

## OCCASIONAL ACTUARIAL RESEARCH DISCUSSION PAPERS

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The papers published prior to June 1983 are listed below. Beginning with this volume summaries of the Discussion Papers published during each session will be published in the Student Society Journal.

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<i>No.</i>	<i>Date</i>	<i>Author</i>	<i>Title</i>
1	1974	P. W. Bayley	An index of property rents.
2	1975	G. C. Taylor	Separation of inflation and other effects from the distribution of non-life insurance claim delays.
3	1975	G. C. Taylor	Survey of principle results from the theory of risk.
4	1976	M. C. Bennett	NCD systems in motor insurance.
5	1976	M. R. Sanders	Ratemaking.
6	1976	A. S. Puzey	Distributions fitted to non-life claim events and amounts.
7	1976	B. S. Sachdeva	Description of non-life market.
8	1976	G. T. Foster	The reinsurance market.
9	1976	G. C. Taylor	A review of credibility theory.
10	1976	W. R. Rowland	Non-life accounting.
11	1976	R. G. Gillespie	Risk theory.
12	1976	J. M. Giddings	National and industry non-life investigations.
13	1976	W. M. Abbott & G. Booth	Solvency.
14	1976	R. H. Laing	Catastrophe.
15	1976	A. S. Brown	Taxation of non-life insurance.
16	1976	O. J. Tattersall	Expenses in general insurance.
17	1976	J. L. Manches	Data collection and definition.
18	1976	D. Ramsay	A commentary on "Investment return and property liability insurance ratemaking" by R. W. Cooper.

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| 19 | 1976 | D. H. Craighead  | The Lloyds system.  |
| 20 | 1976 | M. C. Bennett  | Models in motor insurance.  |
| 21 | 1977 | S. Haberman  | Royal Commission on the distribution of income and wealth: Report on behalf of the Government Actuary's Department relating to assets held by life offices and pension funds.                           |
| 22 | 1977 | J. C. Fagan  | Maturity guarantees under investment-linked contracts.  |
| 23 | 1979 | A. S. Puzey  | The security of occupational pension benefits.  |
| 24 | 1979 | S. Benjamin  | Unchecked notes on 'stochastic immunization' of maturity guarantees, following consultation with Tom Collins.   |
| 25 | 1980 | Institute of Actuaries and Faculty of Actuaries. Joint Working Party on Computers and Actuarial Notation | (a) Alternative actuarial notations—some proposals for discussion.<br>(b) An account of work carried out to review the International Actuarial Notation and make proposals for achieving computability. |
| 26 | 1980 | A. J. Wilson   | Matrix methods for pension fund valuations.   |
| 27 | 1980 | P. P. Boyle & J. Mao   | Optimal risk retention under partial insurance.   |
| 28 | 1980 | T. P. Collins  | Immunization theory for unit-linked policies with guarantees.   |
| 29 | 1982 | S. Haberman  | Estimation of the effect of home responsibility protection on married women's pension rights.   |
| 30 | 1980 | R. E. Beard  | Further thoughts and experiments with inflation.  |

## SUMMARIES OF RESEARCH DISCUSSION PAPERS

*(Copies of these papers may be borrowed from the Institute Library)*

### A LIMITED EXPERIMENT ON $V_2$

BY S. BENJAMIN

*(Paper No. 31 deposited in the Library in July 1983)*

THE note indicates (i) that a  $V_2$  net premium reserve can be immunized by a (redeemable) gilt whereas an ordinary net premium reserve cannot, and (ii) that a  $V_2$  reserve is relatively insensitive to  $i$ , the rate of interest for future new money.

### ALTERNATIVES TO THE NET PREMIUM VALUATION

BY C. D. DAYKIN

*(Paper No. 32 deposited in the Library in July 1983)*

FOLLOWING proposals for a statutory minimum standard of valuation for long-term insurance liabilities involving a net premium approach, associated with market values for the corresponding assets, a paper presented to the Institute in January 1975 by Bews *et al.* (*J.I.A.*, 102, 61) suggested some modifications of the straightforward net premium method, which would take into account directly the yield which had already been secured on assets backing the accumulated reserves. Their paper drew attention to some of the weaknesses of the modified net premium methods, which have become referred to as  $V_2$  and  $V_3$  split interest methods, but no further work appears to have been published on the practical problems of using these approaches.

The present paper looks again at the  $V_2$  and  $V_3$  modifications to the net premium method of valuation, in the context of Part VI of the Insurance Companies Regulations 1981, which appears to lay down a minimum standard of valuation in terms of a net premium valuation at a single rate of interest may be determined having regard to the yields already secured, as well as to a conservative assumed yield on future investments.

The conclusion is drawn that the  $V_2$  and  $V_3$  methods may produce reserves significantly weaker than was apparently intended by the regulations and that severe limitation of future premiums valued is essential if reserves of a strength of

an ordinary net premium valuation at an appropriately weighted average of the secured yield and the long-term rate of interest are to be obtained. The paper also demonstrates how the  $V_2$  and  $V_3$  reserves respond to changes in the assumed long-term rate of interest and secured yield and behave in sometimes unexpected ways.

## THE ANALYSIS, AND AN APPLICATION, OF DIVORCE DATA

BY J. G. SPAIN

*(Paper No. 33 deposited in the Library in January 1984)*

A few years ago, it occurred to the author that some form of insurance against the financial hazards associated with divorce might be attractive to those at risk, which is a large proportion of the married population. This may seem fanciful, but there is a real need, particularly since current draft legislation is aimed at attaining the concept of 'a clean break'.

This is the idea behind the paper. While the statistical background has been scrutinized prior to publication (*J.I.A.*, **109**, 453), this is not the case for the rest of what has been written, for which the author takes full responsibility.

As will be clear, detailed consideration of the various problems led the author to the inevitable conclusion that such a contract could not be underwritten extensively by a prudent U.K. financial institution, for the reasons stated.

## THE MATCHING OF ASSETS TO LIABILITIES

BY A. J. WISE

*(Paper No. 34 deposited in the Library in April 1984)*

The paper, which has been published in full (*J.I.A.*, **111**, 375), is supplementary to another by the same author (*J.I.A.*, **111**, 445).

It provides the detailed mathematical analysis on which the primary paper is based, and describes the general mathematical model and the alternative definitions of matching which are used. Explicit solutions for matching portfolios are stated with proofs which have been checked by Dr T. Stanley of the City University. Formulae for selected stochastic models are given together with the algorithm which was used to derive all the solutions quoted in the primary paper.

The analysis is given an alternative geometrical treatment and there is also a description of the key features of the actuarial model to which the matching theory relates.

**RADIATION-INDUCED DISEASES:  
ASSESSMENT OF THE CANCER RISKS OF  
LOW-LEVEL IONIZING RADIATION  
EXPOSURE**

BY S. HABERMAN

*(Paper No. 35 deposited in the Library in April 1984)*

THIS research memorandum has been written in response to a remit to the Government Actuary's Department from the Industrial Injuries Advisory Council (IIAC). The IIAC are reviewing the terms under which radiation-induced diseases are prescribed as industrial diseases and, as part of this process, have invited evidence from a number of organizations and individuals. Evidence has been submitted by Dr Alice Stewart (Department of Social Medicine, University of Birmingham) based on her analyses of results from the long-term cohort study of workers exposed to low-level radiation at the Hanford Works, Washington, U.S.A.

The Hanford Works is one of the largest nuclear plants in the U.S.A. and has been in full production since 1944. About 30,000 persons have worked at Hanford and up to 1977 there had been about 4,200 deaths among current and ex-employees.

Some of the methodology adopted by Dr Stewart and her colleagues is controversial and has attracted scientific criticism. However, it is their results which have received wide publicity and stimulated a heated debate. Their first paper, for example, 'shows' that low-level radiation has a strong, positive cancer induction effect with the risk of death from radiation-induced cancer being estimated at about ten times the level of the conventional International Commission on Radiological Protection (ICRP) estimates. Subsequent papers from Dr Stewart and her colleagues have refined these estimates.

The purpose of this research memorandum is to comment critically on the literature surrounding the Hanford investigations (over 60 papers and letters) and, in particular, advise on the soundness of Dr Stewart's methodology and results.

The conclusions of this review are that the published works of Dr Stewart and her colleagues do *not* represent valid statistical analyses or interpretations of the actual observations. This does *not* mean that there are no excess cancer risks from low-level radiation—just that the case has not been proven either way. Indeed, there is a problem of statistical power. Any investigation into the effect of low-level radiation at work is very likely to involve insufficient data to increase adequately the statistical power of the study. This means that it may be *impossible*, in a practical sense, to determine definitively whether the risks of low-level ionizing radiation are significantly higher than the conventional ICRP recommendations.