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Neutral or Fair?  
Actuarial Concepts and Pension-System Design

Monika Queisser and Edward Whitehouse

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NEUTRAL OR FAIR? ACTUARIAL CONCEPTS AND PENSION-SYSTEM DESIGN

Monika Queisser and Edward Whitehouse

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## SUMMARY

1. Economists and policymakers increasingly use the word “actuarial” in the analysis of pension systems and retirement incentives. But the debate is often confused. “Actuarial fairness” and “actuarial neutrality” are promoted loosely as desirable goals of pension reform. This paper distinguishes two actuarial concepts and discusses their importance for defined-benefit, defined-contribution and notional accounts pension plans.

- Actuarial fairness, which requires that the present value of lifetime contributions equals the present value of lifetime benefits. Actuarial fairness relates to the entire lifetime of contributions and benefits
- Actuarial neutrality, which requires that the present value of accrued pension benefits for working an additional year is the same as in the year before (meaning that benefits increase only by the additional entitlement earned in that year). Conversely, retiring a year earlier should reduce the pension benefit both by the entitlement that would have been earned during the year and by an amount to reflect the longer duration for which the pension must be paid. Actuarial neutrality is a *marginal* concept, relating to the effect of working an additional year.

2. The discussion shows that it is very difficult to design pension systems around these actuarial concepts alone. Most retirement income systems have several components; some of these may be actuarially fair or actuarially neutral but others, notably safety-nets to protect retirees from poverty, will by definition not fulfil the conditions of actuarial fairness or neutrality. Finally, both concepts are defined across the population, regardless of the systematic differences in life-expectancy between women and men or between low-income groups and richer workers. People who expect to live longer will get a better deal out of the pension system than those who are expected to die earlier.

## RESUME

3. Les économistes et les décideurs utilisent de plus en plus le terme “actuariel” dans le cadre de l’analyse des systèmes de pension et des incitations à la retraite. Pour autant, le débat manque souvent de clarté. « L’équité actuarielle » et « la neutralité actuarielle » sont deux concepts vaguement encouragés comme étant des objectifs souhaitables pour les réformes de pension. Ce document fait la distinction entre ces deux concepts actuariels et montre leur importance pour les plans de retraite à prestations définies, à cotisations définies et pour le modèle des comptes notionnels.

- L’équité actuarielle préconise que la valeur actuelle des cotisations sur l’ensemble de la carrière professionnelle soit égale à la valeur actuelle des prestations perçues pendant la retraite.
- La neutralité actuarielle préconise que la valeur actuelle des prestations de pensions constituées pour une année supplémentaire de travail soit la même que pour l’année précédente (signifiant que les prestations augmentent seulement conformément aux droits supplémentaires gagnés cette année-là). A l’inverse, partir à la retraite un an plus tôt devrait réduire les prestations de pensions par les droits qui auraient dû être acquis cette année et par un montant reflétant l’allongement de la durée pendant laquelle la retraite doit être payée. Neutralité actuarielle est un concept *marginal*, en rapport avec l’incidence de travailler un an de plus.

4. Le débat montre qu’il est très difficile d’élaborer des systèmes de pension autour de ces concepts actuariels seuls. La plupart des systèmes de retraite ont plusieurs éléments; certains peuvent être actuariellement justes ou actuariellement neutres mais les autres comme notamment les filets de sécurité devant protéger les retraités de la pauvreté, ne pourront par définition remplir les conditions d’équité ou de neutralité actuarielle. Finalement, les deux concepts sont définis parmi la population, sans se soucier des différences systématiques dans la longévité entre femmes et hommes ou entre les groupes de bas revenus et les travailleurs plus aisés. Les personnes qui vivront plus longtemps obtiendront de meilleurs résultats de leur système de pension que ceux qui mourront plus tôt.

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## NEUTRAL OR FAIR? ACTUARIAL CONCEPTS AND PENSION-SYSTEM DESIGN

### 1. Introduction

5. The looming financial crises faced by many OECD countries' retirement-income systems have three main demographic and economic roots: fewer babies, longer lives and early retirement. All of these challenges require policy responses that are based on sound technical analysis using demographic and economic data. Many of these techniques involve "actuarial" calculations, which rely on empirical analysis of the probabilities underlying mortality and other risks, and the laws of compound interest.

6. Economists and policymakers increasingly use the term "actuarial" when writing about pension systems. The tendency to advocate actuarial-based pension reforms perhaps stems from the credibility that the term "actuarial" brings or appears to bring. This is probably because the actuarial profession is traditionally associated with measuring and ensuring solvency.

7. However, the debate about the application of actuarial principles to pension-system design has unfortunately become confused. Governments, policy advisors and pension experts loosely use terms such as "actuarially fair" and "actuarially neutral" to describe desirable attributes of pension systems. But the terms are used by different people to mean different things. And it is often unclear precisely what is meant.

8. This paper aims to define the different "actuarial" concepts in a formal manner (section 2). It goes on to look at different types of pension scheme (section 3) and how they measure up against the benchmark actuarial concepts (section 4). Since these are technical questions, the paper includes formal, mathematical descriptions of the key concepts. These are set out in Boxes so that readers who are less interested in technical detail are able to skip the formulae. Section 5 looks at country practices on actuarial adjustments to pensions for early and late retirement. Section 6 explores the relevance of actuarial concepts in pension policy.

9. A companion paper — Queisser and Whitehouse (2007) — will look in greater detail at the measurement of retirement incentives in different kinds of pension plan, a subject that is closely linked to the concept of actuarial neutrality.

### 2. Actuarial concepts

10. This section defines and explains the two main actuarial concepts that are analysed in detail in this paper. It also examines their inter-relationship. These two concepts are:

- Actuarial fairness, which requires that the present value of lifetime contributions equals the present value of lifetime benefits.

- Actuarial neutrality, which requires that the present value of **accrued** pension benefits for working an additional year is the same as in the year before (meaning that benefits increase only by the additional entitlement earned in that year). Conversely, retiring a year earlier should reduce the pension benefit both by the entitlement that would have been earned during the year and by an amount to reflect the longer duration for which the pension must be paid.

11. The two concepts differ fundamentally in the time periods that each covers. Actuarial fairness relates to the entire lifetime total of contributions and benefits. Actuarial neutrality is, in contrast, a marginal concept, relating to the effect of working an additional year. It is also important to note that both concepts only make sense *ex ante*. Actual or *ex post* outcomes will differ because the calculations are based on probabilities but, in reality, people die at different ages.

### 2.1. Actuarial fairness

12. An actuarially fair pension is one that equalises lifetime individual pension entitlements to lifetime individual pension contributions. By definition, therefore, there is no redistribution towards or away from any individual: what you get out in retirement is the same as what you paid in when working, together with any interest that was earned before retirement. To examine actuarial fairness, we obviously need to measure lifetime contributions and benefits.

13. Box 1 shows the formal way in which lifetime contributions can be calculated, giving a present value for contributions at the time of retirement. The most central – and contentious – issue in this calculation is the interest rate that is applied to contributions as they accumulate over the working life. There are three possible choices of benchmark interest rate.

#### *Market rate of return on investments*

14. Many commentators – Disney (2004, 2006), Lindbeck and Persson (2003) and Hassler and Lindbeck (2004) *inter alia* – argue that contributions should be assumed to earn the market rate of return on investments (on a balanced portfolio mixing equities and fixed-interest securities). An individual, DC, retirement savings account is seen as a suitable counter-factual, since it would be the instrument available to individuals if there were no pension system mandated or provided by the government. It is the retirement savings medium open to individuals for their voluntary savings. But what level should then be assumed for the interest rate? The central question in the choice of level is whether equities offer a higher rate of return than riskless assets, even adjusting for the cost of the additional risk borne. The literature on this question is vast, but the evidence for an equity premium is strong.<sup>1</sup>

15. A second approach is theoretical rather than empirical. Theoretical, dynamic macroeconomic models show that the rate of return on risky assets must exceed the riskless interest rate, otherwise the economy would be dynamically inefficient.<sup>2</sup>

16. Thus, there is a mix of empirical and theoretical evidence that the risk-adjusted rate of return on investments is greater than the return on riskless assets. There is also broad support in the literature for using the market rate of return on investments as the benchmark for assessing actuarial fairness. (Note that a “benchmark” is something that is used as a reference point for measurement. This does not imply anything as regards the desirability or not of organising pension systems around DC schemes.)

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1. See, *inter alia*, Blanchard (1993), Constantinides, Donaldson and Mehra (1998), Jagannathan and Kocherlakota (1996) and Mehra and Prescott (1985).

2. See Auerbach and Kotlikoff (1987), for example.

*Riskless interest rate*

17. A minority of analysts deny the existence of an equity premium. In this case, the additional return that investments in equities can earn is simply a reflection of the higher risk.<sup>3</sup> If this position is taken, the appropriate interest rate to use as a return on contributions to assess actuarial fairness would be the riskless interest rate. This seems particularly relevant in the context of a public pay-as-you-go (PAYG) pension scheme because it is the interest rate at which the government can move money over time.<sup>4</sup> Thus, the counterfactual to use in this case is investment in a long-term government bond and the corresponding interest rate would be used to determine whether a system is actuarial fair or not.

*Fiscally sustainable returns*

18. From the perspective of a pension system, it is important to set the rate of return on contributions at a level that is fiscally sustainable over the longer term. The Aaron-Samuelson condition<sup>5</sup> shows that, in a PAYG system, the fiscally sustainable rate of return is the sum of productivity (or average-earnings) growth and the growth (or shrinkage) of the workforce. But “actuarial fairness” and “fiscal sustainability” are fundamentally different concepts. One might argue that fiscal sustainability is the binding constraint on pension policy, but that does not mean that the rate of return on contributions implied is “fair”. With population ageing and a shrinking workforce, fiscal sustainability requires that the government takes individuals’ pension contributions and pays an investment return less than the long-term bond interest rate. It is hard to describe this as “fair”. Indeed, applying the framework of actuarial fairness to this situation would mean that governments could take contributions from individuals now, pay down debt (saving the riskless interest rate on it) and pay back to individuals a pension in the future with a lower interest rate.

19. We do not, of course, deny the importance of fiscal sustainability as a guide to pension policy. However, there is a distinction between fiscal sustainability and actuarial fairness. The assessments below, therefore, use only the first two benchmarks – the rate of return on investments and the riskless interest rate – to measure accumulated pension contributions at the time of retirement.

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3. See Bodie (1995), for example.

4. It also requires that default on sovereign debt is equally as unlikely as a default on future (PAYG) pension promises, which is a contentious question. See McHale (1997).

5. Aaron (1966) and Samuelson (1958).

**Box 1. Cumulative value of pension contributions at the time of retirement**

For simplicity, individual earnings are assumed to grow at a rate  $g$ . Earnings at a given period  $t$  in continuous time can be written as a multiple of earnings in period zero, when the individual joins the pension fund:

$$w_t = w_0 e^{gt}$$

Multiplying the above formula by the contribution rate,  $c$ , gives the flow into the pension fund in each period. This contribution must then be adjusted forward from the time the contribution is made,  $t$ , and the time when the pension is claimed,  $T$ . Denoting the interest rate used for this adjustment as  $r$ , the value of the capital accumulated from a year's contributions at retirement ( $k$ ) can be written:

$$k = cw_0 e^{gt} e^{r(T-t)}$$

The next stage is to integrate the previous formula over time to give the present value of accumulated contributions at the time of retirement,  $K$ . The result is:

$$K = cw_0 e^{rT} \frac{e^{(g-r)T} - 1}{g - r}$$

A scheme can be said to be actuarially fair if this is equal to the pension wealth, with both lifetime contributions and lifetime benefits measured at the time of retirement.

20. Having calculated what has been paid in, the next stage is to examine lifetime benefits: what is paid out. A “pension” is a stream of benefits paid over time until some contingency occurs, usually the death of the beneficiary or of the beneficiary’s spouse. This flow of benefits can be converted into a “stock” of lifetime pension capital, commonly known as pension wealth. The calculation is based on the “annuity factor” whose derivation is explained in Box 2. Multiplying the pension entitlement by the relevant annuity factor gives pension wealth.

21. Annuity factors show the present value of a pension of one unit. If the annuity factor were, for example, 16.5 and the annual value of the pension were \$ 1 000, then pension wealth would be \$ 16 500. The size of the relevant annuity factor depends on how long the pension is likely to be paid and how its value evolves over time. It therefore depends on age of retirement, mortality rates and the way in which pensions in payment are adjusted (indexed to price inflation or average earnings growth, for example).

**Box 2. Calculating annuity factors**

A “pension” is a stream of benefits paid over time until some contingency occurs, usually the death of the beneficiary or of the spouse of the beneficiary. This flow of benefits can be converted into a “stock” of lifetime pension capital, which is often called pension wealth. The calculation is based on the “annuity factor”: multiplying the pension entitlement by the relevant annuity factor gives pension wealth.

The annuity calculation is based on the survival function, *i.e.*, the probability of being alive at a particular time  $t$  conditional on being alive at the starting point, in this case, the age at which the pension is first drawn. The survival function,  $s_t$ , is the product ( $\Pi$ ) of one minus the mortality rates from the time the pension is withdrawn to the relevant age. Formally, the survival function to time  $t$  is

$$s_t = \prod_{i=0}^t (1 - \lambda_i)$$

where  $\lambda$  is the hazard function or mortality rate, that is, the probability of dying in a particular year conditional on surviving to the beginning of the year. Time is indexed  $i$  from the time the pension is drawn (0) to the time at which the survival probability is measured,  $t$ .

Life expectancy, LE, is simply the sum of the survival functions from the age at which the pension is first drawn – R – to a terminal age, T, which is age 100 in the mortality data used in this paper

$$LE = \sum_{i=R}^T s_i$$

The present value of an annuity depends on the probability of being alive to claim the pension in each period, as measured by the survival function. The calculation also needs to discount future incomes, because there is an opportunity cost to delaying consumption. The discount rate is denoted  $z$  in the following formulae.

Finally, account must also be taken of the adjustment of pensions in payment to reflect changes in costs or standards of living: “indexation” or “uprating” policy. The value of the adjustment to pensions in real terms is shown below as  $u$ . Since the riskless interest rate,  $z$ , is a real rate,  $u$  will be zero if benefits are indexed to prices. For uprating in line with earnings or combinations of earnings and prices, the value of  $u$  will depend on the assumption for earnings growth. For example,  $u$  would be 2% if pensions were earnings indexed and real earnings were assumed to grow at 2% per year. If pensions were not indexed at all, then  $u$  would be minus the assumed inflation rate.

In each future period, the present value of the pension flow (PVPF) is

$$PVPF = s_i (1 + z)^{-i} (1 + u)^i$$

where  $s$  is the survival function,  $z$  is the discount rate and  $u$  is the amount by which real pensions are increased each year. The value of the pension payment received in a future period is the initial payment, discounted, adjusted through uprating procedures and multiplied by the probability that the pension is still around to receive the benefit. Summing these present values of flows gives the present value of the stock of the pension. This is the annuity factor

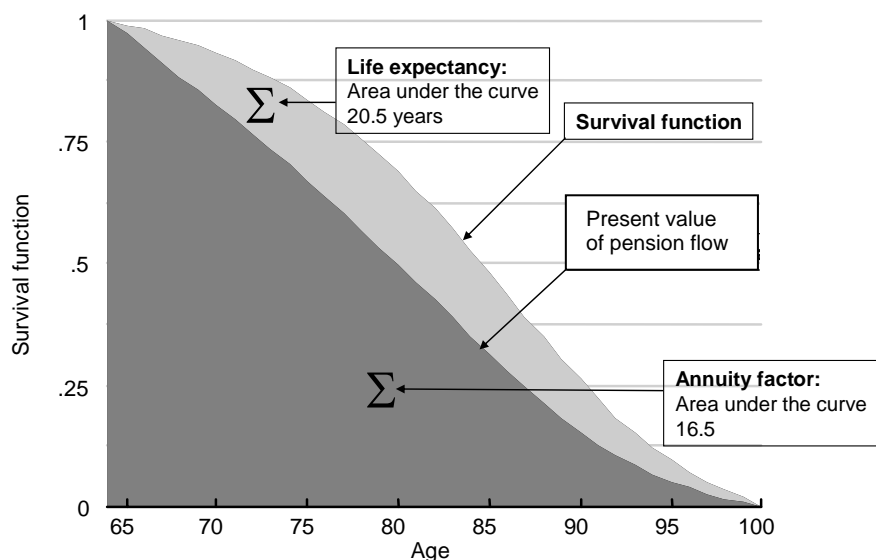
$$A = \sum_{i=R}^T s_i (1 + z)^{-i} (1 + u)^i$$

where  $A$  is the annuity factor.

The steps in these calculations are illustrated graphically in Figure 1. The curve above the light grey area is the survival function for a man retiring at age 64 with the OECD average mortality rates for 2040. Life expectancy is the area under the curve, that is, the light grey plus dark grey areas, which comes to 20.5 years. The discounted survival function is below the survival function. The area under this curve – the dark grey area – is the annuity factor, which is 16.5 in this case.

The annuity rate is the inverse of the annuity factor. In the example, the annuity factor is 16.5, meaning that a pension of \$ 1 000 a year has a present value of \$ 16 500. Equally, a lump sum of \$ 16 500 would be needed to buy a pension of \$ 1 000 a year, giving an annuity rate of 6.1%.

**Figure 1. Calculating annuity factors**



22. Annuity factors also depend on the choice of discount rate. The appropriate discount rate to use in the calculation is the riskless interest rate, which in OECD countries is approximately the long-term government bond interest rate (because the risk that government defaults on its obligations is considered to be zero or, at least, very low). There is a range of reasons for this choice.

- First, the stream of pension pay-outs, be they from a private annuity provider or from a public pension scheme, are assumed to be equally free from default risk as long-term government bonds.
- Secondly, private annuity providers typically invest (or are required to invest) in long-term government bonds to ensure that they can meet the stream of pension liabilities over time. So these assets will earn the long-term government bond rate.
- Thirdly, when the government acts as a pension provider, the long-term government bond rate determines the state's inter-temporal budget constraint. By way of illustration, the government could either offer a pension in a year's time or borrow money and pay the pension from today.

23. Pension wealth should, therefore, be measured using the riskless interest rate to discount future pension payments.

24. These two calculations give the present value of lifetime contributions and lifetime benefits at the time of retirement. It should immediately be obvious that the concept of actuarial fairness can only be applied where there is some sort of pension contribution. Schemes that are financed out of general government revenues cannot be assessed for actuarial fairness. To assess the features of different plans, we use the benefit/cost ratio. This is simply the present value of lifetime benefits divided by lifetime contributions. A pension scheme is actuarially fair if the benefit/cost ratio is one. It is actuarially “unfair” if the ratio is less or greater than one; in the latter case, the scheme is unlikely to be financially sustainable in the long term because each individual’s lifetime benefits are greater than his or her lifetime contributions.

25. Finally, it is important to recall that these actuarial concepts are measured *ex ante*. Longer lived individuals will get a better deal from most pension systems than the short-lived. Actuarial fairness is measured based on population mortality and life expectancy.<sup>6</sup>

## 2.2. Actuarial neutrality

26. The second “actuarial” concept is actuarial neutrality. This concept is based on a comparison of entitlements conditional on different ages of withdrawal of pension benefits. Actuarial neutrality is a central concept both to equity between individuals who retire at different ages and to incentives to retire.<sup>7</sup>

27. Actuarial neutrality, as defined here, requires that pension wealth for retiring a year later is the same as pension wealth when retiring today plus whatever pension is accrued during the additional year of work. Actuarial neutrality therefore relates to the pension already accrued at the beginning of the year and not to the extra pension earned during the year.

### *Comparison with previous studies*

28. Other studies — including the second round of the National Bureau of Economic Research’s (NBER) international project on retirement incentives (Gruber and Wise, 2002, 2003) and Disney and Whitehouse (1998) — define actuarial neutrality and changes in pension wealth in the same way as this paper.<sup>8</sup>

29. However, some analyses of them impose additional conditions for actuarial neutrality to the single condition in our definition.<sup>9</sup>

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6. One could, in principle, compare lifetime contributions and benefits for each individual after his or her death. But it would not be very revealing.

7. Börsch-Supan (2004) therefore uses the term “incentive-compatible” to mean a concept akin to actuarial neutrality, as defined here.

8. Note that the related question of measuring retirement incentives is explored further in the companion paper Queisser and Whitehouse (2006).

9. Burkhauser (1980) uses the term “actuarially fair” for the exact same concept that we term “actuarial neutrality”. Similarly, Oshio and Yashiro (1997) and Börsch-Supan and Schnabel (1997) use “actuarially fair” with reference to benefits for people who retire at different ages.

- Gruber and Wise (1997, 1998, 1999) — the first round of the NBER project on retirement incentives — preferred a measure of the implicit tax or subsidy on continuing in work of change in gross pension wealth less employer and employee contributions. The reason for including the employer contribution as a cost to the employee is “the assumption that the employer share is fully borne by the worker in the form of lower wages”.<sup>10,11</sup>
- Similarly, Blöndal and Scarpetta (1998) define an actuarially neutral pension system as one in which “the increase in pension benefits is exactly offset by the higher cost in terms of contributions and forgone pensions at all ages”. Again, this appears to include both employer and employee contributions.
- Desmet and Jousten (2003) measure actuarial neutrality taking account only of employee (and not employer) contributions. They suggest that actuarial neutrality requires that the additional pension entitlement from an extra year’s work should equal the employee contribution.

30. The definition used in this paper compares accrued pension entitlements at different ages but it does not consider any contributions paid or benefits earned during additional years of work. We see three main reasons for doing so:

31. First, these extended definitions of actuarial neutrality confuse neutrality over retirement and the actuarial fairness of the pension scheme. They require marginal contributions to equal marginal benefits. But this confuses actuarial fairness (which is all about whether people get out of the pension system what they put in) with the treatment of people who retire at different ages.

32. Secondly, there is a series of problems in measuring “pension” contributions that affect most OECD countries.

- Many pension schemes do not have an earmarked “pension” contribution. For example, Belgium, Spain and the United Kingdom, among others, have “social-security” contributions that finance benefits for a number of contingencies, such as unemployment, industrial injuries, sickness, maternity *etc.*
- There are no pension contributions in other countries. For example, public pensions in Australia and New Zealand are paid for out of general government revenues.
- A significant proportion of — albeit not all — public retirement benefits are financed from general revenues in other countries. In Canada, for example, the means-tested and basic benefits (which OECD, 2005 estimates will account for half of all public pensions in the long term) are general revenue financed. Only half of total public pensions — from the earnings-related plan — will be contribution-financed.

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10. Diamond and Gruber (1997).

11. It also appears that some contributors did not follow this methodology exactly. For example, the studies of Japan (Oshio and Yashiro, 1997) and the Netherlands (Kapteyn and de Vos, 1997) imply that only employee contributions are included in the calculation. The paper on Spain (Boldrin, Jimenez-Martin and Peracchi, 1997) includes personal income taxes as well as social security contributions. Social security contributions in the United Kingdom cover a range of benefits; the study of the British pension system included all of these contributions (Blundell and Johnson, 1997).

- Even in countries where there are earmarked “pension” contributions, there are frequently cross-subsidies from general revenues to finance benefits, meaning that the effect of pension-system levies on incentives cannot be measured by contributions alone.

33. It is not possible accurately to compare benefits and contributions in these cases, and so definitions of actuarial neutrality that include contributions can consistently be applied only to a tiny minority of pension schemes in OECD countries.

34. Thirdly, adding in employer contributions makes sense if one is trying to measure marginal actuarial fairness: *i.e.*, how the additional pension accrued within a year compares with the contributions that employers and employees have used to pay for it. However, it does not make sense if one is trying to measure retirement incentives. Deducting the employer contributions from the change in pension wealth introduces rather than offsets double counting. If workers do bear the entire cost of the employer contribution in the form of lower wages, then the wage measure used in the study — median wages in Gruber and Wise (1998), multiples of the OECD average-production-worker wage in Blöndal and Scarpetta (1998) — already reflects this.

#### *Defining actuarial neutrality*

35. The way in which pension wealth is calculated depends on when the individual leaves the labour market relative to pension eligibility ages. If he or she retires and can immediately claim the pension, then pension wealth is simply the annuity factor (whose calculation is explained in Box 2) multiplied by the replacement rate. But it becomes more complicated for people who stop working and contributing to a pension scheme before they can claim a pension under that scheme. The pension wealth calculation then needs to take account of the risk that the worker might die before claiming the pension.

36. To illustrate with an example: a pension system allows retirement only at age 65. If a worker leaves a job at age 60, he or she has to wait until 65 to claim the pension. The pension wealth is calculated as if the worker was already 65, and so needs to be discounted back to age 60 and, in addition, reduced to allow for the probability of dying between age 60 and 65. So even if the pension entitlement were the same regardless of whether the worker left at age 60 or age 65, the pension wealth would be lower for the 60 year old because he has to wait to receive it.

37. Actuarial neutrality is defined formally in Box 3. This concept relates to the pension entitlements of people who retire and draw their benefits at different ages. It relates both to equity between retirees of different ages and to incentives to retire early or late.

**Box 3. Defining actuarial neutrality**

Define  $PW_{x|y}$  as pension wealth measured at time  $x$  conditional on drawing the pension at time  $y$ . Then actuarial neutrality requires that

$$PW_{t|t+1} = PW_{t|t} + \delta$$

*i.e.*, that the pension wealth deriving from already accrued rights is the same if retirement is deferred. The only difference is the additional entitlement earned during the year, here represented by  $\delta$ .

Pension wealth at time  $t$  is calculated as the pension entitlement,  $p$ , multiplied by the annuity factor,  $A$ . Thus,

$$PW_{t|t} = p_t A_t \text{ and } PW_{t+1|t+1} = p_{t+1} A_{t+1}$$

However, the formula for actuarial neutrality requires the wealth from the pension drawn at  $t+1$  to be measured at time  $t$ , not  $t+1$  as in the latter formula. The difference between the two allows for additional discounting back to time  $t$  and for the probability of dying during the year. This adjustment is achieved by multiplying by the discounted survival function at time  $t+1$  and dividing by the discounted survival function at time  $t$ . Formally, therefore, the condition for actuarial neutrality is:

$$PW_{t|t+1} = PW_{t+1|t+1} PVPF_{t+1} / PVPF_t$$

where  $PVPF$  is the function describing the present value of the flow of pension payments, defined in Box 2.

**3. A taxonomy of pension schemes**

38. Having introduced the actuarial concepts, this section presents a taxonomy of four different types of pension schemes. The analysis focuses on “insurance-oriented” pension plans, which target some level of earnings replacement during retirement. Actuarial concepts are less useful when it comes to schemes with very little or no link between contributions and benefits, such as minimum pensions, resource-tested retirement income programmes and basic pensions.<sup>12</sup>

*Defined-benefit plans*

39. Some 17 OECD countries have public, defined-benefit (DB) plans, making them by far the most common form of pension-insurance provision in OECD countries. In DB schemes, the amount a pensioner will receive depends on the number of years of contributions made throughout the working life and on some measure of individual earnings from work. As for private DB plans, these are mandatory (or quasi-mandatory) in Iceland, the Netherlands and Sweden. There is widespread coverage of voluntary, DB, occupational plans in Canada, Germany, Ireland, Japan, the United Kingdom and United States.

*Defined-contribution plans*

40. The next most common form of pension-insurance provision is the defined-contribution (DC) plan. In these schemes, each worker has an individual account in which contributions are saved and invested, and the accumulated capital is usually converted into a pension-income stream at retirement; lump-sum withdrawals are rarely permitted. Typically, the capital has to be used to buy an annuity, *i.e.* a guaranteed pension payment until death, which meets certain conditions (such as indexation of benefits and provision of survivors’ benefits). Six OECD countries have mandatory DC pensions: Australia, Denmark,

12. See OECD (2005), Chapter 1 for a more detailed typology of different types of pension scheme.

Hungary, Mexico, Poland and Sweden. Voluntary coverage of DC schemes is widespread in many OECD countries, particularly Canada, Germany, the United Kingdom and United States.

#### *Points systems*

41. Some countries have earnings-related schemes that do not follow the “traditional” DB model. There are four points systems in OECD countries: French occupational plans and the German, Norwegian and Slovak public schemes. Workers earn pension points based on their individual earnings for each year of contributions. At retirement, the sum of pension points is multiplied by a pension-point value to convert them into a regular pension payment.

#### *Notional accounts*

42. The final variant of earnings-related schemes is notional accounts, found in three OECD countries: the public plans of Italy, Poland and Sweden. These schemes record each worker’s contributions in an individual account and apply a rate of return to the accounts. The accounts are “notional” in that both the incoming contributions and the interest charged to them exist only on the books of the managing institution. At retirement, the accumulated notional capital in each account is converted to a stream of pension payments using a formula based on life expectancy at the time of retirement. Since they are designed to mimic the features of funded, defined-contribution plans, they are often called “notional defined-contribution” schemes.

### **3.1. Calculating benefits**

43. The way pension benefits are determined differs between the four types of pension schemes.

#### *Defined-benefit plans*

44. Benefit calculation in DB schemes is usually based on an accrual rate (or, sometimes, on multiple accrual rates): the pension entitlement for a year’s coverage as a percentage of earnings. Another important rule is the measure of earnings on which pension entitlements are calculated (typically lifetime re-valued average earnings, but sometimes a limited number of “final” or “best” years’ pay). The final element is the way that earlier years’ earnings are adjusted in the pension formula to reflect changes in costs and standards of living between the time a pension entitlement is earned and the time of retirement. Usually, this valorisation is to economy-wide average earnings.<sup>13</sup>

#### *Defined-contribution plans*

45. In DC plans, the pension depends on the contribution rate paid by employees and their employers, the investment return earned and the terms on which the accumulated capital is converted into an income stream (the annuity factor).

#### *Points systems*

46. Pension points are accumulated by dividing either contributions (as in France) or earnings (as in Germany) by the pension-point cost. The sum of accumulated points at the time of retirement is then multiplied by a pension-point value to determine the pension entitlement. In most cases, the evolution of the value of benefits during retirement is also determined by the time path of the pension-point value. The

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13. Valorisation is purely in line with prices in Belgium, France and Spain. Finland, Poland and Portugal valorise with a mix of earnings and prices. OECD (2005), Table 2.2 provides more details.

pension-point value in such cases determines both the valorisation of past earnings and the indexation of the benefit in payment.

#### *Notional accounts*

47. In notional accounts, the benefit depends on the accumulation of contributions and notional interest. This accumulated notional capital is then divided by an annuity factor at the time of retirement to calculate the pension benefit.

### **3.2. *Inter-relationship between different kinds of earnings-related scheme***

48. The three kinds of public, earnings-related pension plan – DB, points and notional accounts – are closely related. All take an input – individual earnings in different years over the career – and turn it into an output, a pension entitlement. The difference is in the parameters that are used in the benefit calculations. Box 5 shows how these parameters are related.

49. All these types of earnings-related scheme adjust earlier years' earnings or contributions to account for changes in costs and standards of living between the time pension entitlements are earned and paid out. In DB plans, this adjustment is achieved directly through valorisation: the revaluation of earlier years' earnings. The uprating of the pension-point value in points system performs the same role. In notional accounts schemes, the adjustment comes through the notional interest rate applied to contributions.

50. If the procedure for adjusting earlier years' earnings is the same – say that valorisation, pension-point value uprating and the notional interest rate are all linked to growth of economy-wide average earnings – then the relationship between the different kinds of earnings-related schemes is revealed. In DB plans, the pension earned each year depends on the accrual rate: pension relative to earnings. In pension-point schemes, the annual pension earned depends on the ratio of the pension-point value to the pension-point cost. If this is the same as the DB accrual rate, then the schemes deliver the same benefits for a given career earnings path. The calculation of the annual accrual is slightly more complex with notional accounts. Box 5, however, shows that the ratio of the contribution rate to the notional account to the annuity factor gives annual pension accruals relative to earnings.

#### Box 4. Defined-benefit, points and notional-accounts pension systems

Publicly provided, earnings-related pension schemes follow three broad types. This Box looks at the inter-relationship between the three using some basic algebra.

A simple, generic defined-benefit (DB) plan pays a constant accrual rate,  $a$ , for each year of service. It is based on lifetime average revalued earnings. The pension benefit can therefore be written as:

$$DB = \sum_{i=0}^R w_i (1+u)^{R-i} a$$

where  $w$  are individual earnings in a particular year (indexed  $i$ ),  $R$  is the year of retirement and  $u$  is the factor by which earlier years' earnings are revalued. In most OECD countries, this is the growth of economy-wide average earnings.

In a points system, pension points are calculated by dividing earnings by the cost of the pension point ( $k$ ). The pension benefit then depends on the value of a point at the time of retirement,  $v$ . Thus, the pension benefit can be written as:

$$PP = \sum_{i=0}^R \frac{w_i v_R}{k_i}$$

A significant public-policy variable is the policy for uprating the value of the pension point, shown by the parameter  $x$ . By writing the pension-point value at the time of retirement as a function of its contemporaneous value, the equation becomes:

$$PP = \sum_{i=0}^R \frac{w_i v_i}{k_i} (1+x)^{R-i}$$

In notional accounts, the inflow each year is wages multiplied by the contribution rate. The notional capital is increased each year by the notional interest rate,  $n$ . At retirement, the accumulated notional capital is divided by a notional annuity factor,  $A$ , sometimes called the  $g$ -value. The pension benefit can be written as:

$$NA = \sum_{i=0}^R \frac{w_i c}{A} (1+n)^{R-i}$$

If the policy for valorising earlier years' earnings is the same as the uprating procedure for the pension point and the notional interest rate (i.e.,  $u = x = n$ ), then the structure of the three equations is very similar. In this case, the DB accrual rate ( $a$ ) is equal to the ratio of the pension-point value to its cost ( $v/k$ ) and to the ratio of the notional-accounts contribution rate to the annuity factor ( $n/A$ ).

This has two implications for the comparison of these different types of pension scheme. First, the effective accrual rate can be calculated for pension-point schemes (the ratio of point value to cost) and notional-accounts schemes (the ratio of the contribution rate to the annuity factor). Secondly, the valorisation procedure in DB schemes, the uprating policy for the pension-point value and setting the notional interest rate are exactly parallel policies. Different choices of variables have the same effect in the different types of systems. Although DB, points and notional-accounts systems can appear very different, they are in fact closely related variants of earnings-related pension schemes.

Notional-accounts schemes have a built-in mechanism to adjust benefits to changes in life expectancy. Some countries, such as Finland, Germany and Japan, have incorporated similar mechanisms into DB or points systems.

#### 4. Assessing pension schemes against the actuarial benchmarks

51. This section examines how the concepts of actuarial fairness and actuarial neutrality apply to the different kinds of pension scheme. It shows at what level parameters of pension plans must be set in order to produce actuarially fair or neutral benefits. This discussion is not meant to assess the desirability of different kinds of pension scheme, nor, indeed, whether the two actuarial concepts are particular desirable features of pension plans. Instead, the aim is to clarify technical aspects of pension-system design.

##### 4.1. Funded, defined-contribution plans

52. In funded, DC pension plans, each member contributes into an individual retirement savings account and withdraws the balance at retirement.

##### *Actuarial fairness*

53. Funded, DC plans are actuarially fair at the accumulation stage. If one accepts the argument that the benchmark interest rate for measuring accumulated contributions at the time of retirement is the market rate of return on investments, then that is what the DC plans pay. Alternatively, if the chosen benchmark is the riskless interest rate, then participants could typically match that return by investing the entire assets of the DC plan in long-term government bonds.

54. Turning to the withdrawal stage, if the pension is taken as either a lump sum or a series of withdrawals from the accumulated balance, the plan is again by definition actuarially fair (this time at the withdrawal stage). If the pension is taken as an annuity, then actuarial fairness depends on the functioning of the annuity market. Studies of voluntary annuity markets in the United Kingdom and the United States have shown that annuities pay out less than they would if insurance companies were to base their calculations on the relevant interest rates and projected population mortality.<sup>14</sup> However, this does not necessarily mean that annuity prices are “actuarially unfair” since they reflect the fact that usually only people with a longer life expectancy would choose to buy an annuity. Moreover, when annuities are mandatory, prices are much closer to the actuarially fair level.<sup>15</sup>

55. Funded, DC pension plans are therefore actuarially fair by definition.

##### *Actuarial neutrality*

56. The next question is whether funded DC plans offer actuarially neutral benefits for workers who retire at different ages.

57. Annuitised benefits (*i.e.* regular pension payments), from DC plans are calculated using “actuarial” techniques, that is, with reference to life expectancy and long-term interest rates. The annuity provider swaps the accumulated pension capital for a promise to pay a stream of payments until the beneficiary or survivors die.

58. If an individual defers claiming the pension, two things happen to the accrued pension entitlement. First, the capital earns an extra year’s investment returns. Secondly, the annuity factor in a year’s time will be smaller reflecting the shorter expected duration over which the pension is paid.

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14. The issue of market imperfections in the provision of annuities has generated a large literature that is beyond the scope of this paper. Readers are referred *inter alia* to Bateman and Piggott (1999), Brugiavini (1993), Friedman and Warshawsky (1990) and Mitchell *et al.* (1999).

15. Finkelstein and Poterba (2002, 2004). Walliser (2000) provides a theoretical explanation.

However, the annuity provider and the individual do not value the differences between pensions drawn today or in a year's time in the same way. Individuals have to take into account that they might die during the year of deferral and they will also value money received in a year's time less than money received today. The insurance company, however, does not take account of the probability that the individual might die during the year because annuity offers by age are conditional on the individual having survived to that age. The insurance company will thus only be interested in life expectancy at the moment when the individual claims the pension.

59. The conditions for actuarial neutrality for DC schemes are set out formally in Box 6. This derives a formula for the rate of return on investments that delivers actuarial neutrality. Table 1 shows the required real rate of return on the accumulated balance that would deliver actuarial neutrality meaning that the flow of pension benefits measured at the same point in time would be equal regardless of when individuals retire. The calculations use OECD average mortality rates projected to 2040 and they assume that the pension in payment is indexed to prices. The assumed discount rate is 2%. However, what matters for actuarial neutrality is the gap between the discount rate and the rate of return on investments. A higher discount rate would mean a higher actuarially neutral rate of return on investments (and *vice versa*).

**Table 1. Real investment return required for actuarial neutrality by age and sex**

<i>Age</i>	<i>55</i>	<i>56</i>	<i>57</i>	<i>58</i>	<i>59</i>	<i>60</i>	<i>61</i>	<i>62</i>	<i>63</i>	<i>64</i>	<i>65</i>	<i>66</i>	<i>67</i>	<i>68</i>	<i>69</i>
Men	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.8	3.9	4.0	4.2
Women	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.2	3.3	3.4	3.6	3.8	3.9	4.1

Note: Assumes a real discount rate of 2%.

Source: Authors' calculations.

60. Table 1 shows that a man who considers retirement at 63, would need a rate of return on investments of around 3.4% for the system to be actuarially neutral between retiring at 63 or 64. For a woman of the same age, the actuarially neutral rate of return would be lower – at 3.2% – due to the fact that she has a lower probability of dying before collecting the benefit.

61. Funded DC plans are never exactly actuarially neutral. However, if one accepts that there is an equity premium or that conditions of dynamic efficiency must be met, then there is a gap between the riskless interest rate (that is to say the discount rate used in the actuarial calculation) and the market rate of return on investments. In this case, it would be possible that funded DC plans are approximately actuarial neutral.

**Box 5. Actuarial neutrality in defined-contribution plans**

Define  $K_t$  as the accumulated pension capital in the account at time  $t$ . In order to derive the pension benefit, pension capital has to be simply divided by the annuity factor, *i.e.*,

$$p_t = K_t / A_t.$$

Pension capital at time  $t+1$  is capital at time  $t$  plus the investment returns on the capital earned in that year, denoted  $\rho$ .

Pension wealth for a benefit drawn at any time measured at that time is equal to accumulated capital at that point. Formally, this is

$$PW_{\eta t} = K_t A_t / A_t = K_t$$

Pension wealth at time  $t+1$  measured from time  $t$  is given by

$$PW_{\eta t+1} = K_t (1 + \rho) PVPF_{t+1} / PVPF_t$$

The formula for the present value of the pension flow,  $PVPF$ , is (see also Box 2):

$$PVPF = s_i (1 + z)^{-i} (1 + u)^i$$

The ratio of the discounted survival functions depends only on the mortality rate and the discount rate.

Setting pension wealth at time  $t+1$  equal to pension wealth at time  $t$ ,  $PW_{\eta t}$ , delivers the condition for actuarial neutrality in these schemes:

$$\rho = (1 - x) / x$$

where  $x$  is the ratio of the present value of the pension flow functions at the two different points in time:  $PVPF_{t+1} / PVPF_t$ .

**4.2. Notional-accounts schemes**

62. Notional accounts are a variant of public, earnings-related pension scheme that share some features of a funded, DC scheme. Countries that have introduced notional-account schemes use different notional rates of return in the accumulation stage and different discount rates in the calculation of the pension payments.

*Actuarial fairness*

63. The conditions for actuarial fairness in notional-accounts schemes are similar to those in funded DC schemes because both involve a rate of return on capital (real or notional) and rely on actuarial principles to convert accumulated pension capital into a pension benefit.

64. Beginning with the accumulation stage, actuarial fairness depends on the relationship between the notional interest rate and the benchmark rate of return. Existing notional-account schemes have different notional interest rates. In Italy, the notional interest rate is the five-year moving-average of GDP growth. In Poland, the rules for the notional interest rate have changed. Until 2004, this was price inflation plus 75% of the growth of the real covered wage bill. Since then, the notional interest rate has been 100% of the growth of the covered wage bill but no less than price inflation. This new rule is also applied retrospectively back to 2000. The notional interest rate in Sweden is the growth of average earnings.

65. If the benchmark used is the market rate of return on investments, then notional accounts are very likely to be less than actuarially fair. Dynamic efficiency and the equity premium point to a gap between, for example, average earnings growth and the market rate of return.<sup>16</sup> Historical experience also points to market rates of return larger than growth in average earnings. If, however, the benchmark used is the riskless interest rate, then notional accounts schemes are likely to be rather closer to actuarially fair (because the riskless interest rate is below the market return on investments). But notional accounts plans are not exactly actuarially fair on either definition.

66. At the withdrawal stage, actuarial fairness depends on the actuarial calculation to convert accumulated notional capital into a stream of pension benefits, that is, the annuity factor. The calculations in all countries are based on population mortality rates. However, existing notional-account schemes use very different discount rates. Italy uses 1.5% and Sweden uses 1.6%. Poland implicitly uses a discount rate of zero because the calculation is based on life expectancy alone without any discounting. It is unclear whether these differences in rates reflect systematic differences in national economies – in the return on capital or the trend rate of national-income growth, for example – or instead are results of the policy-making process.

67. Table 2 shows the annuity factors at age 60 and 65 at various different discount rates. With a 1.6% discount rate, as employed in Sweden, the annuity factor at age 65 is 16.6. With a zero discount rate – the implicit rule in Poland – the annuity factor would be 19.7. It is perhaps easier to understand the differences between the two by looking at annuity rates (central panel of Table 2), which are the inverse of the annuity factor. These show, for example, that the pension benefit would be 6% of accumulated notional capital in for a 65-year-old retiree in Italy or Sweden, compared with just 5.1% in Poland. The Table also shows the calculations using our baseline assumption of a 2% riskless interest rate. If the riskless interest rate were indeed 2%, then benefits would be 4-6% smaller than the actuarially fair payout in Italy and Sweden (bottom panel of Table 2). At an effective discount rate of zero, as in Poland, the pension is 20% or so lower than with a 2% discount rate.

**Table 2. Annuity factors and annuity rates at age 60 and age 65 by discount rate**

<i>Discount rate (%)</i>	<i>2</i>	<i>1.6</i>	<i>1.5</i>	<i>0</i>
<b>Annuity factor</b>				
Age 60	18.6	19.5	19.7	23.9
Age 65	15.9	16.6	16.8	19.7
<b>Annuity rate</b>				
Age 60	5.4	5.1	5.1	4.2
Age 65	6.3	6.0	6.0	5.1
<b>Relative to baseline (%)</b>				
Age 60	0.0	-4.7	-5.8	-22.1
Age 65	0.0	-4.0	-5.0	-19.1

Source: Authors' calculations.

68. In conclusion, notional-accounts schemes are not, by definition, actuarially fair as some commentators have asserted. It is possible that they might approximate actuarial fairness, but only if

- the benchmark rate of return used to assess fairness at the accumulation stage is not the market return on investments; and

16. See Disney (2004, 2005), Hassler and Lindbeck (1999) and Lindbeck and Persson (2003) for an extended discussion.

- the discount rate used to calculate the annuity value relative to accumulated capital is the riskless interest rate.

#### *Actuarial neutrality*

69. The introduction of notional-account schemes was in part motivated by the desire to create flexible pension schemes that offered actuarially neutral benefits at a range of different retirement ages. How does the reality of these schemes measure up to this objective?

70. The conditions for actuarial neutrality in notional-account schemes are the same as in funded defined-contribution schemes. Under the baseline assumptions of average OECD mortality rates and price indexation of pensions in payment, Table 1 above applies to notional-account schemes in the same way as it applies to DC plans. Actuarial neutrality requires that the notional interest rates follow the schedule in Table 1. At age 65, for example, this requires the wage-bill (in Poland) and GDP (in Italy) grow at a rate of around 3.5% real. Again, it is important to remember that this assumes a riskless interest rate of 2%. If the riskless interest rate were higher or lower, then the notional rate of return required for actuarial neutrality would also be higher or lower. The reason for the gap between the two is that the actuarial calculations in the benefit formula do not allow for the fact that a person deferring retirement might die before claiming the benefit. These notional-accounts schemes are highly unlikely to be actuarially neutral because it is unlikely that the three variables mentioned above used for the notional interest rate will be substantially above the riskless interest rate (as needed to compensate for discounting and mortality risk).

71. The analysis for Sweden is complicated by the fact that accrued pensions are adjusted to reflect the mortality experience of the cohort as well as being paid a notional interest rate equal to earnings growth. Unisex mortality rates between age 60 and 65, for example, are projected to be between 0.45 and 0.7% in the UN/World Bank database. However, because there is no adjustment for discounting, the increase in pension wealth from working an extra year is likely to be below the actuarially neutral level.

#### **4.3. *Defined-benefit and point plans***

72. Most OECD countries have mandatory pensions that provide defined benefits or have a similar kind of earnings-related scheme, the pension-point system.

73. As explained in section 3, benefits in a DB plan are determined by the number of years of contributions and some measure of individual earnings. Often, earlier years' earnings are adjusted to reflect changes in costs and/or standards of living, a process called valorisation. The rate at which pension entitlement is built up relative to individual earnings in defined-benefit schemes, for example, 1% of earnings for each year of contributions, is called the accrual rate.

74. Pension-point schemes typically measure individual earnings in relation to economy-wide average earnings and credit points according to this ratio for each period of contributions (*e.g.* in Germany, a worker earns one point per year if he or she is earning the economy-wide average wage). At retirement, the number of accumulated points is multiplied with a point value to calculate the initial level of the pension benefit.

#### *Actuarial fairness*

75. To assess the actuarial fairness of DB plans, we again use the similarities shared with notional-accounts schemes. The analysis in Box 4 showed that a DB plan and a notional-accounts scheme would deliver equivalent benefits if the DB accrual rate equals the ratio of the notional-accounts contribution rate

to the annuity factor. Each of these variables effectively gives the proportion of earnings that is accrued in pension each year.

76. Box 2 explained how to calculate actuarially fair annuity factors. Assuming a riskless real interest rate of 2%, then the fair, unisex annuity factor at age 65 is 15.9 (at OECD average mortality rates and with price indexation of pensions in payment). Under these circumstances, actuarial fairness requires that the DB accrual rate is equal to the contribution rate divided by 15.9.

77. From then on, the conditions for actuarial fairness of DB plans are parallel to those for notional-accounts schemes. In particular, valorisation of earlier years' earnings is the parallel to the notional interest rate. The same two benchmarks for the rate of return can then be applied to valorisation. The first would require that the variable underpinning valorisation grows at the same rate as the market rate of return on investments. These are, of course, most unlikely to coincide. Moreover, there are good reasons to expect that market rates of return will exceed earnings growth, which is the most common valorisation variable in OECD countries. Average-earnings growth will probably be closer to the second benchmark: the riskless interest rate.

78. The conditions for DB plans to be actuarially fair are therefore similar to those for notional-accounts schemes. However, instead of the requirement that the notional-accounts pension is calculated using the appropriate discount rate, the condition is that the DB accrual rate is equal to the DB contribution rate divided by the actuarially fair annuity factor.

79. Other features of DB schemes in practice can also rule out actuarial fairness. For example, the public DB schemes of the United Kingdom and the United States have progressive benefit formulae, which deliver higher replacement rates for low earners. Contributions, however, are linear. This systematic redistribution means that these plans cannot be actuarially fair. Similarly, if earnings for benefits purposes are measured over anything less than the full career, actuarial fairness is impossible. Contributions are paid in each year of work. With a limited number of "best" or "final" years in the pension formula, people with more variable pay or steeply rising earnings with age will tend to get more out than they paid in (and *vice versa*).<sup>17</sup>

80. For point schemes, the assessment of actuarial fairness involves the same steps. There are again two conditions. First, the ratio of the pension-point value to the pension-point cost equals the ratio of the contribution rate to the annuity factor. Secondly, the uprating procedure for the pension point produces outcomes that are the same as using the riskless interest rate.

#### *Actuarial neutrality*

81. Most countries with DB or pension-point plans reduce or increase benefits for early and late retirement, respectively.<sup>18</sup> These benefit adjustments are often (somewhat misleadingly) called "actuarial" adjustments, when these parameters are actually the result of policy choices (although, perhaps, made with reference to actuarial calculations).

82. Actuarially neutral adjustments were defined in section 2 and the derivation of the formula for calculating them is shown in Box 6. As explained above, the compensation for deferring retirement for a year needs to cover mortality risk during the year, discounting and the shorter (longer) duration of benefit

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17. See OECD (2005), Table 2.2 for earnings measures used in OECD countries' schemes and Disney and Whitehouse (1999), section 8.2 for analysis of the issues (and data on non-OECD countries).

18. See Whitehouse (1990) and Duggan and Soares (2002) for a history of actuarial adjustments in the United Kingdom and United States respectively.

payments with retirement a year later (earlier). Therefore, the actuarially neutral adjustment obviously depends on the relationship between annuity factors at different ages (see Box 2).

**Box 6. Actuarially neutral adjustments for early and late retirement**

The pension at time  $t+1$  can be written as

$$P_{t+1} = p_t (1 + \alpha)$$

where  $\alpha$  is the increment to benefits for delaying drawing the pension for a year. Note that there is no additional accrual of benefits allowed for in the equation: actuarial neutrality aims to equalize accrued benefits with an extra year's work.

The formula for actuarial neutrality (see Box 3) is

$$PW_{t|t+1} = PW_{t+1|t+1} PVPF_{t+1} / PVPF_t$$

where  $PW_{x|y}$  is pension wealth measured at time  $x$  conditional on leaving the labour market at time  $y$  and  $PVPF$  is again the present value of the pension flow, as derived above.  $PW_{x|y}$  is simply the pension entitlement multiplied by the annuity factor and can therefore be written as  $p_x \cdot A_x$ . The formula for pension wealth can therefore be rewritten as

$$p_t (1 + \alpha) A_{t+1} PVPF_{t+1} / PVPF_t = p_t A_t$$

Rearranging,

$$\alpha = (A_t - 1) / A_{t+1} \cdot PVPF_t / PVPF_{t+1}$$

This is the adjustment for deferral for a year that delivers actuarially equivalent benefits, *i.e.*, pension wealth is the same.

83. Table 3 shows the actuarially neutral adjustment for benefits at different ages and by sex. It is based on OECD average mortality rates. It again assumes a riskless interest rate of 2% and price indexation of pensions in payment. For example, the upper panel of Table 3 shows that, under these conditions, a man of age 65 deferring the pension for a year would have the same pension wealth as retiring immediately if the pension were increased by 7.4%. Conversely, if he were to retire at age 64 instead of 65, then the accrued entitlement should be reduced by 7.2%. In a system, where retirement ages are flexible, actuarial neutrality requires benefit adjustments that change from year to year, depending on when retirement is taken. For older workers, the odds rise that they will not be around to collect the benefit when it is eventually paid, and so the extra pension paid to those who delay retirement should rise with age. Women are less likely to die at a given age than men and so the neutral adjustment is smaller for them.

84. The second panel of Table 3 shows the result relative to a baseline of normal retirement at age 65. This also cumulates the adjustment for early and late retirement. For example, a man retiring five years early at age 60 would have the same pension wealth (from accrued entitlements) as retiring at the normal age if benefits were cut by 29.2%. Similarly, the system is actuarially neutral if a man working to age 68 receives 25.8% more than a man retiring at 65.<sup>19</sup>

19. It is also important to note that the adjustment factors in Table 3 are multiplicative, whereas most countries use an additive formula for determining the adjustment. For example, say the neutral adjustment over the age range 65-70 in Table 3 were 6% per year in each year. Then the adjustment that would deliver actuarial neutrality would be  $(1.06)^5 =$  a 33.8% increment. It would not be  $1.06 \times 5 =$  a 30% increment, which is

**Table 3. Actuarially neutral adjustment factors by age and sex**

Age	60	61	62	63	64	65	66	67	68	69	70
<b>Annual adjustment (%)</b>											
Men	6.2	6.4	6.7	6.9	7.2	7.4	7.7	8.0	8.2	8.5	8.9
Women	5.6	5.9	6.1	6.4	6.7	7.0	7.3	7.7	8.0	8.4	8.8
<b>Cumulative adjustment (%)</b>											
Men	-29.2	-24.5	-19.3	-13.6	-7.2	0.0	7.7	16.3	25.8	36.6	48.6
Women	-27.2	-22.8	-18.0	-12.7	-6.7	0.0	7.3	15.6	24.8	35.3	47.2

Note: Assume a real discount rate of 2%. Based on projections of OECD average, unisex mortality rates. Assumes price indexation of pensions in payment. Cumulative adjustment shows position relative to retirement at 65.

Source: Authors' calculations.

85. A DB or a points scheme that adjusted benefits in line with Table 3 (based on national mortality rates, of course) would achieve actuarial neutrality, that is exactly compensate for differences in entitlements claimed at different ages due to discounting, mortality risk and the shorter or longer retirement duration. It is important to note that mortality risk is not constant: it varies both with age and between the sexes. As a result, the adjustment should, in principle, also vary.

**Table 4. Actuarially neutral adjustment factors at age 65: sensitivity analysis**

## Discount rate

Discount rate (%)	0	1	2	3	4
Neutral adjustment (%)	5.4	6.0	6.7	7.4	8.2

## Indexation procedure

Indexation	Prices	50:50	Earnings
Neutral adjustment (%)	6.7	6.4	6.0

## Mortality rates

Mortality rates	2002	2020	2040	Japan	Turkey
Neutral adjustment (%)	7.8	7.2	6.7	6.0	7.9

Note: Areas shaded grey show the baseline assumption. Sensitivity to discount rate uses 2040 projected OECD average unisex mortality rates and assumes pensions in payment are price indexed. Sensitivity to indexation procedure assumes a real discount rate of 2% and real earnings growth of 2% and again uses 2040 projected OECD average unisex mortality rates. Sensitivity to mortality rates assumes a 2% real discount rate, price indexation of pensions in payment and actual/projected unisex mortality rates for the years shown. The results for Japan (with the longest life expectancy of OECD countries) and Turkey (with the shortest) assume price indexation, a 2% real discount rate and are based on 2040 mortality projections.

Source: Authors' calculations.

86. These calculations are obviously sensitive to the choice of discount rate. The higher the discount rate is set, the larger the actuarial adjustment will be and *vice versa*. Table 4 shows the adjustment factor at real riskless interest rates of 0 to 4% for retiring a year early, at age 64 rather than 65. (The shaded box shows the baseline assumption.) The calculation is based on OECD average mortality rates (calculated on a

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how national schemes would express it. This introduces a further source of difference between adjustment factors in practice and actuarial neutrality.

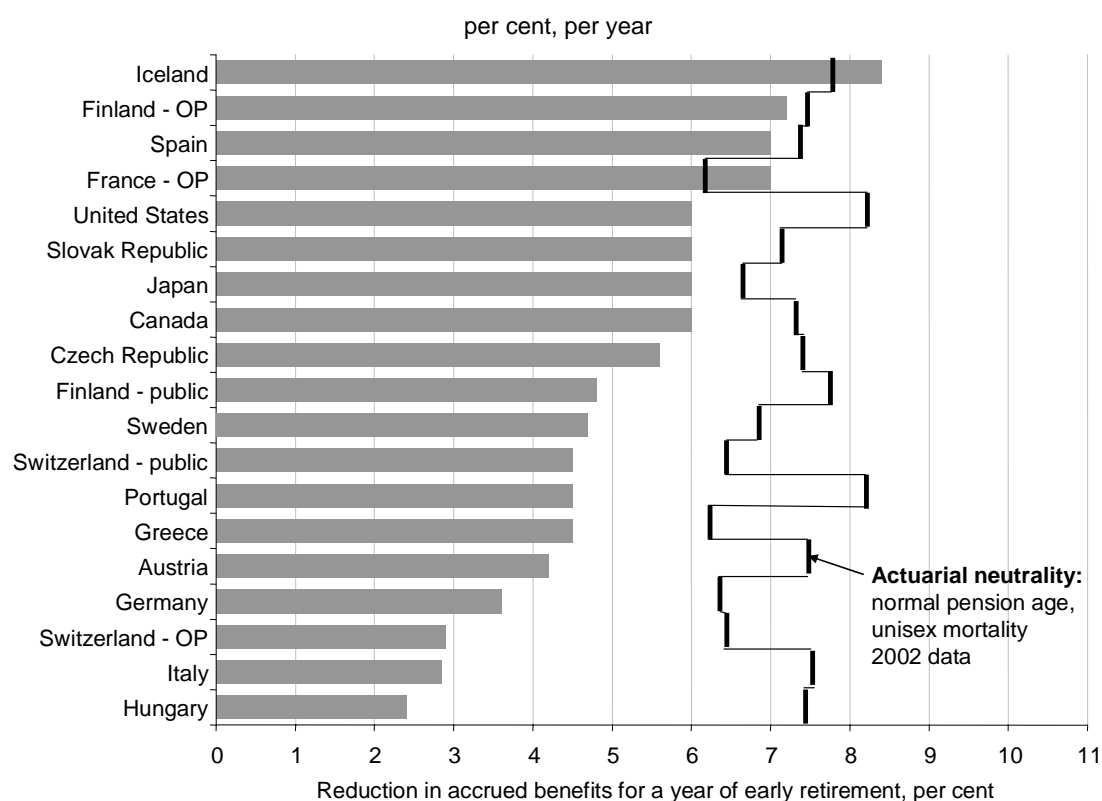
unisex basis). The results are also sensitive to the way pensions in payment are indexed, and so to the evolution of benefits over time. Other things equal, actuarially neutral adjustments are lower with more generous indexation procedures (middle panel of Table 4). Finally, neutral adjustment rates are projected to fall over time as life expectancy increases. On 2002 data, for example, the neutral adjustment is 7.8%, falling to 6.7% using projected 2040 OECD average mortality. For similar reasons, the neutral adjustment is lower in countries with longer life expectancies: Japan and Turkey have respectively the longest and shortest life expectancies at age 65.

## **5. Actuarial neutrality: theory and practice**

87. Actuarial neutrality is an important policy concept for the issue of retirement incentives. Setting the benefit adjustments for early and late retirement will affect workers' decisions when to retire. It is also an important determinant of equity in a pension system: actuarially neutral adjustments will ensure that workers are not treated differently depending on when they choose to leave the labour market.

88. Table 5 in Annex 1 shows in detail how benefits are adjusted in OECD countries for early and late retirement in relevant pension schemes. For each country's pension scheme(s), the Table shows the early pension age if early retirement is possible. The next column shows the reduction in benefits for each year of early retirement. To take a simple example, early retirement is possible from age 62 in Germany. The normal pension age, shown in the third column, is 65. For each year of early retirement in Germany, the benefit is reduced by 3.6%. However, as evidenced by the copious notes to Table 5 in Annex 1, there are many complexities in calculating and presenting these adjustments on a consistent basis.

89. The reduction in benefits for early retirement per year is summarised in Figure 2. For early retirement, the average across 19 schemes in 18 countries is a reduction in accrued benefits for each year of early retirement of 5.08%.

**Figure 2. Pension decrements for early retirement**

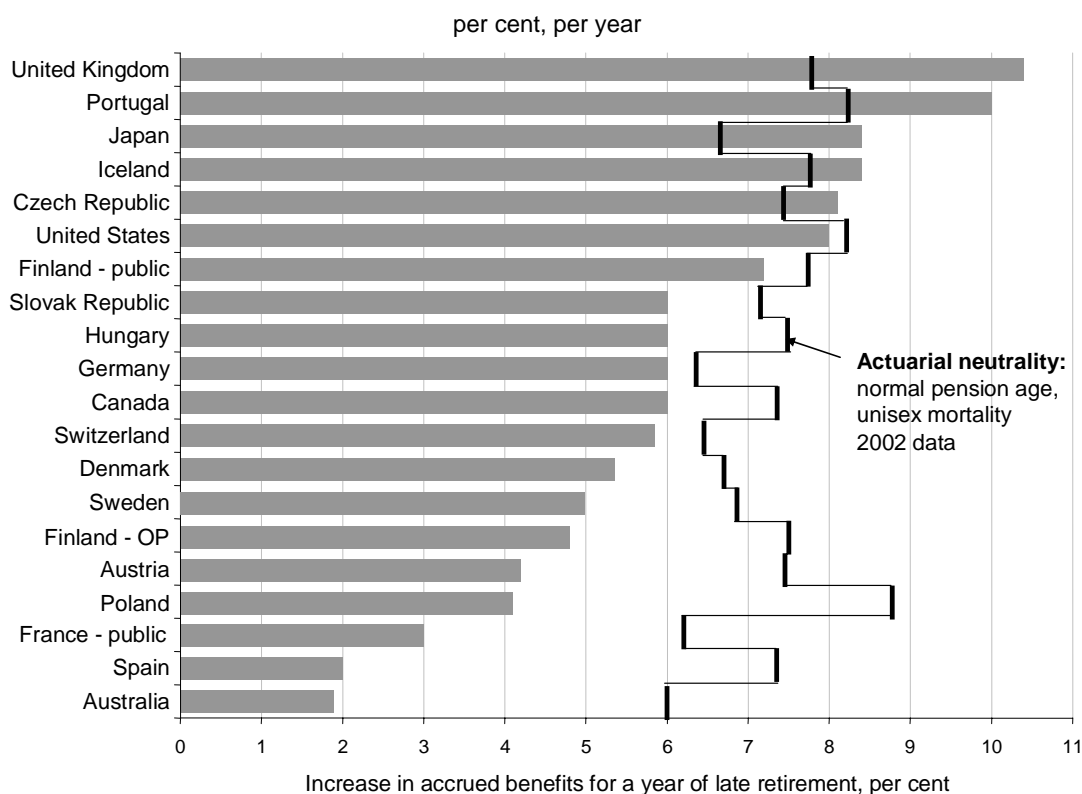
Note: See Table 5 in Annex 1 for a detailed description of derivation of actual adjustments. Actuarially neutral adjustments calculated using unisex tables, country-specific mortality data for 2002, and national pension ages and indexation practices. OP = occupational pension. Assumes a discount rate of 2%.

Source: Authors' calculations.

90. Table 5 in Annex 1 also shows the increment to benefits where it is possible to defer pension receipt beyond the normal pension age and continue working. Again, this is a simple parameter of the system in many cases: Canada, Germany, Hungary and the Slovak Republic all increase benefits by 6% for each year that retirement is deferred. However, in many other cases the situation is more complex. Figure 3 summarises the results. It shows that the average increment for late retirement for 19 countries higher than for early retirement: 6.19%.

91. Whether the adjustments shown in the Table and charts are actuarially neutral or not depends on the age of the individual considering early or late retirement. The age range over which early or late retirement is possible therefore matters. Secondly, the assessment depends on mortality rates in a particular country, and, of course, whether these are today's mortality rates or projected future values. The illustrative values for actuarial neutrality in Figures 2 and 3 are calculated based on unisex mortality rates using 2002 data for the relevant countries. They are estimated at the normal pension age of the scheme and allow for scheme-specific indexation policies. The neutral adjustments are lower the longer is life expectancy, so they are lower for women than they are for men. This also means that they are lower at younger ages and that they will tend to fall over time if longevity continues to increase. Neutral adjustments are lower with more generous indexation of pensions in payment: for example, linking benefits to average earnings rather than price inflation. The charts do, however, suggest that most of the schemes analysed fall short of actuarial neutrality. As a result they subsidise early retirement and penalise late retirement.

**Figure 3. Pension increments for late retirement**



Note: See Table 5 in Annex 1 for a detailed description of derivation of actual adjustments. Actuarially neutral adjustments calculated using unisex tables, country-specific mortality data for 2002, national pension ages and indexation practices. OP = occupational pension. Assumes a discount rate of 2%.

Source: Authors' calculations.

## 6. Conclusions

92. This paper has set out two “actuarial” concepts that can be used when analysing pension schemes and thinking about pension reforms:

- **Actuarial fairness:** the present value of lifetime contributions equals the present value of lifetime benefits.
- **Actuarial neutrality:** the present value of the flow of pension benefits for retiring a year later is the same as for retirement today, plus any additional pension accrued during the year.

93. These concepts are frequently confused. Some commentaries use the terms interchangeably, others argue that actuarially fair systems are, by definition, actuarially neutral. Moreover, actuarial fairness and fiscal sustainability of pay-as-you-go pension schemes are frequently mixed up.

94. Actuarial neutrality and fairness are both related to equity between different individuals who are covered by a particular pension plan. However, there are important distinctions between the two concepts. In particular, actuarial fairness is measured over the full lifetime and so looks at “stock” values of contributions and benefits. In contrast, actuarial neutrality is a “marginal” concept, in that it looks at the

effect of working an extra year. Actuarial neutrality is important when analysing retirement incentives; actuarial fairness is not.

95. The two actuarial benchmarks were used to assess different types of pension plan: funded defined-contribution, defined-benefit, points and notional-accounts schemes.

#### *Actuarial fairness*

96. Funded defined-contribution plans are actuarially fair, because the pension benefit is by definition equal to contributions paid into the scheme plus the investment returns earned.

97. For notional-accounts schemes, the picture is more complex. First, notional interest rates are likely to be less than the market rate of return on investments and so they fall short of the stricter benchmark for actuarial fairness at the accumulation stage. However, notional accounts schemes could be fair at the accumulation stage with the less demanding target of having a notional interest rate of a similar level as the riskless interest rate (which is, perhaps, an appropriate benchmark with pay-as-you-go financing). Secondly, at the withdrawal stage, actuarial fairness depends on the choice of discount rate in the annuity calculation. The countries with notional accounts have all set a fixed discount rate, which may or may not be equal to the riskless interest rate (the condition for actuarial fairness).

98. Similar conditions apply to defined-benefit and points schemes, that relate to the relationship between the accrual rate, contribution rate and annuity factor (defined-benefit plans) or the pension-point value, cost and the annuity factor (points schemes).

#### *Actuarial neutrality*

99. Actuarial neutrality relates to the treatment of people retiring at different ages. Notional-accounts schemes are highly unlikely to be actuarially neutral. This is because the actuarial calculation naturally assumes that the individual has survived until the age of retirement. But, say a 64-year-old choosing between retiring now and at age 65, to achieve actuarial neutrality, requires additional actuarial compensation for the probability of dying within the year. Many people find this result counterintuitive. But this probably stems from the confusion of actuarial neutrality with actuarial fairness.

100. Defined-contribution pensions will be close to actuarial neutrality (as long as the market rate of return exceeds the riskless rate).

101. Actuarial neutrality can be achieved with defined-benefit or points schemes, if adjustments for early and late retirement are based on sound actuarial calculations and assumptions. These show that benefits for people retiring early should be reduced by 7-8% for people retiring at age 64 rather than age 65. This is at OECD average mortality rates: the precise figure is rather lower in countries with longer life expectancy. It will also fall over time if longevity continues to increase, as projected.

#### *Policy implications*

102. This paper is titled “actuarial concepts and pension-system design”. How useful are actuarial concepts for this purpose?

103. First, it is vital to distinguish retirement-income systems from their component pension schemes. Much commentary has focused on the way that pension schemes measure up against the actuarial benchmarks. Indeed, this paper has applied actuarial principles only to pension schemes with a link between earnings or contributions on the one hand and pension entitlements on the other. However, retirement-income systems typically consist of a range of schemes, including, for example, universal or

resource-tested benefits or minimum pensions to ensure older people have an adequate income. There is little point in designing an actuarially perfect pension programme if this is unwound by other parts of the retirement-income system that operate to different criteria.

104. Secondly, retirement-income systems cannot be designed around these actuarial concepts alone: they have other objectives. The most obvious is adequacy of retirement incomes. Are governments willing to impose actuarially neutral reductions for early retirement that push early retiring low-income workers below the poverty threshold? Alternatively, if retirement-income safety nets protect these workers, the effect on incentives is undone. Are governments willing to push the concept of actuarial fairness so far that low-income workers retiring at the normal pension age have insufficient income to support themselves in old age? If not, then the pension system is not actuarially fair.

105. Thirdly, retirement-income systems must also take account of fiscal constraints. In pay-as-you-go financed pension schemes, the sustainability of the scheme and its actuarial fairness are two separate issues.<sup>20</sup> Also, moving towards actuarial neutrality might have implications for the cost of pension provision. If costs increase, taxes and contributions needed to pay for benefits will have to rise; this, in turn, will affect labour-supply incentives of younger workers. Disincentives to work are simply reshuffled between age groups.

106. Finally, both actuarial concepts — fairness and neutrality — are defined across the population. However, there are systematic differences in life expectancy. Women live longer than men on average. And there is considerable evidence that people with low incomes die earlier than the rich. People who expect to live longer will get a better deal out of the pension system — relative to benchmarks of actuarial fairness and actuarial neutrality — than people who are expected to die earlier.

107. Actuarial benchmarks can help policymakers in choosing the structure, parameters and rules of pension schemes and of pension systems. But they do not offer instant solutions to the difficulties in designing retirement-income systems in ways that do not distort incentives.

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20. Defined-contribution pension plans are by definition always fully funded. With these plans, sustainability and fairness are automatic.

## ANNEX 1. EARLY AND LATE RETIREMENT AND PENSION ENTITLEMENTS

Table 5. Treatment of early and late retirees in OECD countries by pension scheme

<i>Country</i>	<i>Scheme</i>	<i>Early age</i>	<i>Reduction</i>	<i>Normal age</i>	<i>Increase</i>
Australia	Targeted	na		65	0.57-3.28% <sup>1</sup>
Austria		62/60	4.2%	65	4.2%
Belgium		60	0	65	0
Canada		60 <sup>2</sup>	6%	65	6%
Czech Republic		60/56-60 <sup>3</sup>	5.6% <sup>4</sup>	63/59-63 <sup>3</sup>	8.1% <sup>4</sup>
Denmark	Public	na		65	5.35% <sup>5</sup>
Finland	Targeted	62	4.8	65	7.20%
	Earnings-related	62	7.2%/0 <sup>7</sup>	65	0/4.8% <sup>8</sup>
France	Public	na		60	3%
	Occupational	55	7%	60	0
Germany		62	3.6%	65	6%
Greece		55	4.5% <sup>9</sup>	65	0 <sup>10</sup>
Hungary	Public	60/59	0/1.2-3.6% <sup>11</sup>	62	6%
Iceland	Occupational	62	7.2-9.6% <sup>12</sup>	67	7.2-9.6% <sup>12</sup>
Ireland		na		65	na
Italy		62/60	2.6-3.1% <sup>13</sup>	65/60	0 <sup>13</sup>
Japan	Basic	60	6%	65	8.40%
	Earnings-related	na		65	na
Korea		60	na	65	na
Luxembourg		60 <sup>14</sup>	0	65	na
Mexico		60 <sup>15</sup>	auto	65	auto
Netherlands		na <sup>6</sup>		65	na
New Zealand		na		65	na
Norway		na		67	na
Poland	Notional accounts	na		65/60	3.7%/4.4% <sup>16</sup>
Portugal		55	4-4.5% <sup>17</sup>	65	10%
Slovak Republic	Points	any age <sup>18</sup>	6%	62	6%
Spain		61	6-8% <sup>19</sup>	65	2%
Sweden	Notional accounts	61	4.1-4.7% <sup>20</sup>	65	4.9-6.1% <sup>20</sup>
	Occupational	55	varies <sup>21</sup>	65	varies
Switzerland	Public	63/62	4.5% <sup>22</sup>	65/64	5.2-6.5% <sup>23</sup>
	Occupational	60/59	2.9% <sup>22</sup>	65/64	2.9% <sup>22</sup>
Turkey		na		60/58	na
United Kingdom		na		65	10.4% <sup>24</sup>
United States		62	5-6.67% <sup>24</sup>	67	8%

Source: Authors' calculations; OECD pension models; OECD (2005).

Notes: Where pension ages for men and women differ they are shown as M/F. "na" means that early retirement or deferral of pension is not available. Schemes where the concept of these adjustments are irrelevant have been ignored. Some countries have legislated changes to some parameters that are not yet in effect: the Table shows the long-term position with all such reforms fully in place. The ability to combine work and pension receipt (particularly after normal pension ages) is common. More detail on country pension systems can be found in OECD (2005). Calculations for late retirement assume a maximum retirement age of 70.

1. The pension bonus is paid as a one-off, lump sum. It is calculated as 9.4% of age-pension entitlement at the time of retirement multiplied by the number of years of deferral squared. The unisex annuity factor for Australia varies from 16.5 at age 65 to 14.3 at age 69. This can be used to calculate the value of the pension bonus as a proportion of the age-pension benefit stream. The result is then comparable with the adjustments to benefits applied in other countries. The values shown are annualized for 1 and 5 years of deferral respectively. With 3 years' deferral, for example, the bonus is equivalent to an increase in age pension of 1.8% per year of deferral.
2. Only the earnings-related pension (not the basic or targeted benefits) can be drawn early.
3. Pension age for women varies with the number of children that they have had.
4. Calculated for a full-career working entering at age 20. The adjustments are defined as 3.6% reduction and 5.2% increase in the total accrual factor rather than the benefit.
5. The adjustment is based on the reciprocal of life expectancy at the age at which the pension is drawn. Life expectancy has been calculated from the World Bank/UN population database projections for 2040.
6. There are separate early-retirement programmes.
7. The adjustment applies for one year from 62 to 63. There is then no adjustment but instead accelerated accrual in the earnings-related scheme.
8. There is no adjustment until age 68 because of accelerated accrual in the earnings-related scheme. The adjustment shown applies from 68 onwards.
9. The pension is not reduced if 37 years of contributions have been made.
10. There is accelerated accrual during the deferral period but no increment to already accrued benefits.
11. There is no reduction if 38 years of contributions have been made; rate of reduction varies with fewer years.
12. Adjustment for private-sector workers depends on scheme. The adjustment for public-sector workers is 6%.
13. Adjustment for early retirement has been calculated from government-provided transformation coefficients projected for 2040. After age 65, the transformation coefficient is constant.
14. Early retirement is conditional on 40 years' insurance.
15. Early retirement is conditional on 1250 weekly contributions (25 years).
16. The adjustments for late retirement have been calculated from projected G-values using the World Bank/UN population database for 2040. Those shown are for men and women at age 60 and 65 respectively. The implicit adjustments increase with age.
17. Adjustment is at a 4.5% rate. However, with more than 30 years' contributions at age 55, the number of years over which the pension is adjusted is cut by one year for each complete 3 years of contributions beyond 30 years. The 4% rate is shown because this would apply for retirement at 55 for a full-career worker who enters the system at age 20.
18. Early retirement is conditional on pension entitlement exceeding 1.2 times the subsistence minimum.
19. The adjustment is higher with fewer years of contributions.
20. The implicit adjustments are calculated from G-values. They increase with age. They also take account of the distribution of the account balances of people who die before claiming the pension.
21. There is no reduction for retirement from age 62. In the age range 55-62, reductions vary between employers.
22. See the annex on "benefit equivalence" for a description of how this was calculated.
23. The increment for late retirement increases with age.
24. This represents an increase on the 7.4% increment that used to be paid. A lump-sum payment of deferred pension plus interest can now also be claimed instead of a pension increment.
25. The reduction is 6.67% for the first 3 years of early retirement and 5% thereafter.

## ANNEX 2. BENEFIT EQUIVALENCE

108. In the German-speaking countries of Austria and Germany and in Switzerland, yet another concept related to actuarial neutrality is commonly used. The concept of actuarial neutrality as defined above requires that pension wealth for retiring a year later is the same as pension wealth when retiring today plus the value of any extra pension accrued during the year.

109. In contrast, benefit equivalence requires that the present value of pension entitlements is the same regardless of when people retire. The adjustments for early and late retirement are calculated so that the change in pension wealth is zero even if the worker earns additional entitlements by contributing for another year. The logic behind the concept of benefit equivalence is that lifetime benefits are the same regardless of when workers retire.

110. Benefit equivalence is achieved when pension wealth is equalised at different ages including any additional entitlements earned through contributions. It therefore applies mainly to early retirement, when people will have contributed for a year less if they retire a year earlier. Benefit-equivalent adjustments seek to compensate for differences in discounting and mortality but also for the additional accumulation of benefits. As a result, they are lower-than-actuarially-equivalent adjustments in a DB or points scheme. (The derivation of the formula is shown in Box 8). The logic behind these adjustments is that, from the perspective of the pension scheme, the lifetime benefit expenditure per person is the same regardless of when they leave the labour market.<sup>21</sup>

111. Table 6 confirms this, showing that adjustments under the concept of benefit equivalence are considerably lower than actuarially neutral adjustments (as shown in Table 3). Taking the same example of a man retiring at 64 instead of 65 years, the benefit would be reduced only by 4.4%, compared with 7.2% for actuarial neutrality.<sup>22</sup> Table 6 is again based on OECD average mortality rates and a discount rate of 2%. The additional pension accrual is from a simple, generic DB scheme.

**Table 6. Benefit-equivalent adjustments to pensions by sex and age**

	<i>60</i>	<i>61</i>	<i>62</i>	<i>63</i>	<i>64</i>
Men	3.4	3.7	3.9	4.2	4.4
Women	2.7	3.6	3.3	4.0	4.4

112. The adjustments currently applied to early retirement benefits in Austria, Germany and Switzerland reflect this benefit-equivalence approach.

21. See Ohsmann, Stolz and Thiede (2003).

22. As explained in Box 8, benefit-equivalent adjustments will vary depending on the way benefits are accrued in particular countries. The analysis in Table 5 was therefore based on a generic DB scheme paying 1% of revalued lifetime average earnings for each year of contributions. This scheme is described in more detail in Section 5 on retirement incentives.

**Box 7. Benefit equivalence**

The adjustments to deliver actuarial equivalence were calculated on the basis of accrued entitlements, equalising the pension wealth in these circumstances. Thus,  $p_{t+1} = p_t (1 + \alpha)$ , i.e., the pension at time  $t+1$  is simply pension at time  $t$  plus only the adjustment factor  $\alpha$  when calculating actuarial equivalence.

For benefit equivalence, write

$$P_{t+1} = p_t (1 + \alpha) (1 + \beta)$$

where  $\beta$  is the additional pension accrued during the year. Following the analysis for actuarial equivalence in Box 7, the formula for benefit equivalence can be re-written as

$$(1 + \alpha) (1 + \beta) = (A_t)^2 / (A_{t+1})^2$$

Clearly, it is not possible to derive universal rules as it is for actuarial equivalence, since the accrual structure for pension schemes varies.

113. In Germany, pensions are reduced by a uniform 3.6% for each year of retirement before the age of 65. So, an individual retiring at 64 rather than 65 after entering the labour market at age 20 and earnings the economy-wide average would have 44 rather than 45 pension points at the time of retirement. The overall benefit for early retirement relative to working to 65 is therefore  $1 - (1 - 3.6\%) \times (1 - 2.2\%)$ , where the first term is the adjustment and the second reflects the reduction in pension points. The overall adjustment is therefore 5.7%. This adjustment is below the 7.2% reduction that would deliver actuarial neutrality (Table 3).

114. A similar calculation applies to Austria. Here the reduction in benefits is 4.2% for each year that the pension is drawn early. As in Germany, pension accrual does not vary with years of service or age, so the missing year from retiring at 64 rather than 65 again reduces benefit by 2.2%. The overall adjustment is therefore  $1 - (1 - 4.2\%) \times (1 - 2.2\%)$  or 6.3%. The adjustment is broadly in line with the requirement for benefit equivalence but below the level for actuarial neutrality.

115. In the Swiss public pension scheme, for each year that the pension is claimed early, it is reduced by 6.8% from the full value. Part of this adjustment reflects the missing year of contributions. Since 44 years are required for a full pension, then  $1/44 = 2.3$  percentage points of the adjustment reflects the missing year and the residual, 4.7 percentage points, the adjustment to reflect the longer period over which the pension is paid. The latter is calculated as  $1 - (1 - 6.8\%) \times (1 + 2.3\%)$ . This is therefore the same as the “actuarial” adjustment as applied in other countries.

116. For Swiss mandatory occupational plans, the government sets the rate at which accumulated credits are converted into a pension income stream. Generally, the statutory annuity-conversion rate is reduced from 7.2% at age 65, by 0.2 percentage points per year of early retirement.<sup>23</sup> The 0.2-point reduction is equivalent to an “actuarial adjustment”, as measured in other countries, of between 2.9 and 3.2% per year of early retirement (increasing with the extent of early retirement). For retirement at 64 rather than 65, for example, this is calculated as  $7.2 / 7 - 1 = 2.9\%$ . Including also the loss of contributions and credits because of early retirement, the benefit is between 6.7 and 8.8% lower per year of early retirement. The loss again increases the earlier that retirement is taken. (The range given applies from age 61 to age 65.)

23. This conversion rate will fall gradually to 6.8% over the ten years starting in 2005.

117. Benefit equivalence rather than actuarial neutrality is, in theory, used to determine the adjustment of pensions for early retirement in Austria, Germany and Switzerland. The calculations show that the public schemes of Austria and Switzerland are close to benefit equivalence. However, German public pensions and Swiss occupational plans adjust pensions by less than the benefit-equivalent amount. In all four plans, this means that the adjustments are well below the level that would deliver actuarial neutrality.

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