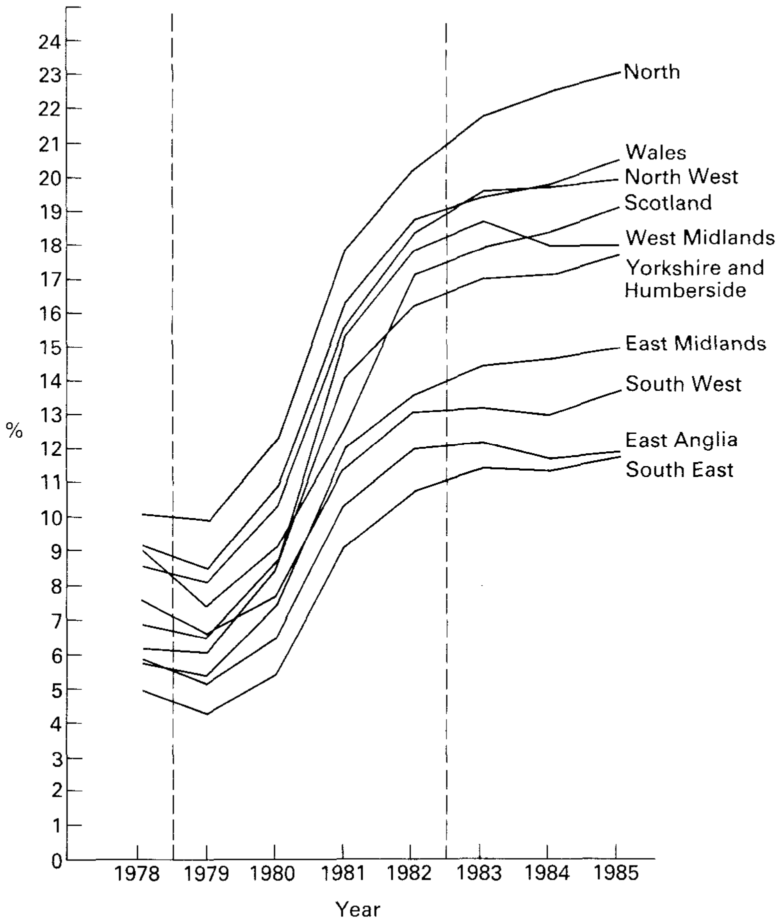

Figure 2. Unemployment rates, by region

and between 1982 and 1983.) The regions tend to keep their relative positions throughout the time period, the workforce in the North and West of the country bearing a much larger part of the burden of unemployment than the workforce in the South and East.

7.4.2 Regional differences are also clear in the median durations of uncompleted spells of unemployment (Table 11). Again, those regions in the North and West of the country have a more adverse experience than those in the South and East. However, the regions are ranked differently by this measure of unemployment. Since 1983, the West Midlands has had only the fourth or fifth highest

Table 11. *Median durations (weeks) of incomplete spells of unemployment, by region. Great Britain, males*

Region	1983	1984	1985	1986
South East	30·9	33·7	35·4	36·0
East Anglia	30·9	33·0	33·0	32·5
South West	30·0	30·7	32·3	32·0
West Midlands	48·1	53·6	55·4	55·5
East Midlands	35·1	37·8	42·0	43·2
Yorkshire and Humberside	37·9	40·7	44·4	42·5
North West	43·3	49·1	50·8	51·3
North	42·7	46·3	50·6	51·6
Wales	39·8	42·1	45·5	44·4
Scotland	38·4	41·2	42·1	43·1

unemployment rate, but substantially longer median durations of unemployment than all other regions. Thus, unemployment here has been concentrated on a smaller group of individuals than has been the case elsewhere. The experience of the Welsh workforce has been different. Wales has had the second or third highest unemployment rates, but only the fourth longest median durations. This implies a greater turnover in the register of unemployed here than in other regions.

7.4.3 Regional data on duration of unemployment in broad age bands has also been used to obtain median durations[(19)] (Tables 12, 13 and 14). These are generally consistent with the results described in Section 7.3. In all regions, those under age 25 experience much shorter spells of unemployment than their elders. In the regions with lowest unemployment rates and shortest median durations, the age 55 and over group experience the longest median durations of unemployment. In regions with high levels of unemployment, the median

Table 12. *Median durations of unemployment (weeks), by region, under 25 years. Great Britain, males*

Region	1984	1985	1986
South East	22·2	22·2	21·8
East Anglia	22·5	20·9	20·6
South West	20·7	20·7	19·7
West Midlands	34·7	32·3	30·2
East Midlands	25·6	25·6	24·6
Yorkshire and Humberside	29·2	29·0	26·9
North West	33·9	30·0	31·0
North	33·9	33·1	31·2
Wales	30·0	29·8	27·2
Scotland	29·6	28·4	26·8

Table 13. *Median durations of unemployment (weeks), by region, ages 25–54. Great Britain, males*

Region	1984	1985	1986
South East	44·8	45·7	46·6
East Anglia	40·9	42·9	41·7
South West	38·7	41·6	30·5
West Midlands	72·1	79·9	83·0
East Midlands	49·2	54·5	59·7
Yorkshire and Humberside	52·6	60·0	57·5
North West	65·6	73·9	76·8
North	58·2	66·7	72·5
Wales	55·4	63·5	63·4
Scotland	51·6	55·0	58·3

durations in the 25–54 age group are usually the longest. This may reflect the experience of older men who foresee no hope of re-employment, choosing to claim other benefits (e.g. invalidity benefit) rather than remain registered as unemployed, that is, they become 'discouraged workers'.[23]

7.4.4 The relative position of the regions changes slightly between age groups and over time. Most notably in the older age group, the East Midlands had the shortest median duration of unemployment in 1984, but by 1986 it had the fifth longest median duration. The rank of Scotland changes considerably with age. Below age 55 it has the sixth longest median duration in 1986, but from age 55 upwards it lies in third place.

7.4.5 This regional variation should be borne in mind in any statistical use of the unemployment data, but it would not be possible to allow directly for area of residence, in any calculations pertaining to assessment of damages, unless a

Table 14. *Median durations of unemployment (weeks), by region, 55 years and over. Great Britain, males*

Region	1984	1985	1986
South East	49·6	48·5	49·2
East Anglia	44·6	46·2	46·1
South West	43·4	45·8	47·1
West Midlands	60·7	73·1	82·6
East Midlands	43·1	55·8	62·1
Yorkshire and Humberside	47·0	58·9	53·5
North West	52·6	68·0	70·2
North	53·3	71·5	80·5
Wales	52·3	61·4	59·7
Scotland	51·0	66·3	74·9

comprehensive attempt was made to model labour force *and* geographic mobility within Great Britain.

7.5 *Industrial Analysis of Unemployment—Historical Data*

7.5.1 Historical tables are available allowing an industrial analysis of unemployment from 1948 to 1968 and are presented by Bloomfield and Haberman.[1] There are discontinuities in the figures, caused by changes in the classification in 1959 and 1966, and by changes in the calculation methods in 1964. However, they give some indication of the relative incidence of unemployment among industries.

7.5.2 Between 1948 and 1959, the industries having the highest unemployment rates were 'Building and contracting' and 'Miscellaneous services', while the lowest rates were associated with 'Paper and printing' and 'Insurance, banking and finance'. The distribution of unemployment is slightly different for the period 1959–68, 'Shipbuilding and marine engineering' having the worst unemployment rate, followed by 'Construction'. The industries with the lowest rates were 'Professional and scientific services', then 'Paper, printing and publishing'.

7.5.3 An industrial analysis of unemployment is available for the period 1974–78, excluding the last quarter of 1976.[24] The classification is restricted to nine broad groups, but these match the earlier, more detailed classifications quite well. In this period 'Construction' had the worst unemployment rates, followed by 'Mining and quarrying' (Table 15). The industries experiencing lowest unemployment were 'Gas, electricity and water' and 'Financial, professional and miscellaneous services'.

7.5.4 Over the three decades covered by these data, there have been few major changes in the relative position of industries. The most notable move has been by 'Miscellaneous services', which includes activities such as entertainment and recreation provision. This group has moved from very high levels of unemployment at the beginning of the period to fairly low levels at the end. This change has

Table 15. *Unemployment rates (%) by industry group. Great Britain, males*

Industry	1974	1975	1976	1977	1978
Agriculture, Forestry and Fishing	2·7	4·3	5·8	6·2	6·1
Mining and Quarrying	4·5	4·4	4·7	5·3	6·5
Manufacturing	2·0	3·6	4·8	4·5	4·5
Construction	7·6	11·3	14·2	14·1	12·7
Gas, Electricity and Water	1·7	1·9	2·6	2·7	2·4
Transport and Communication	2·3	3·2	4·2	4·0	3·9
Distributive Trades	1·9	3·3	4·7	4·9	4·8
Financial, Professional and Miscellaneous Services	1·5	2·3	2·9	3·3	3·3
Public Administration and Defence	2·1	2·7	3·7	4·5	4·8
All Industries	2·5	3·9	5·3	5·7	5·7

been partly caused by the redefinition of categories, but also reflects changing life styles. However, it would appear that some industries have, over a long period, suffered high unemployment rates while different groups have generally enjoyed low unemployment rates.

7.5.5 The comments at the end of Section 7.4 apply here—it would be problematic to allow directly for this variation by industry, although the fact that there is variation should be borne in mind. We return to this point in Section 8.2.

7.6 *Statistics on Working Time Lost Due to Stoppages Caused by Industrial Disputes*

7.6.1 The number of working days lost per 1,000 employees each year from 1965 to 1985 is shown in Table 16.[25] Even in the worst years for industrial disputes, there is only a little over one day lost per employee and usually, less than half a day per person is lost. Thus, industrial disputes are a relatively unimportant cause of lost working time, compared with sickness and unemployment.

7.6.2 There are regional differences in the incidence of stoppages (Table 17), but even greater differences are found when analysis is made by industry (details

Table 16. *Number of working days lost per thousand employees through stoppages in progress. United Kingdom*

Year	Working days lost per 1,000 employees
1965	127
1966	103
1967	122
1968	207
1969	303
1970	488
1971	613
1972	1081
1973	318
1974	647
1975	265
1976	146
1977	448
1978	413
1979	1273
1980	521
1981	195
1982	248
1983	178
1984	1277
1985	298

(Department of Employment Gazette. August 1986, p. 324.)

Table 17. *Number of days lost per thousand employees through stoppages in progress in all industries and services. Great Britain*

	1982	1983	1984	1985
South East	174	138	212	67
East Anglia	163	86	126	60
South West	113	58	258	56
West Midlands	243	152	713	142
East Midlands	222	140	2061	333
Yorkshire and Humberside	322	326	5339	1179
North West	414	331	587	169
North	407	232	4065	859
Wales	314	395	3914	1035
Scotland	328	162	1210	348

not shown here). Industries which have lost relatively little working time through disputes include 'Agriculture, forestry and fishing', 'Textiles', 'Footwear', 'Finance and business services' and 'Miscellaneous services'. Those which have a very poor record of stoppages are 'Motor vehicles production', 'Other transport production and services' and 'Coal mining'.

7.7 *Problems With Sickness and Unemployment Data*

7.7.1 A large number of problems were encountered in the calculation of the sickness and unemployment figures given in Sections 7.2 and 7.3. Therefore, great care must be taken with their interpretation.

7.7.2 The size of the civilian labour force is to some extent related to employment prospects. During periods of high demand for labour, economic activity rates increase. Conversely, during periods of low demand, groups of 'discouraged workers' can be identified.[23] They have left the labour force in the belief that no suitable vacancies exist. The effect which this has on the calculated sickness and unemployment figures is unclear. The largest fluctuations in economic activity rates occur in the female labour force and among those over retirement age and, hence, do not affect our calculations. However, if, for example, male discouraged workers were to contain a high proportion of individuals with health problems or disabilities, both the numerator and denominator of the sickness calculations would be affected.

7.7.3 Investigation of the 1984 Labour Force Survey data reveals about 197,000 male discouraged workers.[23] If these men had been economically active (for example, unemployed but seeking work), the size of the civilian labour force would have been increased by 1·2%. The 1986 Labour Force Survey data show an increase in the number of discouraged workers, particularly in the age range 35–64.[26]

7.7.4 Over the period studied, there have been several changes in the collection and processing of unemployment statistics. Thus, comparisons over time are extremely difficult to make.

7.7.5 The changes which have affected unemployment figures significantly are as follows.[27] In October 1979, fortnightly attendance at unemployment benefit offices was introduced, adding about 20,000 to the unemployment count based on registrations at job centres. A higher rate of supplementary benefit was introduced in November 1981 for men over 60 who had been claiming the lower rate for over a year. This gradually reduced the unemployment count by about 37,000 men. In October 1982, the unemployment count was switched from registrants at job centres to claimants at unemployment benefit offices. The average effect of this change, which involved the computerisation of the count, the exclusion of those not claiming benefits and the inclusion of the severely disabled, was to reduce the count by 190,000. Provisions in the 1983 Budget enabled 162,000 men, mainly over the age of 60, to receive National Insurance credits or the higher long-term rate of supplementary benefit without attending an unemployment benefit office, thus reducing the count. Since March 1986, the compilation of unemployment figures has been delayed by two weeks to occur three weeks after the specified count date. This is estimated to reduce the over-recording of claimants, who cease to be unemployed before the count date, by about 50,000.

7.7.6 The regularly published unemployment rates underestimate the percentage of time lost to unemployment, by ignoring those joining and leaving the register between count dates and also those who are without a job, are seeking work, but are not registered as unemployed. It has been assumed that few men fall into the latter category, having a negligible effect on our calculations. The effect of those leaving the register before being counted is much more important. Recently, information on the duration of completed spells of unemployment has been available for those records which are computerised. This supplementary information was used to improve estimates of time lost to unemployment for three particular years (viz. 1980–81, 1981–82, 1982–83, as shown by Table 8). Unfortunately, attempts to extrapolate back before 1980 do not look promising, particularly in the older age groups and so have been abandoned.

7.7.7 Cohort studies provide a clearer picture of the duration of unemployment. However, there are very few such studies available for reference. The DHSS cohort study is discussed in Section 7.3.[20] Another found that a cohort of 1,630 men, born in 1933, lost 2·21% of their working time to unemployment in 1971. The figures for 1972 and 1973 were 1·87% and 1·51% respectively.[28]

7.7.8 Section 7.4 demonstrates that unemployment is concentrated in certain regions, but adjustments for this factor are impractical, requiring assumptions about future geographic mobility.

7.7.9 Changes in the industrial classifications used in Section 7.5 prevent detailed comparisons of historical unemployment rates.

7.7.10 It is not felt that a history of very good or very bad industrial relations is necessarily an indicator of the quantity of time that will be lost to stoppages in the future. Thus, the data of Section 7.6 should be considered to be of lesser importance than those of the other, earlier sections.

7.8 *Estimates of Average Work Time Lost Through Sickness and Unemployment*

7.8.1 Despite the comments on statistical unreliability in the previous section, we intend to adapt the working life table methodology of Section 6 to using the results of the analyses discussed in Sections 7.2 and 7.3.

7.8.2 The intention is to use the methodology described in Sections 6.1 and 6.2 but with w_x, the labour force participation rates, replaced by estimates g_x, of the average time spent active at age x. In turn g_x will be given by $(1-f_x)$, where f_x is the average time spent *sick or unemployed* at age x. Thus, we intend to replace w_x by $(1-f_x)$.

7.8.3 Given the statistical problems just described and the multiplicity of data sources that have been used in Sections 7.2 and 7.3 we propose to illustrate the calculations on two bases:

(a) a *low basis*, using the 1978–79 Labour Force Survey based estimates of the average number of days lost through sickness from Table 6 and the cohort-based estimates of the average number of days lost through unemployment from Table 9; and
(b) a *high basis*, using the 1982–83 Labour Force Survey based estimates of the average number of days lost through sickness from Table 6 and the 1982–83 Department of Employment based estimates of the average number of days lost through unemployment from Table 8.

7.8.4 The earlier figures were converted to an annual basis (noting that sickness benefit is paid for 6 days per week and unemployment benefit is paid for 7 days per week) and then the estimates for grouped ages were smoothed graphically to provide values of f_x for single years of age.

7.8.5 A problem arises immediately in the application of the earlier methodology in that we need w_x (and hence the $(1-f_x)$ series here) to be unimodal. As is apparent from Tables 6. 8 and 9, the estimates of $(1-f_x)$ obtained are not unimodal but rather U-shaped. However, for restricted age ranges, the sets of $(1-f_x)$ are monotonic decreasing so that the earlier methodology can be applied.

7.8.6 Thus for basis (a) we can only consider ages over 47 and for basis (b) we can only consider ages over 45.

7.8.7 The results in terms of working life expectancy of $\mathring{e}^f_{x:\overline{65-x}|}$ and in terms of the ratio of this index to the corresponding life table expectation of life estimates $(\mathring{e}_{x:\overline{65-x}|})$ are shown in Table 18. The results are similar to those arising from the methodology of Section 6 and given in Table 1. The order of magnitude of the estimates in Tables 1 and 18 is consistent.

7.8.8 A slightly different feature is the smaller degree of variation with age of the ratios in Table 18 for the high basis relative to the other figures in Table 18 and the figures in Table 1. This may be attributed to the rapid decrease in $(1-f_x)$ with age—see comments in the appendices of Bloomfield and Haberman.[1] Indeed, by age 60 this rapid decrease had led to a crossover of the ratios for the low and high bases in Table 18.

7.8.9 The figures in Table 18 indicate that the deductions needed in estimates

Table 18. *Average number of years remaining in the labour force up to age 65, based on average time spent sick or unemployed*

	Truncated $\mathring{e}^f_{x:\overline{65-x}|}$	
Age	Low basis	High basis
45	—	17·38 (94·1%)*
50	13·14 (95·0%)	12·84 (92·8%)
55	8·64 (93·2%)	8·49 (91·6%)
60	4·22 (88·9%)	4·26 (89·8%)

* The figures in parentheses denote the ratios

$$k_x = \frac{\mathring{e}^f_{x:\overline{65-x}|}}{\mathring{e}_{x:\overline{65-x}|}}$$

where the term in the denominator is based on E.L.T. No. 14.

of the average remaining lifetime (up to age 65) to allow for the average time spent sick or unemployed would be:

age 50	5·0%– 7·2%
55	6·8%– 8·4%
60	10·2%–11·1%

Again, these are consistent with the earlier results discussed in § 6.2 on the basis of Table 1.

7.8.10 As earlier, we also consider the ratio of annual annuity values based on $(1-f_x)$ rather than w_x and real rates of interest of 1% p.a., 3% p.a. and 5% p.a. The results are presented in Table 19, which can be compared directly with Table 2. The principal characteristics of Table 19 are similar to those of Table 2—in particular the lack of sensitivity to the real rate of interest used (and a slight increase in the ratio of annuity values with increase in the real rate of interest). Again, the high basis figures appear to be anomalous, in that the ratios increase with increasing age (in contrast to the low basis figures and those quoted in Table 2). This feature arises because of the rapid increase in f_x (i.e. decrease in $(1-f_x)$) with advancing age on this basis, which leads the mathematical results derived in Bloomfield & Haberman[1] to be invalid. Indeed, beyond age 60, the $(1-f_x)$ figures are approximately constant, so that the ratios in Table 19 are very close to 100% for the 'high basis'.

7.8.11 Taking a real rate of interest of $i=3\%$ p.a., the deductions suggested by the figures in Table 19 fall in the range:

age 50	1·6%–4·1%
55	1·8%–3·2%
60	0·9%–2·4%

Table 19. *Comparison of annuity values paid while alive and active and those paid while alive, using the average time spent sick or unemployed methodology*

Age x	Real rate of interest i % p.a.	Ratio of annuity values: Low basis %	High basis %
45	1		96·6
	3		97·0
	5		97·3
50	1	98·3	95·6
	3	98·4	95·9
	5	98·6	96·1
55	1	98·1	96·7
	3	98·2	96·8
	5	98·3	97·0
60	1	97·5	99·1
	3	97·6	99·1
	5	97·6	99·1

These are broadly consistent with the earlier calculations of Section 6.2 at age 50, but not at the higher ages where these deductions are smaller.

7.9 *Critique of the Method*

7.9.1 In Section 6.3, a full critique of the conventional approach to working life tables has been provided. The modified version adopted in Section 7 retains many of these deficiencies identified earlier, in particular a unimodal (or an increasing) curve of age-specific proportions of time spent sick or unemployed, a single lifetime entry transition into the labour force, a single lifetime exit from the labour force, the omission of current economic activity status, the assumptions about stationarity and the use of cross-sectional rather than cohort-based statistics.

7.10 *Overview*

7.10.1 Clearly, the methodology behind the approaches in Sections 6 and 7 is similar. The essence is that each approach uses published mortality rates together with data on the annual age composition of the labour force (stock indices—Section 6) or on flows into and out of the sick and unemployment states (flow indices—Section 7), in an attempt to calculate a joint probability of being alive and active (or working) or, as here, in an attempt to calculate the deduction to apply to the probability of being alive, to allow for the probability of not being active.

7.10.2 As will be discussed in Section 8, this approach can be improved by constructing multi-state (increment-decrement) worklife tables.

7.10.3 The methods that we have described so far are based on routinely collected and published data that cannot be identified with an initial cohort of a specific age and work force status, and so these methods are based on *unconditional* probabilities of work force activity. These unconditional probabilities are *biased* estimators of the appropriate probabilities of future activity, which must be *conditional* (see Section 8) on age and work force status at the time of death or injury. Only multi-state increment-decrement worklife tables (see Section 8) can provide the information to calculate conditional probabilities of future activity, given the age and work force status at the time of death or injury.[11]

7.10.4 As an illustration, we consider the workforce transition for an active 40-year-old male as against an inactive 40-year-old male. The probability of an active status at age 41 is higher for the active 40-year-old than for the inactive 40-year-old. If this inactive male were not removed from the data, the probability of future activity in respect of the active 40-year-old will be *underestimated.* Similarly, the probability of the inactive 40-year-old becoming active will be *overestimated,* if the active person is not removed from an analysis of the inactive 40-year-old. Only in a multi-state increment-decrement table, can the active and inactive be separated at the time of analysis (corresponding to the time of injury or death in the circumstances of an assessment of damages calculation).

7.10.5 Thus, labour-force and employment data, that simply refer to the composition of the labour force by age, cannot, in *strict theoretical terms,* be used to obtain a true probability of future labour force activity, because they do not control for the starting age or the work force status at that age. As we have discussed earlier, attempts to use compositional data (i.e. stock data describing the population structure at a point of time) to make inferences indirectly about the underlying flow variables, can lead to serious problems.

8. THE WORKING LIFE TABLE: MARKOV CHAIN APPROACH

8.1 *Introduction*

8.1.1 A more satisfactory methodology is that based on Markov chains, by way of what might be called an increment-decrement working life table.

8.1.2 As Hoem[9] has eloquently pointed out, this methodology can be traced back to two actuarial papers written by Du Pasquier in 1912 and 1913. More recently, discussion of these ideas has been re-introduced to the British actuarial literature by Haberman[29,30] and Waters.[31]

8.1.13 This approach is markedly different from the conventional working life table approach discussed earlier and, as a result, the two approaches lead to estimates which are not easily comparable.

8.1.4 The key feature of the new approach is that it rests on observed probabilities of movement into and out of the labour force—a flow variable,

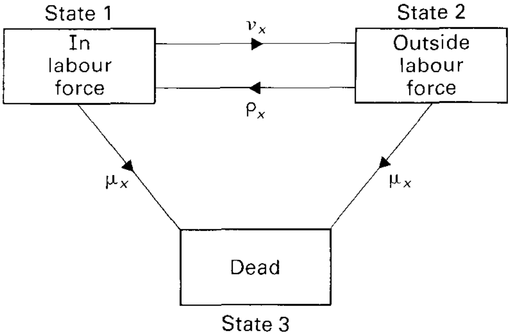

Figure 3. The Markov chain model of labour force participation with mortality: age specific transition intensities

rather than sets of labour force participation rates (w_x) which are measures of stock or structure at a point of time.

8.1.5 The Markov approach is dynamic. Persons are assumed to pass through life, at each age facing the transition intensities observed in the base population during the reference period (see Figure 3). It is assumed in the presentation here that the force of mortality (μ_x) is independent of labour force status. In principle, the model may be expanded to encompass differential mortality between those in the labour force (μ_x) and those outside the labour force (μ'_x and $\mu_x \neq \mu'_x$).

8.1.6 Worklife expectancies summarize the length of time that the average adult would spend in the labour force during his or her lifetime, *if* these probabilities (or intensities) of transition did not change. The age specific rates of labour force accession (ρ_x) and separation (ν_x) summarize the volume of labour turnover which would occur *if* mobility patterns remained constant.

8.1.7 The conventional approach depends (as noted earlier) on the assumption that workers remain in the labour force from their age at entry up to their age of retirement. This particular assumption may have been reasonable during the first half of this century, when worklives tended to be more continuous and then the conventional method would have given reasonably unbiased estimates of worklife durations, but, as work patterns have become increasingly irregular since 1945, the quality of any estimates from the conventional method has declined. As Smith[32] points out, these errors would be greatest for groups having high rates of labour force turnover. For such groups, the conventional model would tend to *underestimate* the size of the labour force and to *overestimate* the average worklife duration. This would apply particularly to women.

8.1.8 Hoem[9] compares in detail the results in terms of working life expectancy estimates derived by the classical approach (Section 6) and the Markov chain approach (Section 8). The data used by Hoem comprises the

Table 20. *Comparison of estimates of worklife time expectancy for men (terminating at age 75). Denmark 1972–74. (Hoem[9])*

		Mean working lifetime		
		Markov chain approach		Mean life
Age	Classical	In labour force	Outside labour force	expectancy
x	approach	at x	at x	at x
16	47·5 (90·2%)*	43·3 (82·2%)*	42·0 (79·8%)*	52·6
20	43·7 (89·4%)	40·8 (83·6%)	38·7 (79·3%)	48·9
25	38·9 (88·2%)	36·9 (83·7%)	34·7 (78·7%)	44·1
30	34·1 (86·7%)	32·3 (82·3%)	30·2 (76·9%)	39·3
35	29·3 (84·8%)	27·7 (80·2%)	24·5 (71·0%)	34·5
40	24·6 (82·6%)	23·1 (77·4%)	19·0 (63·6%)	29·8
45	20·1 (79·5%)	18·6 (73·8%)	14·3 (56·8%)	25·2
50	15·7 (75·7%)	14·3 (68·9%)	9·1 (43·9%)	20·7
55	11·5 (70·0%)	10·4 (63·1%)	4·7 (28·7%)	16·5
60	7·8 (63·0%)	6·9 (55·7%)	2·2 (17·5%)	12·3
65	4·3 (50·8%)	3·6 (42·4%)	0·8 (9·2%)	8·4

* Figures in parentheses denote the ratios of mean working lifetime to mean life expectancy—from the final column.

results collected from Labour Force Surveys in Denmark between 1972 and 1974. The data were collected over five overlapping periods, from three separate samples of respondents, and were analysed so as to produce detailed accession and separation rates, from which the required life tables could be constructed. An extract of the detailed results given in Hoem & Fong[33] is presented in Table 20. Table 20 shows the mean time in the labour force by age x for males:

(i) based on the classical approach,
(ii) based on the Markov chain approach, if the individual is in the labour force at age x, and
(iii) based on the Markov chain approach, if the individual is outside the labour force at age x.

These expectancies are truncated at age 75. For comparison purposes, the corresponding estimates of mean lifetime expectancy, also truncated at age 75 (i.e. $\mathring{e}_{x:\overline{75-x}|}$) are provided, based on the 1971–72 male life table for Denmark.

8.1.9 Comparison of these estimates indicates that, throughout the age range, the classical approach *overestimates* working life time (regardless of labour force status at age x). This confirms the view proposed earlier. The figures in parentheses in Table 20 indicate the ratios of the mean time in the labour force estimates to $\mathring{e}_{x:\overline{75-x}|}$. We can conclude from these figures that the discrepancy resulting from the use of the classical approach can be considerable.

8.1.10 In terms of relative (proportionate) deductions to be made from the estimate of life expectancy to allow for time spent outside of the labour force, we obtain the following percentages:

Age x	Classical %	Markov chain (in labour force at x) %
16	9·8	17·8
20	10·6	16·4
25	11·8	16·3
30	13·3	17·7
35	15·2	18·8
40	17·4	22·6
45	20·5	26·2
50	24·3	31·1
55	30·0	36·9
60	37·0	44·3
65	49·2	57·6

The difference between these two columns lies between 4·4 and 8·4 percentage points. In general, we believe that the difference could be considerable.

8.1.11 We believe that, as a general result, the classical approach leads to overestimates of mean worklife times relative to the Markov approach, and that these errors would be more marked for women under current conditions.

8.1.12 The figures in parentheses in Table 20, based on the classical approach, exhibit the same features as those in Table 1, viz. a decreasing trend with increasing age. The figures in parentheses in Table 20, that are derived from the Markov chain approach and relate to persons in the labour force at the starting age x, only show a decreasing trend beyond age 25. The ratios in this formulation are complex functions of age and consideration of their partial differentials with respect to age does not lead to clear cut results, in contrast to the discussion of Bloomfield & Haberman[1] in relation to the conventional approach.

8.1.13 Smith[32] also compares the worklife expectancies calculated on the basis of the two approaches (viz. classical and Markov chain), using data from the U.S.A. for 1970—the details are given below:

Worklife expectancy at age 20 (all persons)

	Conventional	Markov chain
Men	39·4	37·3
Women	22·0	21·3

So, we see that the conventional approach overestimates the estimates of worklife expectancies, in this particular case, by 5·6% for men and by 3·3% for women. This again suggests that the estimates derived in Sections 6 and 7 by conventional means are *overestimates*—by an order of magnitude of about 5%.

8.1.14 A second function of a working life table, not directly implicated in the estimation of worklife expectancies, is to quantify movements into and out of the labour force. The conventional model derives aggregate estimates of these flows from age to age comparisons of labour force participation rates. The results, taken to describe net flows, give little insight into the process or dynamics of labour turnover. The Markov chain model, however, rests on observed probabilities of labour force entry and exit at each age and enables estimates to be made of net and gross rates of mobility, thereby providing information on the frequency and *timing* of these movements in the average person's lifetime. Timing of these movements is of critical importance and is completely overlooked by the conventional method. The information available from the Markov chain model enables various indices of the distribution of time spent inside and out of the labour force to be computed (including measures of dispersion, e.g. variance).

8.1.15 The timing of any movement is also of critical importance in the application of these methods to the assessment of damages. Only the Markov chain approach gives proper weight to this factor.

8.1.16 The basic formulae for the construction of a Markov chain-based working life table from given transition probabilities are set out in Appendix 3. Adjustments to allow for salary (future earnings) progression and for discounting are also included. The presentation follows that of Alter & Becker(34) and Becker & Alter.(11) Hoem(9) gives a comparable mathematical presentation in terms of transition intensities—this viewpoint is also mentioned in Appendix 3.

8.1.17 Finally, it should be remembered that the Markov chain approach *does* allow for the initial labour force status of an individual aged x—as noted earlier. The conventional model does not allow for this known piece of information.

8.2 *Data Requirements and Results*

8.2.1 It is worth considering the data that are required for the construction of a Markov chain-based working life table. These data need to be detailed and of a high reliability. A number of examples are described fully in the literature—for example by Hoem(9) in respect of Denmark 1972–74 and by Smith(35) in respect of the U.S.A. for 1979–80.

8.2.2 Smith(35) explains that her worklife estimates are calculated for information collected in the Current Population Survey (CPS), a nationwide monthly survey conducted by the Bureau of the Census on behalf of the Bureau of Labour Statistics (BLS). Individuals are interviewed during each of 4 successive months and again in the following year. The questions asked focus on the labour force behaviour of household members during the week preceding each interview. For the 1979–80 study period, individual CPS records have been *linked* so that each person's status at the beginning and end of a 12-month period can be compared. Labour force transitions have been registered if labour force status changes between the two reference dates and hence transition intensities and probabilities are computed. The worklife tables for 1977 have been derived from a single matched sample of about 40,000 persons interviewed in January 1977 and January 1978.(32) The more recent 1979–80 tables investigate worklife tables specific for race and educational category and, to provide the additional demographic detail, required six matched samples with nearly 155,000 matched responses involved in aggregate.(35)

8.2.3 Data of this form are *not* currently available for the U.K., thereby preventing worklife estimates being presented by this superior methodology.

8.2.4 A number of factors affect worklife duration. The conventional approach and the early increment-decrement tables have been specific for sex and age only, but, in reality, labour force attachments are influenced by a variety of factors, including health, occupational training, marital and family status, other sources of income and so on. But it is not feasible to control for all of these factors in computing worklife expectancy. For example, while occupation-specific estimates may be particularly useful for the assessment of damages, it would require development of a clustering scheme for occupations by prevailing work patterns, together with a study of job changes among potentially hundreds of occupations, in order to compute these occupation specific estimates. The multi-state model can incorporate data on moves between occupations if those data are reliable. However, interoccupational mobility has proved difficult to measure accurately and the number of categories involved would lead to a serious fragmentation of the sample.[35] Thus, no occupation-specific estimates have been attempted to date, although Smith[35] does promise to develop in the future a 'few occupational clusters' so that the model can 'realistically control for occupation'.

8.2.5 This latest work by Smith does introduce worklife tables presented separately for subgroups of the U.S.A. population defined by race and education: traits which are normally fixed and stable during the adult years (unlike occupation—see § 8.2.4). An extract of the results is given in Table 21—it

Table 21. *Selected worklife indices by sex, race and years of schooling completed. U.S.A. 1979. (Smith[35])*

Worklife expectancy	Men All	Men White	Men Non-white	Women All	Women White	Women Non-white
at birth	38·8	39·8	32·9	29·4	29·7	27·4
at age 25	33·1	33·8	28·6	24·0	24·1	23·5
at age 60	4·4	4·5	3·3	3·0	3·0	3·0

Worklife expectancy	Men Schooling completed: All	Less than High School	High School to 14 years	15 years or more
at age 25	33·1	29·2	33·8	36·1
at age 60	4·4	3·4	4·7	6·3

Worklife expectancy	Women Schooling completed: All	Less than High School	High School to 14 years	15 years or more
at age 25	24·0	17·9	24·4	27·9
at age 60	3·0	2·3	3·4	3·5

should be noted that these underlying increment-decrement tables are not truncated at age 65 but continue until age 75 and beyond.

8.2.6 There are striking differences, particularly for men, between the two racial groups, with the worklife expectancy of blacks and others being nearly 7 years shorter than for whites. This difference is all the more marked because whites tend to live longer, allowing them greater potential for both longer worklife and post-retirement expectancies. The racial differentials for women are less distinct. The results on educational attainment are summarised in Table 21. These figures reveal a clear and direct relationship between years spent in full-time education and the duration of labour force involvement. Since there are no mortality tables available which distinguish educational attainment and because access to health care tends to be positively correlated with educational attainment, it is likely that these differentials by educational status have been *understated.* The mechanism whereby education affects worklife duration is probably occupational status. Although the link between education and occupation is not perfect, there are many occupations closed to persons who have not met minimum educational requirements.

8.2.7 Table 21 indicates that, on the basis of these U.S.A. data, the average man with 15 years or more of schooling can expect to work 6·9 years longer than his contemporary who left high school before graduation. The same increment in education will have a much more pronounced impact on the worklife duration of a woman, adding, on average, 10·0 years to her economically active life beyond age 25. Smith[35] takes this analysis further.

8.3 *Overview*

8.3.1 Thus, compared to the conventional method of construction of working life tables, the Markov chain (multi-state life table) approach has the following advantages:

(i) it provides a richer picture of the process of labour participation by viewing this as a dynamic process;
(ii) it accounts for multiple entries and exits over an individual's working lifetime;
(iii) it avoids the problems caused by a bimodal curve of labour force participation rates;
(iv) it requires fewer arbitrary assumptions, e.g. stability or stationarity; and
(v) it provides detailed accession and separation rates as well as summary indices.

8.3.2 However, it should be noted that the Markov chain approach does have greater data requirements and higher data processing costs. Information (as noted earlier) is required on gross flows not just on a set of participation rates at a point of time. Gross flow data may come from a retrospective analysis of statistics collected or a linked combination of data from at least two observation points. Further, the complexity of the data requirements does also mean that response reliability is a problem, more so for gross flow data than for labour force participation rates. As Hoem[9] has noted, misreporting of labour force status can be a serious problem for data from population groups with loose ties to the labour force, e.g. those with temporary or part-time employment—groups which may be significant at the lower and upper ends of the adult age range. The probability of faulty reporting of labour force status would need to be allowed for in any applications.

8.3.3 At present, it is not possible to construct a multi-state working life table based on (current) U.K. experience. It is hoped that such data may become available in due course.

9. 'READY RECKONER'

9.1 The practitioner, using the results in this paper, would clearly benefit from the availability of what one might call a 'ready reckoner', giving a range of justifiable deductions to represent the work time lost to sickness, unemployment and other contingencies.

9.2 Because of data problems, it has not been possible to use the superior methodology of the Markov chain described in Section 8. It has been noted there, and elsewhere, that this approach would lead to *larger* deductions than the other methods, based on the classical working life table.

9.3 Concentrating, therefore, on the results described in Sections 6 and 7, we may indicate a possible range of deductions as follows. However, the bias inherent in these methods (referred to in §9.2) needs to be borne in mind for practical applications.

9.4 From Table 2 (Section 6) and Table 18 (Section 7), the following percentage deductions for annuity (present) values for *males* using a 3% p.a. *real* rate of interest would apply (the reader is referred to Section 6.2 in particular):

	LOW	MEDIUM	HIGH
	1973 basis	Arithmetic average of 1977 and 1981 bases	1985 basis
Age	%	%	%
20	0·8	1·8	3·2
25	1·0	2·2	3·9
30	1·3	2·8	4·9
35	1·6	3·5	7·0
40	2·2	3·8	8·2
45	2·5	4·9	10·5
50	3·5	6·7	13·1
55	5·3	10·1	18·3
60	2·7	9·5	19·1

The MEDIUM set of percentages would relate to a view of future experience corresponding to the average experience in terms of economic activity over the last 15 years, ignoring periods of high and low unemployment. The LOW basis would relate to a view of the future corresponding to a period of higher economic activity and *lower* unemployment rates. The HIGH basis would relate to a view of the future corresponding to a period of lower economic activity and *higher* unemployment rates (relative to the MEDIUM basis).

9.5 The results of Table 2 indicate that a change in the rate of interest (from 3% p.a. to 1% p.a. or 5% p.a. would have the following approximate effect on the deductions for the MEDIUM basis:

Age	Change to 1%	Change to 5%
20	+0·9	−0·6
25	+0·9	−0·6
30	+0·9	−0·6
35	+0·8	−0·7
40	+0·8	−0·7
45	+0·7	−0·7
50	+0·7	−0·6
55	+0·5	−0·5
60	+0·2	−0·2

Thus, at age 25, the percentage deduction would be: $2{\cdot}2+0{\cdot}9=3{\cdot}1\%$ on a 1% discounting basis; $2{\cdot}2-0{\cdot}6=1{\cdot}6\%$ on a 5% discounting basis.

These adjustments, as can be seen, vary little with age below age 55. Similar results hold for the more extreme LOW and HIGH bases.

9.6 Investigation of the results presented in Table 20 for Denmark using the Markov chain approach indicates the effect of initial labour force status. Table 20 presents estimates of work life time expectancies separately for males aged x, both for those then *inside* the labour force and those then *outside* the labour force. The difference in Table 20 between the work life time expectancies is wide and numerical experiments suggest that, *if* we were to regard the figures quoted earlier for the U.K. on the MEDIUM basis as referring to males aged x regardless of work force status (as implied by the classical methodology of Sections 6 and 7), then the suggested LOW basis would refer approximately to males aged x then *inside* the labour force and the suggested HIGH basis would refer approximately to males aged x then *outside* the labour force.

9.7 There are no data available concerning the regional variation in sickness or disability rates. The data presented in Tables 12–16 indicate the regional variation in unemployment rates. It is not possible to build regional variation into the deductions presented earlier in a precise manner. However, these limited results suggest that the numerical deductions described in §§ 9.4 and 9.5 would apply to residents in the West Midlands, Yorkshire and Humberside regions and that:

(a) the percentage deductions should be reduced somewhat for persons resident in the South East, East Anglia, South West, East Midlands; and that

(b) the percentage deductions should be increased somewhat for persons resident in the North, North West, Wales and Scotland.

9.8 There are little data available concerning the variation in sickness or disability rates with occupation or industry—there is a brief discussion in Haberman.[3]

9.9 The data presented in Table 15 (and by Bloomfield & Haberman[1]) indicate the occupational/industrial variation into the deductions presented earlier in a precise manner.

But these limited results suggest that:

(a) the deductions should be reduced somewhat for persons employed in the financial service industries, the professions, the gas, electricity and water industries; and paper and printing industries; and that
(b) the deductions should be increased somewhat for persons employed in construction, mining, quarrying and ship-building.

9.10 The results presented in Table 21 for the U.S.A using the Markov chain approach indicate the effect of educational attainment. For males aged 25, numerical experiments suggest that these results would indicate that the MEDIUM basis deductions quoted earlier would become:

Educational Attainment	MEDIUM basis
Formal education terminating at 16	13·0%
Formal education terminating at 18 or a higher age	0·5%
All males aged 25	2·2% (as given in § 9.4)

indicating an extremely wide variation. These results would be difficult to apply to the U.K., particularly in view of their original presentation in terms of the socio-economic environment, education system and retirement age pertaining to the U.S.A.

9.11 One further caveat that would apply to the earlier comments referring to the variation in deduction by region of residence, occupation and industry, is that we have assumed that an individual remains in the same category throughout his economically active life. Thus, there is no occupational, socioeconomic or regional mobility (upward or downward) throughout an individual's working lifetime. This point has been made in Sections 6.3 and 7.4. The data in Table 21, which refer to race and educational attainment, suffer less from methodological difficulties, because the model used is the increment-decrement (or Markov chain based) working life table and because the characteristics chosen are relatively stable throughout an individual's working lifetime (as discussed more fully in § 8.2).

9.12 All the results discussed in this paper should further be qualified by the caveat that the underlying models (of Sections 6, 7 or 8) assume that economic activity rates and labour force separation and accession rates do not vary in the future from the bases chosen. As mentioned already in the text, it is unlikely to be true that the future would be free from marked secular trends.

10. APPLICATIONS OF THE MARKOV CHAIN APPROACH TO THE WORKING LIFE TABLE TO UNEMPLOYMENT INSURANCE

10.1 There is a considerable literature on the subject of unemployment insurance—see for example, the review by Malinvaud.[36] Here, we will only consider one type of policy (individual insurance) and illustrate how the methodology of the multi-state working life table might be used in the determination of premiums and reserves.

10.2 The policy that we shall consider is as follows: at proposal, the policyholder is at age x and is in employment; the policyholder is to pay a premium of P per annum annually in advance while not receiving benefit from the policy; a benefit of B is payable weekly during a spell of unemployment, with no benefit payable for the first period, d, of any spell of unemployment. The analogy with a conventional PHI policy with deferred period d is clear.

10.3 From the point of view of entitlement to benefit, a policyholder would not be limited to one spell of unemployment. Indeed, he/she could experience many spells of unemployment that would provide benefit entitlement, providing the times of onset are prior to the end of the coverage. We shall consider an n-year policy. Beenstock[37] considers a policy with two terms, in that the policy expires at time n so that a claim can only be made if the policyholder becomes unemployed prior to time n; however, the policy also stipulates that benefit cannot be claimed beyond time $n+m$. Here, we are taking the simpler case of $m=0$.

10.4 In the economic literature, there is some discussion about policy design. Thus, Beenstock[37] considers a single premium policy. Shavell and Weiss[38] consider a policy where the benefit is related to the duration of unemployment (again this would be similar to a conventional PHI or sickness insurance policy in the U.K.). Sampson[39] suggests that the benefits should also incorporate a lump sum benefit when the spell of unemployment begins. These latter features are designed to limit the impact of moral hazard: the presence of unemployment insurance may lengthen the duration of unemployment because of its effect on the effort devoted to job search and on the 'reservation wage'—the minimum acceptable wage offer that would 'persuade' the unemployed individual to return to employment.

10.5 With respect to the labour market and the unemployment risk, an individual can be in any one of four different states:

(1) employed;
(2) unemployed;
(3) inactive, viz. not employed and not actively seeking employment; and
(4) dead.

For convenience here, we shall ignore state 3, collapse the specification into a 3-state model and utilise Figure 3 as a representation of the model, with a suitable change of definition for states 1 and 2.

10.6 Then, for the particular case we are considering, with a policyholder aged x in state 1 at proposal, P is given by:

$$P\sum_{t=0}^{d-1} v^t({}_tp_x^{11} + {}_tp_x^{12}) + P\sum_{t=d}^{n-1} v^t({}_tp_x^{11} + {}_tp_x^{12} - {}_tp_x^{12}(d)) = B\int_d^n v^t{}_tp_x^{12}(d)\,dt$$

where the probability terms are defined in Appendix 4, and expenses have been ignored for the moment. Numerical values of P would be determined by numerical integration.

10.7 If the benefit plan were modified so that zero benefit were paid for the first period d_1, of unemployment, a benefit of B_1, were paid during unemployment of duration d where $d_1 < d < d_1 + d_2$, and a benefit of B_2 ($< B_1$) were paid during unemployment of durations d, where $d > d_1 + d_2$, then the equation for P becomes:

$$P\sum_{t=0}^{d-1} v^t({}_tp_x^{11} + {}_tp_x^{12}) + P\sum_{t=d}^{n-1} v^t({}_tp_x^{11} + {}_tp_x^{12} - {}_tp_x^{12}(d_1))$$

$$= B_1 \int_{d_1}^{d_1+d_2} v^t{}_tp_x^{12}(d_1)\,dt + B_1 \int_{d_1+d_2}^{n} v^t({}_tp_x^{12}(d_1) - {}_tp_x^{12}(d_1 + d_2))\,dt$$

$$+ B_2 \int_{d_1+d_2}^{n} v^t{}_tp_x^{12}(d_1 + d_2)\,dt.$$

10.8 Expenses can also be incorporated. Thus, if an expense E is incurred each time a benefit-paying period commences, we would need to add the following term to the right hand side of the gross premium equation:

$$E \int_0^{n-d_1} v^{t+d_1}\,{}_tp_x^{11}\, v_{x+t}\; {}_{d_1}\bar{p}_{x+t}^{22}\, dt.$$

10.9 To render the model more realistic, differential mortality for the unemployed may be incorporated so that the transition intensity from state 2 to 3 becomes $\mu'_x > \mu_x$ (transition intensity from state 1 to state 3).

10.10 Further, transition intensities dependent on the duration in the unemployed state may also be introduced: hence we would need to replace ρ_x and μ'_x by $\rho_{x,u}$ and $\mu'_{x,u}$ where u is the duration of unemployment. It is likely that re-employment probabilities vary markedly with the duration of employment so that a modification that permits the introduction of $\rho_{x,u}$ is likely to have a significant effect.(40)

10.11 The computation of reserves at time s, say, would need to take account of whether:

(a) the policyholder is receiving benefit at time s;
(b) the policyholder is not receiving benefit at time s and is in state 1 at time s; or

(c) the policyholder is not receiving benefit at time s and is in state 2 at time s (i.e. within the deferred period d or d_1).

Expressions for the reserves can be derived using the above methodology.

11. CONCLUSIONS

11.1 We have described three separate methodological approaches to the estimation of working lifetime expectancy, with particular emphasis on the relative deduction to be applied to the conventional (life table based) expectation of life ($\mathring{e}_{\bar{x}}$ or $\mathring{e}_{\bar{x}:\overline{n}|}$).

11.2 It has been possible to provide some numerical results for two of these approaches (the two inferior ones discussed in Sections 6 and 7) and to indicate the sensitivity of the results to attained age, using representative data from the recent socio-economic experience of the U.K. One difficulty discussed fully in the text is the recent dramatic changes in economic activity rates, unemployment rates and so on, which result in a wide range of variation in the indices we have derived. Further, we have also calculated discounted annuity values payable during working lifetime and emphasised the relative deductions to be applied to conventional (life table based) temporary annuity values (e.g. $a_{x:\overline{n}|}$). Here, we have considered the sensitivity of the results both to attained age and to the real rate of interest used in the discounting procedure.

11.3 As discussed fully in Sections 6.3, 7.9 and 7.10, there are important methodological problems with the approaches of Sections 6 and 7. These difficulties are not present in the more complex Markov chain-based methodology of Section 8 which also benefits from requiring fewer restrictive assumptions, but there are no data available from the U.K. which enable the required multi-state life tables to be constructed. Some examples from Denmark and the U.S.A. have been quoted—as mentioned in Section 8.1, these indicate that the classical approach of Section 6 overstates worklife expectancy estimates for men, which could imply that the resulting deductions derived by the methodology of Section 6 (Tables 1 and 2) are *underestimates* of the deductions that would emerge from a Markov chain approach, *ceteris paribus*. We believe that it is a general result that the estimates from the approaches of Sections 6 and 7 are biased consistently in this particular direction. Further numerical experiments, with U.K. data, would be helpful to quantify this bias.

11.4 It is possible that the necessary data for the construction of multi-state life tables will become available in the near future from the MRC National Survey of Health and Development, which is a follow-up study of a representative cohort of persons born in 1956 (N. Britten, personal communication).

11.5 In applying the results of this paper to the practical assessment of damages, the deductions suggested to allow for the contingencies of sickness, unemployment and so on would need modification to allow for those benefits (e.g. social security benefits) which would be payable in respect of these contingencies *and* also to allow for the implications of Section 23 of the Social Security Act 1989 (referred to in § 2.1).

11.6 Section 10 takes a tentative step towards the application of the theory of the multi-state working life table to the pricing of and reserving for individual unemployment insurance. Other possible applications for this methodology were described in Section 1.

12. ACKNOWLEDGMENTS

The authors would like to acknowledge and thank the Institute of Actuaries, Faculty of Actuaries, Bacon and Woodrow and William M. Mercer Fraser for their financial support during the course of the underlying research project.

REFERENCES

(1) BLOOMFIELD, D. S. F. & HABERMAN, S. (1989). The Assessment of Damages and the Measurement of Work Time Lost to Sickness, Unemployment and Stoppages. Actuarial Research Paper No. 9, Department of Actuarial Science and Statistics, City University.
(2) OWEN, R. & SHIER, P. S. (1986). The Actuary in Damages Cases—Expert Witness or Court Astrologer? *J.I.A.S.S.* **29,** 53.
(3) HABERMAN, S. (1987). Long Term Sickness and Invalidity Benefits: Forecasting and other Actuarial Problems. *J.I.A.* **114,** 467.
(4) PREVETT, J. H. (1968). Actuarial Assessment of Damages. *J.I.A.* **94,** 293.
(5) TRAVERSI, A. T. (1956). Actuaries and the Courts. *Australian Law Journal,* **29,** 557–561.
(6) STREET, H. (1962). *Principles of the Law of Damages.* Chapter 5. Sweet and Maxwell.
(7) KEMP, D. A. (1975). Kemp and Kemp: *The Quantum of Damages* (4th Edition). Chapter 8. Sweet and Maxwell.
(8) LUNTZ, H. (1974). *Assessment of Damages for Personal Injury and Death.* Chapter 6. Butterworths.
(9) HOEM, J. M. (1977). A Markov Chain Model of Working Life Tables. *Scand. Actuarial Journal,* 1–20.
(10) WOLFBEIN, S. L. (1984). The Length of Working Life. *Population Studies,* **3,** 286–294.
(11) BECKER, W. E. & ALTER, G. C. (1987). The Probabilities of Life and Work Force Status in the Calculation of Expected Earnings. *Journal of Risk and Insurance,* **54,** 364–375.
(12) HOEM, J. M. & FONG, M. S. (1976). A Markov Chain Model of Working Life Tables, Report No. 1. Working Paper No. 2. Laboratory of Actuarial Mathematics. University of Copenhagen.
(13) OPCS (1987). Labour Force Survey 1985. H.M.S.O., London.
(14) OPCS (1987). English Life Tables No. 14. 1980–82. Series DS No. 7, H.M.S.O., London.
(15) GARFINKLE, S. (1956). Tables of Working Life for Women. *Monthly Labour Review,* **79,** 654–9, 901–7, 1152–8.
(16) HUGHES, P. R. & HUTCHINSON, G. (1986). The Changing Picture of Male Unemployment in Great Britain. 1972–81. *Oxford Bulletin of Economics and Statistics,* **48,** 309–330.
(17) DHSS Social Security Statistics, H.M.S.O.
(18) General Household Survey 1982. No. 12. H.M.S.O., London.
(19) Monthly Statistics from Employment Gazette.
(20) MOYLAN, S., MILLAR, J. & DAVIES, R. (1984). For Richer, For Poorer? DHSS Cohort Study of Unemployed Men. DHSS Research Report No. 11. H.M.S.O., London.
(21) Department of Employment (1983). Who Becomes Unemployed? *Department of Employment Gazette,* **91,** 21. H.M.S.O., London.
(22) Department of Employment (1978). Duration of Employment. *Department of Employment Gazette,* **86,** 1048–1058. H.M.S.O., London.

(23) Department of Employment (1986). Classification of Economic Activity. *Department of Employment Gazette*, **94,** 21–27. H.M.S.O., London.
(24) Department of Employment (1978). *Department of Employment Gazette*, **86,** No. 1 and No. 11. H.M.S.O., London.
(25) Department of Employment (1986). Stoppages caused by Industrial Disputes since 1965. *Department of Employment Gazette*, **94,** 323. H.M.S.O., London.
(26) Department of Employment (1987). Labour Force Outlook for Great Britain. *Department of Employment Gazette*, **95,** 253–263. H.M.S.O., London.
(27) Department of Employment (1986). Unemployment Figures: The Claimant Count and the Labour Force Survey. *Department of Employment Gazette*, **94,** 417–422. H.M.S.O., London.
(28) The Distribution of Unemployment and Sickness among the United Kingdom Population. Unpublished mimeograph.
(29) HABERMAN, S. (1983). Decrement Tables and the Measurement of Morbidity I. *J.I.A.* **110,** 361.
(30) HABERMAN, S. (1984). Decrement Tables and the Measurement of Morbidity II. *J.I.A.* **111,** 78.
(31) WATERS, H. R. (1984). An Approach to the Study of Multiple State Models. *J.I.A.* **111,** 363.
(32) SMITH, S. J. (1982). New Worklife Estimates reflect Changing Profile of Labour Force. *Monthly Labour Review*, March 1982, 15–20.
(33) HOEM, J. M. & FONG, M. S. (1976). Markov Chain Model of Working Life Tables. Supplement to Report No. 1. Laboratory of Actuarial Mathematics Working Paper No. 2. University of Copenhagen.
(34) ALTER, G. C. & BECKER, W. E. (1985). Estimating Lost Future Earnings using the New Worklife Tables. *Monthly Labour Review*, Feb. 1985, 39–42.
(35) SMITH, S. J. (1985). Revised Worklife Tables reflect 1979–80 Experience. *Monthly Labour Review*, August 1985, 23–30.
(36) MALINVAUD, E. (1985). Unemployment Insurance. *The Geneva Papers on Risk and Insurance*, **10,** 6–22.
(37) BEENSTOCK, M. (1985). Competitive Unemployment Insurance Pricing. *The Geneva Papers on Risk and Insurance*, **10,** 23–31.
(38) SHAVELL, S. & WEISS, L. (1979). The Optimal Payment of Unemployment Insurance Benefits over Time. *Journal of Political Economy*, **87,** 1347–1362.
(39) SAMPSON, A. A. (1978). Optimal Redundancy Compensation. *Review of Economic Studies*, **45,** 447–452.
(40) NICKELL, S. J. (1979). The Effect of Unemployment and Related Benefits on the Duration of Unemployment. *The Economic Journal*, **89,** 34–49.
(41) Department of Employment (1987). Labour Force Outlook for Great Britain. *Department of Employment Gazette*, **95,** 253–263. H.M.S.O., London.
(42) APOSTOL, T. M. (1974). *Mathematical Analysis*. Second Edition. Addison Wesley.

APPENDIX 1

DEFINITION OF LABOUR FORCE

The definition of labour force used in this paper corresponds to that used in the Labour Force Survey. The definition is given below—a full discussion can be found in the May 1987 issue of the Department of Employment Gazette.[41]

The civilian labour force includes employees, employers and self-employed people (but excluding those in the Armed Forces), together with people identified by censuses and surveys as without a job and seeking work in a reference week, or prevented from seeking work by temporary sickness or holiday, or waiting for the results of a job application or waiting to start a job they had already obtained. People participating in one of the Government's employment and training schemes are included, as are those on training courses under the Training Opportunities Programme and its successors if they did some paid work or looked for work in the reference week. Full-time students are included if they did any paid work in the reference week or if they looked for work and were not prevented from starting work by the need to complete their education.

APPENDIX 2

MATHEMATICAL COMMENT ON WORKING LIFE TABLE INDICES

Consider the ratio of annuity-values discussed in § 6.2. In the text this ratio is defined as:

$$k(x,i) = \frac{\ddot{a}^{w}_{x:\overline{65-x}|}}{\ddot{a}_{x:\overline{65-x}|}}$$

with rate of interest i and $v = (1+i)^{-1}$.
The ratio is of the following form (although not precisely so because of the adjustment needed in respect of the unimodal shape of the w_xs).

$$h(x,i) = \frac{\int_x^{65} l_t w_t v^t dt}{w_x \int_x^{65} l_t v^t dt}.$$

We consider the change in $k(x,i)$ with respect to changes in the rate of interest, i.

It is convenient to use $h(x,i)$ as a surrogate for $k(x,i)$.
Then:

$$\frac{\partial}{\partial i}(\log_e h(x,i)) = \frac{\left[\left(\int_x^{65} l_t w_t v^t dt\right)\left(\int_x^{65} t l_t v^t dt\right) - \left(\int_x^{65} l_t v^t dt\right)\left(\int_x^{65} t l_t w_t v^t dt\right)\right]}{(1+i)\left(\int_x^{65} l_t w_t v^t dt\right)\left(\int_x^{65} l_t v^t dt\right)}.$$

It can be proved that, because l_t and v^t are decreasing functions of t, the above numerator is positive if w_x is a decreasing function of age. (See Apostol,[42] page 177, for mathematical background and Bloomfield & Haberman[1] for a proof.) Under this condition, $h(x,i)$ is an *increasing* function of the rate of interest—which confirms the empirical evidence in the text.

APPENDIX 3

FORMULAE FOR MARKOV CHAIN MODEL

Let q_x represent the probability of death in the year following the attainment of exact age x for an individual who is inside or outside the labour force. As noted earlier, we are assuming in the presentation here that mortality is independent of labour force status.

Let l_x represent the number of survivors at age x. This group can be divided into those who are active in the work force, ${}^1l_x$, and those who are not active in the workforce, ${}^2l_x$.

$$l_x = {}^1l_x + {}^2l_x.$$

Let the four relevant probabilities for work force transition be represented as follows:

$\tilde{p}_x^{12}$= the probability that a person who is active at age x will be inactive at age $x+1$,
$\tilde{p}_x^{11}$= the probability that a person who is active at age x will be active at age $x+1$,
$\tilde{p}_x^{21}$= the probability that a person who is inactive at age x will be active at age $x+1$, and
$\tilde{p}_x^{22}$= the probability that a person who is inactive at age x will be inactive at age $x+1$.

The above transition probabilities are conditional on survival from age x to $x+1$, so that:

$$\tilde{p}_x^{12} + \tilde{p}_x^{11} = 1 \qquad \tilde{p}_x^{21} + \tilde{p}_x^{22} = 1.$$

Assuming that the probability of death and the probability of transition between workforce statuses are independent (or equivalently, that the transition intensity is μ_x, regardless of whether a person is inside or outside of the labour force at age x), the number of inactive and active survivors at age $x+1$ may be defined respectively as:

$$\begin{aligned} {}^1l_{x+1} &= (1-q_x)({}^1l_x\tilde{p}_x^{11} + {}^2l_x\tilde{p}_x^{21}) \\ {}^2l_{x+1} &= (1-q_x)({}^2l_x\tilde{p}_x^{22} + {}^1l_x\tilde{p}_x^{12}) \end{aligned}$$

where $\qquad l_x = {}^1l_x + {}^2l_x \quad \text{and} \quad l_{x+1} = l_x(1-q_x).$

Then the expected working lifetime for a person active at age x up to age 65 would be:

$$\frac{1}{{}^1l_x}\sum_{t=0}^{64-x}[(1-q_{x-t})({}^1l_{x-t}\tilde{p}_{x+t}^{11} + \tfrac{1}{2}{}^1l_{x+t}\tilde{p}_{x+t}^{12} + \tfrac{1}{2}{}^2l_{x+t}\tilde{p}_{x+t}^{21}) + \tfrac{1}{2}{}^1l_{x+t}q_{x+t}]$$

approximately.

Similarly the expected working lifetime for a person inactive at age x can be defined, and the expected working lifetime for a particular group at age x with some active and some inactive can be defined.

The above expression can be interpreted by considering each of the separate terms:

(a) those who are active at the start of the year and stay active for a full year,
(b) those who survive the year but move from active to inactive,
(c) those who survive the year but move from inactive to active, and
(d) those who are active at the start of the year but die during the year.

As Hoem[9] describes, it is straightforward to express the conditional transition probabilities used above in terms of the underlying transition intensities. Under certain assumptions (of constant intensities over each integer year of age) with $\gamma_x = \rho_x + \nu_x$, we can derive

$$\tilde{p}_x^{12} = \frac{\nu_x}{\gamma_x}(1-e^{-\gamma_x}) \quad \text{and} \quad \tilde{p}_x^{21} = \frac{\rho_x}{\gamma_x}(1-e^{-\gamma_x})$$

from which $\tilde{p}_x^{11}$ and $\tilde{p}_x^{22}$ can be obtained by subtractions of $\tilde{p}_x^{12}$ and $\tilde{p}_x^{21}$ respectively from unity. Similarly $1-q_x = e^{-\mu_x}$.

The advantage of these formulae is that they connect the probabilities directly to those functions, the intensities, which would be estimated from the data available.

Expected earnings at age x can be calculated from the above equation by introducing a function in the form of a salary (or earnings) scale representing the progression of salary with attained age: s_{x+t}.

Discounting for the time value of money and an allowance for inflation can similarly be allowed for by the inclusion of an appropriate factor of the form $v^t = e^{-\delta t}$ into the above summation, where δ is the (real) force of interest.

APPENDIX 4

UNEMPLOYMENT INSURANCE: DEFINITIONS AND FORMULAE

${}_tp_x^{11}$ is the probability that an individual aged x who is a member of the labour force at age x will be alive and a member of the labour force at age $x + t$.

Thus, if we let $S(x)$ be a stochastic process with continuous-time parameter x denoting the exact age attained, then the transition probability

$${}_tp_x^{11} = Pr[S(x+t) = 1 | S(x) = 1].$$

Similarly, transition probabilities ${}_tp_x^{12}$, ${}_tp_x^{13}$ and so on may be defined.

In the presence of non-differential mortality (i.e. the transition intensity μ_x or force of mortality applies both to the transition from state 1 to state 3 and to that from state 2 to state 3), then it may be shown that

$${}_tp_x^{11} = {}_t\tilde{p}_x^{11} \cdot {}_tp_x$$

where $${}_tp_x = \exp(-\int_0^t \mu_{x+u} du) \quad \text{and}$$

${}_t\tilde{p}_x^{11}$ is the probability than an individual age x who is a member of the labour force at age x will be a member of the labour force at age $x + t$, when mortality is not present—as in Appendix 3. Similarly, we can define ${}_t\tilde{p}_x^{12}$, ${}_t\tilde{p}_x^{21}$, ${}_t\tilde{p}_x^{22}$.

The $\tilde{p}$ probabilities can be calculated in a recursive fashion.

Note that $\tilde{p}_x^{11} + \tilde{p}_x^{12} = 1$ and $\tilde{p}_x^{22} + \tilde{p}_x^{21} = 1$.

Let $w_x = {}_{x-\alpha}\tilde{p}_\alpha^{21}$ where α is the lowest age under consideration and $w_\alpha = 0$ (i.e. everyone is outside of the labour force at exact age α).

Then $w_{x+1} = w_x\tilde{p}_x^{11} + (1 - w_x)\tilde{p}_x^{21}$.

Similarly, expressions for $y_x = {}_{x-\alpha}\tilde{p}_\alpha^{12}$ may be obtained recursively.

Alternatively ${}_tp_x^{11}$, ${}_tp_x^{12}$, can be solved from the Kolmogorov partial differential equations for the stochastic processes, viz.

$$\frac{\partial}{\partial t}({}_tp_x^{11}) = -(\nu_{x+t} + \mu_{x+t})\,{}_tp_x^{11} + \rho_{x+t}\,{}_tp_x^{12}$$

$$\frac{\partial}{\partial t}({}_tp_x^{12}) = -(\rho_{x+t} + \mu_{x+t})\,{}_tp_x^{12} + \nu_{x+t}\,{}_tp_x^{11}.$$

Similar equations hold for ${}_tp_x^{13}$, ${}_tp_x^{21}$, ${}_tp_x^{22}$ and ${}_tp_x^{23}$.

The above are a pair of simultaneous equations. By differentiation and substitution, it is possible to obtain a second order *ordinary* differential equation for ${}_tp_x^{11}$ (or for ${}_tp_x^{12}$) which can then be solved by standard numerical techniques.

We also define ${}_t\bar{p}_x^{11} = \Pr[S(x+u) = 1 \text{ for all } u \in [0,t] | S(x) = 1]$ i.e. the probability that an individual remains in the labour force (state 1) throughout the interval $(x, x+t)$ given that he/she is in state 1 at age x.

${}_t\bar{p}_x^{22}$ may be defined similarly.

Then it can be shown that:

$$ {}_t\bar{p}_x^{11} = \exp\left[-\int_0^t (\nu_{x+u} + \mu_{x+u})\, du \right] $$

and

$$ {}_t\bar{p}_x^{22} = \exp\left[-\int_0^t (\rho_{x+u} + \mu_{x+u})\, du \right]. $$

Finally, we shall need the probability that an individual is in state 2 throughout the time interval $(x+t-d,\ x+t)$ where $d \geqslant 0$ given that he/she is in state 1 at time x. This probability is denoted by ${}_tp_x^{12}(d)$.

Formally, ${}_tp_x^{12}(d) = \Pr[S(x+u) = 2 \text{ for all } u \in [t-d, t] | S(x) = 1]$.

It can then be shown that

$$ {}_tp_x^{12}(d) = \int_{u=0}^{t-d} {}_up_x^{11}\, \nu_{x+u}\, {}_{t-u}\bar{p}_{x+u}^{22}\, du. $$

To derive this expression we would need to hold x and t fixed and consider the state of the stochastic process at time $t-d-h$ for $h > 0$, and then consider the limit as $h \to 0$.

ABSTRACT OF THE DISCUSSION

Mr R. K. Cornwell, F.I.A.A. (opening the discussion): It is 22 years since the subject of the actuary's role in the quantification of damages has been discussed at a sessional meeting, although Owen and Shier's paper, 'The Actuary in Damages Cases', was presented to the Students Society (*J.S.S.* **29,** 53) five years ago.

The assessment of any damages award, either explicitly or implicitly, makes assumptions about: the future mortality of the injured plaintiff; the future mortality that he would have experienced had it not been for his injury or death; the future mortality of any dependants; the future rate of investment return; the future rate of inflation; the future rate of taxation; the future rate of increase of the plaintiff's salary, both before and after injury; and the probability of future redundancy or ill-health had the plaintiff not been injured. The authors demonstrate three approaches to the problem: two working life tables and a multi-state model using a Markov chain approach. They then show how this Markov chain approach could be used for other applications, such as unemployment insurance.

In § 2.1 the nature of the contingencies being examined is discussed. The major differences with the traditional actuarial decrement of mortality are highlighted. Unemployment is difficult to define and the rate of unemployment is subject to large cyclical, regional and occupational variations. At the individual level there are further influences, such as attitudes to work, ability to take on work due to caring for dependants and a whole variety of other factors. One can only agree with the comments in § 2.1.9 that all these influences conspire to make statistical measurement of the contingencies of sickness and unemployment somewhat problematic.

A major weakness in the practical usefulness of the numbers derived in the paper is described in § 2.1.10. Much work time lost is in the form of short illness that is covered by normal sick leave arrangements and causes no loss of income. This is partly allowed for by the use of sickness benefit data which have a three-day qualifying period. However, an employee may also be covered by an employer's long-term sickness plan, much reducing the financial loss for the sickness. How should the existence of these plans be allowed for? Sickness and invalidity benefits from the state also reduce the financial loss. Many employees would also expect redundancy benefits. These may substantially reduce the financial loss caused by losing a job, as will unemployment benefits. As the authors say, in an actual case the deductions would need to be altered to allow for these factors. In effect, the deductions in the paper provide an upper limit to the deduction for contingencies. Perhaps one way of calculating the effect of such benefits on the deduction is, when using the multi-state approach, that the plaintiff would lose only a fraction of his income, not all of it, when not active in the work force. Another method might be to incorporate an off-period when no financial loss is suffered, as in PHI. The authors demonstrate how this might be done in their exposition on unemployment insurance.

The authors provide a very full critique of the conventional working life in § 6.3. One can only agree with their conclusions that the method has a major flaw, the one-entry/one-exit assumption. Nevertheless, the figures in Table 2 have some interesting features. The cyclical nature of unemployment is dramatically highlighted by the huge disparity in deductions between the 1973 and 1985 survey results. The factors affecting these figures are not purely cyclical. As the authors observe in § 6.2.5, the trends of later entry to the work force and earlier retirement are significant factors in the differences. I believe that these trends are likely to continue. The increase in the ratios $k(x,i)$ with the real rate of interest will provide only a minor compensation for the greatly decreased annuity factors resulting from the use of a higher real interest rate.

In Section 7 the authors conduct a detailed examination of unemployment and sickness statistics and incorporate them into a working life table. The difference in the deductions derived in the two working life table approaches is very great. I am unsure of the reason for this, and would appreciate an explanation from the authors.

Multi-state models have many applications, not just for this sort of work. As well as for unemployment insurance and PHI, they are being used in the calculations for long-term health care schemes. This model is clearly superior to the previous methods. It is a pity that no United Kingdom data are available to calculate the appropriate deductions. The example of calculations from Denmark and the United States of America is most useful in demonstrating the effect of using this method. From these examples, the authors estimate that the deductions calculated earlier were about 5% too low. This is quite significant, although, presumably, the effect of compound interest in annuity calculations would reduce this.

As the authors state, a multi-state model is dynamic and flexible. It would, theoretically, be possible to investigate the effect of varying rates of unemployment in some cyclical fashion. Although this would have to be done in an arbitrary way, it might provide an indication of the effect of this phenomenon—an individual will, after all, live through times of high and low unemployment. It might also show that deductions are less sensitive to the current state of the economy than the figures in Table 2 show. What the 'average' level of unemployment to be used in such a study will be somewhat of a guess. The figures in Table 21, especially the varying work life expectancies by length of education, were interesting. One could say that they show the value of education both to the individual and to the community. However, there are a number of factors such as intelligence and social background which might account for a large part of the variation if they were introduced into the model.

In Section 9, the authors provide a ready-reckoner for use by practitioners. In view of the size of the deductions in relation to the awards, this seems a most useful step. Their suggestions as to modifying their recommended deductions for an individual's specific status seem reasonable. The authors state that if the Markov chain method had been used then the deductions would be higher. This is, perhaps, compensated for by the absence of any allowance for income replacement while not working, through state benefit, employers' schemes or redundancy benefits. Perhaps, in true actuarial fashion, the two largely offset each other and the deductions are about right.

The suggested deductions use a 3% real interest rate, which is lower than the rate that has been used by the courts. It is to be hoped, however, that the courts can be persuaded to use these figures as a basis for their assessments. Whatever the problems with the data, it is a far more scientific approach than that used at present.

In Section 10, the authors show how the Markov chain approach could be extended to unemployment insurance. I am unsure as to the viability of unemployment insurance. It has many of the difficulties of PHI, such as uncertain claim rates and cyclical variation. The people who might need insurance the most will probably not be able to afford it, because of being charged very high premiums. The authors' method might be useful for costing community-based unemployment insurance schemes. However, the current method of funding unemployment benefits has a useful automatic stabilising effect on the economy, which a fully funded scheme might lose, because it increases Government expenditure in times of high unemployment and reduces it when unemployment is low. However, it is still a very interesting method and, perhaps it might be able to be used in budgeting.

Mr R. Owen: Actuaries, as trained statisticians, appreciate that the more complex a problem, the more vital it is to use statistical models to solve the problem. Unfortunately, most judges have not had such training, and prefer to adopt the argument which says that the more complex a problem, the less relevant the use of statistics. In our paper (*J.S.S.* **29,** 53), P. S. Shier and I attempted to introduce lawyers to the mathematics underlying the calculation of what they call 'multipliers', and we call 'annuity values', and to introduce actuaries to the legal concepts involved in damages cases. Unfortunately, what happened was that the lawyers chose only to read the legal sections which they found a useful summary, and the actuaries only read the actuarial sections, which they found trivially simple! Clearly, there is still a large communication gap to be bridged.

As long as damages continue to be awarded in lump sum form, then we should continue to press for a scientific approach to their calculation. The danger is that judges may choose to adopt our proposals selectively. Generally, we believe that current multipliers adopted by the courts, and hence the damages awarded, are too low. It may well be that, if further research along the lines of Section 8 is carried out, it will be shown that the deductions for contingencies currently applied by the courts are too low. It would be unfortunate if damages awards were to be reduced as a consequence.

Mr S. F. Yeo: Having read the paper, I referred back to the award-winning paper to the Students Society by Owen and Shier (*J.S.S.* **29,** 53). This was useful for two reasons. Firstly, its title, 'The

Actuary in Damages Cases—Expert Witness or Court Astrologer?' reminded me, as a practitioner, of the difficult task an actuary undertakes when he, as an expert witness, prepares evidence to be used in damages cases. Secondly, I re-read the section of that paper where Owen and Shier discuss the deduction for 'other contingencies', in which they suggest that further investigation of this deduction should consider three basic questions: what contingencies need to be taken into account; what allowance should be made for each; how should such allowances be incorporated into the calculations? Whilst the authors have made a fairly full investigation of the second question, they have not discussed in any depth either the first or third.

Although there is some discussion in Section 2 of the definition of various contingencies, and the needs of the courts, I did not feel this was carried through into the rest of the paper, where much laudable effort is spent with the available statistics to ensure that they are comparable and consistent, without necessarily confirming that they are relevant for damages purposes. Similarly, there is an attempt to present a 'ready reckoner' in Section 9, but my feeling is that, in view of the difficulty of getting an actuarial approach to mortality and real rates of interest accepted, it is unlikely that even the simplified approach adopted in Section 9 would find favour in court. Given a choice between the scientific approach to the deduction or the use of real rates of interest, I believe that plaintiffs would clearly favour the latter being adopted.

I found the authors' use of the Markov chain approach convincing. In particular, the discussion in § 8.1 could almost have stood by itself as a justification of the approach. The authors build on this basic approach and attempt to analyse the work time lost by age and location and compare the effect of those variables with that of the rate of interest. They do this in Table 2, although I was disappointed that in a paper of such detail the authors should have resorted to the presentation of annuities with payments made annually in advance (rather than continuous annuities). In § 6.2.11, the authors say it "indicates that the ratios, $k(x,i)$, are less sensitive to the level of the real rate of interest than to attained age". What strikes me about Table 2 is that there is a huge variation by year of survey so that, for example, the ratio appropriate to a 60-year-old at 1% interest in 1973, is only matched in 1985 by reducing the age to as low as 25 and increasing the interest rate to 5%. Although the authors acknowledge this in § 6.2.16, where they say "there is a wide range in the figures which would make application problematic", I think further work in this area is necessary before the results of the authors' work can be applied in practice. I would be especially interested in the results of an analysis of the 1956 cohort alluded to in § 11.4.

Another result which seemed interesting was that in § 9.10, which showed the results for the U.S.A. using the Markov chain approach to indicate the effect of educational attainment. This analysis produced a very sharp distinction in rates of absence according to educational attainment. My subjective observations of employers suggests that further study in this area in the U.K. would be of value.

Sir Michael Ogden, Q.C. (a visitor): I do not think you should despair. The tables that I and a number of you here sweated over a few years ago are brought out with great regularity in courts. Although there are occasional difficulties, most judges are happy to have them drawn to their attention. Furthermore, I understand there may be legislation in this area in the comparatively near future.

The authors go a long way towards providing a solution to the major lacuna in the Inter-Professional Working Party's Tables. In my view, it is essential that courts are offered assistance in assessing contingencies other than mortality, and, at present, the working party's tables give no help with this. It would be helpful if the Institute would give some thought to providing a service to the legal profession in arranging to have published in legal periodicals the current yield of index-linked Government stock. Whenever I sit as a judge and ask what the yield is no one knows, and I am not told until the next day. Then I am not 100% confident that I am always given the right answer, since it has to be calculated from all the figures relating to such stocks published in the financial press.

I consider that one important modification to the principles enunciated in the paper needs to be made in order to prevent double counting to the detriment of plaintiffs. It is necessary, because some of the factors taken into account in the paper for the purposes of calculating what the courts call the multiplier are taken into account when assessing the multiplicand. Short-term unemployment, ill health and industrial disputes are all taken into account in most cases when assessing the multiplicand. Two examples will illustrate this point. In the construction industry, it is common for workers, for example bricklayers, to move from one job to another, and this often involves a period of unemployment between jobs. In a straightforward case, the multiplicand for such a person is actual earnings at the time of death or injury, based upon earnings for a few years prior to the accident, and therefore, taking into account time lost due to short-term unemployment, ill-health and industrial disputes. Exactly the same thing happens in the case of a self-employed taxi driver. In the ordinary way, his earnings in real terms will remain constant and will take account of minor short-term illnesses.

The contingencies other than mortality with which the courts are concerned are the risks of long-term ill health causing loss of earnings, losing employment for any reason from what appears to be a steady job, and, to an extent which I suspect is very small, the risk of loss of earnings due to a long industrial dispute, such as the miners' strike. The calculation could be made the other way round; but this would involve increasing the multiplicand to allow for actual past short-term loss of earnings, and would, in my view, constitute an unnecessary complication. More to the point, it is not how the courts do it, and I do not believe that the courts will be persuaded to change their practice in this respect. What is to be regarded as 'short term' must, perforce, be an arbitrary decision. However, as long as the basis on which that decision is reached is provided, in summary form, in whatever document is published, I consider that it will suffice. This paper, taking account as it does of short-term unemployment, would be detrimental to a plaintiff, and that is why an adjustment is, in my view, necessary.

I agree with the authors that what the courts need is a 'ready reckoner'. Ideally, if it can be done, what is needed is a median percentage figure to be used to adjust the figure provided in the Government Actuary's Tables, coupled, by all means, with minimum and maximum figures taking all factors into account, save those affecting a particular plaintiff alone, but taking no account of short-term loss of earnings for any reason. If this can be done, and I appreciate the difficulties, especially in respect of a maximum deduction, I have no doubt that it will be accepted with alacrity by a great many judges. Indeed, if we do succeed in getting legislation through, then the courts will be obliged to do so. This is an important paper, which ought to lead to something of inestimable value to the courts.

Mr R. J. Squires: Concerning what Sir Michael Ogden has just said; although I was very much encouraged by his remarks that what the courts would be looking for would be something helpful in coming to a conclusion, I was rather less encouraged when he moved on to talk about a ready reckoner. I am dubious whether there is such a thing as a right answer, or even a true and fair value. That phrase is of interest in another area, that of the artillery. The approach of the artillery is not to try to judge precisely where the target is, but to put one shell way to the left of where you think it is and another shell to the right, and observe what happens. When you have that data, you are then able to make a better estimate of where you want to put the rest of the shells.

One of the subjects raised in this paper is the problem of getting useful data. The point is that biased data can be useful as long as you know what the bias is. It all adds to helping to find a reasonable answer. Whether it is right or whether it is true and fair is another matter.

Mr J. Lockyer: To what extent are pooling assumptions valid in the assessment of awards, and to what extent is heterogeneity acceptable? As actuaries in insurance, we attempt to place risks in broadly homogeneous groups, while accepting that these groupings may still encompass a wide spectrum of risks. Conversely, as buyers of insurance, we have a choice. Intuitively, or otherwise, we can make a judgement whether, on the one hand, the insurers are under-rating our own particular risk, in which case we happily submit to the pool, or, at the other extreme, whether our experience is likely to be such that we are going to subsidise the pool. In that case, we might decline to take insurance at all, or at least go and look elsewhere. The poor accident victim has no choice. His circumstances are unique. It is no comfort to him or his dependants that the generality of awards is right on average. He cannot try at another court if he feels that the assumptions made in the assessment of his damages do not properly apply to him. Philosophically, it seems that we should be asking what the expected earnings would be of a body of people who are exactly, not merely approximately, like him.

In § 2.1.8 the authors attest to the stability of mortality if AIDS is ignored, but there is still a wide range of individual circumstances which can give rise to differences in curtate expectation of life, which might more than compensate for the suggested adjustments for work time lost. Perhaps one should take into account whether the plaintiff was a non-smoker or whether he had just been accepted for life insurance on ordinary terms. Perhaps one should inquire about his family history or whether he had had an adverse medical history prior to the accident. The opener and others have already mentioned that the loss of income on redundancy may also depend upon the expectation of redundancy payments, and, maybe, loss of earnings on sickness will depend upon sickness compensation schemes. Should the expected rate of sickness also take into account the actual sickness record of the individual compared to others in his industry? This is rather idealistic stuff, and probably not achievable in practice—certainly not in the form of a ready reckoner. However, if one starts from a broad brush approach, and then attempts to make allowance for work time lost on a basis which does not take account of the individual's specific circumstances, then one may face the danger suggested by Mr Owen, that the judiciary may unwittingly make selective use of statistics to the detriment of the claimant.

The paper is also of value in demonstrating more scientifically than hitherto where work time lost through sickness and unemployment is likely to be of significance, and where, on the other hand, adjustment is likely to be such that it must be considered to be of only spurious accuracy.

Mr P. D. G. Tompkins: My comments follow from what Sir Michael Ogden said. To adjust the multiplicands, to take out the short-term effect of having a period of short sickness or unemployment in recent years, would be rather a high level of complexity to require of the court in order, then, to apply some ready-reckoner factors which the actuaries had derived. However, there is a difference between the long-term rate of sickness and unemployment which may be experienced by the person, and the long-term effect of short-term sickness and unemployment.

What the paper illustrates quite clearly is the build-up of the short-term experience and the level of sickness being experienced by people of different ages, and how much more substantial it is for those in their sixties than for those in their twenties—something like a factor of 10. It is obviously necessary to make some fairly intuitive conclusion from the factors suggested as a ready reckoner as to what is going to be appropriate over the term for which the particular person's loss of earnings is being assessed. Somebody who is in his sixties is going to have only a very short period of working life ahead of him, and the factors that need to be taken into account are more likely to be those of recent years.

In § 9.4, where there is a table showing the low, medium and high figures, it is suggested that the medium set might be selected to represent the economic activity over the period of, say, the last 15 years. Whether this is an appropriate term to take, I am not sure. Somebody who is in his sixties would clearly not be working for a further 15 years—so one would be tending towards the high number of years there—and for somebody in his twenties, clearly towards the low figure. I think that we have a problem here that we are meeting in other areas, such as assessing inflation rates and interest rates, and also the question of best estimates for SSAP 24 purposes in pensions funds: how much account we take of present day, and how much account we take of the long-term past.

I suspect that courts find it easier to look at what is happening now in a period of high unemployment. Somebody, for instance, in the bricklaying industry may actually suffer—or his estate may suffer—to the detriment of his earnings being reduced by a rather larger amount than they would have been in a period when construction was booming.

Mr C. M. Stewart: About 10 years ago Professor Haberman and I worked together briefly on part of the estimates for the State earnings-related pension scheme. He constructed a model as one of the main instruments for the estimates. This involved the use of unemployment rates and sickness rates periods during which there was no accrual of earnings-related benefits. Unemployment is the state of not being in employment. It does not concern the self-employed. An employed person can be sick or unemployed; a self-employed person can be sick, but cannot become unemployed and claim benefit. Professor Haberman, therefore, knows well the importance of finding out exactly what the parameters are before he starts assessing their values. He will find that those using his models, e.g. in the courts, will be less strong in mathematics and very strong on parameters, not only in questioning what they are, but how he arrived at their values. I emphasise this, because the model is going to be used in a severely practical context, and it may not be Professor Haberman who chooses the values for the parameters.

In § 7.10.5, the authors point out that one of the big advantages of the Markov approach is that it is specific for the work force status at the age of commencement. This is not so with a collective method. On the other hand, with a collective method, you do have an overall idea of what the results of the estimation process will be. I am always a little afraid of processes like the reversionary method or the Markov chain method. You can feed in various parameter values, but you are not sure whether, in the end, it will look reasonable or unreasonable. Bearing in mind where the authors' model will be used, they should be very careful about the robustness of their estimation process, the exact nature of their parameters, and how strong and how reliable the values that they attach to their parameters are.

Mr C. A. Evers: It is of particular interest to have a paper that strengthens the use that actuarial science can be put to in the area of damages. The improvement to the techniques for establishing the quantum of damages will have to be accepted by the courts, and for that to take place actuaries will need to explain successfully to the courts the methodology which lies behind the work in this paper. This explanation will need to be to the legal profession as a whole, because many cases are settled before they reach the courts. It can be difficult to explain to lawyers, for example, the use of averages and how averages might apply to an individual plaintiff. It is much more difficult to explain stochastic processes and Markov chains if they lie behind the new procedures which are being proposed. However, the idea of using ready reckoners is something which is likely to be easier to be accepted by the courts.

Mr C. G. Lewin: In Table 20 there is a suggestion that the annuity value depends a great deal on whether a man is in work or out of work at some particular point in time. I was not clear whether, in using this conclusion, the courts would apply it according to the time of the accident or to the time the damages were assessed. One can see dangers, from a moral viewpoint, if it were the latter, because the individual might take steps to ensure that he was out of work at that particular time.

This led me to think about some of the broader issues; to wonder whether, as a society, we are striving after the impossible even to try and compensate an individual exactly for the particular loss which has been suffered. After a serious accident or event there are so many consequences which can follow; some are social and some are purely financial. Even of the financial consequences, some are totally incapable of assessment, because it is not known what the future would have held for the particular individual. He might have been promoted; he might not. He might have changed his job; he might not. He might have been very active prior to his accident, but have been planning to cut down his overtime significantly as he approached retirement. Even if the court were to inquire quite closely into an applicant's circumstances, it could not get close enough to all the relevant factors to be able to make even an approximate assessment which could be regarded as sufficiently reliable.

Therefore, I am much more attracted by the idea that, as a community, we ought to have some kind of a scale which we apply universally. Whether it should apply in all cases, or only in cases of provable fault by a third party, is for further consideration, but I prefer the former. If a person suffers a severe loss because of an accident, there is a case for the community to provide a particular scale of benefits (perhaps through the National Insurance Scheme). That scale, by its nature, would have to be on a collective basis and be approximate. It might depend purely on age and earnings, or purely on age. It might even be a single monetary scale independent of anything other than the degree of disablement. The scale would necessarily have to be set on the low side to prevent it being over-generous in too many cases. The advantage of this proposal is that every one of us would know that if we were to have this kind of misfortune, we would be covered for a predetermined sum. We could be sure that we were starting from a firm base in deciding whether we wished to take out any supplementary personal insurance.

The greatest weakness of the present system is its uncertainty; that after an accident, whether it can be proved to have been anybody's liability, and if it is not the victim's liability, what he will receive for it. Therefore, I believe that, from a community viewpoint, there is a case for moving towards some kind of universal scale, and then some of the problems discussed in this paper may become of less relevance.

Mr M. D. Werth: The points I should like to make are concerned not so much with damages but with creditor insurance, which looks at accident and sickness, and also unemployment insurance. The factors that are considered there are different from damages, in the sense that it is much more important to consider involuntary umemployment, and in particular redundancy, as opposed to general unemployment. There are, unfortunately, no statistics that are readily available for either of these, and ad hoc reductions to general unemployment rates have to be used.

We also have to look at changing definitions of unemployment. In October 1989, the Government introduced another rule change to the Social Security Act, which requires people out of work for more than 13 weeks to accept low-paid jobs or risk losing their benefits. This new, 'actively seeking work' provision should reduce the mean duration of unemployment. Of increasing importance is the reduction in the labour market due to the fall in the number of school-leavers. It is estimated that by 1994 the number of 16- to 18-year-old school-leavers available for work will have fallen by 20%. When looking at future unemployment insurance, we must consider the free movement of labour within the Single European Market.

The paper also highlights the difference in unemployment by region. It is also interesting to look within the regions. In the north of England, unemployment rates in Cleveland are twice as high as in Cumbria. I have found that the problems with statistical models for unemployment insurance are: inadequate data; the changing economic conditions; and psychological attitudes to claiming benefits. Also, we have insufficient knowledge of the population exposed to the risk of involuntary unemployment.

Mr H. H. Scurfield: I speak as the parent of a daughter whose husband became disabled in a car accident. The accident was nearly three years ago, and the case is not yet settled. I support Mr Lewin, with this particular case, because of the uncertainty over the three years and its continuing impact on two people's lives.

Last year, when they were concerned with liability, my son-in-law was required to go through all the medical routines to establish the full case, and he had to see twelve separate doctors, each with a different specialty. That seems an enormous number. With each doctor the whole story had to be gone through again. Psychologically, it is destroying. This year, having established liability, they are concerned with quantum, and an up-date on his medical condition is needed. Again a whole series of doctors is involved. Psychologically destroying again. The National Health Service in this country is particularly good at dealing with spinal injuries and he had very good medical attention. The advice given by other patients in hospital was: "Do go carefully in trying to get employment again—especially too quickly. Any penny you earn comes straight off what you can get from the state. If there is any payment of compensation, that will affect the situation considerably". Is this good pyschology?

One other aspect I should like to mention is to those who are employers: on his CV, when he was seeking a job, my son-in-law said that he was disabled. He never received even one response. As soon as he changed it and did not admit that he was disabled, he received a response from the first employer he sent it to. It is food for thought.

Mr J. H. Prevett, O.B.E. (closing the discussion): This is the first time we have had a paper very firmly directed towards the problems of assessing damages since my own paper 22 years ago (*J.I.A.* **94,** 293).

The work of the Inter-Professional Working Party of Actuaries and Lawyers, chaired by Sir Michael Ogden, led to the publication, in May 1984, of a booklet entitled, 'Actuarial Tables with Explanatory Notes for use in Personal Injury and Fatal Accident Cases'. The introduction to the tables submitted that the yield on index-linked Government stocks should be taken as a guide to the selection of a rate of interest for discount purposes, and the resultant tables of multipliers made it clear that this could lead to a substantial increase in the general level of damages. Members of the working party felt that there would be a very serious danger that, if judges felt compelled to use higher multipliers, based on a lower discount rate than at present, they might seek to compensate for this factor, being horrified at the figures emerging, by increasing the deduction for contingencies to bring out cash levels which were more acceptable to them. There was full mutual agreement between the legal and actuarial members of the working party that some modern research was necessary in this area. We knew that it would take time to come to fruition, but guessed correctly that it would also take time for the new tables to become accepted. It is six years since the publication of those tables. They have not yet, I understand, been formally blessed by any court. Certainly this paper is not too late. Have we progressed very far in the past 22 years?

There was, in most of the discussion, an acceptance that we need a more scientific approach in this area. Mr Owen stressed the need for a statistical approach for the solution of complex problems, and wondered whether the Judiciary readily accepted that. Sir Michael Ogden told us that the tables were often cited in settlements. He told us not to despair. I hope that he is right. The ready reckoner is an important part of the conclusions of the paper, and was supported by several speakers. There was an acceptance by many speakers that we need to codify the results of very detailed and complex research into a way in which it can be practically applied. One or two speakers, nevertheless, queried whether it was the right way forward. The opener and others raised points where further research could be carried out to follow on from this paper. One which the opener suggested to the authors is the reason for the big difference between the two working life table approaches. There was agreement between the opener and Mr Yeo of the need for the results of the cohort study referred to in § 11.4, and that could well lead to further research that will be useful in the damages area.

A number of speakers widened the scope of this discussion, not only talking about the contingencies effect on damages, but the whole approach to assessing damages. Mr Evers welcomed the extension of actuarial methodology in a wider area than looking at the basic multipliers as the new tables have done. Mr Tompkins drew analogies with problems in more traditional areas of actuarial work, such as pensions and life assurance, and raised the questions that we face in those areas, as indeed in this one, of the relative importance of short-term factors and the present economic and financial situation with the long-term uncertainties with which we have to deal. Mr Lewin, in looking at the whole area of compensation, raised the question of whether we ought not to have some modest level of no-fault compensation in the whole area of dealing with the victims of accidents.

The authors extended the scope of their paper beyond the damages area to the possibility of unemployment insurance, either on a commercial basis, or within the context of social security. This was not taken up by many speakers although Mr Werth raised it, and talked about the need to consider the whole European market.

Several speakers emphasised that the relevance of this paper, if it is going to be of practical significance, must depend upon the acceptance by the legal profession of an actuarial approach to the basic problem of assessing damages. Mr Yeo said he would welcome the adoption of the conclusions of this research, but he pointed out that we were also waiting for the adoption of the approach behind the new tables. Mr Evers emphasised that there has always been a problem of communications between the legal and actuarial professions. I tried to emphasise that in my paper in 1968. I think we have made some advance in that area. The fact that we had a joint working party of actuaries and lawyers was indeed a step forward. There still is some way to go.

Mr Lewin questioned whether we are not, perhaps, striving after the impossible in seeking to solve this problem of lump sum compensation for damages. We all recognise that it is not a perfect solution; that you can never compensate the plaintiff correctly; you will always overcompensate or undercompensate. All one can attempt to do, even with all the science at our disposal, is to achieve a very rough form of justice.

So far as our long-term hopes are concerned, these were raised in 1989 when a Private Member's Bill, sponsored by CITCOM, and supported by members from both sides of the House, received a Second Reading without a division, and went on to complete its Committee stage. The Bill included a clause adapted from one drafted by the Law Commission with assistance from a working party of members of the Institute and Faculty as long ago as the early 1970s. This provided, in broad terms, that where damages fell to be assessed, either party to the action could adduce actuarial evidence, and where they did so, the court should have some regard to it. The President of the Institute and the President of the Faculty wrote to the Solicitor-General expressing support for the inclusion of such a statutory provision in the CITCOM Bill. Unfortunately, the Bill failed to complete its Report stage on 7 July 1989. Letters addressed to the Institute President and the President of the Faculty by the Lord Chancellor's department included the following passage:

"An amendment was put down for debate at Report stage which would have made admissible as evidence the tables published by the Government Actuary's Department, without further proof of their correctness. Such a provision has been advocated by Sir Michael Ogden Q.C. and the editors of *Kemp and Kemp*, among others. At present, the tables are, strictly, hearsay and not admissible without formal proof. The amendment to Clause 1 would have overcome this difficulty.

"Although this proposed change cannot become law through the Citizens' Compensation Bill, the Government are consulting the Judiciary about it. As the Solicitor-General said in the House of Commons on 7 July, subject to the outcome of those consultations, the Government will be seeking a future legislative opportunity to give effect to the proposal. However, at this stage I cannot say how soon that opportunity will arise."

Sir Michael Ogden referred to this possibility. I understand that the consultation with the Judiciary was completed before Easter 1990, or it was hoped it would be, and we await a further statement of intent from the Government. If it is positive, then there will, at last, be an opportunity for the actuarial profession to make a major contribution to the assessment of damages in personal injury and fatal accident litigation. The conclusions of the authors' paper will, then, constitute an invaluable tool for both legal and actuarial practitioners in this area.

The President (Mr R. D. Corley): In listening to the discussion, I have, inevitably, been drawn to thinking about comparisons with the history of life underwriting, a subject which was discussed in this Hall last month. At the very beginning of the nineteenth century it was not possible to get life assurance unless you could prove you were fit. One or two life offices started to venture into the market for impaired lives, and at least one believed that, if a prospective policyholder was inspected by a group of eminent doctors, his life expectancy could be determined, and so a premium could be assessed. The particular office of which I am thinking kept its belief for all of three years, by which time it was close to being insolvent. From then on, a more scientific approach prevailed, and the office is thriving today.

It seems to me that in the assessment of damages and the assessment of annuities following that, we are somewhere near the same state. I have listened to the discussion and have noticed with some pleasure that we are moving from the belief that enough evidence is in itself sufficient, to the belief that what we want is not only evidence about the particular case, but also scientific knowledge about the general case. However, moving from the subject to the more general point, the discussion we have been having, and the paper on which it has been based, lie within the traditions of mainstream actuarial research and development.

The authors have taken a complicated set of contingencies and subjected them to analysis by established actuarial methods. They have then moved forward to suggest that there is an even better approach, again with good actuarial antecedents, which could be used if the information were to be collected in such a way as to provide the necessary data. Many advances in actuarial science in the past have been made by exactly this approach.

It is perhaps not surprising that such fundamental work was completed within a university regime, and we can be grateful that some necessary financial support was available. It is undoubtedly true that the importance to the profession of the educational and research work undertaken within the universities has been increasing over recent years. However, it is also a matter of record that the Institute Council has not yet solved the problem of securing any long-term source of funds to support agreed projects. Some research with commercial value will find its own finance; but, for the on-going and fundamental work there seem to be only three alternatives. These are: to attempt to create a large endowment fund; to ask all Fellows for an annual subvention in addition to their substantial subscriptions to the Institute; or, on present forecasts of university funding, to see the actuarial strength within universities dwindle.

However, this paper was well done; and it has provided us with a welcome base for an interesting discussion. It is a worthy addition to an outstanding catalogue of papers produced by Professor Haberman, either on his own or in collaboration with other authors, and I should like to thank both him and Mrs Bloomfield for bringing their paper here.

WRITTEN CONTRIBUTION

The authors subsequently wrote: We take issue with Mr Yeo's allegation that there is insufficient justification of the particular contingencies chosen for investigation. The paper is intended to put onto a more scientific footing what is already the practice in the courts, where the three contingencies chosen have historically been allowed for. Our work confirms the importance of sickness and unemployment, and demonstrates the very small effect of industrial disputes. Sir Michael Ogden confirmed that this is the currently accepted view in the courts. If it should be considered necessary to include further contingencies, the Markov chain approach of Section 8 will permit this.

Some speakers have commented on the importance of allowing for contingencies like unemployment and sickness, relative to the importance of selecting an appropriate real rate of interest for discount purposes. We agree with Mr Prevett that judges should be encouraged to employ the 'best' estimates in *both* cases. Thus, for the rate of discount, a valuable guide is provided by the yield on index-linked Government stocks and the allowance for 'other contingencies' should be based on the methodology and estimates which we describe in our paper.

The problem highlighted by Sir Michael Ogden, regarding the double counting of short periods of sickness or unemployment, which would occur if our deductions were made to an award based on recent earnings, is very important. We acknowledge the appealing simplicity of calculating the basic award in this manner and, therefore, we are considering ways in which our deductions could be modified to eliminate the difficulty.

The opener is unsure why the deductions produced by the two methods based on the conventional working life table (Sections 6 and 7) lead to greatly different deductions. The estimates are shown in Tables 1 and 18 and are repeated below for the older ages:

	Table 1.				Table 18.	
Age	1973	1977	1981	1985	Low Basis	High Basis
50	95·4%	92·8%	89·6%	83·2%	95·0%	92·8%
55	93·4%	89·8%	85·3%	77·4%	93·2%	91·6%
60	95·9%	90·9%	84·3%	75·0%	88·9%	89·8%

We do not regard these figures as being widely different. However, let us look at why the estimates would not be the same even if Table 18 *were* based on data from the *same* years as used for Table 1. The methodology of Section 6 is based on the mid-year estimates of age-specific labour force participation rates, which provide the proportion of the population in an age group who are in the labour force at a point of time. The methodology of Section 7 is based on estimates of the average number of days lost through sickness and unemployment per person from a particular year's experience. Unless the flows between the various labour force states are stationary or in equilibrium, the two methodologies will lead to different results. This is analogous to the study of nuptiality where proportions married (stock data) and marriage rates (flow data) from the same year would only be consistent if all flows into and out of the marital states were stationary.

We agree with the opener's suggestion that the multi-state model be applied to investigate the effect of cyclically varying rates of unemployment. Another methodological improvement that could be made concerns the introduction of a salary scale. Instead of allowing it just to vary with attained age, it would be possible to introduce a salary function that depended also on the time spent in State 1 (in the labour force).

One of the problems that concerns the use of the multi-state methodology is the lack of suitable U.K. data for the estimation of the basic parameters. We have noted at length in the paper that the more conventional approaches of Sections 6 and 7 lead to biased results. In connection with this, we agree with Mr Squires' general comments regarding the possible usefulness of biased data, providing that it is clear what the direction of the bias is.

Mr Stewart raises some interesting points. We agree with his closing remarks on the importance of testing the sensitivity of any results to changes in the parameters. He has likened the life-table-based methods of Sections 6 and 7 to the collective approach to pension and sickness fund valuation, and the Markov chain based method of Section 8 to the reversionary approach. In these other actuarial areas of application, the collective approach has the advantage of practicability, but makes sweeping assumptions and does not fully recognise the important dynamics of the underlying process. The reversionary approach has the advantage of theoretical accuracy, but is very difficult to implement. These themes run through the comparison of these methodologies in our paper. Whichever approach is used, we agree with Mr Stewart that considerable skill will be needed in the choice of parameter values.

Several speakers comment on the use of the 'ready reckoner'. It has been included as a means of condensing a large amount of complex information into a form which could be applied in practice. It would be very unwise to use these figures without regard to their derivation, so it is important that practitioners be made aware of their limitations.

Mr Lockyer considers the validity of the assumed pooling of individuals in the assessment of awards for damages. The victim of an accident is an individual and Mr Lockyer considers which particular characteristics should be allowed for in a damages assessment. The multi-state methodology described in the paper would allow for attained age and labour force status at the date of the accident. We have indicated, also, that it may be possible to allow for occupation and educational attainment, if the required data become available. Of course, there is a limit to the number of factors that can be allowed for, so that there will be, inevitably, some omitted factors and hence some residual heterogeneity in the populations to which the estimates can be legitimately applied. Regarding accounting for an individual's actual sickness or unemployment record, this further information could be incorporated using a credibility approach, where a weighted average of the past record and the anticipated future experience is taken.

As is mentioned in § 11.4, it is possible that cohort-based data from the National Survey of Health Development (based on a sample of the 1956 birth cohort) will become available, that would enable a multi-state model to be constructed for the U.K. and more refined estimates to be made, based on the methodologies of Sections 6 and 7. We are more encouraged by the positive references that several speakers have made to this possibility.

We are particularly grateful to the President for his generous comments on the value of our research work and his more general and equally generous comments on the importance of the actuarial research which is being carried out by the Department of Actuarial Science and Statistics at City University.