



City Research Online

City St George's, University of London

Citation: Booth, P. M. & Cooper, D. R. (2000). The tax treatment of pensions (Actuarial Research Paper No. 122). London, UK: Faculty of Actuarial Science & Insurance, City University London.

This is the unspecified version of the paper.

This version of the publication may differ from the final published version. To cite this item please consult the publisher's version.

Permanent repository link: <https://city-ref-test.eprints-hosting.org/id/eprint/2258/>

Copyright and Reuse: Copyright and Moral Rights remain with the author(s) and/or copyright holders. Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge, unless otherwise indicated, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way. For full details of reuse please refer to [City Research Online policy](#).



City University
London

School of
Mathematics

The University for business
and the professions

Department of Actuarial
Science and Statistics

The Tax Treatment of Pensions

Actuarial Research Paper No. 122

by P Booth and D Cooper

ISBN 1 901 615 42 1

April 2000

“Any opinions expressed in this paper are my/our own and not necessarily those of my/our employer or anyone else I/we have discussed them with. You must not copy this paper or quote it without my/our permission”.

The Tax Treatment of Pensions¹

Philip Booth²

and

Deborah Cooper³

Department of Actuarial Science and Statistics, City University, London

April 2000

¹ The work was financed by a grant to City University from the National Association of Pension Funds and Royal Sun Alliance. The authors would like to thank the project sponsors and George Mavranos, the Research Assistant who worked on this project.

² Philip Booth is Senior Lecturer in Actuarial Science at City University, a Fellow of the Institute of Actuaries and a Fellow of the Royal Statistical Society. He is Director of the Social Insurance Reform Research Unit at City University.

³ Dr Deborah Cooper is Lecturer in Actuarial Science at City University and a Fellow of the Institute of Actuaries.

Executive Summary

- The low level of state pensions in the UK means private pension schemes have a crucial role in delivering adequate retirement incomes and minimising government spending on the elderly. This approach will only work if the tax regime for private pensions is appropriate.
- A stable tax regime is particularly important for private pension schemes, given the long-term nature of the commitments. However, the present UK regime lacks a clear rationale, so there is no reason to believe that the recent major changes will last.
- This paper attempts to throw light on the debate about appropriate tax regimes for private pension schemes. We investigate the arguments for different tax regimes for pre-funded private pension schemes and quantify their relative financial effects.
- The arguments as to whether general savings should be taxed on a comprehensive income tax basis or on an expenditure tax basis (where investment income is exempt from tax) are finely balanced. However pensions have special features that suggest that, in their case, an expenditure tax basis is more appropriate. In particular, we would recommend the form of expenditure tax where tax is collected at the back end (when the pension benefits are received). The most important of these special features is that private pensions can be regarded as having an important role in ensuring that people do not rely on means-tested benefits in retirement. The existence of extensive means testing for state benefits in retirement (and its recent extension through the adoption of the minimum income guarantee) provides an incentive for individuals to under-provide when planning their retirement income. A favourable tax position for pension funds can provide a positive incentive (albeit an imperfect one) for individuals to provide for themselves in retirement.
- Until 1997 the UK regime most closely resembled an expenditure tax basis. However, the July 1997 Budget abolished tax credits on UK equity dividends, with the result that the income from some three quarters of pension fund investments is now taxed at the corporation tax rate rather than being exempt. This made a big shift away from an expenditure tax basis.
- We have carried out detailed calculations of the financial impact of different tax regimes on the cost of providing private pensions through both defined contribution and defined benefit schemes. Our results show the following:
 - The current system for taxing pensions lies about half way between a comprehensive income tax and an expenditure tax system.
 - With a full expenditure tax regime, the pension available to a defined contribution pension scheme member would typically be over a third (36.5%) higher. The contributions required to fund a defined benefit scheme would be reduced by a similar amount.
 - The effect of abolishing tax credits on dividends from July 1997 has been to reduce the pension income attainable by defined contribution pension plan holders by around 7% and to increase the cost of defined benefit pension schemes by between 5% and 11%, depending on how much they invest in equities.

- The current regime for taxing pensions is more favourable than that for taxing ISAs: for example, for someone with low to middle earnings an ISA would deliver 15% lower benefits than a defined contribution pension scheme. This is partly because of the availability of a tax-free lump sum from a pension scheme, partly because of the progressive nature of the current tax system and partly because ISAs' advantage in terms of dividend tax credits is due to end in 2004.
- Abolition of higher-rate tax relief on contributions would reduce the pension of someone on middle to high earnings by 16%. Moreover, it would also reduce the pension for low to middle income earners unless the higher-rate tax threshold is increased faster than inflation.
- Calculations in respect of defined benefit schemes gave results that were very similar to the results from defined contributions schemes. The methodology and the presentation of those results are, nevertheless, different.
- An increase in pension contributions of 7%, in order to preserve the same level of pension in retirement, would represent an increase in labour costs of about 1% of salary. This could have significant effects on labour demand. Whether this cost is borne by the employer or employee would depend on the nature of the scheme and whether it was a defined contribution or defined benefit scheme. Economic theory suggests that the incidence of the tax would not be expected to affect its impact.
- Finally, we note the practical point that any system which did not give full tax relief on contributions to approved pension schemes would be extremely difficult to implement in the case of the 9 million members of defined benefit occupational schemes. As well as severe administrative problems in calculating and collecting the tax, there would be acute issues of equity both within and between schemes.
- Our analysis and calculations have had to make some simplifying assumptions and have ignored the considerable issues that would be involved in the transition from one tax regime for pensions to another. However, they provide some support for three overall conclusions:
 - The cost of pension provision is sensitive to the choice of tax regime.
 - In UK circumstances there is a good case for saying that the most appropriate tax regime for pre-funded private pension schemes is the expenditure tax basis with tax collected at the back-end (EET), whether the schemes are of the defined contribution or defined benefit type.
 - Any change to the present UK regime should be in the direction of an expenditure tax basis with tax collected at the back-end.

The Tax Treatment of Pensions

Introduction

State pensions in the UK are low by the standard of most other developed countries. Instead there is a heavy reliance on private pension schemes for the dual purpose of bringing the income level of retired individuals and their dependants up to a comfortable level and minimising the need for government welfare spending on the elderly. Two conditions are necessary for this approach to work. Firstly, enough people must be willing to lock up enough money in approved pension schemes until their retirement. In particular, the return *after tax* must be sufficiently attractive compared with the returns from saving and investing in other ways or spending the money. Secondly, the impact on the Exchequer, that is, the timing and level of tax revenues and expenditure outflows, must be acceptable to the government.

This paper investigates some of the financial effects of different tax regimes for private prefunded pensions with a view to providing some guidance as to which would be optimal in the circumstances of the UK.

It is particularly important to have an appropriate and stable tax regime for prefunded pensions because of the long time scale that is generally involved in building up an adequate pension fund. Eighty years may elapse between the time when a pension scheme member pays their first contribution and the time when they draw their last benefit from the pension fund and make their last claim on state welfare and pension benefits. If rules are changed it can be a complicated and costly matter to protect the legitimate expectations of those who have been making provision on the basis of the old rules. The fact that the present system of taxing pensions and saving lacks a self-evident or government-provided rationale makes it reasonable to doubt that there will be no further changes.

However, there is today no clear consensus on the best way to tax prefunded pension schemes. A wide variety of tax regimes for pensions are in place around the world. In the UK the basic approach of taxing the money passing through pension funds once only – at the point where it is paid out as benefits – is of long standing: it dates from 1921. However, this approach has been subject to increasing restrictions on the contributions permissible to approved schemes and recently has come into more serious question.

Significant changes already made include the capping of the tax-free lump sum in 1987 and the removal of tax credits on UK equity dividends in 1997. This latter change effectively ended the tax-free status of investment returns, which had been enjoyed for 76 years. Further changes recently suggested in some quarters include restricting tax relief on contributions to the basic rate and taxing pension funds' short-term capital gains. Although these options have not been pursued in the recent Green Paper, "Partnership in Pensions" (1998), it is widely believed that they were given serious consideration. The previous Government went further still with a proposal in "Basic Pension Plus" (1997) to reverse the basic approach so that tax would be levied on the money flowing into rather than the money flowing out of pension funds. In addition, April 1999 saw the introduction of Individual Savings Accounts (ISAs), which provide partial exemption from tax on savings but in a different way from the system used for pensions.

We first consider briefly (in section 2) the economic issues surrounding the taxation of pensions and of savings more generally. In particular, we analyse the effects of the present tax rules for pension funds in the UK by reference to the main theoretical benchmarks and summarise the general arguments for different systems of taxing pensions. Then in section 3 we compare the cost of providing pensions under various possible tax regimes and various scenarios in terms of earnings' patterns and investment strategies. (The Appendices contain further details of the assumptions used.) Finally, in section 4 we summarise our conclusions.

1 Practical Issues in the Tax Treatment of Pensions

1.1 Alternative Tax Treatments of Savings

Economists often distinguish between two distinct types of tax system, a comprehensive income tax and an expenditure tax. A *comprehensive income tax* taxes all sources of income explicitly. In its most comprehensive form it will also tax sources of imputed income, such as imputed rental income from owner-occupied houses and accrued but unrealised capital gains. An *expenditure tax*, on the other hand, only taxes consumption. Effectively it exempts from tax the returns from savings until they are consumed.

There are two main forms of expenditure tax. The first involves giving tax relief on income that is saved, exempting from tax any interest and gains accumulating on those savings, but then taxing the total proceeds as and when the savings are withdrawn for consumption. This form is often described as EET, with E denoting an exemption or relief from tax and T denoting a point at which tax is payable. It is often suggested that pension provision in the UK is taxed in this way (see, for example, De Ryck, 1996). However, as will be discussed below, the system is not as simple as this today.

Tax exempt special savings accounts (TESSAs), personal equity plans (PEPs) and ISAs have generally followed the other form of expenditure tax regime: no relief is given for the investment, but the accumulating interest and gains and the proceeds of the investment are exempt from tax. This system is often described as TEE.

In a tax system which is neither progressive nor regressive, EET produces an equivalent outcome to TEE, although the timing and pattern of tax payments differs between the two. Examples illustrating the equivalence between these forms and other forms of expenditure tax (such as giving investment relief for company investments) are given in Meade (1978). In progressive tax systems, however, different forms of expenditure tax are not equivalent (see Knox, 1990).

Throughout this paper, the E and T notation will be used with the suffix “⁺” to represent tax at a rate higher than the marginal rate of tax and “^{partial}” to represent tax at a lower rate than the marginal rate of tax or a partial exemption from tax. Using this notation, a comprehensive income tax system is TTE: that is, all income is taxed when it is received so saving is from taxed income; interest income from savings is taxed; but proceeds of saving do not suffer further tax.

1.2 Tax Position of Pension Fund Contributions, Investment Returns and Benefits

To put the present UK system of taxing Inland Revenue-approved pension schemes into the above framework, we need to look in detail at the tax treatments of contributions, investment income and benefits. These are discussed below. Of necessity the rules differ in detail between the two main types of scheme, although the aim is to achieve equivalence. The two types are: *defined benefit* schemes where the benefits are predetermined by reference to the scheme member's average or final salary and the contribution levels are adjusted from time to time as necessary to secure those benefits; and *defined contribution* schemes where the contributions are fixed but the benefits vary depending on the investment performance of the fund and annuity rates at retirement. Most occupational schemes provided by employers fall into the first category. All personal pension schemes fall into the second, and so will the "Stakeholder" pensions proposed in the Green Paper.

Contributions: in the case of defined contribution schemes full tax relief is given on contributions (whether made by employer or employee) of up to 17.5% of earnings for that tax year (higher at older ages). In the case of defined benefit schemes (which include most occupational schemes) the 17.5% limit applies to employee contributions only, but there are also limits on the scheme benefits and funding levels permitted which put an effective ceiling on total contributions.

Investment income (including capital gains): all investment income is exempt in the sense that no further tax is paid once the income is in the hands of the fund. In the case of investments in bonds, property and cash, any tax deducted at source is reclaimable by the pension fund, so the entire return is tax-free. However, in the case of investments in equities the returns are generally taxed at source in the company's hands and this tax cannot be reclaimed by the pension fund (prior to July 1997 a tax credit was available for the return from UK equities received in the form of dividends). The tax rate suffered is thus the UK corporation tax rate (31% in 1998-99, 30% in 1999-2000) or, in the case of overseas equities, the equivalent tax rate of the foreign country plus any non-reclaimable withholding tax.⁴

Benefits: benefits taken in pension form are taxed at normal income tax rates. A lump sum benefit of up to 150% of final salary, or 25% of a defined contribution fund, may be taken tax-free. There is a cap on the lump sum (£126,000 in 1998-99) linked to the retail price index.

The overall effect of these tax rules in practice is complex:

- Despite the limits, contributions made to approved schemes are generally fully exempt. This is because breach of the contribution limits would result in the scheme losing Revenue approval and hence the regime for unapproved schemes applying. The first E is, therefore, for most employees, unqualified for approved schemes.
- The apparent exemption of investment income is illusory: Some three-quarters of the average pension fund was invested in equities at the time dividend tax credits were withdrawn⁵. Equities are taxed at the relevant corporation tax rate. So, assuming an average corporation tax rate of

⁴ For the purpose of the present paper it is assumed that the nominal corporation tax rate is also the effective rate. The divergence between the effective and the nominal tax rate varies between countries and over time and is the subject of an extensive literature. The two biggest causes of divergence have been largely removed in the UK by the withdrawal of accelerated capital allowances in 1984 and the reduction of inflation.

⁵ 76% per W.M. All Funds Universe, Quarter 2, 1997

31% and income tax basic rate of 23%, the current system of taxing investment returns could be regarded as T , or even T^+ , by a basic-rate taxpayer.

- Typically one quarter of benefits are taken in tax-free form, so the final T is partial.

Overall, therefore, the current system could best be described as ETT^{partial} or ET^+T^{partial} . We shall refer to it as ET^+T^{partial} .

It is only possible to assess the costs of this taxation system, relative to a pure EET system, by considering present value calculations for different sample earnings patterns. This is similar to the conclusions of Knox (1990) and Dilnot and Johnson (1993) who assessed the “tax expenditure” cost to the government in a similar way.

If higher rate tax relief on contributions were abolished, it would produce a system of $E^{\text{lower rate}}T^+T^{\text{partial}}$. However, if the intention is to restrict the benefit of deferring tax until retirement to the basic rate tax by collecting the higher rate tax upfront, it would be necessary also to abolish the higher rate of tax on pension benefits. In other words, $E^{\text{lower rate}}T^+T^{\text{lower rate}}$ would be necessary to produce the desired effect. The abolition of higher rate tax relief on its own would produce an entirely arbitrary result. Neither the current pension fund tax system, nor proposals to abolish higher rate tax relief and move to $E^{\text{lower rate}}T^+T^{\text{partial}}$, have any obvious economic rationale, unlike EET, TEE (the ISA regime) or TTE (the comprehensive income tax regime).

2 The Appropriate Tax System for Pensions

In this section we summarise the arguments for and against applying a comprehensive income tax regime and the alternative expenditure tax regime to UK pensions.

2.1 The Income/Expenditure Tax Debate

The arguments as to whether income or expenditure should be used as a tax base have been rehearsed by Hobbes, Mill, Fisher and Kaldor. A more recent discussion of the economic arguments in favour of using an expenditure tax base is found in Kay and King (1990). They suggest that an expenditure tax treats two individuals the same, regardless of when they choose to consume the income which they earn, whereas a comprehensive income tax gives rise to the double taxation of savings. This is because a comprehensive income tax taxes income when it is earned and also taxes interest before the money is spent. In the case of pensions, therefore, it can be argued that an income tax system taxes post-retirement consumption more than pre-retirement consumption. However, the main economic point in the debate concerns the distortion of decisions to consume or save. An expenditure tax allows individuals to receive interest gross of tax. They can therefore determine their preferences for consumption now or in the future without distortions imposed by the tax system. By contrast, a comprehensive income tax (TTE) (where returns to saving were taxed) would create such distortions, with associated inefficiencies.

There is an alternative argument, however. When wages are saved they become another factor of production (capital). It can be argued that the returns to all factors of production should be taxed equally. Taxes just on expenditure are equivalent to taxes just on wages with no tax on returns to

capital⁶. Hence a tax on labour distorts the work/leisure decision in the same way that a tax on capital distorts the save/consume decision. To tax returns to labour but not tax returns to capital encourages those engaged in production to use less labour and more capital. It would seem reasonable, looking only at these economic arguments, to tax the returns to all factors of production. This would suggest a comprehensive income tax base rather than an expenditure tax base. This is the most powerful argument against an EET basis for the taxation of pension funds. Tax revenues have to be raised; the question is whether the consumption/savings decision should be distorted to the same extent or to a lesser extent than the work/leisure decision.

In one sense, pension funds have the same economic characteristics as general savings: they represent a fund of financial assets and capital giving rise to investment returns. However, in an institutional and legal sense, pension funds are distinct from general savings. They are collective funds of non-returnable contributions, they are mutual insurance funds (in the case of defined benefit schemes and annuitised defined contribution schemes) and they represent deferred pay. Whilst the general discussion about the taxation of savings in section 2.1 is relevant to pensions, there are additional considerations which should also be taken into account. We look at these in section 2.2.

2.2 Other Elements of the Debate on the Appropriate Tax System for Pension Funds

2.2.1 Inflation

Whether tax systems should include indexation or other adjustments for inflation has been discussed in Meade (1978), Kay and King (1990) and Fabian Society (1990). In the case of investment income almost all countries tax the nominal return on investments (Denmark is an exception). As is shown in Booth and Cooper (1999), for example, a tax on nominal returns can reduce a real return from 3% to 1% at a 6% rate of inflation. This is, in effect, taxation of capital or double taxation of previously earned income. Capital gains tax, in respect of company shares, can also be a double tax. Insofar as a rise in a share's value takes place due to retained profits, the investor is taxed twice: once on the tax levied on the profits and once on the capital gain which arises from the retention.

A tax on real returns would probably be difficult to operate, so governments might have to choose between taxing the nominal return or exempting investment returns from tax completely. In the case of pension funds, where money has to be locked up for considerable periods of time and an important social function is being served, it might be better to err on the side of not taxing at all. The alternative of taxing interest income at income tax rates (or at a pension fund provider's corporation tax rate) would, in times of high inflation, lead to an unintentional and unplanned erosion of capital, with serious financial consequences. This issue may seem esoteric but it was, in fact, the main reason why tax free accumulation of pension fund assets was granted in 1921, after the experience of the inflation of the period during and shortly after World War One.

⁶ This argument is not always clearly understood. It is often suggested that EET does tax returns from capital because tax is ultimately paid on all the benefits received. However, the equivalence of EET with TEE (shown by Meade, 1979) demonstrates that tax is not being paid on returns to capital. It is clear that returns to capital are not taxed by TEE because no tax is paid on interest at any stage. If TEE and EET are equivalent, tax cannot be paid on returns to capital in the EET case either. In EET, it is true that tax is paid on the total accumulated fund, when it is paid out as a benefit. However, the tax is also deferred on the whole of the fund: the two effects cancel out leaving the equivalent, in present value terms, of a tax just on returns to labour. The equivalence arguments are discussed in detail, for a single period investment in the Meade report. The generalisation to a multi-period model is trivial.

2.2.2 Means-tested benefits and pension incentives

Fiscal encouragement for pension provision can also be justified on the grounds that means-tested benefits in old age discourage some people (particularly those on low incomes) from providing for themselves. It has been government policy for some time that those who do not have a private income in old age should have an income provided by the state. This income comes in the form of a basic state pension, means-tested cash benefits and means-tested non-cash benefits (such as housing benefit). The means-tested benefits element has been entrenched in the recent pensions Green Paper, (DSS, 1998). Le Grand and Agulnik (1998) write, "Thus direct spending on universal pensions ... acts as a positive disincentive for personal savings; a disincentive effect that is further complicated if the pension is not universal but income and asset-tested". In fact, of the total income a pensioner could expect to receive in the UK, if they had no independent means, a considerable proportion is income and asset-tested. Hence, if private pension provision were encouraged, this should reduce the cost to the state of means-tested benefits.

This argument would be still weightier, if, as proposed in the Green Paper, the government indexes its guaranteed minimum income to earnings and not prices. Indexing means-tested benefits to earnings would greatly increase the disincentives to saving in the absence of further offsetting incentives, through the tax system or otherwise (see Cooper, 1999).

2.2.3 Income spreading

One feature of the EET form of expenditure tax, in a progressive tax system, as compared with the TEE form, is that EET allows individuals to minimise the tax they pay by spreading their income. Thus, people can make contributions to pension schemes when they are paying higher-rate tax (obtaining relief at 40%) and then receive the pension when they are paying tax at the basic rate. Fabian Society (1990) seem to suggest that income spreading is not a desirable feature of the tax system (although recognising the impracticality of eliminating it). This is a curious view to take when the very purpose of pension schemes is to spread income (after tax) more evenly over a person's lifetime and when income spreading reduces the need for expenditure on means-tested state benefits and for taxes to fund that expenditure.

We would argue that it is socially desirable for individuals to have the ability to spread income across their lifetime and this should be recognised for tax purposes. In any event, the purpose of a progressive tax system is that those with the ability to do so should pay more tax. In principle, it is lifetime income and not annual income which is the better measure of the lifetime ability to pay tax and which should be taxed in a progressive way. Deferring pay through a pension fund is one way of levelling out annual income so that each year's income (after deducting pension contributions and adding in pension payments) is a fairer representation of lifetime income.

Saving through pension funds involves individuals forgoing consumption for a substantial period of time (several decades and the lifetime of ten to fifteen governments); indeed, for those who die before retirement age and without dependants the consumption is forgone permanently. If we accept that it is a social aim of government to promote independent pension provision, then pension funds need to have greater certainty of tax regime and a more favourable tax regime than other types of saving. Thus, even if all forms of saving do not follow an expenditure tax regime, it may still be reasonable for pensions to do so.

2.2.4 Tax expenditures

Each year the Inland Revenue publishes in Inland Revenue Statistics estimates of the annual “cost” of tax reliefs, which are commonly termed “tax expenditures” (see section 2.3). In the case of reliefs relating to pensions, the figures implicitly assume that there is a subsidy to pension provision through its tax treatment. Is this the case?

Le Grand and Agulnik (1998) say, “Pension provision is subsidised through the tax system in three ways. First, individuals can claim back any tax they have paid on money that has been put into their pension fund... Second, pension funds get tax relief on their investment income... Third, the lump sum component of any pension payment is tax-free.” However, their consideration of investment returns is theoretically incorrect. They do not consider the underlying corporation tax that is paid by companies (see above). Indeed, it is later stated that whilst dividends are no longer tax-free, capital gains remain tax-free: but retained profits, which can give rise to capital gains, are, of course, taxed. Whether the gain arises from an increase in net asset value per share or more commonly from an increase in the after-tax profit per share (or a multiple thereof), the return is reduced in direct proportion to the corporate tax rate. However, leaving aside the errors of detail, there is the fundamental economic issue in relation to the tax treatment of investment returns of whether the tax system described provides, in effect, a subsidy to pensions.

Whether the tax system provides a subsidy, depends on the chosen benchmark for comparison, an issue that is not discussed by Le Grand and Agulnik. If the benchmark is a pure expenditure tax, pensions are subsidised in respect of the tax-free lump sum but over-taxed on investment income. If the benchmark is a comprehensive income tax, there may be an implicit subsidy depending on whether pension contributions are included in the definition of comprehensive income. However, the issues discussed above (i.e. the importance of allowing income spreading, the difficulties of allowing for inflation in the taxation of investment returns and the long-term nature of pension funds) lend additional weight to the arguments for using the expenditure tax as a benchmark. The tax treatment of pensions should therefore not be seen as a system of hidden subsidies.

2.2.5 Unfunded pension schemes

If we consider how an unfunded pension scheme, such as the civil service scheme, operates, effectively employers continue to pay a portion of salary to employees after their retirement. No tax is paid until the pension is received in retirement. This appears to be accepted as a reasonable position. From a legal standpoint, a funded pension is simply a way of employers choosing to pre-fund the benefits they expect to pay out, in order to smooth costs. There is no reason why this should change the fundamental tax position. This “pure” interpretation of the position of the pension fund is no longer strictly accurate. The development of early-leaver rights and so on, gives the employee a clearer contractual interest than was intended at the outset of the pension fund industry. Nevertheless, this understanding of the original purpose of pension funds, and the analogy with the civil servants’ schemes, is worth bearing in mind.

2.2.6 Conclusion

In conclusion, we have a preference for an EET tax system for the following reasons:

- There is an economic case in favour of an expenditure tax for savings in general, although this case is not overwhelming
- There is a social case for an expenditure tax regime for pensions because it has the effect of reducing the incentive for individuals to adjust their spending habits to maximise means-tested benefits
- In times of moderate or high inflation, an income tax on nominal investment returns can lead to an implicit tax on capital
- An expenditure tax allows an investor to “income spread” which reduces the discrimination against those with fluctuating incomes in an annual, progressive income tax system.

However, we recognise that there are justifications for other regimes. Moreover, the current pension fund tax regime does not follow any one of the three standard systems of EET, TEE or TTE but is a mixture of components from each. The abolition of higher-rate tax relief would create an even more complex hybrid.

We have, therefore, carried out calculations comparing three mixed regimes (the current regime, the pre July 1997 Budget regime and the current regime but with higher rate tax relief abolished) with three theoretical regimes (a pure EET expenditure tax, a pure TTE comprehensive income tax and the proposed ISA regime, which is close to the TEE form of expenditure tax). The results of these calculations are in section 3.

2.3 Government’s attitude towards “revenue lost”

Each year the government calculates the “revenue lost” from tax expenditures (see 2.2.4). Our conclusions about the appropriate tax regime for pensions has implications for these calculations. A number of critiques have been made of the Inland Revenue approach to the calculation of tax expenditures.

Firstly, the Inland Revenue tax expenditure calculations are flawed for reasons explained by Dilnot and Johnson (1993) and Knox (1990), as well as for additional reasons. According to Dilnot and Johnson (1993), until 1990 the Inland Revenue published estimates for pension fund tax expenditures (that is, the cost to the Inland Revenue of pension fund tax relief) simply by adding the cost of tax relief on contributions to the cost of tax relief on investment income. Thus no account was taken of the tax that would be paid on the pension when it was received. From 1991, the Inland Revenue produced estimates on a different basis, deducting the tax paid on pensions in payment for the year in question (but not estimating future revenue). Dilnot and Johnson point out two other problems with the calculations. Firstly, if the tax status of pensions were changed, the amount of savings through pensions would be reduced. Secondly, they take no account of the appropriate benchmark against which pensions should be judged. A further point could be made. The Inland Revenue calculations take no account of the taxation of company profits received by pension funds as part of their investment returns. Even before the July 1997 Budget changes, returns arising from retained profits were effectively taxed at the corporation tax rate. Distributed profits were taxed at the difference between the corporation tax rate and the rate of the dividend tax credit (a difference of between 10% and 15% for most of the 1990s). Thus the Inland Revenue estimates do not “look through” to the tax treatment of the companies providing the investment returns for pension schemes.

With regard to the post-1990 calculations, the deduction of current tax revenue from the present generation of pensioners when calculating the tax expenditure fails to take account of changing population structure and the demographic profile of pension schemes. The Inland Revenue should deduct the tax revenue from future pensioners (for whom the tax expenditure on contributions is being calculated) rather than deducting the revenue from current pensioners.

The most important criticism of the calculations is that no benchmark is specified against which the taxation of pensions is measured. This is a fundamental principle of public finance economics. The basic literature on tax expenditures recognises the importance of properly defining the benchmark with which the tax treatment of the relevant vehicle should be compared. Thus, if the benchmark is a comprehensive income tax, we will obtain a very different figure for the tax expenditure than if the benchmark is an expenditure tax. Willis and Hardwick (1978) suggest that a tax expenditure arises where an exemption or relief exists which is not an essential part of the tax structure but which has been introduced to ease the burden on a particular class of taxpayers or to provide an incentive to apply income in a particular way. This definition is important. If the norm is to ensure that savings are exempt from tax (expenditure tax) then pensions do not form a tax expenditure (indeed there will be a negative tax expenditure). If the norm is a comprehensive income tax, pensions do form a tax expenditure, although that tax expenditure may still be justified according to the criteria in section 2.2 of this paper.

3 The Tax Calculations

3.1 Assumptions

3.1.1 Pensions Tax Regimes

The tax regimes for pensions which we shall compare are described in Table 3.1.1.1

In order to ensure consistency across tax regimes, we assumed that individuals with defined contribution pension schemes would adjust their contributions so as to maintain the same net income, after tax and pension contributions, whatever the tax regime. This means that any differences in tax regime will always be reflected in the amount of pension that is received.

We assumed that the general income tax regime, in particular the tax rates and thresholds, was that in force for 1998-99. That regime includes the statutory provision that the main tax thresholds will be indexed annually in line with prices. Whilst this statutory provision has on occasions been overridden in the Finance Act, price indexation is broadly what has happened for some years. It has to be noted, however, that the results in sections 3.2 and 3.3 are sensitive to this assumption. The figures would be significantly different if thresholds were indexed to earnings. In particular, the tax advantages from income spreading under a back-end expenditure tax (EET) regime are minimal with price indexation, but would be more significant with earnings indexation.

Table 3.1.1.1
Tax Regimes

Post-97	$ET^{+T^{partial}}$	the current regime , i.e. dividend tax credits cannot be reclaimed
Pre-97	$ET^{partial} T^{partial}$	the pre-July 1997 Budget regime with tax credits available at a rate of 20% on dividends paid on UK equities
Basic rate	$E^{basic\ rate} T^{+T^{partial}}$	as Post-97 regime , but with relief on contributions at the higher rate of tax abolished . The contribution will be adjusted so that the contributor's net pay remains the same.
"ISA"	$TT^{partial} E$	the ISA regime as known at the time of doing the calculations and as it might have applied to an investment made in April 1998, had it been in force. This is close to a pure expenditure tax regime with the tax collected at the front end (TEE) . Viz.: contributions are made from net income and all investment income is received gross except for equity returns. UK equity dividends are grossed up assuming a 20% tax credit for 1998/99, a 10% credit from 1999/2000 to 2003/2004 inclusive and a 0% tax credit thereafter. It is assumed that the ISA can be used to buy life annuities with tax being paid on the interest component only.
Comprehensive Income	TTE	a pure comprehensive income tax system. No tax relief is given on contributions: contributions are adjusted so that net income remains the same. For simplicity we have assumed that 20% tax is levied on all investment returns except for UK equity returns and US equity returns, which are both assumed taxed at source at the corporation tax rate, with no further tax due.
Pure Expenditure	EET (subject to caveat re US equities)	a pure expenditure tax regime with the tax collected at the back end . Full relief given on contributions; no tax paid on investment income. Dividends and UK equity returns arising from capital gains are both grossed up at the rate of corporation tax ⁷ . The lump sum is used to purchase a pension annuity, which is then taxed, rather than a life annuity taxed only on the interest component. This regime is EET except that withholding tax cannot (by virtue of the current UK/US double tax treaty) be reclaimed in respect of US equities. An implicit assumption is that capital gains from UK equities arise from the retention of profits.

3.1.2 Investment Return and Salary Assumptions

⁷ Conceptually, this is a difficult issue. It is clear that dividends should be grossed up at the rate of corporation tax. However, should capital gains be grossed up? The argument for grossing up capital gains is that one source of capital gains is the retention of profits which have been taxed at the corporation tax rate. However, capital gains may arise for other reasons as well. In theory, we should split capital gains into those arising as a result of profit retention and those arising as a result of changes in equity values for other reasons. However, this would not be practical.

We investigated the tax cost of different regimes under a range of scenarios in terms of investment allocation, investment return and salary pattern. The same scenarios were used for defined contribution and defined benefit schemes, except that in the latter case we also had to specify a number of scenarios concerning the membership profile of the scheme. The scenarios and the assumptions underlying them are described in detail in the Appendices. A brief summary is given here.

The cost of different tax regimes will depend on the investment allocation policy of the pension fund as between equities and other investments. We used three funds with different investment policies, which we describe as 'Low Equity', 'Mid Equity' and 'High Equity'. The distribution of investments in the Mid Equity fund is close to that of the average pension fund as described in *The W.M. Company UK Pensions Funds Universe* (WM, 1998).

Similarly, the cost of some tax regimes depends on the earnings' pattern of the individuals making the contribution to the pension fund. Three earnings' patterns were used, which can be described as 'Low-Middle Earnings', 'Middle-High Earnings' and, for the defined contribution calculations only, 'Variable Earnings'.

Table 3.1.2.1 shows the investment return figures that will be used for all asset categories under the above tax assumptions. The rationale for these figures is given in Appendix 1.1.

Table 3.1.2.1
Net Investment Returns under Different Tax Regimes

Investment Category	Tax regime					
	Post-97	Pre-97	"ISA"	Basic rate	Comp. Income	Pure expend
UK equities	6.9%	7.55%	7.55%*	6.9%	6.9%	8.63%
US equities	7.15%	7.15%	7.15%	7.15%	7.15%	7.15%
Conventional gilts	5.2%	5.2%	5.2%	5.2%	4.16%	5.2%
Index-linked gilts	4.95%	4.95%	4.95%	4.95%	3.96%	4.95%
Property	8.1%	8.1%	8.1%	8.1%	6.48%	8.1%
Cash	4.7%	4.7%	4.7%	4.7%	3.76%	4.7%

* 7.23% from April 1999 - April 2004; 6.9% thereafter

3.2 Results for Defined Contribution Schemes

The defined contribution calculations were performed assuming that the cost of pension provision is 10% of gross salary. That is, if the contribution is tax free at the individual's marginal rate of tax, 10% of gross salary is paid into the scheme, and if the contribution is taxed, the net income of the individual remains the same as it is in the tax free case.

Rather than trying to present detailed comparisons for every permutation of three funds, three earning strategies and six tax regimes, we focus on the following:

- All tax regimes will be compared for the Low-Middle earnings' pattern and the Mid Equity fund. This will give a basic understanding of the effect of the different tax regimes. It will be possible

to compare, for example, the extent to which the tax-free status of the lump sum offsets the taxed position of the equity investments by comparing the Post-97 regime and the pure expenditure tax regime.

- Results for all three investment funds will be compared for the Post-97, Pre-97 and pure expenditure regimes, using the Low to Middle earnings' pattern. The important issue here is the extent to which investment policy affects the pension received from the three different tax regimes.
- Results for all three earning patterns will be compared for the Post-97 and Basic Rate tax regimes using the Mid Equity Fund. This enables us to consider the effect of abolishing higher rate tax relief. We also look at how those entering the workforce on low earnings are affected by the removal of higher-rate tax relief, in view of the assumed erosion of the real value of tax thresholds.
- Results for all three earnings' patterns will be compared for the Post-97 and the "ISA" tax regimes using the Mid Equity fund. This will show the effect of moving between tax systems that are similar in expenditure tax theory (that is from (approximately) EET to (approximately) TEE) but which have different effects on individuals who have different earnings' patterns.

The figure used to compare the different regimes is the "replacement ratio", which is defined as: {the net amount of the pension annuity purchased at retirement} divided by {the salary at retirement}. In other words it is a measure of the extent to which the pre-retirement level of income is maintained after retirement and, therefore, of the productivity of the pension scheme. Annuity prices were calculated using the conventional gilt yield assumption used for investment returns. The annuity was fixed in nominal terms. The figures shown for replacement ratios are after allowing for all relevant tax on pension fund benefits, and assuming the individual will have purchased the annuity in the most tax-efficient way. Any state pension benefit would be regarded as the "top slice" of income and will not be considered here.

3.2.1 The Results for the Defined Contribution Calculations

The replacement ratios for different earnings patterns and tax regimes are given in tables 3.2.1.1 to 3.2.1.3.

Table 3.2.1.1
Replacement Ratios for the Low Equity Investment Policy:
all Earnings Patterns and Tax Regimes

Tax Regime	Earnings Pattern		
	Low-Mid	Mid-High	Variable
Post-97	0.47	0.30	0.31
Pre-97	0.50	0.31	0.32
"ISA"	0.40	0.23	0.28
Basic rate	0.45	0.26	0.29
Comp. income	0.33	0.19	0.23
Pure expenditure	0.58	0.33	0.34

Table 3.2.1.2
Replacement Ratios for the Mid Investment Policy
all Earnings Patterns and Tax Regimes

Tax Regime	Earnings Pattern		
	Low-Mid	Mid-High	Variable
Post-97	0.52	0.32	0.33
Pre-97	0.56	0.34	0.35
“ISA”	0.44	0.25	0.30
Basic rate	0.50	0.27	0.31
Comp. income	0.38	0.21	0.26
Pure expenditure	0.71	0.40	0.40

Table 3.2.1.3
Replacement Ratios for the High Equity Investment Policy
all Earnings Patterns and Tax Regimes

Tax Regime	Earnings Pattern		
	Low-Mid	Mid-High	Variable
Post-97	0.51	0.32	0.33
Pre-97	0.57	0.35	0.36
“ISA”	0.43	0.25	0.30
Basic rate	0.49	0.27	0.31
Comp. income	0.39	0.21	0.26
Pure expenditure	0.77	0.42	0.43

One interesting observation is that the replacement ratios for the higher-paid individuals (the Mid-High and Variable earnings' patterns) are much lower than those for the lower-paid individual. This is because the (assumed) rate of earnings increase for individuals on the higher earnings patterns is greater than it is for the individual on the Low-Middle earnings. Consequently, the Low-Middle earnings pattern benefits from a greater real return (over and above salary increases) on investments.

3.2.2 Discussion of the Results

3.2.2.1 The Low-Middle earner

We will first compare tax regimes for the individual with Low-Middle earnings. This individual never reaches national average earnings but, because the higher rate tax allowance is assumed to fall relative to earnings, does pay higher-rate tax from age 53.

Under the Mid Equity investment policy (Table 3.2.1.2), moving from the Pre-97 to the Post-97 tax regime (that is, removing dividend tax credits) has led to a reduction in the replacement ratio from 0.56 to 0.52. This is a fall of 7% in the pension.

If the pension fund tax regime were changed to the “ISA” regime, the replacement ratio would fall to 0.44, a fall of 21% compared with the pre-July 1997 budget position. This fall is partly caused by the loss of the special advantage of the tax-free lump sum and partly by the loss of the ability to spread income for tax purposes (when this individual is paying higher rate tax). The “ISA” tax system allows tax credits to be reclaimed but only at a rate of 20% for one year and then at 10% for

a further five years. This is in accordance with the Government's current plans. It therefore does not allow a true comparison of the Post-97 or pure expenditure (EET) systems with a pure TEE system.

The move from the Post-97 tax system to the comprehensive income tax system (TTE) would lead to a reduction in the replacement ratio from 0.52 to 0.38. There are clearly considerable benefits to the individual from being able to defer tax and to obtain tax-free investment income from non-equity investments and a tax-free lump sum. In present value terms, the current tax position of pensions is worth 37% of the value of benefits compared with the benefits available from a comprehensive income tax system.

The abolition of tax relief on pension contributions at the higher rate of tax would reduce the replacement ratio from 0.52 (under the Post-97 tax regime) to 0.50. Thus there is a 4% reduction in the pension as a result of this restriction, for an individual on modest earnings. The removal of higher-rate tax relief will be considered further below for different income patterns. However, it can be seen that, because of the fall in the higher-rate threshold relative to earnings, it can affect individuals on quite low earnings.

A move to a complete expenditure tax regime (in which the lump sum is taxed) would increase the replacement ratio for the Low-Middle earner to 0.71, an increase of 36.5% compared with the Post-97 tax regime. The advantage of the pure expenditure tax regime is that equity returns would be received fully gross.

The results of these calculations demonstrate that the amount of pension an individual can accrue is very sensitive to the tax system in which contributions are invested and benefits paid. Assessment of the tax treatment of pensions should be made against an appropriate benchmark. However, the current (Post-97) tax position is not close to either of the traditional benchmarks (comprehensive income or expenditure tax). If anything, it is closer to a comprehensive income tax regime than an expenditure tax regime, whereas the pre-July 1997 Budget regime was slightly closer to an expenditure tax regime. The "ISA" regime does not provide full exemption from tax for savings interest because of the treatment of equity returns.

3.2.2.2 Investment Policy and Tax Regime

The interesting result here is the extent to which the effect of the tax treatment of dividends is sensitive to investment policy. From *a priori* reasoning, funds with greater proportions invested in UK equities will lose more from a tax change introducing the taxation of equity returns. Further, if a tax change is likely to affect investment policy it could have other, unintended, consequences, such as reducing equity investment in favour of bond investment. This could lead to more bond issues, with a consequent gearing up of company balance sheets.

The Low Equity, Mid Equity and High Equity funds had respectively 30%, 55% and 70% of their assets invested in UK equities. Considering the Low-Middle earner, moving from the Pre-97 to the Post-97 tax regime (that is, removing dividend tax credits) reduces the replacement ratio:

- from 0.50 to 0.47 for the Low Equity fund (Table 3.2.1.1), a decrease of 6%
- from 0.56 to 0.52 for the Mid Equity fund (Table 3.2.1.2), a decrease of 7%
- from 0.57 to 0.51 for the High Equity fund (Table 3.2.1.3), a decrease of 10.5%.

Thus the reduction in pensioners' potential income from this tax change is significant in each case, and it varies significantly between the different funds. (The effects are a little smaller for those on higher earnings but the pattern is similar.)

For the same Low-Middle earner the effect of moving from the Post-97 regime to the pure expenditure tax regime is that the replacement ratio rises significantly:

- from 0.47 to 0.58 for the Low Equity Fund (Table 3.2.1.1), an increase of 23.4%
- from 0.52 to 0.71 for the Mid Equity fund (Table 3.2.1.2), an increase of 36.5%
- from 0.51 to 0.77 for the High Equity fund (Table 3.2.1.3), an increase of 50.1%.

A significant part of the change in the replacement ratio caused by moving to an expenditure tax regime results from allowing equity returns to be taken gross.

The extent to which the effect of the tax regime depends on the amount of the fund invested in equities is interesting and can be expected to result in substantial behavioural consequences. In particular, imposing tax on returns from equity, whilst other investment returns remain exempt, could lead to a shift from a higher to lower allocation of UK equities in pension fund portfolios.

3.2.2.3 Abolishing Higher-Rate Tax Relief

The effect of abolishing higher-rate tax relief is shown by comparing the Post-97 and the Basic Rate tax regimes. The contribution to the defined contribution scheme has been adjusted so that net post-contribution earnings remain the same. This means that the loss of wealth to the individual from the removal of higher-rate tax relief can be judged by looking only at the annuity received in retirement. *A priori* we expect that the abolition of higher-rate tax relief would affect individuals with variable or high earnings more than an individual with low earnings.

As has been observed, abolishing higher-rate tax relief has the effect of reducing the replacement ratio for the Low-Middle earnings' pattern from 0.52 to 0.5.

An individual with a Middle-High earnings' pattern will see the replacement ratio fall from 0.32 to 0.27, (Table 3.2.1.2), a decrease of 15.6%. This arises for two reasons. Firstly, income spreading towards retirement is prevented. Secondly, there will be an element of double taxation. Tax will be paid on earnings contributed to a pension scheme at the rate of 17% and, also, tax might be paid on part of the pension at a rate of 40%. The combination of the abolition of dividend tax credits and abolition of higher-rate tax relief leads to a fall in the replacement ratio of 21%.

An individual with a Variable earnings' pattern will experience a fall in the replacement ratio from 0.33 to 0.31 if higher-rate tax relief is abolished (Table 3.2.1.2). This is smaller than the fall for the Middle-High earning individual. It might be expected that the person on Variable earnings would benefit more from the ability to income spread using higher-rate tax relief: however, in this case it appears that the individual with the Variable earnings' pattern loses less from the abolition of higher-rate tax relief. One reason for this is that the calculations have not allowed the individuals to vary their contributions depending on their income in a particular year. In order to get the maximum benefit from income spreading one should increase contributions in the years when higher-rate taxes are being paid.

3.2.2.4 The Effect of Moving to an "ISA" Tax System

The Post-97 tax regimes and the “ISA” regime are similar in expenditure tax theory; however, there are certain practical differences and also differences in detail:

- In the Post-97 regime there is a tax-free lump sum that would not be allowed under a pure expenditure tax.
- Individuals obtain the advantage of income spreading from the Post-97 tax regime, but not from the “ISA” regime.
- In the Post-97 regime equity returns are received net of tax, whereas, for a limited period, there is a partial tax credit in respect of equity dividends from the “ISA” regime.

A priori, one would expect the Post-97 regime to be more favourable than the “ISA” regime (that is, the tax-free lump sum is more valuable than the short-term tax credit). It should be more favourable still for those on higher incomes. This reasoning is confirmed by the calculations.

The replacement ratio falls from 0.52 to 0.44 for the individual on the Low-Middle earnings' pattern when the “ISA” tax regime is used instead of the Post-97 tax regime (Table 3.2.1.2). This is a fall of 15.4%.

The replacement ratio falls from 0.32 to 0.25 (22%) for the individual with Middle-High earnings and from 0.33 to 0.30 (9.1%) for the individual with variable earnings.

It may be tempting to conclude from these results that it would be appropriate to impose the “ISA” regime on the grounds that it will have more favourable distributional consequences, shown by comparing the effect on the individual with Low-Middle earnings with the effect on the individual with Middle-High earnings. However, this depends on one's starting point. If allowing income spreading is regarded as a desirable feature of a progressive tax system, so that the system is a closer proxy for progressively taxing lifetime income (rather than progressively taxing income in individual years), then the Post-97 tax regime is more appropriate. To some extent the tax-free lump sum under the Post-97 tax regime compensates investors for receiving equity returns net of tax. This is shown by the fact that the Post-97 tax regime is closer to the result of the pure expenditure tax regime than is the “ISA” regime.

3.2.3 Conclusions on the Taxation of Defined Contribution Schemes

From the comparison of different tax regimes, it can be seen that the Post-97 tax regime lies between a pure expenditure tax regime and a comprehensive income tax regime. The “ISA” regime was closer to a comprehensive income tax, relative to the Post-97 pension-fund regime, since the partial dividend tax credit in the ISA regime does not compensate for the absence of the tax-free lump sum. However, the Post-97 tax regime cannot be said to be “favourable”, as is assumed in Inland Revenue tax calculations, unless we establish an appropriate benchmark. It is clearly unfavourable relative to the pure expenditure tax benchmark. More generally, pension savings are not fully tax-free: they follow a considerably less favourable regime than pure EET, despite the tax-free lump sum.

The effect of removing dividend tax credits (moving from the Pre-97 to the Post-97 tax regime) has a greater effect on funds more heavily based in UK equities. It may, therefore, artificially reduce the attractiveness of UK equities to UK pension funds. Unsurprisingly, the effect of abolishing higher-rate tax relief bears more heavily on the higher-paid. However, if our assumption that tax thresholds will fall in value relative to earnings over time is correct, the abolition of higher-rate tax relief will affect even those on very modest earnings. The abolition would prevent people from spreading

income to times in their life (retirement) when income is much lower. Higher-paid individuals are also likely to suffer double taxation of income saved for pension purposes if higher rate tax relief is abolished.

3.3 Calculations for Defined Benefit Pension Schemes

3.3.1 Assumptions

The scheme and membership profiles, together with the valuation method used to derive the tax cost calculations for defined benefit pension schemes are described in Appendix 1. The investment and tax regimes used are those set out in the section on defined contribution schemes.

In order to make the results of the calculations most widely applicable a ‘typical’ final salary pension scheme was used, with the benefits being those most frequently observed by the Government Actuary’s Department’s survey (GAD, 1991). The detailed assumptions underlying the model scheme are also outlined in Appendix 1.

3.3.2 Results for Defined Benefit, Final Salary Occupational Pension Schemes

The standard contribution rates⁸ for the Post-97, Pre-97 and pure expenditure tax regimes are given in Table 3.3.2.1.

Table 3.3.2.1
Standard contribution rates

	Low Equity	Mid Equity	High Equity
Post-97	13.5%	12.1%	12.0%
Pre-97	12.9%	11.2%	10.8%
Pure Expenditure	11.3%	8.9%	8.2%

The contribution rates are expressed as a percentage of gross salary. Since the entire salary has been treated as pensionable, the rates given in Table 3.3.2.1 are not salary specific. This is not the case for the comprehensive income tax (TTE) and the “ISA” regimes, since the contribution to the pension scheme is paid from the net salary, and the benefit provided by the scheme is the net pension (without further deduction of tax). Because of movements at retirement from higher-rate to basic-rate tax brackets, the overall level of benefit paid, relative to gross salaries, falls as the proportion of active members in the higher tax bracket increases. We have investigated three membership profiles, one where all employees pay tax at the basic rate (Low Salary), one with 42% of the membership paying tax at the higher rate (Middle Salary), and another with 62% of the membership paying tax at the higher rate (High Salary). The standard contribution rates for the comprehensive income tax and “ISA” regimes are given in Table 3.3.2.2.

Table 3.3.2.2
Standard contribution rates for the
Comprehensive Income and “ISA” Tax Regimes

⁸ The standard contribution rate is the cost of providing the future accruing benefits of the members of the scheme, calculated according to the valuation method chosen, and expressed as a percentage of pensionable salary.

Tax Regime	Salary	Investment		
		Low Equity	Mid Equity	High Equity
"ISA"	Low	12.1%	10.8%	10.7%
	Middle	11.9%	10.7%	10.5%
	High	11.8%	10.6%	10.4%
Comprehensive Income	Low	13.7%	11.7%	11.2%
	Middle	13.5%	11.5%	11.0%
	High	13.4%	11.5%	11.0%

In all cases the standard contribution rate can be applied to the total gross salary of the active membership to obtain the annual amount of the standard contribution required by the pension scheme.

The benefit funded under the comprehensive income tax and "ISA" regimes is the accrued pension, net of tax. Thus, in order to calculate the liabilities and contribution rates, it was necessary to make assumptions about how incomes would be taxed in the future. The assumption made was that tax rates would remain the same, and tax thresholds would increase in line with inflation. This is consistent with the assumptions made for the defined contribution calculations. The calculations were slightly complicated by the different rates at which tax thresholds and salaries are assumed to increase but, more importantly, introducing an assumption about future tax regimes must increase the uncertainty in the results significantly. This might affect an employer's future financial planning and detract from the value of the pension scheme. There is a discussion in Appendix 2 about the difficulties of calculating pension costs when the benefits funded are net of tax.

3.3.2.1 Comparison of Tax Regimes

As might have been expected, given our assumptions, investing in equities can reduce the cost of occupational pension provision, but the relative attractiveness of equity investment depends on the extent to which investment income and capital gains are taxed. For example, the removal of tax relief on dividends (moving from the previous to the current tax regime) increases the standard contribution rate by between 5% for the Low Equity Fund and 11% for the High Equity Fund (Table 3.3.2.1). These results are consistent with those found for defined contribution schemes.

The expenditure tax regime gives rise to the lowest cost, even though the level of benefit being funded is higher than under any of the other regimes. This is partly because grossing up the assumed (net) rate of equity growth at corporation tax more than compensates for the difference in the amount of the benefits. In addition, in some circumstances the benefit accrued in the pension scheme is lower than the single persons' allowance, and so would not be subject to tax, even under an EET regime. This is an extreme form of income spreading benefit which, in fact, makes the scheme "EEE" for those who receive a low pension in retirement. Consequently, the comprehensive income Tax regime is relatively more costly than the pure expenditure system. This is discussed further in Appendix 2.

If there were a pure expenditure tax regime, the standard contribution rate relative to the Post-97 regime would be reduced by 17% for the Low Equity Fund, 26% for the Mid Equity Fund and 32% for the High Equity Fund. As expected, these results support the conclusion that the present tax system can be viewed as biased against investment in equities as well as being a long way from an expenditure tax basis.

The “ISA” regime also appears to have low costs, relative to the other regimes (apart from the pure expenditure regime). However, note that the contribution rates given in Section 3.3.2 solely represented the cost of funding the pension scheme. In addition, under an “ISA” regime, tax would be paid on the contribution paid to the fund. This would either be paid directly by the employee, or the employer’s contribution would be deemed a taxable benefit. The amount of tax paid, as a percentage of gross salary, is given in Table 3.3.2.3a. If the tax is added to the standard contribution rate, we can derive the total cost of providing pension scheme benefits under an “ISA” tax regime. This is given in Table 3.3.2.3b.

Table 3.3.2.3a
Tax Paid on Pension Scheme Contributions
Under an “ISA” Regime

	Low Equity	Mid Equity	High Equity
Low Salary	2.8%	2.5%	2.4%
Middle Salary	3.6%	3.2%	3.2%
High Salary	4.1%	3.7%	3.7%

Table 3.3.2.3b
Total Cost of Pension Scheme Benefits
Under an “ISA” Regime

	Low Equity	Mid Equity	High Equity
Low Salary	14.8%	13.3%	13.1%
Middle Salary	15.4%	13.9%	13.7%
High Salary	15.9%	14.3%	14.1%

The effect of the tax is to increase the cost of the pension scheme by between 23% and 35%, depending on the investment profile of the pension fund and the salary profile of the membership. The result is a total pension cost that is greater than both the Post-97 and the Pre-97 tax regimes, even though the benefit funded under the “ISA” regime is less⁹.

The comprehensive income tax regime is the most expensive arrangement for employers. This is apparent from Table 3.3.2.2, where it is possible to see that, even though the pension scheme is providing a lower benefit, the effect of tax on investment income means that the cost of providing the benefits is not reduced proportionately. However, as for the “ISA” regime, tax would be paid on the contribution paid to the fund. The amount of tax paid, as a percentage of gross salary, is given in Table 3.3.2.4a and the total cost of providing pension scheme benefits under a comprehensive income tax regime is given in Table 3.3.2.4b.

Table 3.3.2.4a
Tax Paid on Pension Scheme Contributions
Under a Comprehensive Income Tax Regime

	Low Equity	Mid Equity	High Equity
--	-------------------	-------------------	--------------------

⁹ See Appendix 2 for further explanation of the result.

Low Salary	3.1%	2.7%	2.6%
Middle Salary	4.0%	3.5%	3.3%
High Salary	4.7%	4.0%	3.8%

Table 3.3.2.4b
Total Cost of Pension Scheme Benefits
Under a Comprehensive Income Tax Regime

	Low Equity	Mid Equity	High Equity
Low Salary	16.9%	14.4%	13.8%
Middle Salary	17.5%	15.0%	14.3%
High Salary	18.1%	15.5%	14.8%

As in the “ISA” example, taxing contributions increases the cost of the pension scheme by between 23% and 35%. The total cost of providing pension benefits under the comprehensive income tax regime is thus significantly higher than the cost under any of the other regimes discussed¹⁰. Note also that adding tax to the standard contribution rate results in costs that increase, as a proportion of gross salary, as the proportion of active members in the higher tax bracket increases. If tax thresholds continue to increase in line with prices and salaries increase faster than prices, pension costs will be an increasing proportion of the cost of employment under these two tax regimes.

3.3.2.2 Abolishing Higher Rate Tax Relief

In order to arrive at the true cost of pension provision if higher-rate tax relief is removed from pension contributions, we need to estimate the extra amount paid in tax should relief be granted at the basic rate only. These figures will clearly depend on the proportion of members paying tax at the higher rate. We have used the same salary profiles that were used to investigate the effect of the comprehensive income tax and “ISA” regimes. The cost of providing an occupational pension for the Middle Salary membership is increased by 0.24% of gross pay, regardless of the investment profile or tax regime used for comparison. The extra tax paid as a percentage of salary for the High Salary membership is approximately 0.85%, depending on the investment profile or tax regime.

Broadly, the removal of higher-rate tax relief increases the cost of occupational pension provision by between 2% and 3% for a Middle Salary membership, and between 6% and 9% for a High Salary membership. Quite apart from the issues of fairness addressed elsewhere, since tax thresholds are increased in line with prices only, removal of tax relief at the marginal rate of tax will make pension provision an increasingly expensive option for employers.

The contributions made by employers to defined benefit schemes are a general contribution to the funding of the benefits promised by the scheme. The funding requirement will vary from year to year according to the investment, salary and demographic experience of the scheme and the extent to which the actual experience differs from that assumed at the time contributions were made in previous years. Thus, the contributions cannot readily be identified either with specific individual members (unless there is only one member) or with specific tax years. Hence, it would be difficult to demonstrate that the burden of any tax on employer contributions was being shared equitably

¹⁰ See Appendix 2 for further explanation of the result.

between the members of a scheme, and members of different pension schemes could face different tax charges even though their pay and pension entitlements were identical. Such a tax charge would also be awkward to administer. These and other practical difficulties are spelled out in detail in NAPF (1998).

3.3.3 Conclusions on the Taxation of Occupational Defined Benefit Pension Schemes

The cost of defined benefit occupational pension provision is clearly sensitive to the tax structure in which pension schemes have to operate. Our comparisons show that a pure expenditure tax regime could result in considerably lower pension costs, particularly for schemes with an average or above average exposure to equity investment.

The removal of dividend tax credits increases the standard contribution rate required by between 5% and 11%. This represents an increase in the cost of labour of about 1% of salaries, and could have significant effects on labour demand, or on the pension benefits employers are willing to offer.

The “ISA” and the comprehensive income tax regimes have the major advantage to the Inland Revenue that tax is collected much earlier. However, there are several disadvantages from the point of view of the employer.

- Firstly, the perceived tax benefits of pre-funding are removed, so removing the incentive to establish a trust fund separate from the employer’s finances, from which benefits can be paid.
- Secondly, the pension scheme valuation could become more difficult, and the results more uncertain, because the benefit paid under this tax regime depends on the income tax structure at the time the benefit vests.
- Thirdly, the administration of the pension scheme would become more complex since, in order to be equitable, tax must be paid at the marginal rate appropriate to each employee. The standard contribution rate required by defined benefit pension schemes is not member specific. Thus, member specific contribution rates would have to be calculated, and tax applied appropriately. Similarly, the tax deducted from investment income should be a function of the employees’ marginal tax rates. These calculations would significantly increase the administrative burden imposed by the pension scheme, making the tax regime more costly and occupational pension schemes less attractive as an employee benefit: it may well lead to significant scheme closures. Even in our simplified model scheme attributing contributions was complex: it might be impossible to undertake this function on an equitable basis in an actual defined benefit pension scheme.
- Fourthly, some members will join and leave pension schemes without having accrued sufficient benefit to incur a tax liability. If these people are unable to earn additional retirement income elsewhere, they will be penalised under a TEE scheme to the extent that they lose the value of the single persons’ allowance when in retirement.
- Similarly, on death in service the spouse’s pension might be low relative to the tax threshold. Under a comprehensive income tax, the surviving spouse is effectively taxed at the marginal rate of the deceased, even though the spouses might be non-earners themselves. Currently, the tax system in the UK does not transfer tax liabilities between individuals in this way.

Abolishing tax relief at the employees’ marginal rate of tax also increases employer costs, although not as substantially as the comprehensive income tax regime. In addition, some of the same administrative problems would be experienced.

On the other hand, if the provision of defined benefit occupational pension schemes were to be moved to an expenditure tax basis, their cost would be reduced quite substantially. This could make the provision of occupational pensions a far more attractive option to employers, reducing the numbers choosing to close their schemes and even leading to an increase in provision.

3.4 Some Additional Case Studies

A large number of projections and comparisons have already been made. However, it is worth considering some further issues. For example, it could be argued that people investing in ISAs expect the dividend tax credit to continue to be repayable at the 10% level after 2004: if this were not the case, ISAs would only have a small benefit for basic rate taxpayers. Secondly, investors might also expect the tax-free lump sum to be withdrawn from pension funds. Thirdly, our assumptions regarding the indexation of the higher-rate tax bracket to earnings may be unrealistic (although this has been the practice for many years, at some stage the fall in the higher-rate tax bracket relative to average earnings might become unsustainable).

To make comparisons of different earnings patterns and investment strategies for both defined benefit and defined contribution schemes would create more cross comparisons than are necessary to understand the effects of the above changes in assumptions. A consideration of defined contribution outcomes for one earnings pattern and for one investment strategy will provide a good indication of the relative costs of some incremental changes to our assumptions and so we restrict our considerations to the low-mid earner, investing in the mid-equity fund.

3.4.1 Case study one

We first consider the effect on the replacement ratio if the tax free lump sum is abolished and all the fund has to be used to purchase a pension which is then taxed.

The net replacement ratio for our chosen individual in this case is 0.49. This compares with the replacement ratio when the lump sum could be taken tax-free and used to purchase a life annuity of 0.52 (under the post-1997 Budget regime). The removal of the tax free lump sum had resulted in a fall in the replacement ratio of 6%.

We argued in Section 1 that neither the second “E” of EET nor the final “T” are full “E” or “T”. As far as the second “E” is concerned, taxes are paid on investment returns from equity investments. As far as the final “T” is concerned, the cash lump sum is tax free. These two may offset each other somewhat. It is therefore worth considering the effect of removing the tax-free lump sum together with the restoration of the removal of dividend tax credits. This provides a replacement ratio of 54% which is 4% lower than the pre-1997 budget regime and 4% higher than the post-1997 budget tax regime.

Removing the tax-free lump sum would have been an alternative to removing the dividend tax credit. In a sense the tax-free lump sum can be regarded as a “concession” which partially compensates for the fact that equity returns are taxed. Removing the tax-free lump sum and restoring the tax credit would create a more coherent tax system.

3.4.2 Case study two

We next consider the effect on the replacement ratio for the ISA investor if tax credits continue at 10% of the gross dividend in perpetuity.

The replacement ratio for the low-mid earner investing in the mid-equity fund would increase from 0.44 to 0.46, that is, by 5%.

Note that the replacement ratio from the revised ISA regime (assuming the 10% dividend credit continued in perpetuity) would be 94% of the replacement ratio from the revised pension regime (assuming no tax free lump sum). This compares with the replacement ratio for the actual ISA regime being 85% of the replacement ratio of the standard post-1997 Budget regime.

3.4.3 Case Study three

Very briefly, we note that if we assume tax brackets increased in line with earnings, the replacement ratios under the post-97 budget regime increase by about 10% relative to the case reported. The increase arises for two reasons. Firstly because we assume individuals are able to invest more in their pension scheme, since they will be paying less tax and, secondly, because a smaller proportion of their post tax income will be taxed.

4 Conclusion

The Inland Revenue estimate that, in 1997-8, tax relief on pension schemes cost the Exchequer a net revenue loss of £12,300 million (IR, 1998). Putting to one side serious problems with the methodology used in the calculation and the fact that this figure should decrease substantially over the next 30 years as the present system becomes mature, effectively the Inland Revenue has assumed that the appropriate benchmark is an income tax regime. If an expenditure tax regime were to be chosen as a benchmark, far from operating in a favourable tax environment, pension schemes would be seen to be making contributions to the Inland Revenue in the region of 3% of pensionable salary (based on the assumptions and calculations made in this paper). This amounts to approximately £10,000 million.

The economic arguments as to whether general savings should be taxed on a comprehensive income tax basis or an expenditure tax basis (the latter allowing an exemption of interest income from tax) are finely balanced. Important determining factors are whether it is desired to tax returns from capital on the same basis as returns from labour; and whether saving is actually the same as consumption, or whether it should be considered deferred consumption. However, with regard to pensions savings there are a number of "economics of second best" arguments one can make in support of the expenditure tax basis as a benchmark. Indeed, the most appropriate form of expenditure tax is one that exempts pensions from the tax system until the point at which consumption takes place. Apart from producing lower costs (or higher pensions), the expenditure tax basis has several practical advantages. In particular, it preserves the progressive nature of our tax system, enabling individuals to spread income from a time of relative wealth (employment) to a time of relative poverty (retirement).

Our analysis and calculations have had to make some simplifying assumptions and have ignored the considerable issues that would be involved in the transition from one tax regime for pensions to another. However, they provide some support for three overall conclusions.

- The cost of pension provision is sensitive to the choice of tax regime.
- In UK circumstances there is a good case for saying that the most appropriate tax regime for prefunded private pension schemes is the expenditure tax basis with tax collected at the back-end (EET), whether the schemes are of the defined contribution or defined benefit type.
- If there is to be any change to the present UK regime, it should be in the direction of an expenditure tax basis with tax collected at the back-end. Recent changes have moved the tax position in the opposite direction to a position which is essentially arbitrary.

References

- Atkinson and Stiglitz (1980), *Lectures on Public Economics*, London, McGraw-Hill
- Barclays Capital (1998), *Equity/Gilt Study*, Barclays Capital, London, UK
- Bank of England Quarterly Bulletin (BEQB) (1997), Bank of England, London, UK
- Booth, P. M. and Cooper, D. R. (1999 pending), *Pension Funds Tax Costs*, to be submitted to Insurance: Mathematics and Economics
- Cooper, D. R. (1999), *A New Contract for Welfare: Partnership in Pensions*, Economic Affairs, Vol. 19, No. 3, pp 3-8, Institute of Economic Affairs, London, UK
- Department of Social Security (DSS) (1997), *Basic Pension Plus*, DSS, London, UK
- Department of Social Security (DSS) (1998), *A New Contract for Welfare: Partnership in Pensions*, Cm 4179, London: The Stationery Office
- De Ryck K. (1996), European Pension Funds: their impact on European capital markets and competitiveness, European Federation for Retirement Provision, UK/Belgium.
- Dilnot, A. and Johnson, P. (1993), *Tax Expenditures: The Case of Occupational Pensions*, Fiscal Studies, Vol. 14, No. 1, pp. 42-56, Institute for Fiscal Studies, London, UK
- Fabian Society (1990), *The Reform of Direct Taxation, Report of the Fabian Society Taxation Review Committee*, Fabian Society, London, UK
- Government Actuary's Department (GAD), (1991), *Occupational Pension Schemes 1987: Eighth Survey by the Government Actuary*, HMSO, London, UK
- Greenwood, P.M. and Keogh, T.W., (1997), *Pension Funding and Expensing in the Minimum Funding Requirement Environment*, British Actuarial Journal, Vol. 3, pp. 497-549
- Heady, C. (1993), *Optimal Taxation as a Guide to Tax Policy: A Survey*, Fiscal Studies, Vol. 14, No. 1, pp. 15-41, Institute for Fiscal Studies, London, UK
- Inland Revenue (IR), (1998), *Inland Revenue Statistics 1998*, London: The Stationery Office
- Kaldor N. (1955), *An Expenditure Tax*, Unwin University Books, London, UK
- Kay J. A. and King M. A. (1990), *The British Tax System*, fifth edition, Oxford University Press, Oxford, UK
- Knox, D. (1990), *The Taxation Support of Occupational Pensions: A Long-Term View*, Fiscal Studies, Vol. 11, No. 4, pp. 29-43, Institute for Fiscal Studies, London, UK

Le Grand, J. and Agulnik, P. (1998), *Tax Relief and Partnership Pensions*, Centre for Analysis of Social Exclusion, CASE Paper No. 5, London School of Economics, London, UK

Meade J. E. (1978), *The Structure and Reform of Direct Taxation*, George Allen and Unwin, London, UK

National Association of Pension Funds (NAPF), 1997, *Annual Survey*, NAPF, London, UK

National Association of Pension Funds (NAPF), (1998), *Making Pensions Easy: NAPF's Tax Simplification Report*, National Association of Pension Funds, London, UK.

Office for National Statistics (ONS), (1997), *New Earnings Survey*, ONS, London: The Stationery Office

Robinson, A. (1997), *The Tax Treatment of Savings for Pensions Products in the EU*, European Policy Forum, London, UK

Thomas, M., Walker, A., Wilmot, N., and Bennett, N., (1998), *Living in Britain*, London: The Stationery Office

Willis, J. R. M. and Hardwick, P. J. W. (1978), *Tax Expenditures in the United Kingdom*, Heinemann, London, UK

W.M. (1998), *The W.M. Company UK Pension Funds Universe – Quarter 2 1998*, The WM Company, UK

Appendix 1 Assumptions

A1.1 Investment and Salary Assumptions in Investigations

It is important to use a set of investment assumptions which ensures consistency between different asset categories and which is compatible with historical experience and with information contained in current investment markets. The following approach was taken:

Long-term bond yield: long-term yields at the time of the investigation were used.

Index-linked gilt yield: total nominal returns were assumed to be 0.25% less than the return from conventional gilts. This assumes a small risk premium from the latter.

Inflation: an approximate relationship of index-linked gilt real yields + risk premium (see above) + market expectations of inflation = conventional gilt yields was used to derive market expectations of inflation.

UK equity market dividend yield: the current gross yield on the FTSE Actuaries All-Share index at the time of the investigation was used.

UK equity market dividend growth: equity dividend growth cannot be inferred unambiguously from market information. The assumption was made that it would be both reasonable and consistent to assume that future real dividend growth does not depend on inflation or bond yields. It is therefore reasonable to use real dividend growth assumptions calculated from historical data. This was added to the inflation estimate to give an estimate of nominal dividend growth.

UK equity total returns: this is the sum of nominal dividend growth and the dividend yield.

Cash returns: current cash returns are known. However, estimates are needed of the return on cash over the long-run. It was assumed that cash would provide a nominal return of 0.5% less than long gilts, thus assuming a slight upward slope of the yield curve in long-run equilibrium.

Property returns: current property yields are known but future rental growth is not. Historically, rental growth over a long period has not differed significantly from inflation. Total property returns were therefore assumed to be equal to the sum of current yields and future inflation.

US equity returns: US equities were used as a proxy for overseas equities. There is no intrinsic reason why expected US equity returns should be different from UK equity returns. It was assumed that all dividends would be received net with no opportunity to receive relief. It was therefore assumed that gross US equity returns would equal gross UK equity returns. US equity returns would be reduced by tax paid on the dividends (assumed, for simplicity, to be 20% of the dividend yield). The tax basis would vary for UK equities but remain the same for all regimes for US equities.

The above analysis gives rise to the investment returns to be used on the pre-July 1997 Budget basis, given in Table A.1. Lines showing the final figures for the return for each category are in bold. In addition, national average salary growth is assumed to equal inflation plus 2%.

Table A1.1
Investment Return Assumptions

Category	Return
Conventional gilts	5.2%
Index-linked gilts	4.95%
	$2.2\% + 2.1\% = 4.3\%$
UK equity dividend growth	
UK equity dividend yield	3.25%
Total UK equity return	7.55%
Property Yield	6%
Property rental growth	2.1%
Total property return	8.1%
US equity return	7.15%
Cash return	4.7%
Inflation	$5.2\% - 0.25\% - 2.85\% = 2.1\%$
National Average Salary Growth	$2.1\% + 2\% = 4.1\%$

A number of the relationships shown above should not strictly speaking be additive. However, obtaining strictly accurate values for investment assumptions is not an important part of this work. Where historical figures are used, they are taken from Barclays Capital (1998), except for national average real salary growth. The figures adjusted for the different tax regimes are given in table 3.1.2.2.

One aspect worth discussing further is the relationship between UK equity and conventional fixed interest returns. The figures presented here indicate a risk premium of 2.35%. This is less than has been achieved historically. The authors believe that this risk premium is a reasonable estimate of the level which may be achieved in the future but it is worthwhile reconciling it with historical evidence. The assumed real equity return is reduced, as compared with historical figures, because the current dividend yield is 3.25% rather than the average value of 5.03% recorded in Barclays Capital (1998). It is implicitly assumed that all the reduction in dividend yield is reflected in reduced equity returns rather than compensated by higher future dividend growth. Also the assumed future real conventional gilt return here is 3.1%, compared with the historical figure of 2.1% recorded in Barclays Capital (1998). It is regarded as reasonable to assume that the lower return exhibited in the historical study was due to the effect of unanticipated inflation in the post-second world war period. Once again, it is worth noting that the investment return assumptions are not critical to the conclusions of this study. We are merely looking for reasonable and consistent returns figures across different tax regimes.

A1.2 Investment Funds

Three investment funds were used, because the cost of alternative tax regimes will depend on the investment allocation policy of the pension fund. The asset distribution of the three funds is set out in Table A1.2.

Table A1.2
Sample Investment Funds

Investment Category	Proportions Invested		
	'Low Equity'	'Mid Equity'	'High Equity'
UK Equities	30%	55%	70%
US Equities	15%	15%	10%
Property	10%	10%	5%
Index-linked bonds	20%	6%	5%
Conventional bonds	20%	10%	5%
Cash	5%	4%	5%

A1.3 Earning Patterns and Other Assumptions Required for Defined Contribution Calculations

The cost of different tax regimes will also depend on individuals' earnings. Three earnings patterns are therefore used with six different tax regimes. The three earnings patterns used for the defined contribution calculations are given in Table A3

Table A1.3
Earnings Patterns

Low - Middle	Individual starts contributing at age 18 at 10% of earnings (gross contribution) Earnings start at £12,000 per annum Rise in real earnings is post-war national average earnings increase plus a scale rise of 2% for first five years and 0.5% thereafter Retires at age 65
Middle – High	Individual starts contributing at age 21 at 10% of earnings (gross contribution) Earnings start at £18,000 per year Rise in real earnings is post-war national average earnings increase plus a scale rise of 6% per annum for ten years and 1.5% thereafter This individual will generally pay higher rate tax although not in the earliest years
Variable	Individual starts contributing at age 21 at 10% of gross earnings (gross contribution) Earnings pattern such that present value of earnings is the same as B but the pattern of earnings is much more variable.

The rates of income tax at different levels of earnings are given in Table A1.4

Table A1.4
Income Tax Assumptions

Earnings Band	Rate of Tax
£ 4,045	0%
£ 4,045 - £ 8,145	20%
£ 8,144 - £ 30,145	23%
£ 30,145 +	40%

All tax brackets are assumed to increase in line with inflation.

The contribution ceiling of 17.5% of net relevant earnings is not breached with any of the earnings patterns in any of these cases.

Where appropriate, the maximum of 25% of the fund is taken as a cash-free lump sum at retirement, subject to the earnings cap of £126,000 increased in line with inflation. The lump sum is used to purchase a life annuity, of which the interest component is taxable. This is necessary to ensure a consistent comparison of incomes in retirement from different income patterns and tax regimes.

It is notable that the higher-rate tax bracket falls so sharply relative to earnings that the individual on the Low-Middle earnings pattern pays higher-rate tax from age 53, despite the fact that this individual does not reach average earnings. The higher-rate tax bracket is falling steeply relative to earnings because of its indexation to prices rather than to average earnings. It is tempting to assume that this situation cannot continue and make an appropriate adjustment to the higher rate tax bracket. However, it seemed appropriate to the authors to use the assumptions that approximated most closely to the policy that has been followed over the past ten years.

Other key assumptions are given in Table A1.5.

Table A1.5
Other Assumptions

Continuing expenses are 1.25% of the fund plus £12 per annum and initial expenses are 5.25% of the contribution.

Annuity prices are calculated using gilt yields adjusted for the appropriate tax base; expenses of 4% of the purchase price are assumed. Mortality is according to PA (90) rated down two years of age.

Under those tax regimes where tax is paid on benefits, tax is paid on the annuity at the current income tax rates using the tax brackets and inflation assumptions outlined above. The annuity which is purchased with the tax-free lump sum is taxed on the interest portion. State retirement pension would be the top slice income under these assumptions and is not considered when calculating replacement ratios.

Appendix 2 Detailed Assumptions for Defined Benefit Pension Funds

The detailed benefits for the model defined benefit scheme are described in Table A2.1.

Table A2.1
Pension Scheme Benefits

Category	Benefit
Normal Pension Age	65
Accrual Rate	1/60 ^{ths}
Pensionable salary	basic salary
Death after retirement spouses pension	50% pension
Early retirement	with a 6% per annum reduction
Post retirement increases	Inflation
Death in service lump sum	4 times salary
Death in service spouses pension	50% accrued service
Withdrawal benefit	Statutory minimum

This broad structure would apply mostly to contracted-out pension schemes. However, the issue of contracting out is irrelevant to our tax calculations and so has been ignored.

Similarly, we assume that choices between benefits, such as the lump sum at retirement, or the ability to take a transfer value on withdrawal, have no effect on the financing of the scheme: that is, we assume they take place on a basis that is actuarially neutral to the funding of the scheme.

A2.1 The membership

Information was gathered from a variety of sources in order to construct a membership that could be deemed typical of an established occupational pension scheme (for example, GAD, 1991, NAPF, 1997). The weighted average age of the active members is 41, and the membership is split between active members, deferred pensioners and pensioners in approximately the proportions 38%, 25% and 37%, respectively. The number of deferred pensioners is relatively high as the ability to take transfer values was ignored.

Members' salaries were increased in line with the national average salary increase assumption, together with a promotional salary scale that was chosen to give a salary profile similar to that of the employed population as a whole. The consequence is that the salary profile of the active members is relatively steep at younger ages and flat towards retirement.

The results of the calculations give a distribution of liabilities between active, deferred and pensioner members that is approaching a mature scheme, according to Greenwood and Keogh (1997).

If the active membership of the pension scheme is assumed to be paid at the same rates (by age) as the employed population, their rates of pay are always below the threshold for paying higher-rate tax (ONS, 1997). This is because each member is assumed to receive the average rate of pay for the appropriate age bracket, so that the full distribution of earnings is not taken into account. In fact, the earnings distribution is not an important variable for any of the calculations except those

investigating the effect of higher-rate tax relief removal. In order to investigate the effect of removing higher-rate tax relief on contributions paid to occupational pension schemes, we repeated the calculations for memberships with different, higher, starting salaries. In fact, it is reasonable to assume that a higher percentage of members of occupational pension schemes will be paid in excess of the higher-rate tax threshold, because a larger percentage of those on low pay tend not to have access to occupational pension schemes (Thomas et al, 1998). This was regarded as a reasonable working way forward.

A2.2 The valuation method and basis

The Projected Unit Method was used to value the liabilities and to calculate the standard contribution rate of the pension scheme. This method implicitly assumes that the membership profile of the scheme is stable with respect to age, past service and salary distributions, which is reasonable given the way the membership was constructed. The standard contribution rate is effectively calculated as the cost arising in the year following the valuation date, in respect of liabilities accrued due to service completed in that year, allowing for future salary growth.

The valuation interest rate has been derived from the three investment funds described in Appendix 1. The rates are shown in Table A2.2 for the various tax regimes considered. Note that, for simplicity, the 5 year dividend tax credit awarded to ISAs has been ignored, with the result that the valuation interest rate for the current regime and the "ISA" regime are the same.

Table A2.2
Valuation Interest Rates

	Low Equity	Mid Equity	High Equity
Post-97	6.1%	6.5%	6.6%
Pre-97	6.3%	6.9%	7.1%
"ISA"	6.1%	6.5%	6.6%
Comp. Income	5.6%	6.2%	6.4%
Pure Expenditure	6.9%	8.0%	8.4%

Note that these rates of interest are lower than might commonly be adopted for an actuarial valuation of an ongoing occupational pension scheme. The rationale for their choice is given in Appendix A1.

Standard tables were used for mortality pre and post-retirement, and assumptions consistent with the derivation of the membership were made for the rates of withdrawal and early retirement. Other financial assumptions are given in Table A2.3.

Table A2.3
Inflation and other financial assumptions

Inflation	2.1%
Real salary growth	2.0%
Promotional salary growth	2.0%
Increases to pension in payment	2.1%

Calculations for the effect of removing higher-rate tax relief were made by increasing the tax paid to the Inland Revenue, rather than reducing the benefit paid. This seemed a reasonable approach to take for our purposes, although it is different from that followed for defined contribution schemes. Tax was calculated as though the employer was paying the appropriate age-related contribution on behalf of each employee.

A2.3 Practical Difficulties with the “ISA” and Comprehensive Income tax calculations

In order to make the comparisons of the standard contribution rates in Section 3 reasonable, we assumed that the pension scheme would be adjusted to provide an equivalent level of benefits under each tax regime. Hence we took the gross benefit under a pure expenditure tax (EET) regime accrued up to the date of exit, whether due to death, retirement or withdrawal, and applied the appropriate rate of tax to arrive at the value of the net EET benefit. This value was the benefit assumed to be funded under the “ISA” (TEE) and comprehensive income tax (TTE) regimes.

However, in several respects this assumption is an over-simplification:

- Some members will join and leave pension schemes without having accrued sufficient benefit to suffer a tax liability. For these, the benefit under the expenditure tax regimes is effectively provided on a fully exempt (EEE) basis. In the case of a retirement pension this could be justified by arguing that tax rates operate progressively and, by virtue of the single person’s allowance, the individual has been allowed to transfer income from a relatively ‘high’ tax period into a low tax period. The result of this is that it costs more to provide the net benefit under an “ISA” or comprehensive income regime in these cases.
- However, offsetting this is the likelihood that members retiring with a pension smaller than the single person’s allowance from one pension scheme will have accumulated entitlement to pension elsewhere. Similarly, those taking a deferred pension might enter alternative employment where they accrue extra pension, taking their total retirement pension above the single person’s allowance. A pension scheme could allow for this in its funding by making a necessarily approximate assumption about the average rate of tax paid by pensioners. This would reduce the cost of provision. However, the uncertainty of this calculation, and the extent of the error likely on an individual basis, is likely to make the experience of the scheme more volatile.
- In practice, pension schemes under an “ISA” or comprehensive income tax regime are likely to adjust their rate of accrual, so as to approximate the level of net benefit provided under an expenditure tax regime. Then, those people unable to earn additional retirement income elsewhere, will be penalised to the extent that they lose the value of the single person’s allowance when in retirement.
- Similar problems arise on death in service. Many pension schemes provide a lump sum payable gross (because it is paid under a discretionary trust) and pay a spouse’s pension calculated as a proportion of the member’s accrued pension. The pension might be low relative to the tax threshold. Under a comprehensive income tax, the surviving spouse is effectively taxed at the marginal rate of the deceased, even though the survivor might be a non-taxpayer. Currently, the tax system in the UK does not transfer tax liabilities between individuals in this way.

From a purely tax perspective, therefore, our calculations may understate the cost in some cases of providing a given level of net benefits under an “ISA” or comprehensive income tax regime relative to a pure EET regime. However, these are situations where there is a relatively high probability that the recipient of the pension benefits will also be receiving means-tested state benefits, so that any minor difference in after-tax pension will be exactly offset by a difference in state benefits, leaving both the recipient and the Exchequer unaffected overall. In short, it seems reasonable to ignore these cases for the purposes of our comparisons.

DEPARTMENT OF ACTUARIAL SCIENCE AND STATISTICS

Actuarial Research Papers since 1992

32. England P.D. and Verrall R.J. Dynamic Estimation for Models of Excess Mortality. January 1992. 19 pages. ISBN 1 874 770 32 8
33. Verrall R.J. A State Space Formulation of Whittaker-Henderson Graduation, with Extensions. January 1992. 13 pages. ISBN 1 874 770 33 6
34. Verrall R.J. Graduation by Dynamic Regression Methods. January 1992. 37 pages. ISBN 1 874 770 34 4
35. Gerrard R.G. and Haberman S. Stability of Pension Systems when Gains/Losses are Amortized and Rates of Return are Autoregressive. March 1992. 12 pages. ISBN 1 874 770 35 2
36. Haberman S. HIV, AIDS and the Approximate Calculation of Life Insurance Functions, Annuities and Net Premiums. April 1992. 28 pages. ISBN 1 874 770 36 0
37. Cooper D.R. Savings and Loans: An Historical Perspective. May 1992. 29 pages. ISBN 1 874 770 37 9
38. Verrall R.J. Dynamic Bayes Estimation for AIDS Delay Tables. May 1992. 16 pages. ISBN 1 874 770 38 7
39. Kaye G.D. Data Sources Relating to Life Assurance Expenses. May 1992. 39 pages. Presented to the Staple Inn Actuarial Society and Royal Statistical Society - February 1992. ISBN 1 874 770 39 5
40. Renshaw A.E., and Haberman S. On the Graduation Associated with a Multiple State Model for Permanent Health Insurance. May 1992. ISBN 1 874 770 40 9
41. England P.D. Statistical Modelling of Excess Mortality Number 3. June 1992. 163 pages. ISBN 1 874 770 41 7
42. Bloomfield D.S.F. and Haberman S. Male Social Class Mortality Differences Around 1981: An Extension to Include Childhood Ages. 21 pages. June 1992. ISBN 1 874 770 42 5
43. Berg M.P and Haberman S. Trend Analysis and Prediction Procedures for Time Nonhomogeneous Claim Processes. 33 pages. June 1992. ISBN 1 874 770 43 3
44. Booth P.M. The Single Market for Insurance, Free Capital Movements and attempts to Fix Exchange Rates. October 1992. 28 pages. ISBN 1 874 770 44 1
45. Verrall R.J. Chain Ladder with Varying Run-off Evolutions. February 1993. 15 pages. ISBN 1 874 770 45 X

46. Gavin J., Haberman S. and Verrall R.J. Moving Weighted Average Graduation using Kernel Estimation. November 1992. 14 pages. ISBN 1 874 770 46 8
47. Gavin J., Haberman S. and Verrall R.J. On the Choice of Bandwidth for Kernel Graduation. November 1992. 21 pages. ISBN 1 874 770 47 6
48. S. Haberman. Pension Funding with Time Delays and the Optimal Spread Period. May 1993. 13 pages. ISBN 1 874 770 48 4
49. S. Haberman. Stochastic Investment Returns and the Present Value of Future Contributions in a Defined Benefit Pension Scheme. May 1993. 22 pages. ISBN 1 874 770 49 2
50. A. Zimbidis and S. Haberman. Delay, Feedback and Variability of Pension Contributions and Fund Levels. May 1993. 19 pages. ISBN 1 874 770 50 6
51. S. Haberman. Pension Funding: The Effect of Changing The Frequency Valuations. June 1993. 19 pages. ISBN 1 874 770 51 4
52. S Haberman. HIV, AIDS Markov Chains and PHI. June 1993. 15 pages. ISBN 1 874 770 52 2
53. S Haberman. A Consideration of Pension Credit and Termination Insurance. June 1993. 22 pages. ISBN 1 874 770 53 0
54. M Z Khorasane. Survey of Actuarial Practice in the Funding of UK Defined Benefit Pension Schemes. July 1993. 19 pages. ISBN 1 874 770 54 9
55. P M Booth, R G Chadburn and A S K Ong. A Utility Maximisation Approach to Asset Allocation. September 1993. 40 pages. ISBN 1 874 770 55 7
56. R G Chadburn. Bias in Select Mortality Investigations. August 1993. 62 pages. ISBN 1 874 770 56 5
57. M Z Khorasane. A Comparison of Pension Funding Strategies by means of Simulations for a Model Scheme. August 1993. 43 pages. ISBN 1 874 770 57 3
58. A E Renshaw, P Hatzopoulous and S Haberman. Recent Mortality Trends in Male Assured Lives. June 1993. 23 pages. ISBN 1 874 770 58 1
59. E Pitacco. Disability Risk Models: Towards A Unifying Approach. September 1993. 33 pages. ISBN 1 874 770 59 X
60. M Boskov and R J Verrall. Premium Rating by Geographic Area Using Spatial Models. September 1993. 14 pages. ISBN 1 874 770 60 3
61. R G Chadburn. Managing Mutual Life Offices: The Use of an Expense Ratio in New Business Decision Making and Expense Control. October 1993. 21 pages. ISBN 1 874 770 61 1
62. Haberman S. Pension Funding Modelling and Stochastic Investment Returns. 56 pages. March 1994. ISBN 1 874 770 62 X
63. Renshaw A E and Verrall R J. The Stochastic Model Underlying the Chain-Ladder Technique. 25 pages. April 1994. ISBN 1 874 770 63 8

64. Haberman S and Sung J-H. Dynamic Approaches to Pension Funding. 22 pages. April 1994.
ISBN 1 874 770 64 6
65. Renshaw A.E. On the Second Moment Properties and the Implementation of Certain GLIM Based Stochastic Claims Reserving Models. 36 pages. September 1994. ISBN 1 874 770 65 4
66. Booth P.M., J.N. Allan, and J.W. Jang. An Evaluation of the UK Life Insurance Mismatching Test. September 1994.
ISBN 1 874 770 66 2
67. Booth P.M. and Stroinski K. Insurance and Investment Markets in Poland. September 1994.
35 pages. ISBN 1 874 770 67 0
68. Ong A. A Stochastic Model for Treasury-Bills: An Extension to Wilkie's Model. September 1994. 12 pages.
ISBN 1 874 770 68 9
69. Bloomfield D.S.F. Moving on from Undergraduate Exams to Professional Exams: Actuaries. November 1994. 22 pages.
ISBN 1 874 770 69 7
70. Huber P. A Review of Wilkie's Stochastic Investment Model. January 1995. 22 pages.
ISBN 1 874 770 70 0
71. Renshaw A.E. On the Graduation of 'Amounts'. January 1995. 24 pages.
ISBN 1 874 770 71 9
72. Renshaw A.E. Claims Reserving by Joint Modelling. December 1994. 26 pages.
ISBN 1 874 770 72 7
73. Renshaw A.E. Graduation and Generalised Linear Models: An Overview. February 1995.
40 pages. ISBN 1 874 770 73 5
74. Khorasane M.Z. Simulation of Investment Returns for a Money Purchase Fund. June 1995.
20 pages. ISBN 1 874 770 74 3
75. Owadally M.I. and Haberman S. Finite-time Pension Fund Dynamics with Random Rates of Return. June 1995. 28 pages.
ISBN 1 874 770 75 1
76. Owadally M.I. and Haberman S. Stochastic Investment Modelling and Optimal Funding Strategies. June 1995. 25 pages.
ISBN 1 874 770 76 X
77. Khorasane M.Z. Applying the Defined Benefit Principle to a Defined Contribution Scheme. August 1995. 30 pages.
ISBN 1 874 770 77 8
78. Sebastiani P. and Settini R. Experimental Design for Non-Linear Problems. September 1995. 13 pages.
ISBN 1 874 770 78 6
79. Verrall R.J. Whittaker Graduation and Parametric State Space Models. November 1995.
23 pages. ISBN 1 874 770 79 4
80. Verrall R.J. Claims Reserving and Generalised Additive Models. November 1995. 17 pages.
ISBN 1 874 770 80 8
81. Nelder J.A. and Verrall R.J. Credibility Theory and Generalized Linear Models. November 1995.
15 pages. ISBN 1 874 770 81 6

82. Renshaw A.E., Haberman S. and Hatzopoulos P. On The Duality of Assumptions Underpinning The Construction of Life Tables. December 1995. 17 Pages. ISBN 1 874 770 82 4
83. Chadburn R.G. Use of a Parametric Risk Measure in Assessing Risk Based Capital and Insolvency Constraints for With Profits Life Insurance. March 1996. 17 Pages. ISBN 1 874 770 84 0
84. Haberman S. Landmarks in the History of Actuarial Science (up to 1919). March 1996. 62 Pages. ISBN 1 874 770 85 9
85. Renshaw A.E. and Haberman S. Dual Modelling and Select Mortality. March 1996. 30 Pages. ISBN 1 874 770 88 3
86. Booth P.M. Long-Term Care for the Elderly: A Review of Policy Options. April 1996. 45 Pages. ISBN 1 874 770 89 1
87. Huber P.P. A Note on the Jump-Equilibrium Model. April 1996. 17 Pages. ISBN 1 874 770 90 5
88. Haberman S and Wong L.Y.P. Moving Average Rates of Return and the Variability of Pension Contributions and Fund Levels for a Defined Benefit Pension Scheme. May 1996. 51 Pages. ISBN 1 874 770 91 3
89. Cooper D.R. Providing Pensions for Employees with Varied Working Lives. June 1996. 25 Pages. ISBN 1 874 770 93 X
90. Khorasane M.Z. Annuity Choices for Pensioners. August 1996. 25 Pages. ISBN 1 874 770 94 8
91. Verrall R.J. A Unified Framework for Graduation. November 1996. 25 Pages. ISBN 1 874 770 99 9
92. Haberman S. and Renshaw A.E. A Different Perspective on UK Assured Lives Select Mortality. November 1996. 61 Pages. ISBN 1 874 770 00 X
93. Booth P.M. The Analysis of Actuarial Investment Risk. March 1997. 43 Pages. ISBN 1 901615 03 0
94. Booth P.M., Chadburn R.G. and Ong A.S.K. Utility-Maximisation and the Control of Solvency for Life Insurance Funds. April 1997. 39 Pages. ISBN 1 901615 04 9
95. Chadburn R.G. The Use of Capital, Bonus Policy and Investment Policy in the Control of Solvency for With-Profits Life Insurance Companies in the UK. April 1997. 29 Pages. ISBN 1 901615 05 7
96. Renshaw A.E. and Haberman S. A Simple Graphical Method for the Comparison of Two Mortality Experiences. April 1997. 32 Pages. ISBN 1 901615 06 5
97. Wong C.F.W. and Haberman S. A Short Note on Arma (1, 1) Investment Rates of Return and Pension Funding. April 1997. 14 Pages. ISBN 1 901615 07 3
98. Puzey A S. A General Theory of Mortality Rate Estimators. June 1997. 26 Pages. ISBN 1 901615 08 1
99. Puzey A S. On the Bias of the Conventional Actuarial Estimator of q_x . June 1997. 14 Pages.

ISBN 1 901615 09 X

100. Walsh D. and Booth P.M. Actuarial Techniques in Pricing for Risk in Bank Lending. June 1997. 55 Pages. ISBN 1 901615 12 X
101. Haberman S. and Walsh D. Analysis of Trends in PHI Claim Inception Data. July 1997. 51 Pages. ISBN 1 901615 16 2
102. Haberman S. and Smith D. Stochastic Investment Modelling and Pension Funding: A Simulation Based Analysis. November 1997. 91 Pages. ISBN 1 901615 19 7
103. Rickayzen B.D. A Sensitivity Analysis of the Parameters used in a PHI Multiple State Model. December 1997. 18 Pages. ISBN 1 901615 20 0
104. Verrall R.J. and Yakoubov Y.H. A Fuzzy Approach to Grouping by Policyholder Age in General Insurance. January 1998. 18 Pages. ISBN 1 901615 22 7
105. Yakoubov Y.H. and Haberman S. Review of Actuarial Applications of Fuzzy Set Theory. February 1998. 88 Pages. ISBN 1 901615 23 5
106. Haberman S. Stochastic Modelling of Pension Scheme Dynamics. February 1998. 41 Pages. ISBN 1 901615 24 3
107. Cooper D.R. A Re-appraisal of the Revalued Career Average Benefit Design for Occupational Pension Schemes. February 1998. 12 Pages. ISBN 1 901615 25 1
108. Wright I.D. A Stochastic Asset Model using Vector Auto-regression. February 1998. 59 Pages. ISBN 1 901615 26 X
109. Huber P.P. and Verrall R.J. The Need for Theory in Actuarial Economic Models. March 1998. 15 Pages. ISBN 1 901615 27 8
110. Booth P.M. and Yakoubov Y. Investment Policy for Defined Contribution Pension Scheme Members Close to Retirement. May 1998. 32 Pages. ISBN 1 901615 28 6
111. Chadburn R.G. A Genetic Approach to the Modelling of Sickness Rates, with Application to Life Insurance Risk Classification. May 1998. 17 Pages. ISBN 1 901615 29 4
112. Wright I.D. A Stochastic Approach to Pension Scheme Funding. June 1998. 24 Pages. ISBN 1 901615 30 8
113. Renshaw A.E. and Haberman S. Modelling the Recent Time Trends in UK Permanent Health Insurance Recovery, Mortality and Claim Inception Transition Intensities. June 1998. 57 Pages. ISBN 1 901615 31 6
114. Megaloudi C. and Haberman S. Contribution and Solvency Risk in a Defined Benefit Pension Scheme. July 1998. 39 Pages. ISBN 1 901615 32 4
115. Chadburn R.G. Controlling Solvency and Maximising Policyholders' Returns: A Comparison of Management Strategies for Accumulating With-Profits Long-Term Insurance Business. August 1998. 29 Pages. ISBN 1 901615 33 2
116. Fernandes F.N. Total Reward - An Actuarial Perspective. August 1998. 25 Pages. ISBN 1 901615 34 0

117. Booth P.M. and Walsh D. The Application of Financial Theory to the Pricing of Upward Only Rent Reviews. November 1998. 23 Pages. ISBN 1 901615 35 9
118. Renshaw A.E. and Haberman S. Observations on the Proposed New Mortality Tables Based on the 1991-94 Experience for Male Permanent Assurances. February 1999. 40 Pages. ISBN 1 901615 36 7
119. Velmachos D. And Haberman S. Moving Average Models for Interest Rates and Applications to Life Insurance Mathematics. July 1999. 27 Pages. ISBN 1 901615 38 3
120. Chadburn R.G. and Wright I.D. The Sensitivity of Life Office Simulation Outcomes to Differences in Asset Model Structure. July 1999. 58 Pages. ISBN 1 901615 39 1
121. Renshaw A.E. and Haberman S. An Empirical Study of Claim and Sickness Inception Transition Intensities (Aspects of the UK Permanent Health Insurance Experience). November 1999. 35 Pages. ISBN 1 901615 41 3
122. Booth P.M. and Cooper D.R. The Tax Treatment of Pensions. April 2000. 36 pages. ISBN 1 901615 42 1

Statistical Research Papers

1. Sebastiani P. Some Results on the Derivatives of Matrix Functions. December 1995. 17 Pages. ISBN 1 874 770 83 2
2. Dawid A.P. and Sebastiani P. Coherent Criteria for Optimal Experimental Design. March 1996. 35 Pages. ISBN 1 874 770 86 7
3. Sebastiani P. and Wynn H.P. Maximum Entropy Sampling and Optimal Bayesian Experimental Design. March 1996. 22 Pages. ISBN 1 874 770 87 5
4. Sebastiani P. and Settimi R. A Note on D-optimal Designs for a Logistic Regression Model. May 1996. 12 Pages. ISBN 1 874 770 92 1
5. Sebastiani P. and Settimi R. First-order Optimal Designs for Non Linear Models. August 1996. 28 Pages. ISBN 1 874 770 95 6
6. Newby M. A Business Process Approach to Maintenance: Measurement, Decision and Control. September 1996. 12 Pages. ISBN 1 874 770 96 4
7. Newby M. Moments and Generating Functions for the Absorption Distribution and its Negative Binomial Analogue. September 1996. 16 Pages. ISBN 1 874 770 97 2
8. Cowell R.G. Mixture Reduction via Predictive Scores. November 1996. 17 Pages. ISBN 1 874 770 98 0
9. Sebastiani P. and Ramoni M. Robust Parameter Learning in Bayesian Networks with Missing Data. March 1997. 9 Pages. ISBN 1 901615 00 6
10. Newby M.J. and Coolen F.P.A. Guidelines for Corrective Replacement Based on Low Stochastic Structure Assumptions. March 1997. 9 Pages. ISBN 1 901615 01 4.

11. Newby M.J. Approximations for the Absorption Distribution and its Negative Binomial Analogue. March 1997. 6 Pages. ISBN 1 901615 02 2
12. Ramoni M. and Sebastiani P. The Use of Exogenous Knowledge to Learn Bayesian Networks from Incomplete Databases. June 1997. 11 Pages. ISBN 1 901615 10 3
13. Ramoni M. and Sebastiani P. Learning Bayesian Networks from Incomplete Databases. June 1997. 14 Pages. ISBN 1 901615 11 1
14. Sebastiani P. and Wynn H.P. Risk Based Optimal Designs. June 1997. 10 Pages. ISBN 1 901615 13 8
15. Cowell R. Sampling without Replacement in Junction Trees. June 1997. 10 Pages. ISBN 1 901615 14 6
16. Dagg R.A. and Newby M.J. Optimal Overhaul Intervals with Imperfect Inspection and Repair. July 1997. 11 Pages. ISBN 1 901615 15 4
17. Sebastiani P. and Wynn H.P. Bayesian Experimental Design and Shannon Information. October 1997. 11 Pages. ISBN 1 901615 17 0
18. Wolstenholme L.C. A Characterisation of Phase Type Distributions. November 1997. 11 Pages. ISBN 1 901615 18 9
19. Wolstenholme L.C. A Comparison of Models for Probability of Detection (POD) Curves. December 1997. 23 Pages. ISBN 1 901615 21 9
20. Cowell R.G. Parameter Learning from Incomplete Data Using Maximum Entropy I: Principles. February 1999. 19 Pages. ISBN 1 901615 37 5
21. Cowell R.G. Parameter Learning from Incomplete Data Using Maximum Entropy II: Application to Bayesian Networks. November 1999. 12 Pages. ISBN 1 901615 40 5

Department of Actuarial Science and Statistics

Actuarial Research Club

The support of the corporate members

CGU
Government Actuary's Department
Guardian Insurance
Hymans Robertson
KPMG
Munich Reinsurance
PricewaterhouseCoopers
Swiss Reinsurance
Watson Wyatt

is gratefully acknowledged.

ISBN 1 901615 39 1