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The Life-Cycle Distributional Consequences of Pay-As-You-Go and Funded Pension Systems

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and
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Flat-rate pay-as-you-go pension plans and funded pensions produce very different distributional outcomes, the single most important determinant of which is the different lifetime employment and earnings records of men and women.

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This paper — a product of the Finance and Private Sector Development Division, Policy Research Department — is part of a larger effort in the department to investigate the complex issues related to old age security arrangements. The study is funded by the Bank's Research Support Budget under research project "Income Security for Old Age." Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Daniele Evans, room N9-057, extension 37496 (October 1993, 75 pages).

Using a dynamic cohort microsimulation model (LIFEMOD), Falkingham and Johnson examine the life-cycle distributional consequences of a variety of pay-as-you-go (PAYG) and funded pension systems. This technique allows them to investigate both the socioeconomic characteristics and the number of people affected by a change in contribution or eligibility rules in any pension system.

LIFEMOD uses 1985 parameters for the United Kingdom so specific results are not valid for other countries. But winners and losers are likely to be similar across countries. They find that:

• Women benefit much more than men in a flat-rate PAYG system. In simulations, 84 percent of surviving women but only 33 percent of surviving men are net beneficiaries, because women have higher life expectancy and lower lifetime earnings.

• Imposing minimum contributions substantially reduces the number of women who qualify for a pension. Imposing a joint contribution rule on the earnings of married couples significantly increases the number of women qualifying without significantly reducing the proportion of qualifying men.

• In funded pension systems, on average men accumulate much more pension capital than women do because of men's higher earnings and more continuous paid work. Different rates of real interest and earnings growth affect individuals' fund accumulation differently. Women benefit more from high rates of return and low earnings growth because they tend to receive a higher proportion of their lifetime earnings when young. But some men and many women fail to achieve minimum pension levels. If the pension shortfall is compensated for by lump-sum capital top-ups, women receive 93 percent of top-ups (70 percent if joint contributions are used).

• In hybrid pension systems that combine both PAYG and funded elements, the higher the proportion of PAYG payments, the greater the replacement rate for people in the bottom 40 percent of the lifetime earnings distribution (the majority of whom are women). But replacement rates for people in the middle of income distribution are insensitive to any variant of the PAYG-funded combination.

In short, flat-rate pay-as-you-go pension plans and funded pensions produce very different distributional outcomes, the single most important determinant of which is the different lifetime employment and earnings records of men and women.

THE LIFE-CYCLE DISTRIBUTIONAL CONSEQUENCES OF PAY-AS-YOU-GO AND FUNDED PENSION SYSTEMS: A MICROSIMULATION MODELLING ANALYSIS

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This paper was prepared for the Public Sector Management and Private Sector Development Division of the World Bank.

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1. Context

The reform of public pension systems is a prominent policy issue in both the newly industrializing and the older industrial economies. Countries as geographically, economically and ideologically diverse as Argentina, China, Japan and Sweden are now inaugurating, or contemplating the introduction of, public pension reform. Although the proximate political and economic reasons for reform vary between countries, three common influences can be seen to be at work in both the old and the new industrial economies.

First is the demographic condition of population ageing. A rapid fall in fertility rates since the 1960s and rising adult life expectancy have combined to produce a rapid ageing from both the base and the apex of the population pyramid. The proportion of older persons in industrial societies is rising and so also is the cost of the pensions required to support these older people who, for a complex mix of social, economic and physiological factors, can no longer support themselves through participation in the labour market.

Second is the trend towards pension system maturity. Public pensions based on pay-as-you-go principles tend to be cheap to operate when new since they have many contributors and few beneficiaries, but over time these ratios change and the costs rise. Costs can be temporarily contained by incorporating new groups of workers into the pension system, thereby expanding the contribution base, but once most of the population is so covered the scope for further system expansion obviously becomes minimal. After several decades of low-cost expansion many public pension systems are now having to face the uncomfortably high costs of stable steady-state financing.

Third comes the economic and political consequence of a global slow-down in the rate of economic growth. The expansion of public pension provision since the 1960s has been financed by larger public revenues generated by a higher overall level of taxation. Ageing and pension system maturity are together creating further pressures for tax increases to cover rising pension costs, but tax increases are politically more difficult to sustain when overall incomes are stagnant or falling than when they are rising. Furthermore, one interpretation of the slow-down in growth is that it is to some extent a function of high taxes and large and inefficient public sectors.

Together these three influences contribute towards a global interest in cost-reducing reform of public pension expenditure. However, these economic and fiscal pressures are not the only factors that need to be considered in any pension reform; equally important are the distributional outcomes of pension systems. If pension reforms so alter pension outcomes that large groups of the pensioner population become incapable of supporting themselves in old age then the reforms will fail. They will fail politically if they cannot gain the support of the electoral majority, and they will fail economically if the government ends up substituting minimum income welfare payments for pensioners who previously would have received minimum pension benefits. Pension reform proposals, therefore, need to be assessed in terms of their distributional as well as their fiscal and macro-economic consequences.

This paper analyzes the life-cycle distributional outcomes of a wide variety of possible pay-as-you-go and funded pension systems. The second part of the paper briefly surveys the major characteristics of existing pension systems and establishes why distributional outcomes are an important aspect of pension system analysis. Section 3 explains how a dynamic cohort microsimulation model can directly address these distributional issues, and then summarizes the key concepts, principles and parameters of the LIFEMOD microsimulation model (Falkingham and Lessof, 1991, 1992) of the UK used in this paper. The fourth section of the paper presents the results of a large simulation modelling exercise, first looking at the distributional outcomes of pay-as-you-go systems, then looking at funded pension systems, and finally examining some hybrid systems. The final section summarizes the results of the simulation modelling exercise and suggests some policy implications.

2. Categories of pension systems

Pension systems can be designed and operated to achieve a wide diversity of goals, not all of them closely related to income security in old age. Examples can be found of pension systems set up to redistribute income, raise saving rates, provide cheap loans to the government or to reward political loyalty. From the perspective of the *individual*, however, the major purpose of a pension system is to effect an intertemporal transfer of income from years of employment to years of retirement, with the objective of improving the correspondence between the lifetime income profile and the lifetime expenditure profile. The target level of intertemporal income transfer will vary according to personal preference and economic capacity, but minimum and maximum targets can be determined in relation to retirement income. The minimum degree of intertemporal income transfer is that which provides a retirement income just sufficient to prevent (socially/culturally defined) abject poverty in old age, the maximum is that which provides a retirement income at the same level as that received before retirement. Where pre-retirement income is itself below some poverty threshold, the minimum condition dominates the maximum.

In a simple funded pension system, this intertemporal transfer occurs transparently through the accumulation by each worker of a personal capital fund which is used to produce an income stream after retirement. Such a system is highly individualistic, with interpersonal transfers often confined to the actuarially fair gains and losses that are a necessary element of any pension annuity scheme. In a flat-rate public pay-as-you-go scheme, by contrast, the contributions of the current population of workers pay for the pensions of the current population of pensioners. Public pensions of this type rest on an implicit contract between generations to maintain the tax-transfer pension system. This type of pension system is typically viewed as being highly collective for two reasons. First, flat-rate pensions based on flat-rate payroll contributions are redistributive towards people with substantial time out of the labour force and so with low or zero lifetime incomes (graduated contributions obviously increase the degree of redistribution). Secondly, the implicit intergenerational transfer contract necessarily binds as-yet unborn generations to the pension system, since for the system to be sustained they will have to agree to pay for the pensions of current generations of workers.

In a public pay-as-you-go pension system individuals never directly pay for their own pension. But this does not necessarily mean that there is a great deal of interpersonal redistribution in such a pension system; it may be the case that, over the life course, individuals get out of the pension system roughly what they put into it. The nature of the intergenerational contract on which public pay-as-you-go pension systems are based makes it difficult to disentangle the life-time extent of interpersonal compared with intra-personal transfers. The intra-personal (across the same individual's life-course) transfer effects of public pensions are not transparent as they are with individualistic funded pension schemes, but this does not mean that they are inconsequential. Below we report some simulation results which show the extent to which a pay-as-you-go public pension system can bring about intra-personal as well as interpersonal life-time transfers.

Pure public pay-as-you-go or private funded pension systems can be thought of as being at opposite ends of a spectrum of pension types, and many countries operate some sort of hybrid system. Many pay-as-you-go public pension systems combine earnings-related pensions with minimum pension thresholds. They do this in an attempt to meet the objective of poverty prevention in retirement while also providing scope for a degree of income replacement relative to the worker's former earnings. Private funded pension schemes normally have no minimum pension thresholds - poverty prevention in old age is seen as the function of government, not of the pensions industry. However, public funded pension systems, such as the Chilean funded pension system, do provide minimum pension entitlements for contributors whose own capital funds are insufficient to purchase a minimum pension annuity. Minimum pension entitlements of this sort involve a charge on government revenue, and this charge must be included in any evaluation of the overall cost of a public funded pension system. Some of the early assessments of the performance of the Chilean system, for instance, have paid inadequate attention to the potential long-run tax cost of providing top-up pensions to pension system affiliates who have inadequate capital at retirement owing to a history of low or discontinuous pension contributions. It is, of course, very difficult to estimate the likely long-run cost of individual pension capital shortfall until a pension system is mature. In the case of Chile, after just eleven years of operation, the current funded system is flush with funds because contributions significantly outweigh pension pay-outs, but in the long-run the tax cost of pensions for the poorer affiliates may be high. In the simulations presented below we make some estimates of the tax costs of top-up pensions in order to give an indication of the potential scale of this problem.

The categorisation of pension systems by type, according to their position on a spectrum between private funded and public pay-as-you-go, is useful for the purposes of academic pension system analysis, but from the perspective of individual contributors and pensioners, criteria other than the administrative and financial principles of the system may be more important. As already mentioned, the adequacy of any pension system, both in terms of poverty prevention and earnings replacement, is an important criterion, but equally important are the comprehensiveness and the stability of any system. If a public tax-financed pension system provides limited coverage of the population, serving only the long-run retirement saving needs of the fully-employed, or of the high-paid, or of privileged sub-groups such as public servants, then it will tend to effect transfers from the poor to the rich and fail to provide social protection at older ages for the economically more vulnerable sections of society. This is a criticism that can be levelled at many tax-financed pension systems for the military and civil servants. Comprehensiveness is a necessary attribute of any public pension system which has, as one of its goals, the prevention of poverty in old age.

A further attribute of pension systems that is sought by contributors and pensioners is that the income stream in retirement should be stable and secure. This is a difficult goal to achieve in funded schemes because real rates of return vary over time and capital markets undergo periodic crises. Tax-financed public pension systems at first sight appear to offer better prospects of stability because the risks associated with economic uncertainty can be spread by government across all individuals and economic sectors. In practice, however, public pay-as-you go pension systems have displayed substantial instability over time, with recurrent changes to contribution and replacement rates, eligibility rules and taxation policies. When public pay-as-you-go pension systems are immature, with few beneficiaries and many contributors, these changes can consistently be in a liberalising direction; this was the experience in all developed countries in the 1950s, 60s and 70s. System maturity, however, has imposed financial discipline, and changes are now more often aimed at retrenchment. Retrenchment involves reneging on some of the promises offered in the implicit pension contract, and this may involve political costs; proposals put forward in the fall of 1992 in Italy to reduce future public pension levels as part of a general austerity package brought thousands of pensioners onto the streets in protest. The modelling exercise that we carry out below examines the life-cycle earnings profiles of individuals, and *assumes* pension system stability. This is a strong assumption, but a necessary one for comparisons to be made between the outcomes generated by different pension systems.

3. The LIFEMOD microsimulation model

i) Why a modelling approach

The previous section discussed a range of different pension systems. To fully evaluate the distributional implications of these different schemes it is necessary not only to look at the annual costs and benefits, but also to examine the impact over an individual's entire life-cycle. How well do the various schemes meet the criteria of adequacy, comprehensiveness, and stability identified (along with distributional transparency) above. Are certain types of schemes more efficient at redistributing resources from one point in a person's life-time to another i.e. from periods of time when individuals are in employment to times when they are not. Which groups of people will fail to build up adequate contribution records or accumulate a sufficient personal retirement fund? How large will the shortfall be? How much redistribution *between* individuals will be necessary to ensure a guaranteed minimum pension given the diversity of labour market experiences, non-waged caring responsibilities and other demographic characteristics etc.?

To answer such questions we require information on a range of characteristics not just at one point in time but across the entire life-cycle. No such source of longitudinal data exists. Even where longitudinal surveys have been carried out (Medical Research Council 'Douglas cohort'; National Child Development Survey; OPCS Longitudinal Survey, Michigan Panel Study of Income Dynamics (Duncan, 1984, Elder, 1985)) the information is only for periods within the life course, not complete life histories. Economists have frequently attempted to estimate lifetime profiles or functions using a range of econometric and simulation techniques (e.g. Blinder, 1974; Lillard, 1977). While such approaches have shed light on particular aspects of lifetime profiles, they have all failed to a greater or lesser extent to capture the enormous degree of change in the circumstances of individuals over time. For example, plotting the lifetime earnings profile of married men fails to take into account that very few men stay constantly married and constantly in the labour force for their entire lives. It is precisely these changes in marital and employment statuses that are of particular importance in determining an individual's ability to accumulate pension entitlements over their working life. Ignoring the degree of change in personal circumstances when attempting to provide a picture of lifetime welfare is thus a critical omission.

An alternative modelling option which endeavours to incorporate the diversity and constant change in the circumstances of individuals over time lies in dynamic microsimulation models. Microsimulation is the synthetic generation of data about social and economic 'micro' units. There are three major types of microsimulation models: static models; dynamic population models; and dynamic cohort models (Merz, 1991). The type of simulation model which is applicable is dependent on the question which needs to be answered.

Static models are used for estimating the immediate impact of policy changes by systematically varying certain behavioral relations and/or institutional conditions of a microdata base. Perhaps the best known examples of static models are those first developed in the US such as the TRIM (TRansfer Income Model) (Sulvetta, 1976) which is used to investigate the impact of changes to payroll taxes and to both State and Federal income taxes, and TAXSIM - the tax policy analysis model developed at NBER (Feldstein, 1983). Such models take as their microdata base cross-sectional information on a representative sample of the population of a country e.g. TAXMOD at the LSE is based on data from the Family Expenditure Survey (Atkinson and Sutherland, 1988).

Dynamic Population models also take a sample of the population as their initial microdata base. However, in this instance the sample is then projected forward through time. Each microunit of the sample is aged individually by an empirically based survivorship probability (Merz, 1991). In addition, the occurrence of other demographic events may be simulated. For example, a family unit could be diminished in size through divorce or augmented through the birth of a child during the simulation process. By the process of dynamic demographic ageing the size of the cross-section under investigation will be altered. Dynamic population models such as DYNASIM (Orcutt et al, 1976) are therefore particularly useful for forecasting the future characteristics of the population and thus for modelling the effects of policy change over the *longer* period.

Dynamic Cohort models employ the same dynamic ageing process as population models. However the microdata base is not underpinned by the characteristics of a real sample unit but rather the simulation process itself creates 'synthetic' microunit's and forecasts the whole life-cycle from birth to death. The advantage of this type of micro-simulation is the availability of information for *complete* life histories for each cohort member. In contrast, dynamic population models typically produce incomplete life-histories, mapping only a few decades of the lives of individuals from many different age groups (although, the same lifetime profiles could be generated using a dynamic population model where the microunit is children aged 0 and the simulation period 100 years!). Dynamic cohort models are thus particularly suitable for addressing questions concerned with life-times and the life-cycle; for example, accumulation of public and private pension rights. This paper thus relies on a dynamic cohort microsimulation model - LIFEMOD - to provide the longitudinal data necessary.

ii) LIFEMOD

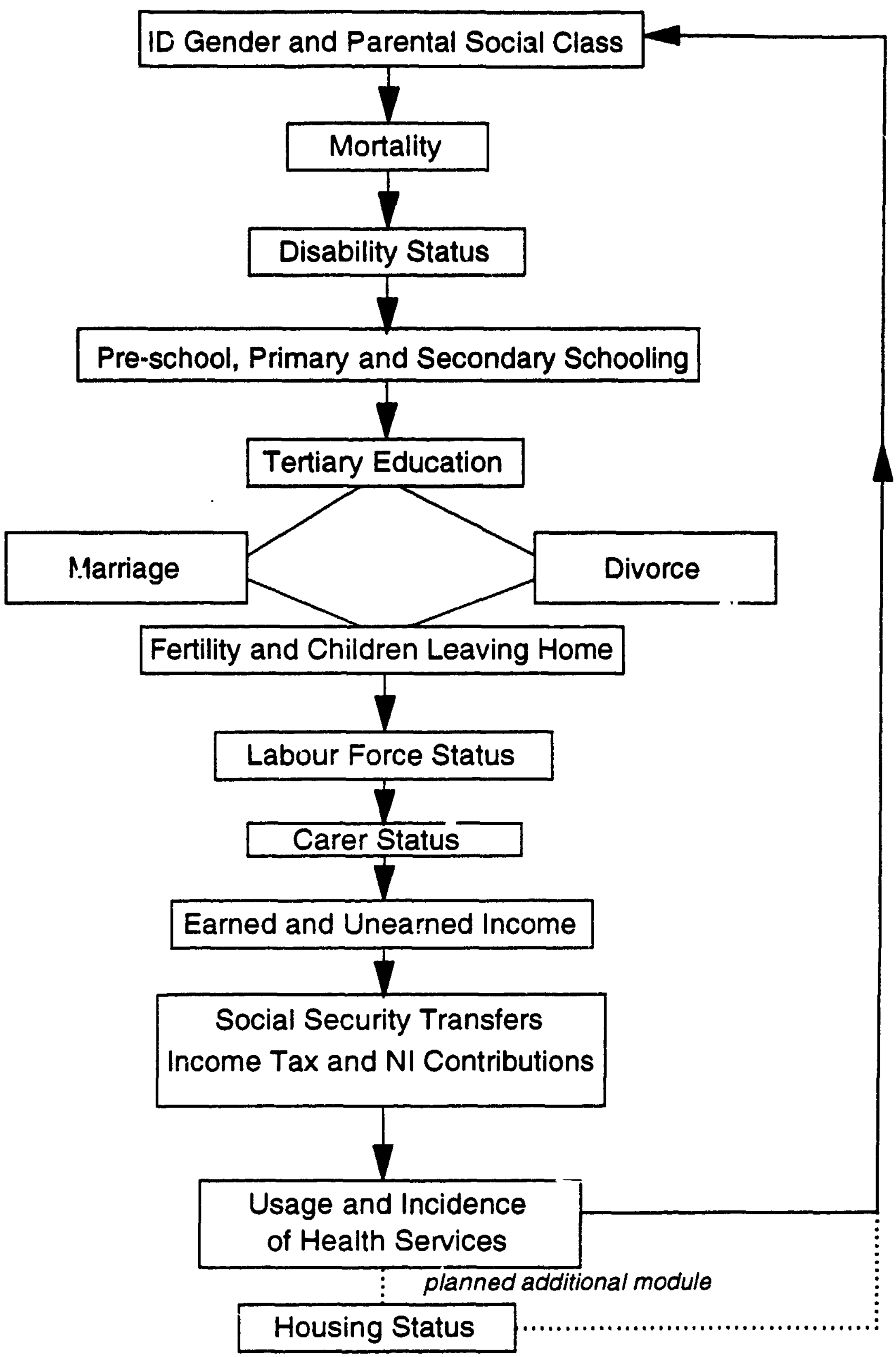
LIFEMOD is an example of dynamic cohort microsimulation, simulating the life histories of a cohort of 2000 males and 2000 females. Each individual is born in the same year and is followed from birth through to death, experiencing major life events such as schooling, marriage, childbirth, children leaving home, employment and retirement as illustrated in Figure 1. There is no immigration or emigration into or out of the cohort, and the only way in which the cohort changes size is from attrition due to mortality.

Ageing of the cohort is achieved through explicit modelling of the demographic and socio-economic process. Because the attributes of each person at time *t+1* are determined using the attributes at time *t*, the cohort is aged 'dynamically' rather than 'statically'. This ageing is based on the probabilities of the various demographic and other transitions occurring. These probabilities are estimated from official statistics, sample surveys and other data sources. Transitions between various states are then simulated by using the relevant probabilities allied with Monte Carlo selection processes.

A randomly generated number ranging from 0 to 1, drawn from a uniform distribution, is assigned to the record of each individual for every year (up to, and including, year 95). Taking mortality experience as an illustration, if the randomly generated number attached to an individual is less than the probability of dying in that year, given the age and sex of the person, then the individual dies and their records are terminated. For example, the death rate for males aged 20 in 1985 was 0.93 per 1000. Since the random numbers are exactly uniformly distributed, two cohort males will be selected to die at age 20. However, where the random number exceeds or equals the mortality probability, the person survives to the next year of life. In this way, they become part of the pool 'at risk of death' in the following year where they are subject to the same procedure (with a new probability of death and different random numbers).

A similar approach is adopted, for example, for entry into the labour-force. The

FIGURE 1: Structure of LIFEMOD



transition probability for any woman is dependent on her age, gender, the age of her youngest child, her previous labour market status, education level and so on. In this instance, once an individual has been selected to be employed via the Monte Carlo process, additional characteristics such as wage or unearned income are subsequently generated using a regression equation.

The LIFEMOD cohort is 'born' into, and subsequently lives in, a world that looks like 1985. Although the steady state assumption results in a highly stylized 'population' it nevertheless provides a useful benchmark against which current government policies, and changes to those policies, can be evaluated. As Summers noted in 1956, the instability of the size of the distribution of income makes data about the lifetime income distribution in the past of little help in analyzing the lifetime income distribution of today, while the future distribution of income is unknown (1956). Summers saw great potential in the construction of steady-state or 'latent' income distributions which would allow one to answer questions about lifetime income distribution given *existing* economic conditions. The steady state world is also assumed in other dynamic cohort models, such as the Australian HARDING (1990b), the Canadian DEMOGEN (Wolfson, 1990) and the West German SFB3 models (Galler and Wagner, 1986).

It is important to note that one effect of this steady state assumption is that the model results are affected by the considerable age, cohort and period effects which are inherent in the transition probabilities applied. Several classic examples of these effects exist. One is that model projections of marriage and fertility may underestimate lifetime rates because of the current trend to delay the age of first marriage. Similarly lifetime education experience may be overestimated, combining the higher rate of entry into tertiary education for 18 year olds in 1985, with those of mature students who did not have the opportunity when they were 18 but are 'returning' to education in the 1980s.

Throughout the model it should be appreciated that this is a *hypothetical* population; the model shows what the population *would* look like if age-gender specific mortality rates remained at the 1985 levels until the year 2080 (i.e. for 95 years) rather that what the population *did* look like in 1985. This is of particular importance when the model is used for cross-sectional analysis, although it should be borne in mind that even for lifetime analysis the cohort experience does not reflect a 'real' lifetime.

It is also important to point out that the micro unit which LIFEMOD simulates is the individual rather than the family or the household, and therefore it is only the characteristics of the cohort individuals *themselves* that are modelled. For example we have no comprehensive information on the children of each cohort member but simply their age, parity, and whether or not they are participating in full-time education (that is, whether or not they are classified as dependent children). LIFEMOD does not contain detailed information about the wider household composition of cohort members, unlike other micro-simulation models such as that developed at Tilburg University (Nelissen, 1987).

Figure 2

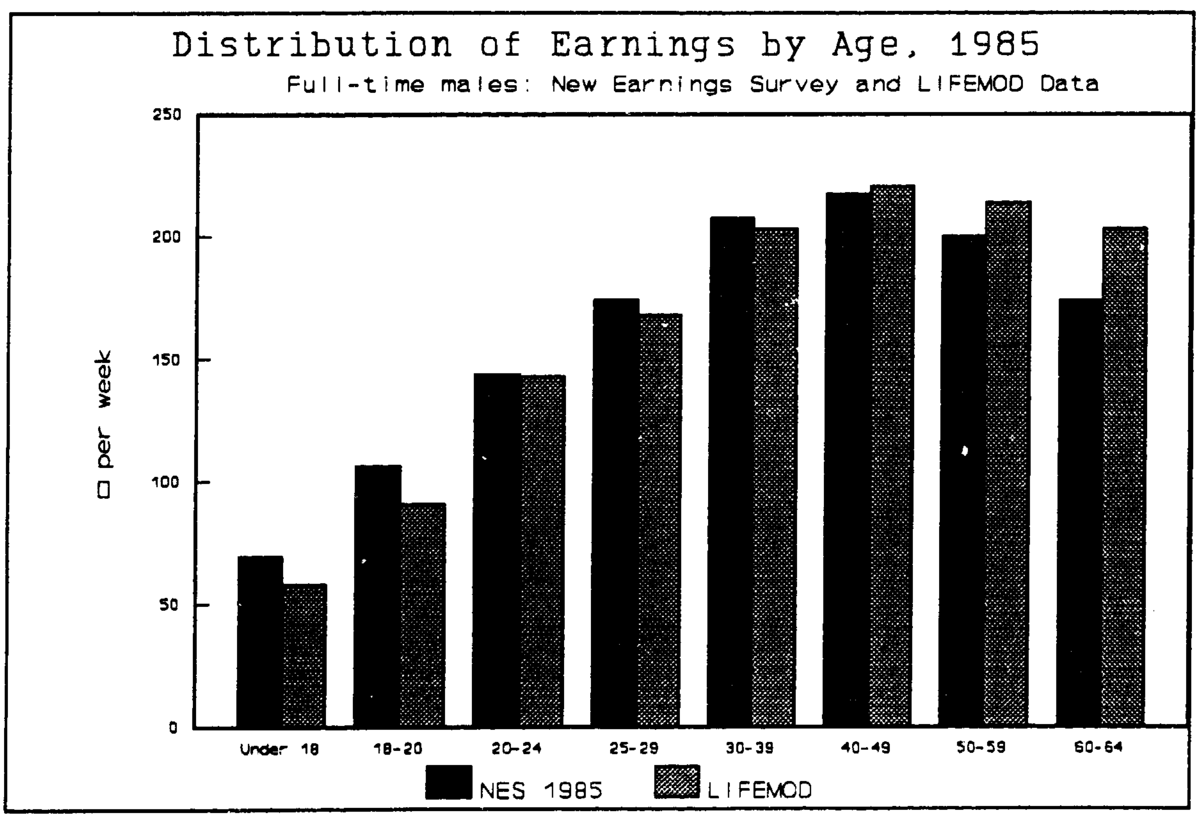
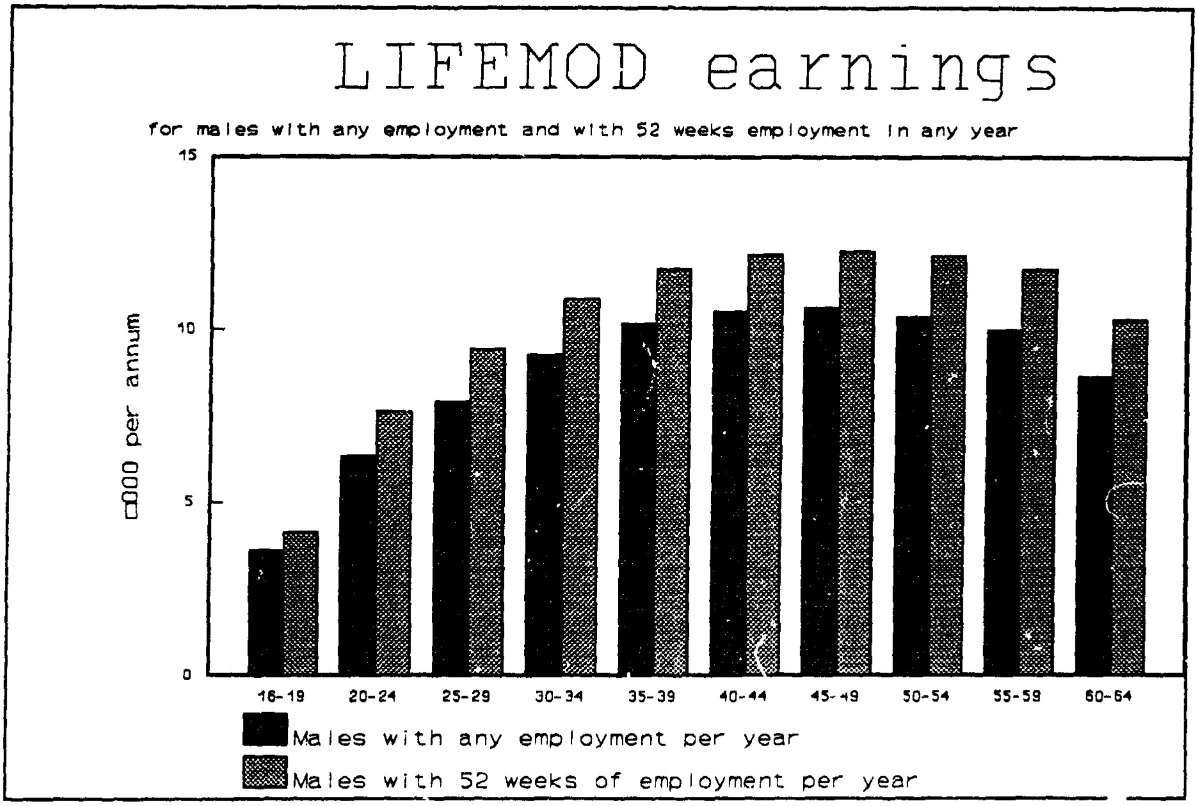


Figure 2 illustrates how the age-specific average full-time male earnings of the LIFEMOD cohort compare with those of the actual 1985 cross-section drawn from the New Earnings Survey. The age-earnings profiles are very similar, although earnings at older ages in the LIFEMOD cross-section are consistently above those in the NES. This reflects the higher educational achievement of the LIFEMOD population compared with the actual UK working population in 1985. Both sets of earnings data show a decline from age 50, and so exhibit the hump-shaped pattern typical of cross-section age-earnings profiles. Note that both these profiles refer to males in full-time employment. Figure 3 shows that average male earnings are consistently below full-time earnings.

Figure 3



In the analysis below, the results from the model are used in three different ways:

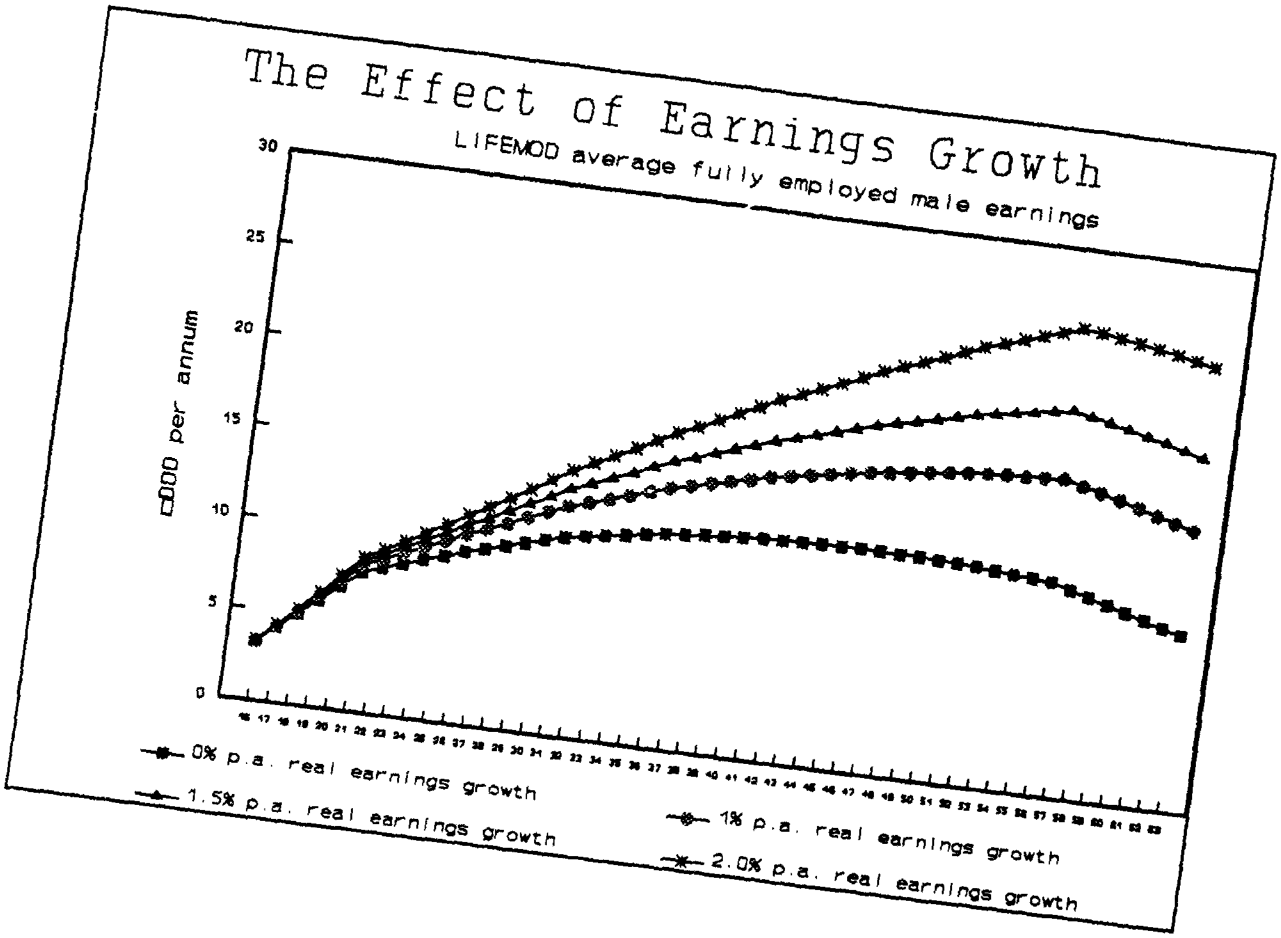
(a) the position of each individual in each year they are alive (from age 16) can be treated as a separate observation (giving 234,000 of them) and the results analyzed as if they represented a *cross-section* through a population of all ages.

(b) Earnings, contributions and pension receipts can be totalled over all years of each individual's life to give results for their *lifetime* distributional effects

In both (a) and (b) we assume that in our steady state world the real rate of return to capital is equal to the rate of real earnings growth at zero. Therefore we can compare the cross-section population profiles to the lifetime cohort profiles in order to examine the distributional impact of PAYG pensions. Because of the current nature of PAYG financing, with this year's contributions paying for this year's pensions, the costings need to be carried out on a constant price basis. This is particularly important in any assessment of the lifetime interpersonal transfer effects of a PAYG system. The imposition of earnings growth on these calculations would inevitably make it appear that almost everyone was a lifetime gainer from a PAYG system. The assumption of zero earnings growth has the same effect as applying a discount rate equal to the rate of real earnings growth to past PAYG contributions.

(c) Again earnings etc. are totalled over the lifetime but now the parameters are altered to incorporate divergent rates of real interest rate and earnings growth. Figure 4 shows the pattern of average male full-time earnings growth over the life-cycle on the basis of three different rates of real earnings growth. We are only able to introduce earnings growth because we abstract from the remaining components of the social security system i.e. other cash benefits which are payable during the earlier phases of the life course. Implicitly, therefore, we are assuming that the system of pension entitlement accumulation is separate and independent of the system of poverty alleviation. Because of the introduction of interest rates and earnings growth, there is no analogous cross-sectional population available for comparison to the cohort as any cross-section drawn from the simulation would suffer from period effects consequent on the rate of real earnings growth. Results embodying positive real rates of return take account of the 'historic' nature of any individual's accumulated pension capital and are used to assess the pattern of asset accumulation and the distributional impact of capital top-ups in funded pension schemes.

Figure 4



4. Simulating pension systems

i) Pay-as-you-go pension systems

Typically in a PAYG scheme this year's contributions (taxes) are equal to this year's benefits i.e. $W^*t^*E = R^*p$ where W equals the working population, t the tax rate, E average wage, R the retired population and p the level of pension benefits. Using LIFEMOD as a cross-section it is possible to establish the necessary payroll tax burden, t, to finance any given level of pension. If p is related to E i.e. $p=\alpha E$ then $t=\alpha R/W$ where α is the required replacement ratio. If the demographic structure of a population is constant across time then changes in t will depend exclusively on α.

LIFEMOD allows us to examine the distributional effect of introducing a payroll tax on the working population to finance pensions for persons over age 65. The level of contribution is set to be actuarially neutral for the cohort as a whole, providing a flat rate pension of 33 percent of average full-time male earnings (the required contribution rate in this case is 15% of earnings). In the LIFEMOD cross-section (as in any cross-sectional analysis of PAYG pensions) there is necessarily a flow of resources from young to old. However, over a lifetime in this steady state world there are no flows between generations as the lifetime contributions and lifetime benefits of each birth cohort are identical. This does not however imply that there is no inter-personal redistribution of resources, but rather that when redistribution occurs, it does so between members of the same cohort. Twenty percent of the LIFEMOD cohort die before reaching retirement age (61% of these are men, 39% women). By definition, these individuals are losers, i.e. tax > benefits, but their losses mean that, of those who survive to age 65, 60% are net beneficiaries from the PAYG pension system, and only 40% are net taxpayers. Those who survive to retirement age (65) on average receive benefits that total nearly twice the amount of contributions made.

Table 1
Lifetime redistribution effects steming from flat-rate PAYG pension

	Q1	Q2	Q3	Q4	Q5
ALL Ratio (ben/contrib)	4.29	2.00	1.31	.94	.61
MEN Ratio (ben/contrib)	3.82	1.52	1.16	.86	.59
WOMEN Ratio (ben/contrib)	4.31	2.12	1.50	1.13	.76

Table 1 shows the ratio of benefits received to contributions paid to individuals who have survived to age 65, ranked (both for the whole population and for men and women separately) by quintile of lifetime earnings. Women experience a higher ratio of lifetime benefits than men in the same quintile. Unsurprisingly those persons with the lowest lifetime earnings receive the highest ratio of benefits to contributions. This holds within the sexes. Thus PAYG has the effect of redistributing resources from men to women and from rich to poor.

The clearest characteristic of net lifetime beneficiaries from this PAYG pension system is gender; women are more than twice as likely as men to gain from the system, with 81% of surviving women but only 37% of surviving men being net beneficiaries. The disproportionate gains of women are a consequence of lower lifetime tax payments due to lower lifetime earnings, and higher lifetime benefits because of higher life expectancy. The average age of death among net beneficiaries is 82.5 years, compared with 73.2 years for net taxpayers. Table 2 shows, for all people who survive to age 65 and for males and females separately, the socio-demographic characteristics of net beneficiaries and net losers from this simple PAYG scheme.

Table 2
Socio-economic characteristics from LIFEMOD of lifetime net beneficiaries and net taxpayers in a simple PAYG pension scheme

ALL SURVIVORS

Characteristics	Net Ben	Net Tax
Age of death	82.5	73.2
Ever lone parent(%)	27.7	10.1
Ever divorced (%)	36.2	37.2
Years divorced	8.8	5.6
Years tertiary educ.	0.9	1.4
Years of unemployment	3.8	4.1
Years of employment	30.9	37.0

MALE SURVIVORS

Characteristics	Net Ben	Net Tax
Age of death	82.7	73.7
Ever lone parent(%)	1.6	1.4
Ever married (%)	82.5	89.3
Ever divorced	34.5	36.6
Years divorced	6.3	4.8
Years tertiary educ.	0.73	1.4
Years of unemployment	6.9	4.8
Years of employment	35.3	38.5

FEMALE SURVIVORS

Characteristics	Net Ben	Net Tax
Age of death	82.8	71.5
Ever lone parent(%)	38.3	35.6
Ever married (%)	93.0	92.2
Ever divorced	36.9	39.0
Years divorced	9.8	8.2
Years tertiary educ.	1.0	1.5
Years of unemployment	2.5	1.9
Years of employment	29.1	32.4

From the first panel of Table 2 it is clear that longevity, lone parenthood, a low level of tertiary education and a history of relatively low participation in the labour force are all characteristics of net beneficiaries from the PAYG system. When the data is divided by sex, in the second and third panels, it becomes clear that lone parenthood is not a significant factor within each gender group, and that that although men are more likely to be net taxpayers if married (cross-sectional surveys show married men to have higher earnings than unmarried men), women are more likely to be net beneficiaries if married (because of an increased probability of bearing children). For men to stand a high chance of being net beneficiaries from this flat-rate tax-financed PAYG pension system, they need to be ill-educated and long-lived.

The results described above concern only the simplest steady state case where eligibility for a pension is dependent solely upon chronological age. The majority of PAYG pensions also incorporate some additional eligibility criteria, usually related to a minimum level and/or duration of contributions. The array of possible contribution conditions is almost unlimited. Here we have confined the simulation exercise to modelling 2 main variations. It is assumed that individuals who fail to meet the contribution requirements receive a reduced flat-rate pension of half the level of the basic pension (i.e. 16.5 per cent of average full-time male earnings).

Contribution condition assumptions

Condition 1 To qualify for a full flat rate pension the cohort individuals have to fulfil the requirement at least 20 years worth of contributions (i.e. 1040 weeks). A degree of contribution record protection is afforded for women with unpaid home responsibilities due to child care. In any year where a woman is not in receipt of *any* earnings and has a child aged under five years of age then she is automatically credited with a full year's contributions.

Condition 2 It is more common to have contribution conditions that combine both duration and level of contribution. Now entitlement is assumed to depend on having 20 years of contribution where in each year the minimum level of contribution is at least one third of the expected contribution made by an average full-time male employee. The same system of contribution protection for non-working women with young children applies. This is similar in principle to the Home Responsibility Protection (HRP) scheme currently operating in Britain where women who do not work during a complete fiscal year and who are in receipt of child benefit are ascribed a full contribution year.

The introduction of a contribution condition dependent solely upon duration makes little difference to pension receipt. Ninety-nine percent of men and ninety-four percent of women who survive to retirement age at 65 have made contributions in at least 1040 weeks of their working lives. Thus the mean level of pension received is barely affected, and only 0.9% of people who were net beneficiaries become net tax-payers. However, when duration is combined with a minimum level of required contribution, this has the effect of excluding a much greater number of people. Ninety-seven percent of men continue to qualify for a full pension, but only two thirds (67%) of women do despite HRP. Because HRP only applies to complete years this has the effect of penalising women with young children who take a low paid job for part of the year. Such women may find themselves in the position where they lose their HRP credit and fail to make sufficient contributions whilst working to qualify as a contribution year.

The introduction of contribution conditions significantly affects who are the winners and losers. Table 3 shows the proportion of men and women who, by any age, have a contribution record sufficient in terms of duration (C1) or duration and level (C2) to meet the minimum contribution requirements set out above.

Table 3
Proportion of men and women who qualify for PAYG pension under different contribution rules, by various ages and lifetime marital status.

	NEVER MARRIED				EVER MARRIED			
	Men		Women		Men		Women	
	C1	C2	C1	C2	C1	C2	C1	C2
35-39	14.1	9.7	10.9	4.0	14.7	10.2	12.2	2.7
40-44	53.3	43.2	33.3	21.6	55.1	48.5	47.6	15.4
45-49	76.2	68.6	53.3	38.9	82.9	76.9	69.4	28.5
50-54	87.8	81.8	63.6	49.4	94.0	90.4	82.6	41.8
55-59	92.3	87.3	74.3	60.8	97.6	95.5	89.5	54.2
60-64	94.8	89.2	84.3	70.7	99.0	97.8	93.6	64.6

As expected, most men reach the duration threshold under *Condition 1* by their mid-40s, because of their propensity to work full-time. Women accumulate their contribution record more slowly, but even so the great majority reach the minimum level by age 65. Although never-married women have more years of employment (and so of contribution) than ever- married women, the home responsibility protection condition allows more ever-married women to meet the necessary minimum number of contributions than never-married women at any age. The combination of minimum duration and minimum level of contribution required under *Condition* 2 is more difficult to meet, particularly for women because much of their employment is low-paid and part-time. Fewer than two-thirds of all women now meet the minimum pension qualification requirements. Ever-married women are affected more because they are more likely than never-married women to work part-time, and therefore many of them fail to make an adequate level of contribution despite satisfying the duration condition.

<u>Joint contributions</u>

So far we have only examined PAYG systems that are based exclusively on individuals' own contribution records. However, in many countries there is provision for joint treatment of married or cohabiting couples. Under our joint contribution rule, we assume that the recorded duration and level of pension contribution by both partners is split equally, as is the HRP protection if received by a non-working mother. Table 4 reports the outcomes for ever-married individuals (never-married individuals cannot, by definition, experience contribution sharing).

Table 4
Proportion of ever-married men and women who qualify for PAYG pension under different contribution rules with contribution-sharing, by various ages.

	Men		Women	
	C1	C2	C1	C2
35-39	8.6	9.2	10.2	7.8
40-44	50.8	48.7	49.1	41.8
45-49	81.9	77.3	75.9	67.7
50-54	94.1	90.3	88.3	82.0
55-59	97.7	95.0	93.6	88.6
60-64	99.0	97.4	96.4	92.1

Table 4 can be directly compared with the right-hand half of table 3; the differences are the direct outcome of contribution sharing. The impact on ever-married men is minimal; under both *Condition 1* and *Condition 2,* men have such an excess of weeks and amount of contributions above the minimum qualifying level that sharing with their partners is virtually costless. For women, on the other hand, the sharing of contributions has an enormous effect on their ability to qualify under the joint level and duration requirements of *Condition 2.* The outcome from any contribution sharing rule will depend crucially on the minimum pension qualifying conditions. As the minimum duration and level of contributions is raised, so contribution sharing will become more costly for men, more of whom will fail to qualify, and less beneficial for women, fewer of whom will be brought up to the minimum threshold. This example shows, therefore, that contribution sharing can have a significant effect on outcomes in any PAYG pension system that has minimum qualifying conditions.

<u>Intergenerational PAYG transfers</u>

If we relax the assumption that fertility and mortality (and so the contributor and beneficiary populations) remain constant but assume that the pension replacement rate α remains the same, then the tax rate must necessarily change. It is just such a change in the ratio of contributors to beneficiaries over the next three decades as the baby-boomers enter retirement that has raised concern in many developed countries about the long-run cost of pay-as-you go public pensions. A stylised example for a hypothetical unfunded pension system in a static economy is illustrated in Table 5. In this example the first cohort (A) contains two people, and population grows over the next six generations before beginning to decline. Members of each generation live for two periods; the first is a time of work and pension contribution, the second a time of retirement and of receipt of pension benefit. Each member of each generation contributes £10 to the social security system while working, and each generation draws a pension funded from the contributions of its successor generation (cohort B pays for cohort A's pensions, C pays for B, D for C, and so on). When the population is growing each generation enjoys pension benefits greater than its pension contributions, so the value of benefits is always higher than the individual contributions of £10 made during working life. Larger gains are enjoyed by the earlier cohorts because of their small size relative to the working population, and the greatest gains are captured by the initial generation which pays no contributions but receives windfall benefits. However, when population begins to decline (from generation G) the pension funds available for each generation become smaller than that generation's net contribution when working; per capita contributions now exceed benefits. When the transfer chain is increasing everyone gains as each generation receives back more than it pays in, but when the transfer chain is decreasing everyone loses.

Table 5
The contributions and benefits of successive cohorts in a hypothetical pay-as-you-go pension system

Cohort	A	B	C	D	E	F	G	H	I	J	K
Cohort size	2	3	4	5	6	7	8	7	6	5	4
Contrib	0	30	40	50	60	70	80	70	60	50	40
Contrib p.c.	0	10	10	10	10	10	10	10	10	10	10
Benefits	30	40	50	60	70	80	70	60	50	40	30
Benefits p.c.	15	13.3	12.5	12.0	11.7	11.4	8.75	8.57	8.33	8	7.5

A demographically-induced intergenerational redistribution of the type illustrated in table 5 is a potentially important consequence of a pay-as-you-go pension system operating under unstable demographic conditions, but we *do not* attempt to model it in this paper. As explained above, dynamic cohort microsimulation models forecast the whole life-cycle of one generation from birth to death, and so do not readily allow for successive generations with different demographic characteristics. We think it may be possible to develop a stacked dynamic cohort model which would allow at least two successive generations to be modelled simultaneously, but this is uncharted territory and is beyond the scope of this paper. A second reason for avoiding the intergenerational transfer issue is that it necessarily requires policy judgements to be made about how to pay for the transfers - do taxes rise, or pension replacement rates fall? As noted in section 1, we assume pension system stability in all our reported simulations, but system stability is not consistent with a shift in demographic ratios.

ii) Funded pension systems

Any simulation of the distributional consequences of a funded pension system must necessarily rest on a number of demographic, financial and administrative assumptions. Before discussing the simulation modelling exercise, we will outline the range of assumptions we have used and indicate what we think are the more plausible scenarios. The modelling of a funded pension system can logically be split into two parts - the accumulation of a capital fund during working life, and the decumulation of this fund during retirement. The process of accumulation is modelled in LIFEMOD, but the decumulation is based on a simple annuity calculation.

<u>Annuity calculations</u>

For the sake of simplicity we assume that all individuals at retirement purchase an annuity with the pension capital that they have accumulated. We do not model any alternative way of using the capital, such as some form of regulated spend-down, as is allowed in the public funded pension systems in Chile and Singapore. There is no reason in principle to prevent the modelling of spend-down systems, but to do so requires the formulation of spend-down rules which are likely to be more arbitrary than the assumption of annuity purchase. For the annuity calculations, we make the following simplifying procedural assumptions:

- that all individuals are born on 1 January and die on 31 December, so that chronological age and calender years coincide
- that retirement occurs on 31 December before the retirement age birthday (i.e. retirement at 65 means retirement occurs on 31 December of the 64th year of life)
- that pensions are paid in an annual lump sum on 1 January of each year;
- that interest on the capital sum is earned in a lump sum on 31 December each year

We assume that the financial institutions that sell annuities charge a lump-sum 4 per cent purchase commission on capital which is a combination of risk premium and administration fee. This figure is representative of premia charged in the British annuity market. These financial institutions are assumed to work in a capital market in which a stable real rate of return of either 2% or 3% or 4% per annum can be earned. The long-run real rate of return in the UK is estimated to be around 3%, and the range from 2% to 4% covers most plausible scenarios. Higher real rates of return could substantially reduce the contribution cost of any particular target pension level. The first decade of experience in the Chilean funded pension system has produced an average annual real rate of return of 12.6%, with a range from 2.9% to 26.5% (Gillion and Bonilla, 1992: 179). However, these reported returns have been biased upwards by the enormous devaluation of the Chilean currency over the same period; had the funds been invested in US fixed interest stock, higher pension payments could have been generated despite apparently lower real rates of return on the investments (Scarpaci and Miranda-Radic, 1991: 40). We think, therefore, that the real rates of return relevant to the advanced industrial economies are the appropriate ones to use in these simulations.

The annual pension that can be provided by any given capital sum, at any real rate of return, will depend on the expected length of pensionable life. This is jointly determined by the age of retirement and the average life expectancy of the subject.

In the simulations we use four alternative ages of retirement, at 55, 60, 65 and 70. Although 60 and 65 are common retirement ages in many pension schemes, 55 is used to indicate the likely pension cost if a further decline in the average age of retirement occurs, and 70 is used to indicate the pension cost if retirement ages are increased to take account of past and projected improvements in mortality experience.

We also use four average ages of death, at 80, 81, 83 and 85. Our annuity calculations are made on a gender-neutral basis, which is calculated according to age and gender-specific life-expectancies, which are then weighted by the appropriate sex ratios for each retirement age. The assumption of gender-neutrality in the annuity market is a deviation from pure actuarial principles and so implies some redistribution from men to women, but is consistent with European Community sex equality legislation. We produce an average gender neutral life expectancy at each of the four retirement ages, which then indicates the average age of death for all people surviving to that retirement age. On the basis of the 1987-8 UK life tables, the average age of death is as follows:

For people surviving to:	Average age at death:
55	80
60	80
65	81
70	83

We provide additional annuity estimates for death at age 85 since these indicate the potential pension cost of a significant future improvement in the life expectancy of older people.

Table 6
Necessary annuity capital values on retirement (£ 1985)

Replacement rate = 70%

Real rate of return 2% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	180545	158737	133897	106872
Die 83	171940	148874	123407	95289
Die 81	162986	138988	112493	83239
Die 80	158375	133897	106872	77033

Real rate of return 3% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	158969	142090	122523	99839
Die 83	152515	134608	113849	89784
Die 81	145668	126671	104648	79117
Die 80	142090	122523	99839	73542

Real rate of return 4% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	141156	128269	112590	93515
Die 83	136302	122364	105406	84774
Die 81	131052	115977	97635	75319
Die 80	128269	112590	93515	70306

Replacement rate = 50%

Real rate of return 2% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	128961	113125	95641	76337
Die 83	122814	106338	88148	68064
Die 81	116419	99277	80352	59457
Die 80	113125	95641	76337	55024

Real rate of return 3% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	113549	101493	87516	71313
Die 83	108939	96149	81321	64131
Die 81	104049	90479	74748	56512
Die 80	101493	87516	71313	52530

Real rate of return 4% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	100825	91620	80421	66796
Die 83	97358	87402	75290	60552
Die 81	93609	82840	69739	53799
Die 80	91620	80421	66796	50219

Replacement rate = 33%

Real rate of return 2% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	85114	74662	63123	50382
Die 83	81057	70183	58177	44922
Die 81	76836	65523	53032	39241
Die 80	74662	63123	50382	36315

Real rate of return 3% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	74942	66985	57760	47067
Die 83	71900	63458	53672	42327
Die 81	68672	59716	49334	37298
Die 80	66985	57760	47067	34670

Real rate of return 4% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	66544	60469	53078	44085
Die 83	64256	57685	49691	39964
Die 81	61781	54674	46028	35507
Die 80	60469	53078	44085	33144

Replacement rate = 15%

Real rate of return 2% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	38688	33937	28692	22901
Die 83	36844	31901	26444	20419
Die 81	34925	29783	24105	17837
Die 80	33937	28692	22901	16507

Real rate of return 3% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	34064	30447	26254	21394
Die 83	32681	28844	24396	19239
Die 81	31214	27143	22424	16953
Die 80	30447	26254	21394	15759

Real rate of return 4% p.a.

	Ret 55	*Ret 60*	*Ret 65*	*Ret 70*
Die 85	30247	27486	24126	20038
Die 83	29207	26220	22587	18165
Die 81	28082	24852	20921	16139
Die 80	27486	24126	20038	15065

In Table 6 we present the capital sums required to purchase gender-neutral annuity pensions for the array of retirement and death ages and real rates of return discussed above. Four variants are reported, which relate to pension replacement rates equal to 70%, 50%, 33% and 15% of the average earnings of fully-employed males in the LIFEMOD population. The average annual income for these men was £10598 in 1985 prices, for all males aged up to 65. Because earnings vary by age, average earnings also vary according to the retirement age selected, but changing this terminal age of earning through the range from 55 to 70 alters this average earnings figure by less than 1.5%. Other baseline earnings figures could be selected against which the pension replacement rates can be calculated, but we have used average fully-employed male earnings in the year of retirement because this is the benchmark against which the current worth of a pension is normally evaluated in both the UK and other countries. The replacement rates used in Table 6 were selected because 70% is the rate provided by the better occupational pension schemes, 50% is close to the average for European public pension systems, 33% is the rate that is projected to be produced by the combined flat-rate and earnings-related UK public pension system for a man with average life-time earnings who retires after the year 2000, and 15% is the replacement rate currently provided by the basic flat-rate UK National Insurance pension (Atkinson, 1991).

In the annuity calculations and simulations we assume full price indexation, on the basis either that there is zero inflation, or that asset values and earnings inflate at exactly the same rate. Pensions are assumed not to be indexed to real earnings growth. This assumption means that pension income falls relative to earned income over time, if there is positive real earnings growth. If pensions payments are to match real earnings growth, the required annuity capital value will have to rise. Full earnings indexation may be an optimal pensions goal, but few existing funded pension systems provide even the full price indexation incorporated in these simulations

In the simulations reported below we consider replacement rate targets other than those set by reference to average male earnings in the year of retirement. Two alternatives that feature in the pensions literature are replacement relative to own final salary and replacement relative to own annualized lifetime earnings. The first of these involves modelling difficulties, because although we know the individual age-earnings profiles of LIFEMOD workers, we do not know specific characteristics of their employment. Replacement relative to final salary is usually taken to mean final full-time salary in the primary career job. In LIFEMOD we cannot determine whether an individual's salary in their final year of full-time employment is in their primary career, or whether they have earlier moved to a lower-paid 'bridging job' as part of a phased movement from primary career to retirement. In the comparisons we make of pensions relative to final salary, this salary is based on earnings in the last reported year of full-time continuous employment which we assume to be representative of primary career earnings.

Own annualized lifetime earnings are easy to compute in LIFEMOD and can be used as a basis for replacement rate calculations. Annualization is important because it takes account of time out of the labour force. Employment and earnings in LIFEMOD are simulated on a weekly basis; annualized earnings for each individual are calculated by summing all earnings, dividing by the number of weeks of employment, and multiplying by 52. In simulations of PAYG pensions based on variant (b) on p.14, this procedure will give valid rankings of annualized lifetime earnings because the steady-state assumptions mean that £1 of earnings is of equal value regardless of the age at which it is received. However, if there is some positive degree of real earnings growth over time as in variant (c) on p.14, then a replacement rate based on average lifetime earnings will be below a replacement rate based on current earnings (unless earnings fall sharply with age after some point) because £1 received early in life was worth relatively more than £1 received late in life. In the simulations reported below of both funded and hybrid pension systems, wherever replacement rates are estimated on the basis of own lifetime earnings, this is calculated on the basis of own discounted annualized lifetime earnings, where the discount rate equals the assumed rate of real earnings growth. This means that all past earnings are revalued onto a current (year of retirement) basis.

Contribution calculations

The accumulation of individual pension contributions is modelled in LIFEMOD, but in order to set some reasonable parameters to the modelling process, and to get some intuitive idea of the sensitivity of results to key assumptions, we have first estimated contribution rates for the average LIFEMOD fully-employed male worker. Again it is necessary to base the modelling on a range of assumptions about real rates of return, real earnings growth, and the age at which contributions commence. We have produced estimates on the basis of contributions beginning at 18, 21 and 25, to take account of alternative assumptions about age of entry into the permanent workforce. Real earnings growth rates of 0%, 1% 1.5% and 2% per annum have been used to establish the lifetime earnings stream. For all four retirement ages used, retirement is assumed to occur in 1985, so the age-specific level of real earnings will vary with the age of retirement as well as the rate of real earnings growth. In Table 7 we report the annual contribution rate that would produce a pension replacement rate of 15%, 33%, 50% and 70% for the average fully-employed LIFEMOD male worker, given alternative assumptions about contribution age, retirement age, age at death, real earnings growth and real rate of return as applied to both contribution and annuity streams. Since the model is of a funded scheme, we have incorporated some plausible adminstration costs which might be levied on contributors to such a pension scheme. We have assumed that the whole of the first year's contribution, and 5% of each subsequent year's contribution, will be devoted to costs of administration. This is equivalent to a reduction in yield of about 1.3%, which is in the mid-range of administration charges currently levied by the British personal pensions industry.

Table 7
Contribution rates required to generate various pension replacement rates

7a: Contribution rates needed to generate a replacement rate of 15% of average male adult earnings

		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 2%													
Retire at 55	80	7	8	8	8	9	10	9	9	10	10	10	11
	81	7	8	9	9	9	10	9	10	11	10	10	11
	83	8	8	9	9	9	10	10	10	11	10	11	12
	85	8	9	10	9	10	11	10	11	12	11	12	13
Retire at 60	80	5	5	6	6	6	7	7	7	7	7	8	8
	81	5	6	6	6	7	7	7	7	8	7	8	8
	83	6	6	7	7	7	8	7	8	8	8	8	9
	85	6	6	7	7	7	8	8	8	9	8	9	9
Retire at 65	80	4	4	4	4	5	5	5	5	5	5	6	6
	81	4	4	4	5	5	5	5	5	6	6	6	6
	83	4	4	5	5	5	6	6	6	6	6	6	7
	85	4	5	5	5	6	6	6	6	7	7	7	7
Retire at 70	80	2	3	3	3	3	3	3	3	4	4	4	4
	81	3	3	3	3	3	4	4	4	4	4	4	4
	83	3	3	3	4	4	4	4	4	4	4	5	5
	85	3	3	4	4	4	4	4	5	5	5	5	5
Real i = 3%													
Retire at 55	80	5	6	7	6	7	8	7	7	8	8	8	9
	81	6	6	7	7	7	8	7	8	8	8	8	9
	83	6	6	7	7	7	8	7	8	9	8	8	9
	85	6	7	7	7	8	9	8	8	9	8	9	10
Retire at 60	80	4	4	5	5	5	5	5	5	6	6	6	6
	81	4	4	5	5	5	6	5	6	6	6	6	7
	83	4	5	5	5	5	6	6	6	6	6	6	7
	85	5	5	5	5	6	6	6	6	7	7	7	8
Retire at 65	80	3	3	3	3	4	4	4	4	4	4	4	5
	81	3	3	3	4	4	4	4	4	4	4	5	5
	83	3	3	4	4	4	4	4	4	5	5	5	5
	85	3	3	4	4	4	5	4	5	5	5	5	6
Retire at 70	80	2	2	2	2	2	3	3	3	3	3	3	3
	81	2	2	2	2	3	3	3	3	3	3	3	3
	83	2	2	3	3	3	3	3	3	3	3	4	4
	85	2	2	3	3	3	3	3	3	4	4	4	4

Table 7a continued: 15% replacement rate

		dy = 0%			dy = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 4%													
Retire at 55	80	4	5	5	5	5	6	5	6	7	6	6	7
	81	4	5	5	5	5	6	6	6	7	6	6	7
	83	4	5	6	5	6	6	6	6	7	6	7	7
	85	5	5	6	5	6	7	6	6	7	6	7	8
Retire at 60	80	3	3	4	4	4	4	4	4	5	4	5	5
	81	3	3	4	4	4	4	4	4	5	4	5	5
	83	3	3	4	4	4	5	4	5	5	5	5	5
	85	3	4	4	4	4	5	4	5	5	5	5	6
Retire at 65	80	2	2	3	3	3	3	3	3	3	3	3	4
	81	2	2	3	3	3	3	3	3	3	3	4	4
	83	2	3	3	3	3	3	3	3	4	4	4	4
	85	2	3	3	3	3	4	3	4	4	4	4	4
Retire at 70	80	1	2	2	2	2	2	2	2	2	2	2	3
	81	2	2	2	2	2	2	2	2	2	2	2	3
	83	2	2	2	2	2	2	2	2	3	3	3	3
	85	2	2	2	2	2	3	3	3	3	3	3	3

Table 7b: Contribution rates needed to generate a replacement rate of 33% of average male adult earnings

		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 2%													
Retire at 55	80	15	16	18	18	19	21	19	20	22	21	22	24
	81	16	17	19	18	19	22	20	21	23	21	23	25
	83	17	18	20	19	20	23	21	22	24	23	24	26
	85	18	19	21	20	21	24	22	23	25	24	25	27
Retire at 60	80	11	11	13	13	14	15	14	15	16	15	16	17
	81	11	12	13	13	14	15	15	15	17	16	17	18
	83	12	13	14	14	15	16	16	16	18	17	18	19
	85	12	13	15	15	16	17	17	17	19	18	19	20
Retire at 65	80	7	8	9	9	10	10	10	11	11	11	12	12
	81	8	8	9	10	10	11	11	11	12	12	12	13
	83	8	9	10	10	11	12	12	12	13	13	13	14
	85	9	10	11	11	12	13	13	13	14	14	14	15
Retire at 70	80	5	5	5	6	6	7	9	10	10	8	8	8
	81	5	5	6	6	7	7	10	10	11	8	8	9
	83	6	6	7	7	8	8	10	11	12	9	10	10
	85	6	7	7	8	8	9	11	12	13	10	11	11
Real i = 3%													
Retire at 55	80	11	12	14	14	15	16	15	16	18	16	17	19
	81	12	13	15	14	15	17	15	16	18	16	17	19
	83	12	13	15	15	16	18	16	17	19	17	18	20
	85	13	14	16	15	16	18	17	18	20	18	19	21
Retire at 60	80	8	9	10	10	10	12	11	11	13	12	12	14
	81	8	9	10	10	11	12	11	12	13	12	13	14
	83	9	9	11	11	11	13	12	13	14	13	14	15
	85	9	10	12	12	12	14	13	13	15	14	15	16
Retire at 65	80	6	6	7	7	7	8	8	8	9	9	9	10
	81	6	6	7	7	8	8	8	8	9	9	9	10
	83	6	7	7	8	8	9	9	9	10	10	10	11
	85	7	7	9	8	9	10	9	10	11	10	11	12
Retire at 70	80	4	4	4	5	5	5	5	5	6	6	6	6
	81	4	4	4	5	5	6	5	6	6	6	6	7
	83	4	4	5	5	6	6	6	6	7	7	7	8
	85	5	5	5	6	6	7	7	7	8	8	8	9

Table 7b continued: 33% replacement rate													
		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution rate		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 4%													
Retire at 55	80	9	10	11	10	11	13	11	12	14	12	13	15
	81	9	10	11	11	12	13	12	13	14	13	14	15
	83	9	10	12	11	12	14	12	13	15	13	14	16
	85	10	10	12	11	12	14	13	13	15	14	15	16
Retire at 60	80	6	7	8	7	8	9	8	9	10	9	10	11
	81	6	7	8	3	8	9	8	9	10	9	10	11
	83	7	7	8	8	9	10	9	10	11	10	10	12
	85	7	7	9	8	9	10	9	10	11	10	11	12
Retire at 65	80	4	4	5	5	6	6	6	6	7	7	7	8
	81	4	5	5	5	6	6	6	6	7	7	7	8
	83	5	5	6	6	6	7	7	7	8	7	8	8
	85	5	5	6	6	7	7	7	7	8	8	8	9
Retire at 70	80	3	3	3	3	4	4	4	4	5	4	5	5
	81	3	3	3	4	4	4	4	4	5	5	5	5
	83	3	4	4	4	4	5	5	5	5	5	5	6
	85	3	4	4	4	5	5	5	5	6	6	6	7

Table 7c: Contribution rates needed to generate a replacement rate of 50% of average male adult earnings													
		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 2%													
Retire at 55	80	22	24	27	26	28	31	29	30	33	31	33	36
	81	23	25	28	27	29	32	30	31	34	32	34	37
	83	24	26	29	29	30	34	31	33	36	34	35	39
	85	25	27	31	30	32	35	33	34	38	35	37	41
Retire at 60	80	16	17	19	19	20	22	21	22	24	23	24	26
	81	16	17	19	20	21	23	22	23	25	24	25	27
	83	17	18	21	21	22	24	23	24	26	25	26	29
	85	18	20	22	22	24	26	25	26	28	27	28	30
Retire at 65	80	11	11	13	13	13	15	15	16	17	17	17	18
	81	11	12	13	14	15	16	16	16	18	17	18	19
	83	12	13	14	15	16	18	17	18	19	19	20	21
	85	13	14	16	17	18	19	19	19	21	21	21	23
Retire at 70	80	7	7	8	9	9	10	10	10	11	11	11	12
	81	7	8	8	9	10	11	11	11	12	12	12	13
	83	8	9	10	11	11	11	12	13	13	14	14	15
	85	9	10	11	12	12	13	13	14	15	15	16	17
Real i = 3%													
Retire at 55	80	17	18	21	20	22	24	22	23	26	24	25	28
	81	17	19	22	21	22	25	23	24	27	24	26	29
	83	18	20	22	22	23	26	24	25	28	26	27	30
	85	19	21	24	23	24	27	25	26	29	27	28	31
Retire at 60	80	12	13	14	14	15	17	16	17	19	18	18	20
	81	12	13	15	15	16	18	16	17	19	18	19	21
	83	13	14	16	16	17	19	17	19	20	19	20	22
	85	14	15	17	17	18	20	19	20	22	21	22	24
Retire at 65	80	8	9	10	10	11	12	11	12	13	13	13	14
	81	8	9	10	11	11	12	12	12	14	13	14	15
	83	9	10	11	11	12	13	13	14	15	14	15	16
	85	10	10	12	12	13	14	14	15	16	15	16	17
Retire at 70	80	5	5	6	7	7	8	7	8	8	8	9	9
	81	5	6	6	7	7	8	8	8	9	9	9	10
	83	6	6	7	8	8	9	9	9	10	10	11	11
	85	7	7	8	9	9	10	10	10	11	11	12	13

Table 7c continued: 50% replacement rate

		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 4%													
Retire at 55	80	13	14	17	15	17	19	17	18	21	18	20	22
	81	13	14	17	16	17	20	17	19	21	19	20	23
	83	14	15	18	16	18	20	18	19	22	19	21	24
	85	14	15	18	17	18	21	19	20	23	20	22	24
Retire at 60	80	9	10	11	11	12	13	12	13	15	13	14	16
	81	9	10	11	11	12	14	12	13	15	14	15	16
	83	10	10	12	12	13	14	13	14	16	15	15	17
	85	10	11	13	12	13	14	14	15	16	15	16	18
Retire at 65	80	6	6	7	8	8	9	9	9	10	10	10	11
	81	6	7	8	8	8	9	9	9	10	10	11	12
	83	7	7	8	8	9	10	10	10	11	11	11	12
	85	7	8	9	9	10	11	10	11	12	11	12	13
Retire at 70	80	4	4	5	5	5	6	6	6	7	6	7	7
	81	4	4	5	5	6	6	6	6	7	7	7	8
	83	4	5	5	6	6	7	7	7	8	8	8	8
	85	5	5	6	6	7	8	7	8	8	8	9	9

Table 7d: Contribution rates needed to generate a replacement rate of 70% of average male adult earnings

		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 2%													
Retire at 55	80	31	33	38	37	39	43	40	42	*	43	45	*
	81	32	34	39	38	40	45	41	43	*	44	*	*
	83	34	36	*	40	42	*	43	*	*	*	*	*
	85	35	38	*	42	45	*	*	*	*	*	*	*
Retire at 60	80	22	23	26	27	28	31	29	31	33	32	33	36
	81	23	24	27	28	29	32	30	32	34	33	34	37
	83	24	26	29	29	31	34	32	34	37	35	37	40
	85	26	27	30	31	33	36	34	36	39	38	39	42
Retire at 65	80	15	16	17	19	20	21	21	22	23	23	24	26
	81	16	17	18	20	21	22	22	23	24	24	25	27
	83	17	18	20	21	22	24	24	25	27	26	27	29
	85	18	20	22	23	24	26	26	27	29	29	30	32
Retire at 70	80	9	10	11	12	13	14	14	14	15	15	16	17
	81	10	11	12	13	14	15	15	15	16	16	17	18
	83	11	12	13	15	15	17	17	17	19	19	19	21
	85	13	14	15	17	17	19	19	19	21	21	22	23
Real i = 3%													
Retire at 55	80	24	26	29	28	30	34	31	33	37	33	35	39
	81	24	26	30	29	31	35	31	33	37	34	36	40
	83	25	27	31	30	32	36	33	35	39	36	38	42
	85	26	28	33	31	34	38	34	36	41	37	39	44
Retire at 60	80	16	18	20	20	21	24	22	23	26	24	26	28
	81	17	18	21	21	22	25	23	24	27	25	27	29
	83	18	19	22	22	23	26	24	26	28	27	28	31
	85	19	20	23	23	25	27	26	27	30	28	30	32
Retire at 65	80	11	12	13	14	15	16	16	16	18	17	18	20
	81	12	12	14	15	16	17	16	17	19	18	19	21
	83	13	13	15	16	17	19	18	19	20	20	21	23
	85	13	14	16	17	18	20	19	20	22	21	22	24
Retire at 70	80	7	7	8	9	9	10	10	10	12	12	12	13
	81	7	8	9	10	10	11	11	12	12	12	13	14
	83	8	9	10	11	11	13	12	13	14	14	15	16
	85	9	10	11	12	13	14	14	14	16	16	16	17

Table 7d continued: 70% replacement rate													
		dY = 0%			dY = 1%			dY = 1.5%			dY = 2%		
Contribution age		18	21	25	18	21	25	18	21	25	18	21	25
	Death age												
Real i = 4%													
Retire at 55	80	18	20	23	21	23	27	23	25	29	26	28	31
	81	18	20	23	22	24	27	24	26	29	26	28	32
	83	19	21	24	23	25	28	25	27	30	27	29	33
	85	20	21	25	24	26	29	26	28	32	28	30	34
Retire at 60	80	12	13	15	15	16	18	17	18	20	19	20	22
	81	13	14	16	16	17	19	17	18	21	19	20	23
	83	13	14	17	16	18	20	18	19	22	20	21	24
	85	14	15	18	17	18	21	19	20	23	21	22	25
Retire at 65	80	8	9	10	10	11	13	12	13	14	13	14	15
	81	8	9	11	11	12	13	12	13	14	14	15	16
	83	9	10	11	12	13	14	13	14	16	15	16	17
	85	10	11	12	12	13	15	14	15	17	16	17	18
Retire at 70	80	5	5	6	7	7	8	8	8	9	9	9	10
	81	5	6	7	7	8	8	8	9	10	9	10	11
	83	6	6	7	8	8	9	9	10	11	10	11	12
	85	7	7	8	9	9	10	10	11	12	11	12	13

<u>Note</u>: * indicates a contribution rate of over 45%

Table 7 reports the required contribution rate relevant to 2304 different combinations of assumptions. All contribution rates have been rounded-up to the nearest full percentage point. The table shows clearly that higher rates of real earnings growth require higher contribution rates (because of the relative diminution in value of contributions earlier in life) and higher real rates of return require lower contribution rates for any particular target replacement rate, because of the faster growth of the capital fund. The greater the excess of real rate of return over real earnings growth, the lower the required contribution rate. Higher contribution ages increase the required contribution rate, and higher retirement ages reduce it.

The apparent 'affordability' of any funded pension system will depend crucially on the key assumptions used in table 7, and there is likely to be a diversity of opinion about the appropriateness of each. The mid-range assumptions that seem most appropriate to Britain are of a long run real rate of return of 3% per annum, and of long-run real earnings growth of 1.5% per annum. The UK Government Actuary's long-run social security projections assume that earnings will grow at 1.5% p.a., and a 3% real rate of return is consistent with achieved investment returns across two investment cycles from the mid 1960s to the mid-1980s (Government Actuary, 1990). This empirical support for these assumptions provides a strong justification for applying them to the LIFEMOD model. In addition, however, there are technical reasons relating to the equivalence of PAYG and funded pension systems in this modelling exercise which require the adoption of a real rate of return around 1.5 percentage points higher than the rate of earnings growth. This issue is considered more fully below in the discussion of hybrid pension systems.

The contribution conditions presented in Table 7 relate to a hypothetical average LIFEMOD male, but we need to determine how many people do better or worse than this average, and by how much. This we can do with the individual life-cycle earnings profiles for the LIFEMOD population. These individuals do not all have a work history of 52 weeks of employment in every year between the first year of pension contribution and the age of retirement, and they have a wide dispersion of earnings according to their past employment and educational history. LIFEMOD allows us to examine the distributional consequences of any particular set of pension system rules and assumptions.

Funded pensions in LIFEMOD

Table 8 presents distributional outcomes for the LIFEMOD population of males, on the basis of a real rate of return of 3% per annum and real earnings growth of 1.5% per annum. The first four columns show, for a range of retirement ages, the average pension capital accumulated over the life course for males according to their position in the lifetime earnings distribution. The amount accumulated with four different rates of contribution from 5% to 20% of earnings are reported. These capital sums are then compared with the appropriate annuity costs in Table 6 to determine the percentage of average male LIFEMOD earnings that would be replaced by contribution rates of 5%, 10%, 15% and 20%; the figures are presented in the final four columns.

It is immediately apparent from Table 8 that lifetime earnings histories have a significant impact on individual ability to accumulate a fund sufficient to provide an adequate pension annuity. From Table 7c we can see that, for contribution beginning at age 21 with retirement at age 65, and with real interest rates at 3% and real earnings growth at 1.5% per annum, the LIFEMOD average fully-employed male needs to contribute 12% of earnings to produce a pension replacement rate of 50% in retirement. From the third panel of Table 8, however, we can see that even with a contribution rate of 15%, only the top four deciles of the lifetime earnings distribution reach this 50% replacement target, and the bottom two deciles fall below the 33% replacement level. If we look at the experience of women under the same contribution and retirement conditions (the third panel of Table 9), we can see a more extreme picture. Not only is the pension replacement rate much lower, with only the top decile accumulating a fund sufficient to purchase a pension annuity equal to 50% of average male LIFEMOD full-time earnings, but the distribution is also more skewed that for men, with the ratio of highest to lowest replacement rate standing at 7.57:1 for women compared with 4.27:1 for men.

Table 8
Proportion of average male LIFEMOD earnings replaced by pensions generated by different contribution rates and retirement ages, ordered by decile of male lifetime earnings

LIFEMOD men									
dY = 1.5%, i = 3%, cont = 21									
	Lifetime Pension Capital					Pension replacement rate			
Contrib.rate	5%	10%	15%	20%		5%	10%	15%	20%
Retirement at 55									
Bottom	7598	15196	22794	30392		3.7	7.5	11.2	15.0
2	10367	20734	31101	41468		5.1	10.2	15.3	20.4
3	11933	23866	35799	47732		5.9	11.8	17.6	23.5
4	13542	27084	40626	54168		6.7	13.3	20.0	26.7
5	15005	30010	45015	60020		7.4	14.8	22.2	29.6
6	16662	33324	49986	66648		8.2	16.4	24.6	32.8
7	18479	36958	55437	73916		9.1	18.2	27.3	36.4
8	20776	41552	62328	83104		10.2	20.5	30.7	40.9
9	24591	49182	73773	98364		12.1	24.2	36.3	48.5
Top	33108	66216	99324	132432		16.3	32.6	48.9	65.2
Retirement at 60									
Bottom	9230	18460	27690	36920		5.3	10.5	15.8	21.1
2	12631	25262	37893	50524		7.2	14.4	21.6	28.9
3	14321	28642	42963	57284		8.2	16.4	24.5	32.7
4	16216	32432	48648	64864		9.3	18.5	27.8	37.1
5	17988	35976	53964	71952		10.3	20.6	30.8	41.1
6	19954	39908	59862	79816		11.4	22.8	34.2	45.6
7	22151	44302	66453	88604		12.7	25.3	38.0	50.6
8	24910	49820	74730	99640		14.2	28.5	42.7	56.9
9	29351	58702	88053	117404		16.8	33.5	50.3	67.1
Top	40033	80066	120099	160132		22.9	45.7	68.6	91.5

Table 8 continued									
	Lifetime pension capital					Pension replacement rate			
Contrib.rate	5%	10%	15%	20%		5%	10%	15%	20%
Retirement at 65									
Bottom	10661	21322	31983	42644		7.1	14.3	21.4	28.5
2	14747	29494	44241	58988		9.9	19.7	29.6	39.5
3	16744	33488	50232	66976		11.2	22.4	33.6	44.8
4	18587	37174	55761	74348		12.4	24.9	37.3	49.7
5	20908	41816	62724	83632		14.0	28.0	42.0	55.9
6	23228	46456	69684	92912		15.5	31.1	46.6	62.2
7	25848	51696	77544	103392		17.3	34.6	51.9	69.2
8	29030	58060	87090	116120		19.4	38.8	58.3	77.7
9	34553	69106	103659	138212		23.1	46.2	69.3	92.5
Top	46899	93798	140697	187596		31.4	62.7	94.1	125.5
Retirement at 70									
Bottom	11951	23902	35853	47804		9.3	18.6	28.0	37.3
2	17061	34122	51183	68244		13.3	26.6	39.9	53.2
3	19010	38020	57030	76040		14.8	29.6	44.5	59.3
4	21326	42652	63978	85304		16.6	33.3	49.9	66.5
5	24017	48034	72051	96068		18.7	37.4	56.2	74.9
6	26783	53566	80349	107132		20.9	41.8	62.6	83.5
7	29700	59400	89100	118800		23.2	46.3	69.5	92.6
8	33280	66560	99840	133120		25.9	51.9	77.8	103.8
9	39915	79830	119745	159660		31.1	62.2	93.4	124.5
Top	54404	108808	163212	217616		42.4	84.8	127.2	169.7

Table 9
Proportion of average female LIFEMOD earnings replaced by pensions generated by different contribution rates and retirement ages, ordered by decile of female lifetime earnings

LIFEMOD women									
dY = 1.5%, i = 3%, cont. age = 21									
	Lifetime pension capital					Pension replacement rate			
Contrib.rate	5%	10%	15%	20%		5%	10%	15%	20%
Retirement at 55									
Bottom	2729	5458	8187	10916		1.3	2.7	4.0	5.4
2	4388	8776	13164	17552		2.2	4.3	6.5	8.6
3	5377	10754	16131	21508		2.6	5.3	7.9	10.6
4	6308	12616	18924	25232		3.1	6.2	9.3	12.4
5	7405	14810	22215	29620		3.6	7.3	10.9	14.6
6	8349	16698	25047	33396		4.1	8.2	12.3	16.5
7	9811	19622	29433	39244		4.8	9.7	14.5	19.3
8	11484	22968	34452	45936		5.7	11.3	17.0	22.6
9	13764	27528	41292	55056		6.8	13.6	20.3	27.1
Top	20854	41708	62562	83416		10.3	20.5	30.8	41.1
Retirement at 60									
Bottom	3285	6570	9855	13140		1.9	3.8	5.6	7.5
2	5226	10452	15678	20904		3.0	6.0	9.0	11.9
3	6484	12968	19452	25936		3.7	7.4	11.1	14.8
4	7600	15200	22800	30400		4.3	8.7	13.0	17.4
5	8697	17394	26091	34788		5.0	9.9	14.9	19.9
6	10034	20068	30102	40136		5.7	11.5	17.2	22.9
7	11598	23196	34794	46392		6.6	13.3	19.9	26.5
8	13626	27252	40878	54504		7.8	15.6	23.4	31.1
9	16189	32378	48567	64756		9.2	18.5	27.7	37.0
Top	24632	49264	73896	98528		14.1	28.1	42.2	56.3

Table 9 continued									
	Lifetime pension capital					Pension replacement rate			
	5%	10%	15%	20%		5%	10%	15%	20%
Retirement at 65									
Bottom	3820	7640	11460	15280		2.6	5.1	7.7	10.2
2	6137	12274	18411	24548		4.1	8.2	12.3	16.4
3	7662	15324	22986	30648		5.1	10.3	15.4	20.5
4	8844	17688	26532	35376		5.9	11.8	17.7	23.7
5	10308	20616	30924	41232		6.9	13.8	20.7	27.6
6	11796	23592	35388	47184		7.9	15.8	23.7	31.6
7	13682	27364	41046	54728		9.2	18.3	27.5	36.6
8	15948	31896	47844	63792		10.7	21.3	32.0	42.7
9	19160	38320	57480	76640		12.8	25.6	38.4	51.3
Top	29075	58150	87225	116300		19.4	38.9	58.3	77.8
Retirement at 70									
Bottom	4284	8568	12852	17136		3.3	6.7	10.0	13.4
2	7031	14062	21093	28124		5.5	11.0	16.4	21.9
3	8752	17504	26256	35008		6.8	13.6	20.5	27.3
4	10237	20474	30711	40948		8.0	16.0	23.9	31.9
5	11819	23638	35457	47276		9.2	18.4	27.6	36.9
6	13542	27084	40626	54168		10.6	21.1	31.7	42.2
7	15637	31274	46911	62548		12.2	24.4	36.6	48.8
8	18582	37164	55746	74328		14.5	29.0	43.5	58.0
9	22357	44714	67071	89428		17.4	34.9	52.3	69.7
Top	32871	65742	98613	131484		25.6	51.3	76.9	102.5

The pension replacement outcomes look very different if, instead of relating pension paid to average male full-time earnings, we consider the pension paid in relation to the average last earnings for each gender and decile group. Table 10 compares, by decile of lifetime earnings, the replacement rates of pensions (generated by a 15% contribution rate on earnings, with retirement at 65) relative to male average full-time earnings and own gender and decile-specific last recorded earnings. The absolute amount of the pension is identical in both cases, but the replacement rates are very different. For the bottom decile of women, a 15% contribution rate produces a pension replacement rate of 21% of the last earnings recieved by this decile group of female workers, which appears quite respectable. However, since the last full-time earnings for this poorest group of women were only £3661 per annum, this replacement rate in fact produces an annual pension of just over £800, or only 7.7% of average male full-time earnings. If poverty prevention is an important element of any pension system, then minimum pensions and replacement rates need to be calculated by reference to some socially-based norm such as average earnings, rather than by reference to own earnings history.

Table 10
Replacement rates produced by a funded pension with 15% contribution of earnings, calculated relative to average male full-time earnings and own gender and decile-specific last recorded earnings.

	Men		Women	
	Av. male Y	Last own Y	Av. male Y	Last own Y
1st	21.4	34.8	7.7	21.1
2nd	29.6	44.9	12.3	34.1
3rd	33.6	47.2	15.4	36.6
4th	37.3	48.9	17.7	39.2
5th	42.0	53.3	20.7	42.1
6th	46.6	52.6	23.7	42.8
7th	51.9	53.2	27.5	41.1
8th	58.3	53.6	32.0	43.2
9th	69.3	54.8	38.4	44.6
Top	94.1	54.7	58.3	47.5

Figure 5

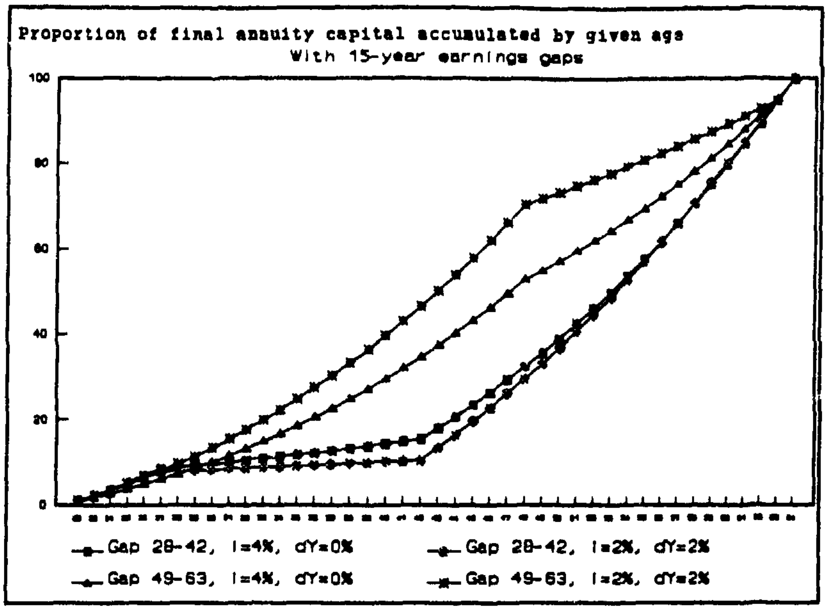
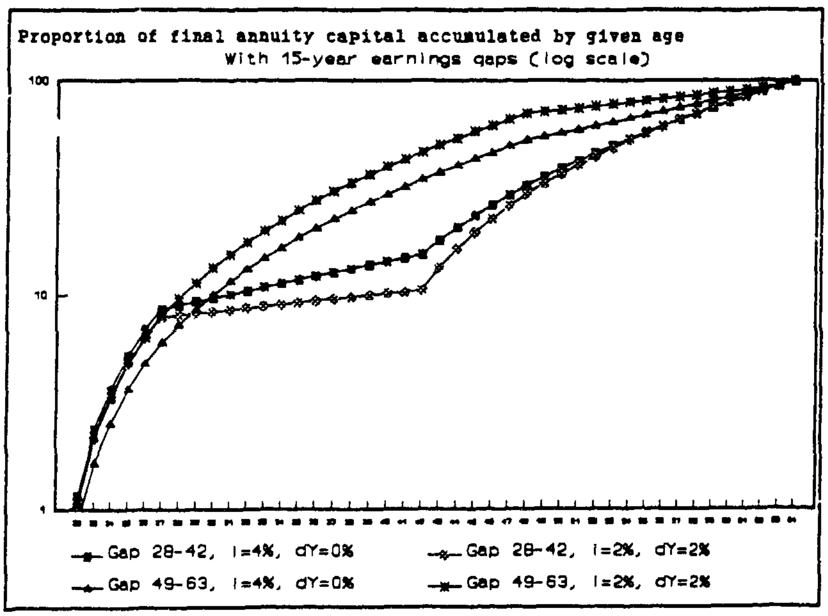


Figure 6



The distributional outcomes of the LIFEMOD simulations reported in the tables above depend upon the interaction of the socio-economic characteristics of the LIFEMOD population with the specific details of pension scheme rules and assumptions. As Table 7 shows, the application of different retirement ages, real rates of return and rates of real earnings growth have a major impact on the contribution rate required for any given replacement rate for an *average* individual; they are, in effect scaling factors. However, these scaling factors have a differential impact on individuals according to their *personal* employment histories; high real earnings growth and low rates of return make earnings in later life relatively more significant in terms of capital accumulation than earnings early in life. Figures 5 and 6 give an indication of this effect for an individual retiring at 65, with the average LIFEMOD full-time male age-specific earnings, but with 15-year earnings gaps early (age 28-42) and late(age 49-63) in life. The figures present the highest cost (real earnings growth [dY] 2%, real rate of return [i] 2%) and lowest cost (real earnings growth 0%, real rate of return 4%) scenarios from Table 7. Although the absolute value of the capital sum accumulated by age 65 will be different in each case, the data is presented in proportional terms for ready comparison. The figures show that, with an earnings gap at young ages, the capital accumulation profile is higher when i = 4% and dY = 0%, than when both i and dY = 2%. However, if the earnings gap appears at older ages, the leverage from past earnings growth when i and dY =2% dominates the effect of past real interest rates at 4% in the absence of any real earnings growth. For individuals who have lifetime earnings profiles that diverge from the average, therefore, the actual rates of return and real earnings growth that they experience will affect their *relative* as well as their absolute pension fund accumulation outcomes.

From LIFEMOD we can determine how many people have their *relative* pension accumulation altered by the interaction of different rates of earnings growth and investment returns. Table 11 shows the extent to which there is movement by individuals between deciles of the pension fund distributions based on actual individual earnings profiles and the alternatives of i = 2%, dY = 2%, and i = 4%, dY = 0%. First, LIFEMOD individuals who survive to age 65 have been ranked according to their decile position in the pension fund accumulation distribution on the basis of i=2%, dY=2%, and then re-ranked on the basis of i=4%, dY=0%. The percentage who remain in or move between deciles in these two distribution is reported in the cells of table 11.

Table 11
Cross-tabulation of decile rankings of pension capital accumulation according to different assumptions about real rate of return and rate of earnings growth

		i=2%, dY=2%									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Top
	1st	82.1	16.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2nd	17.2	61.9	19.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0
	3rd	0.6	19.7	53.6	24.4	1.6	0.0	0.0	0.0	0.0	0.0
	4th	0.0	1.8	21.0	47.5	25.1	4.4	0.3	0.0	0.0	0.0
i=4%	5th	0.0	0.0	4.4	20.6	46.4	24.4	4.1	0.0	0.0	0.0
dY=0%	6th	0.0	0.0	0.3	5.6	22.3	49.4	21.3	1.3	0.0	0.0
	7th	0.0	0.0	0.0	0.3	4.1	19.1	56.9	18.9	0.9	0.0
	8th	0.0	0.0	0.0	0.0	0.6	2.8	16.3	62.1	17.8	0.3
	9th	0.0	0.0	0.0	0.0	0.0	0.0	1.3	17.9	70.9	10.0
	Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	89.7

Clearly these earnings growth rate and interest rate assumptions lead to non-trivial differences in relative pension outcomes, though the majority of the relative movement is across only one decile. We can further examine the data to establish the characteristics of those who move between deciles. In Figures 5 and 6 above we suggested that the key factor is the period in the life-course during which the bulk of income is received. In Table 12 we examine two cases - where 30% or more of lifetime income is received between the ages of 20 and 29 ('young earners'), and where 30% or more of lifetime income is received between the ages of 50 and 59 ('old earners'). For the LIFEMOD population of 3195 individuals who live to at least age 65, 23.3% of lifetime income is received between ages 20 and 29, and 20.4% is received between ages 50 and 59.

TABLE 12

Percentage of LIFEMOD individuals who move between deciles of pension capital distribution according to changes in real rates of return and real earnings growth, by age distribution of original income.

Young earners

All	[1] i2,dY2 = i4,dY0	[2] i2,dY2 → i4,dY0	[3] i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 20-29 (n=2718)	65.31	11.96	22.73
More than 30% life-time earnings ages 20-29 (n=477)	43.40	56.60	0.0
Males	i2,dY2 = i4,dY0	i2,dY2 → i4,dY0	i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 20-29 (n=1464)	66.87	11.95	21.17
More than 30% life-time earnings ages 20-29 (n=44)	20.45	79.55	0.0
Females	i2,dY2 = i4,dY0	i2,dY2 → i4,dY0	i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 20-29 (n=1254)	63.48	11.96	24.56
More than 30% life-time earnings ages 20-29 (n=433)	45.73	54.27	0.0

Old earners

All	[1] i2,dY2 = i4,dY0	[2] i2,dY2 → i4,dY0	[3] i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 50-59 (n=2750)	64.25	21.20	14.55
More than 30% life-time earnings ages 50-59 (n=445)	48.31	2.70	48.99
Males	i2,dY2 = i4,dY0	i2,dY2 → i4,dY0	i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 50-59 (n=1294)	68.24	15.84	15.92
More than 30% life-time earnings ages 50-59 (n=214)	49.07	2.34	48.60
Females	i2,dY2 = i4,dY0	i2,dY2 → i4,dY0	i4,dy0 → i2,dY2
Less than 30% life-time earnings ages 50-59 (n=1456)	60.71	25.96	13.32
More than 30% life-time earnings ages 50-59 (n=231)	47.62	3.03	49.35

Table 12 presents cross-tabulations of interdecile movement. Column [1] shows the percentage of each row that remains in the same decile of the pension capital accumulation distribution regardless of whether real interest is 2% and real earnings growth 2% or real interest 4% and zero real earnings growth. Column [2] shows the percentage who move to a *higher* decile when changing from i = 2%, dY= 2% to i = 4% dY = 0%, and column [3] shows the percentage who move to a *higher* decile when changing assumptions from i = 4%, dY = 0% to i = 2%, dY = 2%. As expected from figures 6 and 7, 'young earners' show a very clear tendency to move to higher deciles under the assumptions of column [2], and 'old earners' show a clear tendency to move to higher deciles under the assumptions of column [3]. Since over 90 per cent of 'young earners' are women (who accumulate of 30% of lifetime earnings before the age of 30 because caring responsibilities restrict their opportunities for subsequent full-time employment), the outcomes of the different earnings growth and rate of return assumptions have obvious gender implications. Because of the high probability of an interrupted employment history in mid-life, women benefit relatively more than men from a scenario in which real earnings growth is low and real rates of return high.

However, despite these relative effects, women reach pension age on average with a pension capital fund much lower in absolute terms than that for men. From LIFEMOD we can examine the co-determinants of low pension capital accumulation. The capital sum accumulated by each of the 1508 men (ANUMEN) and 1687 women (ANUWOMEN) who survive in LIFEMOD to retire at 65 and who have contributed 15% of annual earnings (with i = 3%, dY=1.5%) can be regressed on a number of socio-economic characteristics. In equations [1] and [2] reported in Table 13 the independent variables used are:

UNEMPTOT: total period spent unemployed up to age 65 (in years)
YRSTERT: years of tertiary education
LASTEARN: last full-time earnings
YRSCHILD: total number of years with dependent child under 16 in household

Table 13
Regression estimates of co-determinants of pension capital accumulation

EQUATION 1 — Ordinary Least Squares Estimation

Dependent variable is ANUMEN
1508 observations used for estimation from 1 to 1508

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
UNEMPTOT	-2671.0	96.3553	-27.7201[.000]
YRSTERT	1529.6	344.1266	4.4449[.000]
LASTEARN	4.9689	.10672	46.5608[.000]
CNT	35612.1	1150.5	30.9523[.000]

R-Squared	.73490	F-statistic F(3,1504)	1389.8[.000]
R-Bar-Squared	.73437	S.E. of Regression	16219.8
Residual Sum of Squares	3.96E+11	Mean of Dependent Variable	72344.5
S.D. of Dependent Variable	31470.5	Maximum of Log-likelihood	-16756.3
DW-statistic	1.9243		

EQUATION 2 — Ordinary Least Squares Estimation

Dependent variable is ANUWOMEN
1687 observations used for estimation from 1 to 1687

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
UNEMPTOT	-2414.0	195.4153	-12.3530[.000]
YRSTERT	1198.6	296.0607	4.0486[.000]
LASTEARN	3.3226	.093010	35.7226[.000]
YRSCHILD	-146.6611	39.1864	-3.7427[.000]
CNT	23107.2	1138.5	20.2964[.000]

R-Squared	.51585	F-statistic F(4,1682)	448.0376[.000]
R-Bar-Squared	.51470	S.E. of Regression	15884.7
Residual Sum of Squares	4.24E+11	Mean of Dependent Variable	37921.8
S.D. of Dependent Variable	22802.0	Maximum of Log-likelihood	-18709.8
DW-statistic	1.9703		

These equations show, not surprisingly, that the total amount of pension capital accumulated is positively related to last full-time earnings and to years of tertiary education for both men and women, and negatively related to years of unemployment. For women, pension capital is also negatively related to the number of years with dependent children in the household. Last full-time earnings is the dominant variable in both equations, with an elasticity of .69 for men and .57 for women. The elasticity on UNEMPTOT for women is -.15, and on YRSCHILD it is -.10, so in terms of pension capital accrual having a child under 16 in the household has almost as much impact on women as a year of unemployment. The interruption of employment experienced by women who have children necessarily diminishes their chances of accumulating reasonable pension entitlements in a funded pension system.

Joint contributions

This long-term effect of child-care on women's pension entitlements in a funded system can be ameliorated by some system of contribution-sharing within marriage. To determine the effectiveness of this, we have imposed a contribution-sharing rule on LIFEMOD married couples. The income of married couples is pooled, and pension contributions paid from this joint income are split equally and paid into the individual pension funds of husband and wife during each year of marriage. If the couple divorce, they each carry their individual pension fund with them, and continue to make contributions from their individual earnings while single. If they remarry, contributions from pooled current income of the new couple are again split equally, but the pension funds of husband and wife remain separate. This rule means that, for married couples, individual pension contributions are a function of current joint income, but individual pension funds are a function of individual contribution histories.

Table 14 shows the overall effect of joint contributions in a funded scheme in which all earners make pension contributions of 15% per annum, with i = 3% and dY = 1.5%. The table reports the percentage of the LIFEMOD population surviving to age 65 who accumulate enough capital to purchase an annuity equal to either 50% or 33% of average male full-time LIFEMOD earnings. On the basis of their own contributions, over three-quarters of men reach the 33% replacement rate, and over one-third reach the 50% rate. For women, however, fewer than one-quarter meet the lower replacement rate, and a trivial 6% accumulate enough capital to meet the 50% replacement target. Moving from an own contribution to a joint contribution basis fundamentally changes the outcomes. The proportion of the total population meeting the lower 33% replacement target rises from 48% to 53%, but the proportion meeting the higher 50% target *falls* from 21% to 16%. This is because women's earnings (and therefore contributions) are so much lower than men's that the pooling and equal division of contributions drags many men below the higher target which they reached on the basis of their own contributions. The joint contribution rule significantly benefits women, bringing almost half of them up to the 33% replacement rate, but it does so at a clear cost to their husbands.

Table 14
Percentage of LIFEMOD population retiring at 65 who have accumulated a pension fund sufficient to provide a pension equal to 33% and 50% of average full-time male LIFEMOD earnings, on the basis of own contributions and joint contributions

	All	Men	Women
Own contrib. 33% replacement	48.23	76.3	23.2
Own contrib. 50% replacement	21.3	38.1	6.3
Joint contrib. 33% replacement	53.2	59.0	48.0
Joint contrib. 50% replacement	16.6	20.0	13.5

We can examine the effect of joint contributions more closely by looking at the proportion of people who move between deciles in a ranking of the distribution of accumulated pension capital as we move from an individual contribution basis to joint contributions. Table 15 presents cross-tabulations of the ranking according to these two sets of contribution rules.

Table 15
Cross-tabulation of decile rankings of pension capital accumulation according to different assumptions about contribution rules

		JOINT CONTRIBUTIONS									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Top
OWN CONTRIBUTIONS	1st	49.2	15.4	11.0	7.5	6.3	2.8	3.8	2.5	0.6	0.9
	2nd	29.1	22.5	14.4	10.3	6.9	6.3	3.1	3.1	3.1	1.3
	3rd	14.1	24.1	13.2	12.2	11.9	9.7	5.3	3.8	4.1	1.6
	4th	4.1	18.1	22.8	13.1	9.4	9.7	6.9	8.2	5.9	1.9
	5th	2.5	11.6	13.8	23.8	16.0	14.1	7.2	6.6	3.5	0.9
	6th	0.6	6.9	15.6	14.1	18.1	19.1	8.4	8.4	5.9	2.8
	7th	0.3	1.3	7.5	12.2	13.4	16.3	21.9	12.2	9.1	5.9
	8th	0.0	0.3	1.6	6.6	15.4	13.5	17.9	25.4	14.7	4.7
	9th	0.0	0.0	0.0	0.3	2.5	8.8	22.8	20.0	30.3	15.3
	Top	0.0	0.0	0.0	0.0	0.0	0.0	2.8	9.7	22.8	64.6

Table 15 shows that there is considerable movement across the total income distribution in the relative positions of individuals according to the rules of pension fund accumulation. This is not surprising given the changes shown in Table 14 in the proportions of men and women affected by the joint contribution rule. Further disaggregation by gender is instructive. When ranked on individual contributions, very few men find themselves in the lowest quintile of the distribution (1.7%) and only 21.8% are located in the bottom half. However, if pension contributions during marriage are split evenly between the couple regardless of the source of the income, men's position within the total distribution changes markedly. In this case 13.3% of men are dragged into the bottom quintile and 44.3% into the bottom half. If joint contributions acted to entirely eliminate gender inequality in a funded pension system, we would expect on average 10% of men and 10% of women in each decile grouping. In practice, as Table 16 shows, even after contribution sharing men are still over-represented in the upper deciles, though much less so than on the basis of individual contributions.

Table 16
Proportion of men and women in each decile of distribution on basis of own and of joint contributions

		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Top
M	Own	0.9	0.8	3.8	5.4	10.9	12.6	13.3	16.1	17.8	18.4
	Jnt	5.2	8.1	9.6	10.7	10.7	9.8	11.7	10.5	11.2	12.7
F	Own	18.1	18.3	15.5	14.2	9.1	7.7	7.1	4.5	3.1	2.4
	Jnt	14.3	11.7	10.4	9.4	9.3	10.2	8.5	9.5	9.0	7.6

Capital top-ups

With joint contributions over one third of men and more than half of women still fail to accumulate a fund capable of purchasing a pension annuity at age 65 equal to 33% of average full-time male earnings. If a funded pension system is to satisfy the criterion of poverty prevention, then these individuals will need a tax transfer in order to obtain a minimum pension. We have modelled the cost of providing lump-sum capital top-ups to people who reach age 65 with a pension fund less than the amount required for a 33% replacement rate.

Table 17 shows the mean amount of lump-sum top-up for individual and joint contributions, for the entire LIFEMOD population, and for men and women separately. Not surprisingly, given what has already been said about women's earnings, it is women who receive the majority of the capital top-ups - almost 90% on the basis of individual contributions, and two-thirds of top-ups on the basis of joint contributions. As noted above, the joint contribution rule reduces the proportion of men who reach the 33% replacement threshold, and so increases the proportion receiving lump-sum capital top-ups.

Table 17
Mean amount of annual capital top-ups received by LIFEMOD population at age 65 with minimum pension replacement target of 33% of male full-time earnings

		Mean(£)
ALL LIFEMOD	Own contributions	9585.3
	Joint contributions	5750.0
MEN	Own contributions	2313.8
	Joint contributions	4110.0
WOMEN	Own contributions	16085.1
	Joint contributions	7216.0

The number of people aged 65 in 1985 was about 561,000. This allows us to estimate the cost of lump-sum capital top-ups for the UK population reaching age 65 in 1985; for a funded pension system based on individual contributions of 15% of earnings and a minimum pension target of 33% of average male full-time earnings, the cost is £5.4 billion, and for joint contributions the cost is £3.2 billion. This compares with the actual cost of the public retirement pension in the UK in 1985 of £15.7 billion and a gross national product of £305 billion. These capital top-ups would have required an increase in income tax of between 3 and 5 per cent.

iii) Hybrid pension systems

In practice, hybrid pension systems are likely to be rather more complex than simply a lump-sum addition at retirement to personal funded pensions. Below we present the results of a series of simulations which investigate the effect of combining public pay-as-you-go and private defined contribution pension systems in a number of different ways. For the central analyses of this paper we have adopted i=3%, dY=1.5% as the most plausible assumptions, and when these rates are applied to the income streams of the LIFEMOD population, they produce the replacement rates shown in tables 8 and 9. Different rates of earnings growth and real interest would however produce different replacement rates and could make the overall performance of funded pensions either considerably better or worse than PAYG. The well known *'Aaron condition'* states that if the sum of the growth rates of population and real earnings exceed the market rate of interest, PAYG pension schemes can provide all cohorts with higher returns than funded pensions (Aaron, 1966). LIFEMOD is a single-cohort microsimulation model, but when used in the cross-section implicitly assumes that the population growth rate is zero. The Aaron condition suggests, therefore, that when i=dY in LIFEMOD, PAYG and funded pension schemes should support identical replacement rates for any given contribution rate, that if i>dY funded schemes will be preferable and if i<dY PAYG will be preferable.

Table 18 shows the annual pension income generated in LIFEMOD by four different contribution rates, based either on own or joint incomes, for a PAYG system and for four funded systems with different combinations of i and dY. If i exceeds dY by 2 percentage points or more, then funded pensions dominate PAYG but if i exceeds dY by 1 percentage point or less the PAYG dominates funding. Note that the exact Aaron principle does not hold in these simulations. This is due to the fact that the working-age population in LIFEMOD is larger than the pensioner population because of adult mortality between the ages of 21 and 65. Aaron's formulation of the equivalence conditions for PAYG and funded pension systems is developed using a two-period model in which the population is the same size in both periods. In LIFEMOD, as in any real-world population, adult mortality will always ensure that the contributor population in a PAYG system is larger than the pensioner population even when the population growth rate is zero; in consequence, the exact Aaron condition will never apply.

Table 18 Pension income generated by defined contribution scheme versuses flat rate PAYG under varying assumption concerning real income growth and real interest rates

Contribution rate	PAYG	Funded 1%i 2%dY	Funded 2%i 2%dY	Funded 3%i 2%dY	Funded 4%i 2%dY
5% own	1168	617	821	1101	1489
5% joint		619	826	1111	1508
10% own	2336	1235	1642	2202	2978
10% joint		1238	1652	2223	3016
15% own	3504	1852	2462	3303	4467
15% joint		1857	2478	3334	4523
20% own	4672	2469	3283	4403	5957
20% joint		2476	3303	4446	6031

The importance of adopting an operational equivalence between PAYG and funded systems in the evaluation of any pension mix must be underlined. Changing the assumptions about population and earnings growth and real rates of return will easily allow funded pension systems to outperform PAYG or vice versa. We have deliberately chosen i=3%, dY=1.5% in order to prevent any overall system dominance and to permit a clear discussion of distributional outcomes. In practice, of course, expected economic and demographic conditions in any country may well tend to favour PAYG or funded pension systems.

Tables 19-22 report the distributional outcomes by decile of discounted lifetime earnings for people who survive to age 65 of five hybrid pension schemes in which all workers contribute 20% of annual earnings, in the following combinations: 0% flat-rate PAYG and 20% defined-contribution; 5% PAYG and 15% defined-contribution; 10% PAYG and 10% defined-contribution; 15% PAYG and 5% defined-contribution, and 20% PAYG and 0% defined-contribution. The three panels of table 19 report the results in terms of the proportion of average male full-time annual earnings that would be replaced by pensions based on own-income contributions, for all individuals, and for men and women separately.

Table 19
Proportion of average male annual wages replaced by different hybrid pension systems, when contributions are based on own income.

(19a) All individuals

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	319	.12	.20	.28	.36	.44
D2	320	.20	.26	.32	.38	.44
D3	319	.26	.31	.35	.40	.44
D4	320	.32	.35	.38	.41	.44
D5	319	.38	.40	.41	.43	.44
D6	320	.44	.44	.44	.44	.44
D7	320	.51	.49	.48	.46	.44
D8	319	.60	.56	.52	.48	.44
D9	320	.73	.66	.58	.51	.44
D10	319	1.06	.91	.75	.60	.44
ALL	3195	.46	.46	.45	.45	.44

(19b) Men

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	13	.08	.17	.26	.35	.44
D2	15	.22	.27	.33	.39	.44
D3	52	.27	.31	.36	.40	.44
D4	76	.32	.35	.38	.41	.44
D5	164	.38	.40	.41	.43	.44
D6	189	.44	.44	.44	.44	.44
D7	209	.51	.49	.48	.46	.44
D8	243	.60	.56	.52	.48	.44
D9	263	.73	.65	.58	.51	.44
D10	284	1.06	.90	.75	.60	.44
ALL	1508	.62	.58	.53	.49	.44

(19c) Women

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	306	.12	.20	.28	.36	.44
D2	305	.20	.26	.32	.38	.44
D3	267	.26	.31	.35	.40	.44
D4	244	.32	.35	.38	.41	.44
D5	155	.39	.40	.41	.43	.44
D6	131	.44	.44	.44	.44	.44
D7	111	.51	.49	.47	.46	.44
D8	76	.61	.57	.53	.48	.44
D9	57	.73	.66	.59	.51	.44
D10	35	1.07	.92	.76	.60	.44
ALL	1687	.33	.35	.38	.41	.44

The final row of Table 19a shows that the assumptions of i = 3% and dY = 1.5% create an approximate equivalence between PAYG and funded pension systems within the demographic parameters of the LIFEMOD model (as can be seen, there is a very slight in-built advantage for funded pensions in this and the subsequent tables). The approximate equivalence condition enables us to make direct comparisons of the distributional outcomes of different combinations of PAYG and funded pension systems in Tables 19-22. Table 19a shows that all individuals in the bottom five deciles of the lifetime earnings distribution would fare better from a pure flat-rate pay-as-you-go pension than from any hybrid system and, not surprisingly, the more the final pension depends on own earnings history, the lower is the achieved replacement rate for these bottom five deciles. In general, however, pension outcomes for individuals in the sixth decile of the lifetime income distribution are insensitive to the mix of PAYG and defined contribution pension elements.

The decile rankings in Tables 19-22 are by discounted lifetime earnings. In Table 19 the replacement rates for men (19b) and women (19c) are almost identical within each decile for each of the five types of pension system. This is not surprising; men and women who find themselves in the same decile of the distribution of lifetime earnings should accumulate similar pension entitlements regardless of the pension system. However, as the first column in Tables 19b and 19c shows, women are very heavily over-represented in the bottom half of this income distribution. In consequences, as the bottom line of the three panels of Table 19 shows, while the different pension systems are (by design) more-or-less neutral across the population as a whole in terms of the average replacement rate they generate, they are not neutral between men and women. The higher lifetime earnings of men mean that on average they get almost double the replacement rate of women in a pure funded pension system. By definition a pure flat-rate PAYG system provides the same pension (and the same replacement rate as a proportion of average male earnings) to all people regardless of gender or lifetime earnings.

Table 20 presents the same data, but this time with the pension replacement rate defined in relation to own individual discounted annualized lifetime earnings (where the annualization is based upon number of years of labour force participation for each individual). Although the level of pension received by individuals in similar cells of Tables 19 and 20 is identical, the recorded replacement rates are very different because of the different denominators used. In relation to own discounted annualized lifetime earnings, a pure PAYG pension produces the most widely varying replacement rates, while pure funding produces the least variance of outcomes. Tables 19 and 20 demonstrate very clearly the relative merits of flat-rate PAYG pensions in achieving minimum income goals and of funded pensions in achieving income replacement goals.

Table 20
Proportion of own annualized lifetime earnings replaced by different hybrid pension systems, when contributions are based on own income.

(20a) All individuals

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	319	.39	.65	.90	1.15	1.40
D2	320	.52	.68	.83	.99	1.14
D3	319	.56	.65	.74	.84	.94
D4	320	.57	.63	.68	.73	.78
D5	319	.59	.61	.63	.66	.68
D6	320	.61	.61	.61	.61	.61
D7	320	.65	.62	.60	.58	.56
D8	319	.66	.62	.57	.53	.48
D9	320	.66	.60	.53	.47	.40
D10	319	.68	.58	.48	.38	.29
ALL	3195	.59	.62	.66	.69	.72

(20b) Men

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	13	.28	.45	.62	.79	.96
D2	15	.39	.50	.60	.70	.80
D3	52	.48	.56	.64	.71	.79
D4	76	.53	.57	.62	.67	.72
D5	164	.59	.61	.64	.66	.68
D6	189	.61	.61	.61	.61	.61
D7	209	.65	.62	.60	.58	.56
D8	243	.66	.62	.58	.53	.49
D9	263	.67	.60	.54	.47	.40
D10	284	.67	.58	.48	.39	.29
ALL	1508	.63	.60	.57	.54	.51

(20c) Women

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	306	.39	.65	.91	1.16	1.42
D2	305	.53	.69	.84	1.00	1.16
D3	267	.57	.67	.77	.87	.97
D4	244	.59	.64	.70	.75	.80
D5	155	.60	.62	.64	.66	.69
D6	131	.61	.61	.61	.60	.60
D7	111	.64	.62	.60	.58	.56
D8	76	.64	.60	.56	.51	.47
D9	57	.65	.59	.52	.46	.40
D10	35	.67	.58	.48	.38	.29
ALL	1687	.55	.64	.74	.83	.92

Tables 21 and 22 repeat the analysis of tables 19 and 20. People remain ranked according to their place in the lifetime income distribution, but the replacement rates assume that the pension systems operate under the joint contribution rule. Comparing tables 19 and 20 with tables 20 and 21, it is clear that joint contributions significantly improve pension outcomes for almost all women, both relative to average male earnings and to own annualized lifetime earnings. This improvement for women comes at the expense of men; the final row of tables 19a and 21a show that the overall replacement rates under the two different contribution rules are virtually identical for the population as a whole. Joint contributions do almost nothing to improve the replacement rates for the bottom three deciles of males generated by the pure defined contribution system (19b and 21b) whereas they significantly improve pension outcomes for the bottom 7 deciles of women (19c and 21c). This may be due in part to interdependence between the employment status of spouses, with the wives of unemployed men having low participation rates. It is also a function of the way in which LIFEMOD mirrors the marriage market, with better educated people having a high probability of marrying each other, and vice versa.

Table 21
Proportion of average male annual wages replaced by different hybrid pension systems, when contributions are based on joint income in marriage.

(21a) All individuals

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	319	.27	.31	.36	.40	.44
D2	320	.34	.37	.39	.42	.44
D3	319	.37	.39	.41	.42	.44
D4	320	.41	.42	.43	.43	.44
D5	319	.41	.42	.43	.43	.44
D6	320	.44	.44	.44	.44	.44
D7	320	.49	.48	.47	.45	.44
D8	319	.53	.50	.49	.46	.44
D9	320	.60	.56	.52	.48	.44
D10	319	.80	.71	.62	.53	.44
ALL	3195	.47	.46	.45	.45	.44

(21b) Men

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	13	.10	.19	.27	.36	.44
D2	15	.22	.28	.33	.39	.44
D3	52	.27	.31	.36	.40	.44
D4	76	.30	.33	.37	.40	.44
D5	164	.35	.38	.40	.43	.44
D6	189	.38	.40	.41	.43	.44
D7	209	.43	.43	.44	.44	.44
D8	243	.49	.48	.47	.45	.44
D9	263	.57	.54	.51	.47	.44
D10	284	.78	.70	.61	.53	.44
ALL	1508	[illegible]	.49	.47	.46	.44

(21c) Women

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	306	.28	.32	.36	.40	.44
D2	305	.35	.38	.40	.42	.44
D3	267	.39	.41	.42	.43	.44
D4	244	.44	.44	.44	.44	.44
D5	155	.47	.46	.46	.45	.44
D6	131	.54	.51	.49	.46	.44
D7	111	.60	.56	.52	.48	.44
D8	76	.65	.60	.54	.49	.44
D9	57	.73	.66	.59	.51	.44
D10	35	.99	.86	.72	.58	.44
ALL	1687	.44	.44	.44	.44	.44

Table 22
Proportion of own annualized lifetime earnings replaced by different hybrid pension systems, when contributions are based joint income in marriage.

(22a) All individuals

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	319	.91	1.03	1.15	1.28	1.41
D2	320	.92	.97	1.03	1.08	1.14
D3	319	.81	.84	.87	.91	.94
D4	320	.74	.75	.76	.77	.78
D5	319	.64	.65	.66	.67	.68
D6	320	.62	.62	.61	.61	.61
D7	320	.62	.60	.59	.57	.56
D8	319	.58	.55	.53	.51	.48
D9	320	.54	.51	.48	.44	.40
D10	319	.52	.46	.40	.35	.29
ALL	3195	.69	.70	.71	.72	.73

(22b) Men

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	13	.32	.48	.64	.80	.96
D2	15	.40	.50	.60	.70	.80
D3	52	.48	.56	.64	.71	.79
D4	76	.48	.54	.60	.66	.72
D5	164	.55	.58	.61	.65	.68
D6	189	.53	.55	.57	.60	.62
D7	209	.54	.55	.55	.55	.56
D8	243	.54	.53	.51	.50	.49
D9	263	.52	.50	.47	.44	.41
D10	284	.51	.45	.40	.34	.29
ALL	1508	.53	.52	.52	.51	.51

(22c) Women

	N	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=20	PAYG=15 DC=5	PAYG=20 DC=0
D1	306	.92	1.05	1.17	1.30	1.42
D2	305	.94	1.00	1.05	1.10	1.16
D3	267	.87	.90	.92	.94	.96
D4	244	.82	.82	.81	.81	.81
D5	155	.73	.72	.70	.70	.69
D6	131	.73	.70	.67	.64	.60
D7	111	.77	.72	.66	.61	.56
D8	76	.68	.63	.58	.52	.47
D9	57	.65	.59	.52	.46	.40
D10	35	.63	.54	.46	.38	.29
ALL	1687	.84	.86	.88	.90	.92

As a supplement to this analysis by income deciles, Tables 23 and 24 present the outcome of the different pension mixes with people grouped according to their level of educational achievement. EDU1 is those individuals who left school at the minimum leaving age of 16, EDU2 is those who continued beyond 16 but did not attend university, and EDU 3 is those with university-level education.

Table 23
Proportion of average male annual wages replaced by different hybrid pension systems, when contributions are based on own income and joint income in marriage, ranked by educational experience

EDU	POP	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=10	PAYG=15 DC=5	PAYG=20 DC=0
Own Contributions						
EDU1	ALL	.37	.39	.41	.42	.44
EDU2	ALL	.46	.46	.45	.45	.44
EDU3	ALL	.65	.60	.54	.50	.44
Joint Contributions						
EDU1	ALL	.40	.41	.42	.43	.44
EDU2	ALL	.48	.47	.46	.45	.44
EDU3	ALL	.59	.55	.52	.48	.44

Table 24
Proportion of own anualized lifetime earnings replaced by different hybrid pension systems, when contributions are based on own income and joint income in marriage, ranked by educational experience

EDU	POP	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=10	PAYG=15 DC=5	PAYG=20 DC=0
Own Contributions						
EDU1	ALL	.60	.67	.74	.81	.88
EDU2	ALL	.58	.61	.64	.67	.69
EDU3	ALL	.57	.55	.53	.51	.49
Joint Contributions						
EDU1	ALL	.75	.72	.82	.85	.88
EDU2	ALL	.68	.68	.69	.69	.69
EDU3	ALL	.58	.56	.53	.51	.49

Given that we would expect earnings to be related to educational acheivement the results are not suprising, mirroring the trends described above. The greater the dependency on past earnings the lower the replacement rate for the less well educated. The most striking feature of the tables is the split between individuals with a university level education and all others. Those who have experienced higher education have much higher average lifetime earnings and so they face a lower replacement rate relative to own earnings but a much higher rate relative to average male earnings.

The effect of joint contributions has limited impact on replacement rates relative to average wage. Its effect is more marked with regard to own lifetime wage. Since the proportionate change in pension income is much greater for those with low lifetime average earnings (i.e. wives) than high (i.e. husbands) the net effect of joint contributions is to raise the average replacement rate of each educational group. The replacement rate of persons with higher education is least sensitive to the sharing assumption in part because that group contains fewe women than the other categories.

A further point to note is that in tables 18-24 we have assumed that there is full compliance with PAYG contributions. Any degree of PAYG avoidance would necessarily reduce the level of pensions that could be paid to everyone, whereas non-payment into an (indivualized) funded system only affects the epnsion outcome of the non-payer. Since the cost to individuals of avoiding PAYG contributions is much less than that involved with indivual pension funds (a standard moral hazard problem), it might be expected that the actual replacement rate secured by a given PAYG contribution rate would be lower than we have assumed especially if contribution/tax collection systems are relatively unsophisticated.

Table 25
Gini coefficients of distribution of pension income produced by different hybrid pension systems

Contribution basis	PAYG=0 DC=20	PAYG=5 DC=15	PAYG=10 DC=10	PAYG=15 DC=5	PAYG=20 DC=0
Own	.317	.214	.163	.083	0
Joint	.222	.169	.114	.058	0
Gini coefficient on lifetime earnings: .310					
Gini coefficient on annualized lifetime earnings: .274					

As we have seen, although the pension outcomes for the population as a whole appear to be system-neutral, the different proportional mix of funded and PAYG elements produce very different *distributional* outcomes. Table 25 summarizes the distributional outcomes of the five different pension systems reported in tables 19-22. The gini coefficient for pension outcomes produced by own contributions into the pure defined contribution system is obviously almost identical to that on lifetime earnings. Joint contributions consistently reduce inequality in pension outcomes, as does a larger flat-rate PAYG element. Both act to redistribute pension resources from rich (men) to poor (women). Thus for any government concerned with equity and pension outcomes it is possible, therefore, to think of a trade-off between joint contribution rules in defined contribution pensions and PAYG systems.

5. Summary and conclusions

In the last decade public pension system reform has appeared on the political agenda of almost all the newly industrializing and older industrial countries. The main impetus behind the debate has been the macro economic cost of existing pay-as-you-go public pension systems. Such costs have been escalating rapidly due to population ageing combined with a slow down in economic growth and pension system maturity. In order to ameliorate the fiscal burden many countries are now contemplating a transition from public PAYG to fully funded pension schemes. However, as section 2 of the paper makes clear at the individual level pension systems are designed to acheive an intertemporal transfer of income sufficient to prevent abject poverty in retirement and ideally to acheive income replacement. This paper examines the distributional outcomes of a wide variety of possible PAYG and funded pension systems, highlighting the relative merits of each in achieving the goals of minimum income and income replacement.

This paper has used a dynamic cohort microsimulation model (LIFEMOD). Microsimulation modelling is the *only* way to investigate the relative distributional effects of different pension systems in any given demographic and socio-economic environment, and this paper is a pioneering attempt to analyse pension outcomes using a dynamic cohort microsimulation model. The technique allows us to investigate both the number of people affected by a change in contribution or eligibility rules in any pension system, and to examine their socio-economic characteristics. LIFEMOD is parameterized with reference to the UK in 1985, so specific results cannot be considered valid for other countries. Nevertheless, the general characteristics of winners and losers in any particular pension system are likely to be similar across countries.

In summary, the paper has found the following:

Pay-as-you-go pension systems

- In any flat-rate PAYG system the proportion of net beneficiaries will exceed that of net taxpayers at retirement, because of the premature death of some former tax-payers.

- Women benefit much more than men in such a system; in our simulations 84% of surviving women but only 33% of surviving men are net beneficiaries.

- The gains of women are due to their higher life expectancy than men and lower lifetime earnings.

- High unemployment, low educational attainment and lone parenthood all increase the chance of being a net beneficiary (Table 1).

- The imposition of contribution conditions significantly affects who gains and who loses.

- Almost all women fulfil the condition of at least 20 years worth of contribution, but a third of women fail to meet a condition of 20 years of contribution of at least 33% of average full-time male contributions (Table 3)

- Never-married women fare better than married women under a contribution condition with minimum levels because they are more likely to be in full-time employment and so earning higher wages than are married women.

- Imposing a joint contributions rule significantly increases the number of women qualifying under the duration and level contribution condition, without any significant reduction in the proportion of men qualifying

- As contribution conditions are made more severe, a joint contribution rule becomes less beneficial for women and more costly for men.

Funded pension systems

- The capital sums required to produce any particular level of pension, and the contribution rates required to accumulate these capital sums, depend crucially on the ages at which contributions begin, and retirement and death occur, and on rates of real earnings growth and real rates of return (Tables 6 and 7).

- Men accumulate on average a much higher level of pension capital than do women, because of their higher earnings and more continuous labour force participation.

- Years of tertiary education have a positive impact on pension fund accumulation; years of unemployment and, for women, years with a dependent child in the household have a negative effect (Table 13).

- The variance of pension capital accumulation is much greater for women than for men (Tables 8 and 9).

- If pension replacement rates are calculated by reference to *own* last full-time earnings rather than average male full time earnings, women achieve replacement rates close to those of men, though the absolute value of their pension is much lower (Table 10).

- Different rates of real interest and earnings growth differentially affect the pension fund accumulation individuals (Table 11).

- Women benefit more from high rates of return and low earnings growth, because they tend to receive a higher proportion of their lifetime earnings when young (Table 12).

- The imposition of a joint contribution rule significantly increases the proportion of women who meet any minimum pension threshold, but decreases the proportion of men who reach this level (Table 14).

- Despite the large distributional effect of imposing joint contributions, men still fare better in a funded pension system with joint contributions than do women (Table 16).

- Even with joint contributions, some men and many women fail to achieve minimum pension levels.

- If the pension shortfall is compensated for by lump-sum capital top-ups, women receive 88% of top-ups on the basis of own contributions and 66% on the basis of joint contributions.

Hybrid pension systems

- In mixed PAYG and funded systems, the higher the proportion of PAYG contributions, the greater is the replacement rate for people in the bottom 40 percent of the lifetime earnings distribution (the majority of whom are women) (Table 19).

- Joint contributions reduce but do not eliminate the gains of women from a shift from funded to PAYG systems (Table 21).

- Replacement rates for the people in the middle of the income distribution are insensitive to any variant of the PAYG/funded combination.

- Distributional comparisons between PAYG and funded systems must be based on parameters which allow the different systems to provide similar overall pension replacement rates if using similar comtribution rates.

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