Total Reward and Pensions in the UK by Occupation in the Public and Private Sectors.

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A Report for the Office of Manpower Economics.

by

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Abstract

Over the last 10 years the relative value of public and private sector remuneration packages, including pensions, has changed markedly. This report reviews a comprehensive measure of Total Reward (TR) which includes not just pay, but pensions and other 'benefits in kind', evaluates it as the present value of the sum of all these payments over the lifetime and sets out how to compare it for UK public and private sectors workers in different occupations. We suggest that the current controversy over public-private sector pension differentials and the perennial issues of public/private sector pay gaps requires a life time perspective and that the concept of TR is appropriate. Changes have been implemented to pension schemes across the UK public sector from 2014/15 moving from Final Salary to Career Average schemes. This report sets out how it is possible to simulate how these changes will affect the lifetime TR and how the recent pension changes compare across different public sector schemes. Specifically, we simulate the occupation specific pension wealth accumulated for a representative employee over the lifecycle by examining how the move from Final Salary schemes to Career Average schemes has affected: Doctors, Nurses, Teachers, Prison Officers, Police Officers and Firefighters.

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Executive Summary

While total remuneration or Total Reward (TR) by definition includes pay, pensions and all other forms of benefits in kind, there is no consensus on how this should be calculated. Although there has been a lot of research on selected aspects of the value of pensions across sectors there has been relatively little work on the evaluation of broader concepts of total compensation. Often TR includes: salary, bonus, stock options, stock grants, pensions and other compensation. This literature tends to exclude: hours of work, holiday entitlements, job security (as proxied for by the probability of being made unemployed) and does not attempt to enumerate future benefits in present value terms or to adopt a life cycle perspective on this evaluation. This report uses a combination of different UK data sources to evaluate by simulation the TR of public sector occupations for which the data is available.

Since 2015 there have been major changes in the pension schemes in most public sector occupations. All these occupations for which the Pay Review Bodies have responsibility have moved from Final Salary (FS) Defined Benefit (DB) schemes to Career Average Revalued Earnings (CARE) based essentially on average lifetime earnings. In addition, all the accrual rates and other conditions of service changed at the same time. Earlier research has set out the methodology of computing and simulating TR across the lifecycle in making comparisons between the public and private sector on a broad basis. This report is devoted to: firstly, making these comparisons across different occupations and then secondly comparing how each occupation has fared under the new CARE schemes compared to the old FS scheme. Basically, the question is whether initially low, but steeper private sector earnings profiles, produce the same TR as public sector profiles which (on average) start off higher but progress at a slower growth rate? To answer this question, we define the concept of Accumulated Lifetime TR (ALTR).

This project combines the definition of DB pension wealth accumulated over the lifecycle with a simulation methodology that assesses the implemented changes to the pension parameter settings. In contrast to most previous research on pension wealth we take a lifecycle perspective which is different from analyses that examine aggregate average changes to pension wealth within a sector; our approach allows a comparison of accumulated lifetime pension wealth at every point in a worker's career. The

methodology for computing the Net Present Value (NPV) of pension accruals over the lifecycle can be applied to examine how public sector employees differ across their working lives and may inform us about how changes to specific pension parameters affect their relative position.

In summary, this project:

- Examines the value of real (inflation adjusted) salary changes and pension changes across occupations in the public sector covered by the Public Sector Pay Review Bodies (PRBs) and others.
- Computes the value of TR in each occupation to compare where possible with private sector counterparts. We also provide an understanding how TR varies across occupations.
- Explores how, within each occupation, (where possible) ALTR varies across the subgroups defined by an employee's gender, and region.
- Compares how the old FS scheme is valued against the new CARE scheme for each occupation.

The report finds that public sector workers are, on average, worse off in the recently introduced CARE pension schemes. The overall general results (from the regression analysis) point to the fact that public sector workers as a whole, in terms of their ALTR, are now worse off relative to private sector since the introduction of the CARE reforms by around 3.5%. This figure should be a cause for concern at a time when real (inflation adjusted) relative salaries of public servants has fallen systematically over the last 10 years.

However, the average detrimental effect of CARE relative to FS pension schemes masks substantial occupational variation. The corresponding figure is much larger than the average 3.5% in some specific occupations where major changes in the pension conditions of the workers (e.g Police and Firefighters) have made these groups considerably worse off. In contrast, those in the Prison Service, Teaching and NHS Nurses schemes, whilst still worse off under the CARE scheme compared to the FS scheme, are not hugely disadvantaged. We also found that Doctors/Dentists are also substantial losers in the move from Final Salary to CARE schemes.

In our sector comparisons, we found only relatively small differences between public and private sector Teachers although we find out that private sector Nurses are less adversely affected by the move to CARE pension schemes than their public sector counterparts. This is mainly due to lower hours of work, lower hourly rates of pay and a lower fraction of people in the FS pension scheme in the private sector. In our gender comparison, we found that male Teachers and Doctors were more adversely affected than their female counterparts due to their longer working hours and higher earnings. Specifically, we found that male teachers have lost around 5% of ALTR since the reforms and women Teachers close to half that figure.

This report also examined the relative impact of the 2015 CARE reforms on occupations in the public and private sector across geographical regions and between men and women. Reassuringly we find that variations across geographical regions and between men and women are not of major concern.

The implications of our findings are potentially wide-ranging and pose many important public policy questions. We set out both our general and occupation-specific conclusions. The CARE reforms pose significant challenges to the PRBs in terms of the evaluation of the TR package in the different occupations and jobs in their remit groups. Further technical challenges need to be addressed with respect to the explicit evaluation of ALTR in the light of large-scale pension reforms. Indeed, PRBs may wish to consider whether it could be appropriate to make a recommendation regarding specific pay responses to offset the effects of the Government's pension reforms. Of substantive priority is the situation with Police, Firefighters and Doctors/Dentists. These are issues that will inevitably have to be faced by future governments who need to recruit, retain and motivate the right calibre of people within these key public sector occupations.

1. Introduction

The Great Recession in the world economy which started in 2008 has accelerated the need for pension reform across many countries, the UK included (Burtless 2010). The present UK government and the previous Coalition government have seen public sector pensions as being one of the most important contributory factors in the crisis of government's fiscal position. The deficit brought benefit entitlements and contribution rates under scrutiny, as unsustainable levels of public debt grew. As a result, radical changes have been implemented to pension schemes across the public sector mostly from April 2015. Following the Independent Public Service Pensions Commission Final Report (2011) in the UK chaired by Lord Hutton, these reforms affected the computation of public pension entitlements fundamentally and discontinuously. This will impact the future incomes of all public sector staff, even those who enrolled into established public sector pension schemes with more generous parameters (except for those generally[1] within ten years of their Normal Pension Age[2, 3]).

Rising life expectancy is a major factor in the need for pension reform.[4] This suggests that public sector pensions are paid longer on average to each retiree than envisaged when the schemes were designed. As a result, the financial burden of more expensive pensions have to be predominantly borne by taxpayers (HM Treasury, 2011). This is especially true for the unfunded pension schemes that are typical in the public sector.[5] Longer life expectancies can only be balanced: by working longer; by higher pension contributions; or by lower pension benefits in retirement. While the UK has experienced a long history of public sector pension reforms (Disney et al., 2008), the 2015 changes were fundamental.

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[1] Some workforces (e.g. the police) were offered protection on the basis of age, length of service or a combination of both.

[2] As was determined in April 2012.

[3] Even those within 10 years of their NPA have been similarly affected by higher employee pension contribution rates, even if the nature of their pension scheme is otherwise unaltered.

[4] See for example: http://www.ons.gov.uk/ons/dcp171778_426798.pdf.

[5] Most of UK public sector pension schemes we consider are 'unfunded', in that the pension benefits are not underpinned by a fund and they are paid directly from current workers' contributions and taxes. This position contributes to the fiscal problems faced by the UK government. One exception is the 'funded' Local Government Pension scheme, in which the pot of money that individuals have on retirement is determined by the contributions paid into the scheme, after charges, from investing these contributions in pension funds and from Local Government Revenue (for example Council Tax) (PPI, 2005).

The large literature on the earnings differentials between the public and private sector (see Borland and Gregory, 1999) has addressed the issue of self-selection into careers and more recently considered the public-private differences in earnings dynamics (Postel-Vinay and Turon, 2007) over an employment lifetime. However, this literature has ignored the value of pensions and the issues of Total Reward (TR) over the life cycle (including retirement). This omission is important in the light of the widespread progressive changes in pension arrangements in the public sector.

In the recent recession and fiscal debt crises, there has also been pressure to reduce the overall public sector wage bill which has been growing. As changes to public sector compensation (in terms of pay or pensions or other conditions of service) will have immediate consequences for fiscal budgets, workforce composition, delivery of services, inequality and relative remuneration, it is necessary to carefully evaluate these changes as an element of the total remuneration package. It is also important to be clear what this calculation tells us about public/private sector relative remuneration as this is a perennial comparison fraught with pitfalls. This information is useful in trying to assess the overall position on recruitment, retention and motivation in a range of careers.

There is considerable agreement that any debate about remuneration should include pay and pensions and all other forms of benefits in kind. There is less agreement on how this should be calculated. Although there has been a lot of work on selected aspects of the value of pensions across sectors (e.g., Disney et al., 2009) there has been relatively little on the evaluation of broader concepts of total compensation. Indeed—although the notion of 'Total Compensation' or 'Total Reward' seems to have become widespread and fashionable in Human Resource Management circles, there was no consensus of specifically what TR includes and leaves out. Often (see Greenhill, 1990 and Balsam, 2002) 'Total Remuneration' or the 'Compensation Package' (for executives) is said to include: salary, bonus, stock options, stock grants, pensions and other compensation. This literature tends to exclude: hours of work, holiday entitlements, job security (in terms of the probability of being made unemployed) and does not attempt to enumerate future benefits in present value terms or to adopt a life cycle perspective on this evaluation. These would all seem to be important considerations for an economic evaluation of TR.

Concomitant with the scrutiny of pension payments has been a more wide ranging policy discussion of the 'Total Reward' on offer in each public sector remuneration package. (For antecedents to this, see Quin, 1982, Montgomery et al, 1982, Pesando, 1984, Rosen 1986, Balsam, 2002, Leslie 2008, Danzer et al 2012, 2016.) Some public sector pay review bodies have been placing more emphasis on the comparison of public sector pay in any given occupation with that on offer in comparable private sector counterparts. This scrutiny has included the value of pension benefits and other conditions of employment. This TR methodology was as summarized in section 2 below as set out in Danzer and Dolton (2012) (henceforth D&D 2012) who compared the whole public sector with the whole private sector, in terms of lifetime earnings and pensions and the whole remuneration package.

The paper by D&D 2012 provides a conceptual method for the measurement of TR and estimates its structure (where possible) for the Pay Review Body (PRB) remit occupations in the UK circa 2017 [6]. For the purposes of this review, we will define TR in a sector as the total financial benefits and 'in kind' compensation, evaluated in money terms over the life cycle for a representative worker. [7] This will include conditions of work that can be evaluated in money terms and all direct financial remuneration both now and deferred as pension payments in the future. Hence, we take into account current earnings, pensions, hours of work, paid holidays, employer provided health insurance, the likelihood of unemployment and the lifetime pattern of pension contributions by employers. We set out the original model of this calculation in Appendix B. In practice, we can perform these calculations by pooling the largest available sources of data on public and private sector employees and examining (where possible) how they differ by PRB remit groups, on average, across the life cycle. This means we will use all of the following data in our analysis: The Annual Survey of Hours and Earnings (ASHE), the Labour Force Survey (LFS), the English Longitudinal Survey of Ageing (ELSA), and the British

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[6] These PRB groups will be: Doctors (excluding GPs), Nurses, Teachers, Prison officers and Police Officers. Please note that it is not possible to perform simulations for: the Armed Forces or GPs and Dental Practitioners, as they are not included in the ASHE data. In addition, there are strict limitations on sample sizes in certain occupations which prevent separate analysis by gender, education and region for many sub-samples. These limitations will be discussed with OME directly. The exact definition of each remit group (and any possible logical comparator groups) was determined in conjunction and approval of the OME by the use of the agreed 4 digit SOC and SIC codes.

[7] This will be done by estimating actual mean earnings at each age conditional on a limited set of controls as set out in Danzer and Dolton (2012).

Household Panel Survey (BHPS) combined with Understanding Society (US). Each of these data sets provides different data on the various components of pensionable pay, hours of work and other circumstances. In Appendix A to this report we provide a Data Appendix which includes a list of all the available data which we used in our evaluation of TR.

The main contribution of this project is to bring up to date the estimation of the level of total compensation of public and private sector employees in different occupations using the latest available data. In addition, we re-compute these TR calculations where possible by gender and geographical region. We also make direct comparison of the same job in the private and public sectors in the UK and in different occupational remit groups. Earnings in the public sector start off at a higher entry level than in the private sector. (Figure 2 below also illustrates this pattern in terms of gross hourly earnings over the course of the working life.)[8] Later in the life cycle, stronger wage growth means that the private sector earnings profile rises above the public profile. While both profiles level off at later ages, the private sector profile even declines below the public profile. This shape of the private and public sector profiles has led researchers to impose a quadratic functional form on age-earnings profiles (see Disney et al., 2009). These lifetime earnings profiles are very different for men and women. Public sector men's earnings only overtake their private sector counterparts in their early 50s. In contrast, public sector women overtake their private sector counterparts much earlier, when they are in their early 40s. When performing the analysis on employer-reported earnings (using ASHE data), we consistently find inverted u-shaped median age-earnings profiles. Fundamentally, the question is whether initially low, but steeper private sector earnings profiles, produce the same TR as public sector profiles which (on average) start off higher but progress at a slower growth rate? To answer this question, we use the concept of Accumulated Lifetime TR (ALTR). This ALTR concept evaluates the discounted cumulative value of all real earnings and the financial value of all accrued pension rights and non-pecuniary benefits each year as a person ages. Besides earnings and pension accruals, we include four non-wage and non-pension components in the valuation of TR.

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[9] So, an important contribution of this research is that we evaluate the contribution made to TR by: hours of work, paid holidays, employer-provided health insurance and the probability of employment. Note that we are not able to include other benefits like: company cars, private medical insurance, and stock options, as to our knowledge, there is no consistently available data on the value of these additional allowances. After accounting for imperfections of the labour market (the risk of unemployment), the intuition is that TR in both sectors should be equal for very similar workers performing equal work. Therefore, in some sense, we perform this complex valuation exercise in order to assess a compensating differential over the lifecycle. The idea would be that each individual would attempt to choose the sector which maximised their lifetime TR (or utility). This is a necessary (although quite restrictive) assumption which has been adopted by the whole literature in this area. [10] This may of course then involve switching from one sector to another at some point in the career. In such a framework, it makes sense that the different alternative careers would end up having comparable TR when calculated in present value terms over the whole lifecycle. [11]

The main challenge of D&D 2012 was the conceptual measurement of TR. [12] In order to make the TR package comparable across sectors, the first analysis was limited to men and women with higher education qualifications. We did this for several reasons. Firstly, because a high fraction of the less well educated did not have occupational pensions schemes at the time[13]; secondly, because previous analysis for the less well-educated shows that such a comparison is relatively uninteresting as public sector wages dominate comparable private sector earnings over the whole life cycle; and thirdly because this

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[9] Evidence from the USA suggests that in-kind benefits are more common (Heywood, 1991) and more generous (Quinn, 1982) in the public sector. But much of this analysis excludes stock options, private medical insurance and company car allowances.

[10] For early empirical investigations of the framework see Rosen (1974), Duncan (1976), Brown (1980), Woodbury (1983), Montgomery et al. (1992) and Montgomery and Shaw (1997). Of course, it is quite possible that many people would not be able to calculate or calibrate their lifetime TR or their utility.

[11] Otherwise if one occupation, A, always and everywhere had higher TR than another, B, for all workers, then all people would choose to crowd into A and none would want to enter B. So, for occupations to be chosen differently by different people we must rely on different attitudes to risk, discount rates or other sources of heterogeneity. This follows logically from Rosen (1974) and Rosen (1986).

[12] We evaluate TR in terms of money and so assume that each person has a utility function which is linear in money and is not risk averse.

[13] Automatic enrolment had not yet been fully implemented when the analysis was conducted in D&D (2012). Therefore, the impact of this policy would not have fully materialised in the dataset used at the time.

comparison of the highly educated is really where most of the media attention has focused on.

Figure 1: Lifecycle Current Earnings [14]
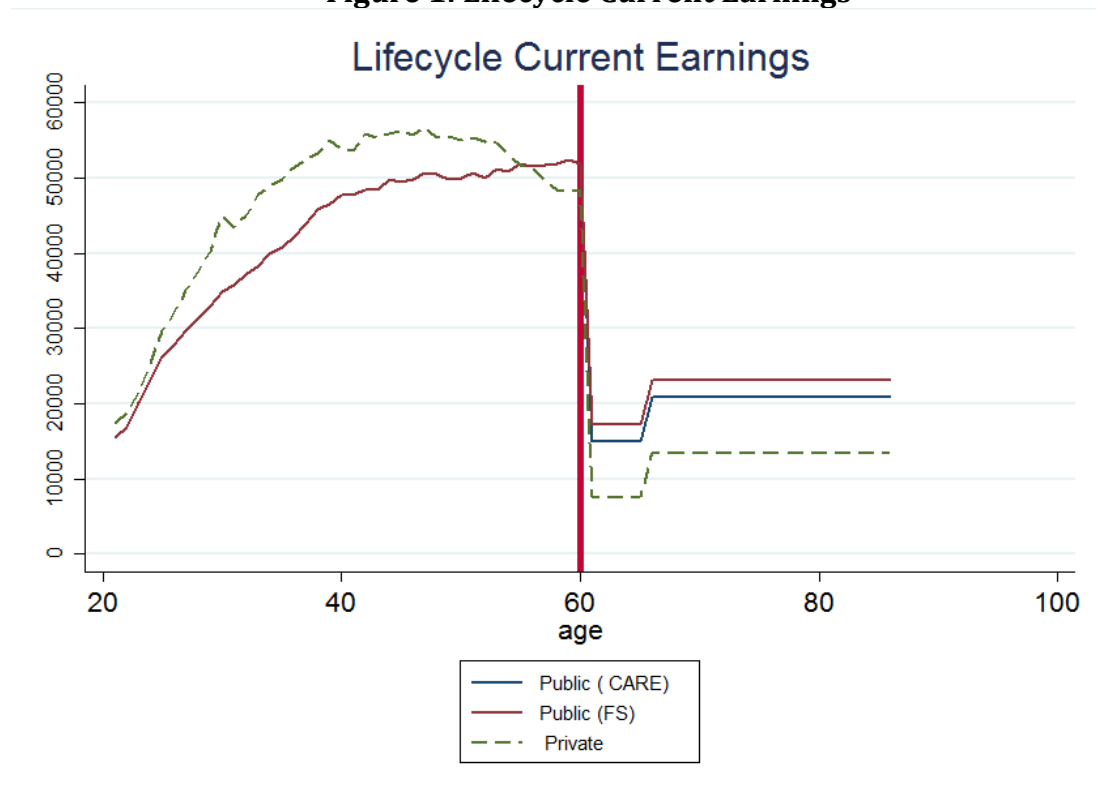
Figure 1 (which is directly comparable to Figure 4 in D&D 2012) provides the motivation for the development of a rigorous definition of TR. The figure shows real data from ASHE on average real annual remuneration for public and private sector employees from their first employment over the whole of their career – based on an average of the ASHE data from 2005-2018 uprated by inflation and graphed over the life cycle. For simplicity, this income measure comprises earnings, and pensions. These two sector profiles are slightly stylized for illustrative purposes. The data in this example are for men and women together in 2018 prices. In the figure in D&D 2012 from age 53 onwards, public sector males are better off, including during their retirement age. [15] This current figure shows that private sector workers (the green dashed line) systematically out-earn their public

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[14] This figure shows actual real earnings of men from ASHE over the lifecycle up to the age of 60 and then retirement income as calculated for the average profile.

[15] It should be noted that this does not imply an optimal switching point from the private to the public sector. The reason is that a switching employee would most likely not receive the counterfactual earnings. Also, the portability of fringe benefits across sectors is probably limited (cp. Mitchell, 1982). We plan to address the question of sector switching in our future research.

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sector counterparts (the red continuous line) from the age of 21 to 55. Seniority enhancements and age for wage pay scales mean that public sector workers earn more than their private sector counterparts from 55 to retirement. In retirement, we see that the old Final Salary (FS) was the most favourable, especially compared to the private sector DC schemes. The new Career Average Revalued Earnings (CARE) scheme, on average is still better than the DC scheme but not as good as the old FS scheme. Hence on average the new CARE schemes are less generous than their old FS counterparts. The reality is that the career average element which makes recipients worse off is potentially offset by their higher accrual rates. This figure, although based on real data, is only an average across all occupations. We will be using more rigorous graphical and regression methods in the rest of this report to measure the size of the effects of the CARE scheme introduction across each occupation compared to its old FS counterpart.

In order to study which sector rewards its employees better, one has to compare the difference in the Net Present Value (NPV) of extra private sector earnings from age 30-50 with the more generous public sector pension provision. Of central interest is the question how much *present value* an individual can generate from employment over the life cycle. We therefore suggest that TR at each given age τ, should comprise *accumulated* earnings plus the *accumulated* wealth of a pension scheme (up to each given age τ), evaluated from the career start (t=21). [16] This approach has previously been considered for the analysis of career choices (Willis and Rosen, 1979; Dolton, 1990; Leslie, 2008). We call the measure which makes entire compensation over the career comparable across different sectors or occupations ALTR. [17] We suggest that the value of the ALTR could be a sorting device into different economic sectors and thus hope to shed light on the incentive mechanism through which workers self-select into, or leave, specific occupations and sectors. The existing literature either focuses on earnings potential and self-selection into specific occupations (e.g. Dolton, 1990); or the public sector as a whole (e.g. Disney and Gosling, 1998); or ignores aspects of TR in modelling recruitment and

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[16] It is possible to evaluate ALTR at any age. As long as future years are discounted by the same rate as past years are uprated, the relative position of the two sectors will remain unaffected; the absolute level of TR will obviously change.

[17] While ALTR is a concept that compares the current stock of earnings and pension wealth, it is also possible to employ a flow version, in terms of changes in accrual values. This can be informative about the gain from staying in employment or in a specific job for another year (on employees' retirement decisions see, e.g., Disney et al., 2009).

retention into occupations. What has changed and is relevant to this study is that Final Salary pension schemes have been replaced by CARE schemes. Our task is to assess the effect of this by occupation. But in broad terms for the whole of the public and private sector the current situation is depicted in Figure 1. Here we see that the effect of the CARE schemes is to make public sector pensions less generous than the FS scheme. It is also the case that the point at which the public sector workers' average wage rises above that of the private sector worker is now later at around 55. The effect of these two changes since 2015 have changed the overall TR in each occupation.

Our main goal is to provide an empirical estimate of TR at any given age and to compare employees in different public and private sector occupations. The valuation of different TR components is largely driven by the fact that private sector workers have lower pension contributions, fewer and less valuable fringe benefits and higher unemployment risks. Evidence on earnings is mixed with a clear dominance of the private sector earnings profile in mid-career and a counter balance of an advantage of public sector employees at later stages of the working life. Private sector employees, however, work more hours per week implying potentially larger annual earnings throughout the entire working life. In order to value the TR across sectors at every point in time (age), we add up all components as described earlier.

Previous research in D&D 2012 suggests the value of benefits in kind, as a fraction of annual earnings, ranges between 15% in the private sector and 20% in the public sector. These shares are relatively stable over the life cycle indicating that benefit growth keeps pace with earnings growth. The effect of unemployment on aggregated pension wealth is increasing over the life cycle. While it accounts for a fifth of annual earnings at career start, the value of accumulated lost pension wealth adds up to 80% of the final annual salary shortly before retirement.

The rest of this report is set out as follows. The next section descriptively outlines the baseline method of calculating TR. (The theoretical details are in Appendix B.) Section 3 sets out the caveats and logical necessary limitations to the baseline analysis. Section 4 expands on the baseline method to explain how it can be extended to compare old Final Salary schemes and the new CARE schemes. This section also suggests how, in principle, a public sector occupation may be compared with a logical private sector counterpart.

Section 5 outlines the use of the data for the project. Section 6 sets out the key research questions and the logical necessary steps in the analysis. The building block components of the TR calculation are set out in section 7 with a graphical analysis and description of the data to be used in the calculations. The substantive results of the simulation are set out in section 8 with sub-sections describing: results of a comparison of the FS pre-reform scheme and the CARE scheme which replaced it; an analysis of the changes in DB pension worth; a comparison by gender within occupations; and a comparison by region within occupation. A brief discussion of policy implications and possible directions of future research concludes this report.

2. Defining Total Reward: The DC/DB Methodological Baseline

In this section we describe the conventional basic comparison of a standard Defined Contribution (DC) pension scheme common in the private sector in the UK with a conventional Defined Benefit (DB) scheme common in the UK public sector prior to 2015.[18] The actual formulae used are set out in Appendix B and further details of the original method are set out in D&D (2012) and Danzer et al. (2016). The measure of TR set out in D&D (2012) is made up of earnings and pensions as well as an array of other components. They account in greater detail for the complexities of the pension system. For instance, they shed light on most components of the UK pension system simultaneously (state pension, state earnings-related pension and various occupational pensions) and estimate the level of pension wealth from different sources. [19] With respect to benefits in kind, we propose simple valuation methods, yet are able to show the importance of fringe benefits in the TR package.

In the valuation of pension entitlements, we follow the previous literature (Gustman et al., 2000). For our purposes, we define pensions as the bundle of retirement related payments from different sources (general and earnings-related state pension,

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[18] Within the public sector, both the pre-1st April 2015 final salary and the post-1st April 2015 career average revalued earnings (CARE) are examples of defined benefit (DB) pension schemes.
[19] We cannot account for more than one occupational pension (however, the fraction of employees holding several occupational pensions is small). We also ignore private pensions as we are interested in the level of job-related remuneration.

occupational pensions). Public sector pension schemes are generally easier to analyze as they are based on general rules which researchers can collect from publicly available reports (PPI Pension Primer, 2008). [20] The parameters of private occupational pensions are individual specific and must be retrieved from the data. The asset value of a DB pension is evaluated as the sum of the discounted DB values from retirement until death. For this computation, knowledge about retirement dates and life expectancy levels at retirement is required. The actual benefit value will depend on the pension plan details provided by different employers (i.e. accrual rates, accrual base, initial vesting period, lump sum options, survivors' benefits) as well as specific employee details like levels of past earnings and number of years of service. The asset value of the earnings-related state pension is computed as the discounted sum of benefits [21]. The asset value of a DC plan is provided by adding up the employer and employee contributions which are paid into the plan and applying real interest rates to the accumulated fund. The fund is then used, on retirement, to buy an annuity—which will yield a stream of earnings until death. Most group personal and stakeholder pensions are similar 'money purchase' schemes. The distinction between DB and DC is important: DB is, in a practical sense, a risk sharing arrangement where the employer (or state) bears most of the risk to fund pensions. Employees are left with the risk of scheme closure or bankruptcy (for instance like in the Maxwell pension scandal). [22] In contrast, the employee bears the entire investment risk of his or her individual pension fund in DC or 'money purchase' schemes. In the following analysis, we ignore the difference in 'investment risk' between schemes.

Another important difference between FS and DC based pension schemes is that the former are 'backloaded' in the sense that they are geared to fractions of final salary in increment based pay structures based on seniority, whereas, the DC schemes are 'front loaded' in the sense that they are based on cash contributions to an annuity fund at each age as a career progresses (see Disney and Whitehouse, 1996). Differences between

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[20] Public sector pension systems have been subject to reforms in recent years, but most of them have only been phased in now or will be in the future. Therefore these reforms do not distort our comparison for those who are already members of a scheme today.

[21] In this analysis, we are ignoring the State Earnings Related Pension Scheme (SERPS) as it now only affects very few people. For example, there are only 4 % of Teachers in the SERPS. This decision on the methodology was taken in consultation with the OME.

[22] The Pension Protection Fund is partially compensating for pension scheme bankruptcy. Since its establishment in April 2005, the PPF has taken over 177 schemes with around 50,000 members (as of August 2010 (see also http://www.pensionprotectionfund.org.uk)).

public and private sector pensions schemes are further skewed in favour of the public sector as many DB schemes are portable to other jobs – whereas, in the private sector most DC are not. In this respect the risks associated with DB and DC schemes are even more distinct.

The data requirements to calculate the TR level for the average public versus private sector pensioner are exacting. Ideally, they would require us to know all of the lifetime earnings for the individual as well as contribution rate information. We need to assume that the life cycle earnings profile can be approximated by looking at the cross-section age earnings profile for the most recent cohorts for whom we have data. However, it should be understood that this is not the same as a true lifetime earnings profile[23].

For an employee who has not contracted out of the compulsory state earnings-related pension, we will value the pension in the way set out in equation (4) in D&D 2012.[24]

Due to the complexities of the UK pension system we have to make some simplifying assumptions in order to perform our calculations of work related pensions: Both DB and DC pension holders are assumed to draw their pension at age 60 [25], while the state pensions (SP) can be drawn at the normal retirement age of 65 (Banks and Smith, 2006). The pattern of retirement ages does not differ significantly across sectors [26],[27]. Given our focus on those employed over their life cycle, we assume that both the public and the private sector employees have the same entitlement to the state pension. The generosity

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[23] In the UK, it is not yet possible to work with data on the lifetime earnings of each individual over their whole career as we simply do not have the data available. Reassuringly in Scandinavian countries they do have such data and Nybom (2017) and Bhuller et al. (2018) show that most of the conventional estimates of lifetime data parameters do not substantially change (e.g. the rate of return to education) when we use our set of repeated cross sections.

[24] Here, we abstract from the fact that SERPS was introduced only in 1978 and that new entrants to the Second Tier State Pension enrolled in the S2P from 2002 on. We set the accrual factor to 0.2 for 69%of years and 0.25 for the remaining working years in order to reflect the reduction in accrual factors in 1988. We have to make this simplification because there is no suitable large scale data source following individuals' pension membership histories over time. D&D 2012 believe the introduction of S2P does not cause any substantial bias as the change from SERPS to S2P was meant to support low income earners, while the pension generosity for the highly educated has changed only marginally.

[25] The reason for this assumption is spelt out in the next section. Essentially the data is sparse after age 60 and falls foul of the Secure Research Service (SRS) cell size data limitations and so can't be used.

[26] As revealed by a non-parametric Kolmogorov-Smirnov distribution test. The Kolmogorov-Smirnov test investigates the hypothesis that the public and private sector retirement age distributions are not significantly different. The p-value of the test statistics for the combined test is 0.253 for men and 0.231 for women. Also, all one-sided tests cannot reject equality.

[27] In money purchase schemes, there is no official earliest pension draw age, so accruals could theoretically be used to buy an annuity at any age. State pension rights are accumulated through the payment of NI contributions and pensions become available after a minimum of 30 years with NI contributions.

of the pension benefits depends on some measure of personal earnings in DB schemes. The accrual fraction is assumed to be 1/60th in private sector FS schemes and 1/80th in public sector FS schemes. [28] Public sector DB schemes are assumed to provide 3/80th lump sum per year of tenure, and the private sector DB schemes are assumed not to provide a lump sum payment. All DB schemes are assumed to have a payment for the surviving spouse of half of the pension entitlement. Survivor's benefits are only valued for men, as their spouses' lives are statistically longer on average. [29] A comparison of our parameter assumptions with those made in papers that evaluate pension schemes (Leslie, 2008; Disney et al., 2009) is given in Table A3 in the Appendix.

It is evident from equation (6) and in the Methodology Appendix B and its constituent parts that the calculation of ALTR is complex and demanding. We describe in section 5 the data that may be brought to bear on this calculation in the UK. But first it is important to step through the substantive caveats and assumptions which need to be made to implement this model. It is important to make these explicit to avoid any confusion over the limitations and applicability of what can be calculated.

3. Caveats to the Basic Analysis.

At this point, some caveats of our analysis have to be kept in mind. These are important limitations to the research work which will be undertaken. In some cases these limitations are imposed by the availability of data – whilst in other cases they are imposed by the limitations of tractable analysis in a short research project time scale and the technicalities imposed by not attempting to estimate more sophisticated dynamic programming models – although these models typically make much more restrictive assumptions than we make in our basic simulations (see, for example, Postel-Vinay and Thuron, 2007). From the outset one should be clear that all the modelling simulations in this report relate to a specific period of time (namely the UK economy between 2005-

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[28] 1/80th accrual fraction was applicable in the NHS, Teacher and Local Government Pension Schemes before the pension reforms in 2007 and 2008 (Steventon, 2008). As the changes applied only to new entrants, our estimates reflect the actual situation for most employees quite realistically.

[29] Women live on average over 2 years more than men. Hence for the average heterosexual representative working man, his partner will on average receive a benefit from the pension for this time difference between their death ages. This is not on average true for working women. We do not intend to make any separate calculations for same sex couples.

2018) and hence may change if a different period of time was considered. It also goes without saying that if any of the assumptions we make in order to perform our simulations were altered then the conclusions may change.

Gross Salary Calculations rather than Net

First, our entire analysis is based on a gross evaluation rather than a net of taxes calculation. (Despite the fact that taxes play an important role in employers' decisions which benefits to provide (Rosen, 1986)). We chose to base our calculations on gross valuations since all DB final salary calculations use these gross valuations and also because in calculating ALTR the tax regime is the same for both public and private sectors. While the relevant cost category for an employer is the TR of a worker, the tax preferential treatment of many fringe benefits (e.g., pensions) induces a trade-off between earnings and benefits from the employee's perspective.

It is also the case that when any job or career is considered it is calibrated in terms of gross earnings (no job is ever advertised in net salary terms). This is because a person's net actual earnings will also be, in part, determined by their personal characteristics, like their marital status. A further complication is that net income is a step function of gross income with a zero-rate tax free allowance, a standard rate on income tax and a higher tax band. These thresholds change every year with the budget which means that the calculations to compute net earnings would also change every year. Hence there are various advantages to using gross earnings figures. Notwithstanding these observations, many employees often make hours of work decisions, choosing to work part time, or retiring early on the basis of their net take home pay and changes in the income tax or taxable allowance rule. Of particular relevance, here are the recent reductions in the annual pension tax allowance and the lifetime tax free pension pot allowance. Specifically, the annual tax-free contribution to a pension which a person could make was reduced in 2015 as was the tax allowance associated with continuing to work and pay into a pension in flexible retirement schemes. The lifetime tax free pension pot allowance was reduced from £1.5m in 2013/14, to £1.25m in 2015/16 to £1m in 2017/18. It is likely that these changes have affected retirement decisions of some members of the PRB remit groups – most specifically, hospital doctors/dentists, salaried GPs and salaried dentists.

An alternative way of thinking about TR is how much it costs an employer to provide an individual employee with certain observed characteristics with a given pay and (actuarially solvent) pension package. To some degree this vindicates the use of gross calculations as this is closer to what the government, as an employer of public sector employees, is actually interested in, i.e. how much is spent on these workers and how does this compare with how much it would cost to employ matched similar individuals in the private sector. For this reason it makes sense to do the calculations gross of tax and ignoring individual unobserved characteristics and averaging over those observed traits that interest us.

The Endogeneity[30] *of Occupational Choice and Unobserved Ability Differences*

Perhaps the most important limitation of our proposed research is that we take the choice of each person to enter a given sector as exogenous. Most specifically we do not attempt to model the fact that occupational choice decisions are simultaneously determined in conjunction with educational investment choices and that both decisions may be affected by an individual's perceptions of their own ability and other unobserved heterogenous factors. We do not consider the possibility that there is a systematic unobservable difference between the type of person who enters the public sector and the type of person who enters the private sector. For example – crudely, if a public sector type person is a risk averse person who is pessimistic about their future promotion and advancement possibilities, but a private sector person is the opposite – risk loving and confident – then we could get systematic underlying differences in the earnings and remuneration in these two groups which is not due to their career or job – but a function of their unobservable characteristics. Also, workers sort into the public or private sector based on differences in job characteristics. These include not only the level of pay, but also job stability (Postel-Vinay and Turon, 2007). In our valuation exercise we attempt to include as many observable job characteristics as possible. However, we are unable to observe differences in preferences or ability between public and private sector workers. Hence our method

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[30] By endogenous, we mean that the variable is not exogenous – i.e. this means that the explanatory variable of interest is not unrelated to the unobserved heterogeneity in the relationship in question. This is also equivalent to saying that the explanatory variable of interest may itself the subject of a choice or decision which arguably could or should be modelled simultaneously. Hence in this particular example, we are saying that the determination of earnings and TR is not independent of the choice of occupation one may make. Put simply we do not have our TR determined at random – we are making choices about an occupation, most likely, in the full knowledge about what this means for future earnings and pensions.

does not study the self-selection of specific types of workers into the sectors, but their realised monetised compensation packages which are at the centre of the policy interest.

Union Membership

Third, a central theme in the literature on compensating differentials concerns union membership, a topic that is omitted from our analysis. Unions may have a direct impact on pay and working conditions and thus potentially affect the level and composition of TR. We do not attempt to take account of the extent to which workers in the public sector in particular occupations are typically more unionized or the extent to which certain more powerful unions may have been able to secure better deals on pay, conditions of work, like working hours or pensions. Likewise, there is a large literature on the endogeneity of union membership decision. So, we do not model the individual's decision to become a union member or not and the possible consequences of this choice on their wage, or employment hours or indeed their pension. To the extent that in most public sector occupations the unions in question negotiate on behalf of all workers irrespective of whether they are union members or not then this is not potentially such an important problem.

Excluded Groups

Fourth, for data reasons our analysis excludes several groups, like the self-employed—most notably for the public sector GPs and general dental practitioners. This is because the crucial groups are omitted from the LFS and ASHE national data sets. The data also exclude the Armed Forces and lowest earning individuals who do not pay any NI contributions. [31] Also note that we will use the ONS official definition of the public sector which omits certain key groups who are paid from tax income—like university Lecturers, and FE Lecturers who are defined by the ONS as private sector employees.

Non-Monetary Calculations

At present in our analysis we have not evaluated the monetary value of other conditions of work like: stress, control over time, autonomy, flexibility, work pressure and other

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[31] Employees who do not pay any NI contributions are not sampled in ASHE. Beyond that threshold, the representativeness of ASHE with respect to low-income earners has been substantially improved (Ormerod and Ritchie, 2007).

working conditions. This was not done as a result of time pressures and the project deadline. However, a possible future extension to our analysis may be possible using data from WERS relating to conditions of work for a limited number of comparable people in the same job across the two different sectors – for example Nurses.

Women's Endogenous Participation Decisions

We make no attempt to control for women's participation decision across the life cycle. Clearly one reason for the marked decline in women's earnings in the second half of the life cycle in the private sector is that many women take time out of the labour market for family reasons. As a result they may suffer loss of career advancement.

For our data analysis we are using the women who are working in the ASHE and LFS data. If these women are a non-random subset of all women (as seems likely) then we need to take this into account in our interpretation of our findings. Specifically, our results will relate only to those men and women who actually work and not to all those who could work.

In addition, if the pattern of working is not independent of the age structure – because for example younger women are more likely to be out of the labour force – than older women or young men – then this may mean that performing the analysis by age may not be a truly balanced sample from the joint distribution of gender and age.

Job Switching

No provision is made for the fact that higher earnings early in the working life in one sector may increase private savings and asset accumulation. While we acknowledge that the timing of remuneration over the working life may differ between sectors and thus influence individual wealth, we ignore this fact because our principal interest rests on work-related remuneration. We are also implicitly ignoring the possibility that state investment (in human capital terms, for instance) is different between public and private sectors. Having quantified and mapped out the nature of the ALTR over the lifecycle for men and women, the natural corollary is to ask whether this pattern of advantage maps into behaviour. For instance, do we observe men switching from the private sector into

the public sector when they get past their mid 40s? An increasingly common phenomena in labour market choices of young and middle aged people is to start their career in one job and then seek a related job in another sector. For example, it is now quite common for Nurses to begin their career in the public sector NHS and then move to a private sector health provider after some years of experience. It is also commonplace for Nurses to work shifts in both the public and the private sector at different times in the week. More complicated still are those who have half time jobs in one sector and half in another. We cannot, of course, model these complexities. In D&D 2012 we provided some preliminary analysis of basic job switching behaviour. A more detailed analysis of these issues remains on the agenda for future research.

Risk Attitudes and Time Preferences

Another caveat is the treatment of diverse kinds of risks (for a detailed analysis in the pension context see Blake, 2006). Attitudes towards risk (risk aversion) and time preferences (discount factor) may differ between public and private sector employees.[32] Furthermore, the risk associated with being a member of either a DB or a DC scheme (bankruptcy risk, interest risk) may differ. In our analysis we will assume constant discount rates across both sectors and ignoring potential differences in the other risk components. A partial mitigation of this assumption is that we do include the probability of unemployment explicitly in our calculations and so this aspect of the difference between risk assessment in the public sector and the private sector has been taken care of.

As we are continuously assuming the same parameters for public and private sector employees, a manipulation of the discount rate only affects the relative weight of future pension income in today's TR. A lower discount rate will be likely to favour the public sector, as it gives more relative weight to pensions which are more generous in the public sector. Based on previous analysis we suggest that the manipulation of discount and interest rates will not change the general findings.

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[32] For instance, deferred compensation might be used to specifically attract workers with low discount rates (Lumsdaine and Mitchell, 1999).

Using Average Earnings over the Lifecycle

Two aspects of the age-earnings profiles deserve some closer attention. First, given the potentially larger variation of earnings in the private than in the public sector at each age, it would be useful to know whether the two profiles are really different from each other. In our standard analysis we reduce the problem of establishing comparability from two sample means (Belman and Heywood, 2004) by using median earnings. To detect whether the mean earnings between sectors are significantly different we construct 95% confidence intervals. While earnings differences are insignificant at the beginning and end of the working career, private sector employees do have an earnings premium at mid-age. Second, like the previous literature we use cross-sectional earnings data. We are aware of the fact that these profiles might potentially differ from true lifetime profiles for compositional reasons. Especially older workers who were made redundant and find it difficult to enter a new job (for reasonable pay) and who face a relatively short period until reaching the retirement age often enter early retirement (Chan and Stevens, 2001). Nevertheless, this approach mimics the perspective of the government which aims at keeping average public sector remuneration comparable to the private sector.

A more recent literature has emphasized the benefits of using panel data over the whole of each person's life to model lifetime outcomes (see von Weizsacker, 1993; Nybom, 2017; Dillon, 2017 and Bhuller et al., 2017). The logical problem with this is that the use of such data may be a fair lifetime reflection of those who are at the end of their working life if all of their previous years information are in the data – but the very fact that these individuals are old means that inferences about them when they are young are not necessarily valid compared to the young of today. Likewise, for the young for whom we may have only 10 years of data then we do not observe their older years so they will not contribute to the data relating to older people. Aggregating this data would therefore require the careful consideration of a particular form of sample composition bias relating to missing old age data for the young and potentially missing young data for the old.

This literature suggests that there may be significant biases from studying the mean or median earnings of a set of different cross sections by age. Unfortunately, there are two significant problems with being able to use lifetime data in the UK. Firstly, the ASHE and LFS do not go far enough back with the same people to be able to utilize data on their whole working lives. Second, the Secure Research Service (SRS) will not permit the

linkage of such data across years to track specific individuals in order to model the nature of this panel over time. In our analysis, we can only recognize these problems and not consider them in detail due to data limitations. One specific warning concerning the use of combined cross section data to model lifetime earnings is that lifetime earnings for a cohort followed over their whole lives are less likely to exhibit a quadratic shape over their lifetimes (as suggested by the Becker-Mincer human capital model). This would involve increasing return to experience (or education) in the early years of a career with falling or even negative returns at the end of a career. But, as can be seen from Figure 2, we do not have a clear quadratic pattern to our earnings profiles. Rather, our age earnings schedules are much closer to being linear for public sector professionals – as they are for the lifetime data (See Nybom, 2017 and Bhuller et al., 2017). Even for the whole of the public and private sectors, see Figure 1, when we aggregate we do not see a quadratic shape for public sector workers – although we do for private sector workers – who we use only as comparators in this study.

The Concept of a Representative Worker

It is important to understand that the methodology used in our analysis requires that we look at average earnings of a specified type of individual over their lifetime. This means that we do not literally follow each person over their life and record their earnings each year. This is not possible with the ASHE and LFS as there are not long enough series of these data to follow people for 40 years. Instead – and in common with other people in the literature – we take all the available data in ASHE and LFS and average over all the years to produce average earnings for each specified type of worker by age over all the life cycle of 40 years. So – in short, we are exploiting the different ages of all the workers in all the cohorts assuming they are comparable. Of course – in many ways – they are not strictly comparable as the cohort specific effects will have different consequences for people of different generations as - crudely – for example, a child of the Thatcher era is not the same as a child of the Blair years.

Hence, to conduct our analysis we use the concept of a 'representative worker' because we wish to make comparisons of the variability of the new pension conditions in each occupation – hence it is most appropriate to do this using an average 'representative' public sector worker with the average life time earnings profile – for someone of their

occupation, gender and region. In this way, we are comparing the age-earnings profile for the typical worker (by occupation, gender and region) and only changing the pension conditions in each occupation. This approach potentially allows us to determine consistently which occupational pension scheme has negotiated the smallest loss (or greatest gain) to its members' pension wealth (for the representative worker in their occupation and sector).

Endogeneity of Retirement Decisions

In our analysis everybody is assumed to retire at age 60 and we ignore the possibility of working at later ages. The main reason for this simplification is to standardize the analysis. The reality is that many people retire before 65 and those that do are not a random subset of the data. In addition, since many of the cell sizes of the group (by age, occupation, gender and region) who retire early are not numerous then SRS limitations on the data mean that the relevant averages are not available to us. [33] For evidence on working beyond the retirement age in the UK, see Meadows (2003). We also assume away additional personal pension plans or other savings policies. We assume there is no difference between the marriage behaviour or longevity of the spouses in the public and private sector. In addition, to minimize the complexities of dealing with the endogeneity of early retirement decisions we only examine people up to the age of 60. This limitation is made all the more important by the raising of the age at which people now qualify for the State Pension and the fact that this differs between men and women – although these ages are coming into line. Also, in some of the new public sector CARE pension schemes the normal pension age is now tied to the (rising) State Pension Age.

The endogeneity of retirement decisions is inextricably connected with why the age-earnings profile (according to conventional human capital theory would) dip down at the end of an average working career. Although much recent evidence (Bhuller et al 2017, Nybom, 2017 and including our own presented later) suggests that for many professions with age related seniority earnings structures, this fall in earnings late in a career does not now occur. Some of this dip may be due to: lower working intensity, lower productivity, or the depreciation of skill, the lack of further promotions or the limited chances of moving to other better paying employment. But it is likely that a part of the

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[33] Since working beyond 60-65 is soon to become the norm then this analysis could be extended in the future.

story is due to the possibility that those with higher earnings earlier in their career do not need to work so hard or put in as much effort at the end of their career to provide for a reasonable pension. These factors will lead to a compositional shift in the sample at older ages – as it could contain fewer of those who had higher earnings when younger.

The reason for spelling out the limitations, assumptions and caveats of our proposed analysis in some details is that we want to make sure that the OME and all members of the PRBs understand the limitations of the analysis we can undertake. It was very important that the OME and economist members of the PRBs aired their constructive suggestions about our approach and data. We have addressed their concerns wherever possible.

4. A Methodology for Comparing Old FS and New CARE Pension Schemes and Examining Private Sector Comparators

The public policy focus has turned to individual pension arrangements in the separate public sector occupations in the light of recent reforms. In Danzer et al. (2016), there was further examination of the pension component of D&D's (2012) simulation method to perform a detailed analysis of the value of each occupation's pension under the old system – before the reforms of 2015 – to compare it with what has now been implemented. [34]

In the Danzer et al. (2016) paper the public sector pension schemes focused on were: the NHS (England and Wales); the Civil Service (UK); Teachers (England and Wales); Local Government (England and Wales); Police (England) and Fire Services (England and Wales). All these schemes experienced changes from April 2015, with the exception of the Local Government Pension Scheme, which introduced the changes in 2014. While

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[34] Pension schemes across different public sector occupations have experienced smaller reforms. Some of the scheme members affected by the changes of the 2015 reforms may have seen the implementation of - adjustments since 2002—like changes to indexation or ill health rules, the closure of specific contracts to new entrants or the abolition of lump sum at retirement, except through a concomitant reduction in pension. To make the base year of the 'old scheme' comparable across occupations we have chosen the year 2002 as benchmark when comparing the 2015 changes. Since the implemented changes of the 2000s were minor, we are *de facto* comparing the post 2015 pension position with the pre-2002 pension position in each occupation. For a detailed description of occupational pensions prior to 2002 see Blake 2003, chapter 6. For an analysis of one of the post 2002 reforms see Crawford and Disney (2014).

different schemes remain for different sectors, the reforms have similarities across groups:

- Importantly, the DB structure of public sector pensions has been maintained, but the pension benefit is now linked to lower CARE, rather than the scheme member's final salary. One important reason for introducing a CARE scheme was to address the unfairness typical of a final salary setting, where workers who experience faster wage growth (such as the more educated) benefit at the expense of staff with low or moderate earnings (Independent Public Service Pensions Commission, 2011). However, this also implies less back-loading of pensions with potentially negative implications for staff retention at older ages, especially of high-flyers (Ippolito, 1985; Disney, 1995).
- The Normal Pension Age (NPA) in public service schemes has been aligned with the higher State Pension Age (SPA). There are exceptions to this: the NPA was set to 60 for the uniformed forces such as Police and Fire Service to reflect the unique characteristics of their work (Independent Public Service Pensions Commission, 2011).
- The average member contributions are increased.

The proposed reforms apply to all members; however, members within ten years of their NPA on 1 April 2012 will have their pension calculated according to the rules in place prior to the introduction of the proposed reforms.

The main differences between the schemes include the rate of accrual, the revaluation of active member benefits and the rate of member contributions. These decisions were set by agreement in negotiations between the public sector unions, and the relevant government departments in conjunction with the HM Treasury. These negotiations determined how the precise parameters of each public sector schemes have changed since 2015.

The permanent reduction in pension generosity will have lasting and sizeable effects on the total lifetime remuneration of affected cohorts of workers. Yet, the reforms will affect public sector employees of both sexes differently, as for instance, the effect of switching from final salary to career average DB schemes will depend on the steepness of the particular age-earnings profiles. Moreover, the different public sector pension schemes face heterogeneous change (e.g. in indexation, contributions, etc.) which complicate the

assessment of the financial consequences. These differences are summarized in Table A4. How will the proposed pension changes affect the lifetime pension wealth across the public sector by gender and education and which pension occupational schemes will be most affected?

This project answers these questions combining the definition of DB pension wealth accumulated over the lifecycle with a simulation methodology that assesses the implemented changes to the pension parameter settings. In contrast to most previous research on pension wealth (Disney et al. 2009; Crawford et al. 2010; a notable exception is Disney and Whitehouse 1996), we take a lifecycle perspective which is different from analyses that examine aggregate average changes to pension wealth within a sector (PPI 2013); our approach allows comparing the accumulated lifetime pension wealth at every point in a worker's career. The methodology for computing the NPV of pension accruals over the lifecycle can be applied to examine how public sector employees differ across the entire life cycle and may inform us about how changes to specific pension parameters affect their relative position.

The purpose of the Danzer et al. (2016) paper was to simulate the impact of these reforms and calculate which occupational pension scheme got the 'best deal'. This project contributes to the informed policy debate by bringing up to date the simulation of the impact of all implemented pension changes on the accumulated pension wealth of public sector employees following the 2015 reforms. We also take account of the impact of the reform already implemented in 2011 by the Coalition Government, which changed the inflation indexation of pension payments from the Retail Price Index (RPI) to the Consumer Prices Index (CPI). Second, we simulate the accumulated pension wealth over the entire life cycle. Third, we provide the first comparative assessment of pension wealth across different public sector occupations. Thirdly, we repeat our analysis by gender and region.

5. Data

A careful comparison of DB pension schemes requires accurate information on age-earnings profiles, pension scheme membership as well as pension scheme parameters. Our computation will be based on the same underlying gender-specific data on age-earnings profiles for a representative public sector worker in different occupations.

It is worth re-iterating that the data requirements to calculate the DB level for the average public sector pensioner are high. Ideally, they would require us to know all of the lifetime earnings for the individual. Our data assumption is that this can be approximated by looking at the cross-section age-earnings profile for the most recent cohorts. However, it should be understood that this is not the same as a true lifetime earnings profile as we discussed in the previous section. To exclusively focus on the wealth effect of the reform, we compute the DB pension wealth for the same representative public sector worker under the pre-2002 versus the reformed pension schemes. [35] The representative worker in a given occupation and sector has the same earnings and working hours, only differentiated by gender and region.

For the estimation of age-earnings profiles, we use all the ASHE data from 2005 to 2018. It is based on a 1 per cent sample of employees' jobs taken from PAYE records of HM Revenue & Customs—where the bonus pay of private sector employees is included. As educational information is missing in ASHE, we map the age specific education-occupation matrix developed by Dolton et al. (2014) into the data. We will follow Disney et al. (2009) and D&D 2012 and Danzer et al. (2016) in estimating these profiles net of sector-specific average earnings growth [36] and in real terms at 2017 gross values using median regressions. ASHE is a large-scale survey and is regarded as the most reliable source of earnings in the UK and it is available from 1997 to 2018. Earnings of public sector employees are taken as hourly pay data from the ASHE. We naturally reflate the earnings data using the ONS CPI index.

Crucial data for the computation of DB pension wealth are pension membership and scheme parameters across occupations. The ASHE data provides information on

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[35] Note, that we choose 2002 as pre-reform date because several small occupation specific reforms have taken place between 2002 and 2015.
[36] This annual growth ranges from minus 1.94%in the private sector in the crisis year 2008/09 to plus 4.84%in the private sector in 2000/01.

membership in a range of occupational pensions. With this information, it is possible to distinguish between public sector workers by age and gender and education under a DB scheme. Scheme parameters as of 2002 (pre-reform) and 2015 (post reform) are collected from publicly available reports (PPI, 2015 and official occupational public sector pension guides) and are reported in detail in Table A4. We assume there are differences in longevity of public sector workers. Life expectancies are gender specific cohort values and depend on occupation and social class [37].

We do not make any specific assumptions about job and pension scheme tenure, but assume that individuals remain a member of the old or reformed pension scheme throughout their entire active working life. For this reason, we ignore that the current reforms affect some workers discontinuously. In particular, we ignore those under tapered protection (which will remain under old pension scheme conditions for a period of time after April 2015 and then move to the new reformed schemes on a transition date) and transition members (all existing members of the old schemes that will move to the new reformed schemes on 1 April 2015). In addition, recent employees (employed from 2002 to 2008 depending on the pension scheme) tend to be in different schemes to those with longer service. For most this remains a final salary scheme, but with changes in accrual rates and later retirement ages. For the sake of simplicity in this report, we also ignore minor changes in pension scheme conditions between 2002 and 2008.

Due to the complexities of the UK pension system, we need to continue to make some further simplifying assumptions, over those outlined in section 3 above, in order to perform our calculations of work related pensions. DB pension holders are assumed to draw their pensions at the NPA as in Table A4. Survivor's benefits are only valued for males, as women live statistically longer than men do. For this analysis, we are assuming constant discount rates across public sector occupations and ignoring differences in the other risk components.

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[37] We use ONS gender-specific life expectancies upon reaching age 65 for analytic classes and occupations for period 2002-2006.
https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCIQFjA
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method%2Fclassifications%2Fcurrent-standard-classifications%2Fsoc2010%2Fns-sec-2010-derivation-
tables.xls&ei=RIC_VYy3AubgyQOfiKioDg&usg=AFQjCNFfSyCayvTmsLKAvSPU_psSVkDacQ&bvm=bv.9926
1572,d.bGQ

For consistency reasons, we use employer-reported working hours in our analysis. [38] As a general observation, the number of working hours is significantly higher in the private sector. While men work on average 38 to 39 hours, their public sector counterparts work on average 35.5 to 37 hours per week, with some substantial variation over the life cycle. The overall pattern of working hours profiles of women in full time work is very similar, with on average one hour less of work. However, in this analysis we consider all workers as our focus is on the differences between: occupations, men and women, and different regions for the population actually in work. Our issue is the effect of the change from FS to CARE schemes for those sub-populations in work. [39] [40] Employee-reported working hours (available from the LFS) are substantially larger, especially for public sector employees, who report working, on average, three (women) to four (men) hours more than reported by their employers (see Figure A5 in Danzer et al., 2016). The overall lifetime working time pattern with a reduction in working hours at older ages for public sector employees is similar in the LFS and ASHE data. Therefore, the presented TR calculations are not sensitive to the use of the measure of working hours.

The ASHE data provides information on occupational pension membership as well as pension contribution rates paid on behalf of the employer and the employee (contribution rates are available for the years 2005-2015 but were not available to us at the individual micro level data from ONS SRS for 2016-18). The previous literature has often assumed sector-specific constant rates for pension contributions. We account for a substantial difference in pension contribution across sectors and across the life cycle by using employer-provided information on employer and employee contributions to different pension schemes in both sectors. Employers normally pay National Insurance Contributions (NIC) on behalf of their employees. In exchange for these NIC, pension entitlements to the state pension are generated. If an employee chooses to join an occupational pension scheme (independently of whether this is a DB or DC scheme), NIC can be reduced (by contracting-out). In a way, NIC are traded for contributions to the

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[38] A further amendment in the future might be to include unpaid overtime work as part of the cost of working.

[39] The full-time information is reported by the employer and the hours reported in the ASHE data range between 25 and 99. Observations with working hours above 100 were removed from the sample rather than imputed. This procedure led to an exclusion of 0.01%of observations.

[40] In previous analysis (D&D 2012) we considered only full-time employees as the focus was on public/private sector differences for the representative full-time worker – rather than those actually in the labour force.

occupational pension scheme. While employer contributions for most occupational pension schemes are commonly around 14% and employee contributions at 6% in the public sector, contributions vary substantially in the private sector. Private sector employer contributions are very low at young ages (around 5%) and rise up to 14%. Employees used to contribute on average 4 to 6% of their pensionable pay. These contribution rates have now changed considerably and it is timely that we examine these recent changes and their impact on the value of pensions.

We do not make any explicit assumptions about job and pension scheme tenure, but assume that individuals remain a member of their current scheme throughout their entire active working life. Rather than taking tenure membership from the data (in a continuously changing pension system), we prefer to allow for career breaks by adjusting age-earnings profiles by the probability of unemployment. [41] Unemployment risk is derived from the five-quarterly longitudinal LFS files, and is defined as the risk of switching from employment to unemployment status (ILO definition) between the first and any of the following four quarters. Differences in unemployment risk are important in the valuation of TR as spells of unemployment provide no work remuneration and produce gaps in the contribution histories to pension schemes. This said, it is important to note that unemployment affects different pension schemes differently. For instance, an unemployment spell reduces a DC pension through lower overall annual contributions, while it lowers a DB pension through numbers of years accrued in the scheme. In our analysis, we account for these complexities by treating all pension schemes separately. Conventional wisdom and some research (Cappellari, 2002) suggests that job security in the private sector is more precarious than in the public sector. This notion has also received support from recent research using LFS longitudinal data that confirms this result. Unemployment risk in the private sector is substantially higher than in the public sector. Also, while the risk of becoming unemployed within the year is—with the exception of those in their early twenties—low and stable in the public sector (around 1%), it is substantial for those between 25-40 (6 to 7%) and from 45 years onwards (up to 3-4%) in the private sector.

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[41] As Disney and Whitehouse (1996) have shown, expected scheme tenure is one of the most important determinants for valuing total accruals.

Regarding benefits in kind we evaluate employer provided health insurance by the fraction of employees within different occupations and sectors who report holding an employer provided private health insurance. The ELSA survey collects information on full private health insurance cover, e.g. BUPA (not additional dental or friendly health plans), for those aged 50 and above. Since the sample sizes are small we first map occupation specific sector affiliations from ASHE into ELSA and then pool all observations irrespective of age and gender (and ignoring educational levels). In the private sector 27% workers have private health insurance cover, whereas only 12% of public sector employees do. Of those who have private health insurance cover in their own name, 2.3% in the public sector say it is paid for by the employer, while 4.7% of private sector workers receive a private health insurance from their employer. It seems that the plans for private workers are more generous. [42] Information on paid holidays is retrieved from the quarterly LFS (2005-2018). In addition to a fixed number of public holidays, employers offer a varying number of paid holidays. There are substantial differences between public and private sector employees: While the former enjoy 30 to 35 paid holidays, the latter are limited to 20 to 27 holidays. The entitlement of paid holidays increases with age in both sectors. Paid holidays are valued at the daily wage rate.

6.   The Key Research Questions and the Steps in the Analysis

In summary this project:
1. Examines the value of real salary changes and pension changes across occupations in the public sector covered by the PRBs.
2. Computes the value of TR in each occupation to compare where possible (and with the guidance of the OME) with private sector counterparts. We also provide an understanding of how TR varies across occupations.
3. Explores how, within each occupation, where possible, TR varies across the subgroups defined by an employee's gender, and region. [43]

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[42] With an average value of £222.90 as of 2018 than for public workers £141.70 as of 2018.
[43] At the proposal stage of this project it was envisaged that a separate analysis by education level may be possible. But the number of observations with sub degree level qualifications in the major graduate level public sector occupations is so small as to preclude analysis. Likewise the number of graduates in the

4. Compares how the old FS scheme is valued against the new CARE scheme for each occupation.

The methodological analysis involved the following steps:

Step 1: Clarify Pension Changes. Clarifying all of the pension changes that have taken place in our PRB occupations since 2014 and the Danzer et al. paper (2016) and summarised in Table A4. Specifically, this meant checking and where necessary updating the: accrual rate, evaluation method of members benefits, lump sum, widow's pension and early retirement details for each remit group. It also involved revising the changes to typical private sector counterpart pension schemes.

Step 2: Methodology. Setting out the Methodology for the analysis and carefully revising it in the light of detailed comments from the OME and PRB Economist members. This included surveying the methods and data to be used, and its limitations, complexities and caveats.

Step 3: Access to Data. Getting access to all the LFS, ASHE and other data set updates to conduct our Secure Research Service (SRS) programming work. This involved the re-writing of all the programs and frequent trips to the ONS SRS facility. At this stage the guidance from the OME on the SOC and SIC codes to be used for each OME remit group and its logical counterparts was sought. We also consulted with the OME regarding viable cell sizes and specifically the possibility of studying certain groups by gender or age, or region, or education level where the cell size is small. All of these details we agreed with the OME as the data work proceeded. A full Appendix guide to the limitations of sample sizes and what comparisons were possible is set out in Appendix A.

Step 4. Calculating reward measures at different levels. TR estimates for public sector employees in each occupation and subgroup of interest was obtained using detailed, up-to-date statistics drawn from four data sources, namely the ASHE, the LFS, the ELSA and

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Police, Fire Service and Prisons is also insufficient to treat them as a separate group for analysis. We therefore were forced to consider Nurses, Doctors, Teachers as graduate jobs and Firefighters, Police and Prison Officers as non-graduate jobs.

the BHPS. These datasets were exploited in terms of their capacity to reveal the determinants of TR. These datasets provided age-earnings profiles, employer and employee pension contributions, employees' hours worked and risk of unemployment.

Using the approach outlined above, produced estimates of TR for public sector employees in each occupation among those included in the PRBs. Where adequate comparators exist, we produced similar calculations also for comparable private sector employees in similar occupations. Within each occupation, and sample sizes permitting, measures of TR (and its components) were obtained for each occupation by gender, and geographical region (residents of Greater London and the South East or other UK regions). These calculations were subject to data cell size limitations imposed by the size of ASHE data.

As several of the occupations in question are characterised by a disproportionately large percentage of graduates, it did not prove possible to implement a subgroup analysis by contrasting graduates with non-graduates. Therefore, our comparisons by occupations which are in large part non-graduate jobs are confined to examining the Police, Firefighters and Prison Officers. Our regional analysis only proved possible by London and the South East and Other Areas combined for some of our occupations.

Step 5. Use the computed measures to explore reward variation within and between occupations. The next step entailed exploring, separately for each sector, how ALTR differs across occupations and within the relevant subgroups. The statistical analysis, in the main is descriptive and relies on simple tabulations and visual tools (e.g., describing how TR and its components vary with an employee's age). However, some basic constructs were obtained by means of inferential statistics tools (e.g., semiparametric median quantile regressions are used to retrieve age-earning profiles; estimation of working hours was implemented by means of OLS regressions; and unemployment risk was estimated using non-parametric kernel methods).

Step 6. Analysis. The initial part of the project was devoted to updating our existing dataset (the 'TR dataset' henceforth), which is comprised of all merged information from ASHE, LFS, ELSA, and the BHPS.

The analysis examined post-2012 pension reforms. These include the alignment of the NPA in several public sector occupational pensions schemes with the State Pension Age (SPA), a general increase in the contribution of pension scheme members, and the introduction of the CARE scheme, which stipulates that the pension benefits are no longer based on the individuals' final salary as in the previous scheme.

The Building Blocks of the ALTR Calculations

There are many elements to the calculation of the ALTR as indicated by the formulae in equations (1) –(7) which may found in Appendix B. The substantive stages to the numerical calculations involve obtaining:

I.   The median age earnings profiles (in hourly earnings) of the average person in each occupation. This is presented in Figure 2. Here we see that Doctors' hourly pay is much higher over all their lifecycle than any other public sector occupations. Note that the hourly pay of Teachers is the next most generous.

II. The median working hours of a representative person in each occupation across their lifecycle. In our data we use the 'average total paid hours per week including overtime'. This is graphed in Figure 3. From this we see that in the ASHE data Firefighters work 42 a week throughout their lifecycle. Correspondingly Doctors/Dentists and Police work 40 hours, Prison Officers 39, and public sector Nurses 38. Private sector Nurses' and Teachers' hours seem to vary below this over their lifecycle. It is important to remember that the ASHE is employer reported hours and due to the important restrictions of the European Working Time Directive it could well be that these reported hours by employers do not reflect the actual hours worked by these employees very accurately. What we see from this is that on average women Teachers and Nurses work around 4-6 hours less over much of their lifecycle compared to their male counterparts. This is

probably due to a higher fraction of private sector teachers and nurses working in part time fractional jobs in more flexible conditions[44]. [45]

III. The average unemployment or redundancy probability [46] by occupation over the lifecycle by occupation. Our calculations on this variable come from the 5 quarter QLFS and are presented in Figure 4. Several occupations have a higher probability of unemployment at the beginning and end of the lifecycle.[47] Firefighters, public sector Teachers, Nurses and the Police all have probabilities which rise from the age of 50 onwards.[48] Doctors have a very low level of unemployment probability which falls monotonically from 2% at the beginning of their career to zero by age 60.

IV. The annual paid holiday in each occupation over the lifecycle. This is represented in Figure 5.   Here we see that public sector Teachers are recorded as having 60 days annual paid leave more or less over the whole of their career. Recall that in the ASHE data this is working hours as reported by the employing Local Education Authority and not, as it would be in the LFS, self-reported hours. It is possible that serving public sector Teachers would dispute this as they may claim that their actual holidays after preparation time outside school terms takes away some of this allocation. In contrast, private sector teachers in the ASHE data only have 20 to 25 days annual leave (20 rising to 25 at age 40). We believe this may indicate a clear difference in the work contracts of public and private sector teachers.

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[44] We know from aggregate data that many private sector teachers and nurses originally come from the public sector when they were younger and may now be choosing to work fewer hours in the private sector to fit around their family and other responsibilities.

[45] In Figure 2 the Prison Officers and the Police have the same number of weekly working hours - 39. We graph them as distinct to facilitate visual distinction.

[46] The definition of unemployment risk we use from the 5 Quarter LFS is that worker is employed in quarter 1, and "unemployed in Q2" OR "unemployed in Q3" OR "unemployed in Q4" OR "unemployed in Q5"

[47] We use the unemployment risk of the private sector as a whole to represent private sector teachers and private sector nurses. Very limited numbers of private sector teachers and nurses have been dismissed from employment in the data so we could not construct reliable data across ages for them.

[48] For police (and probably fire fighters too) this is most likely to be because of the retirement age, so what's being picked up is probably officers who have retired from the police and are looking for a new job (therefore unemployed rather than inactive), rather than officers who've been made redundant.

Most of the other occupations have between 25 and 30 days of annual paid leave a year. The occupation with the highest number of days annual leave is medicine with Doctors receiving 30 days from about the age of 35. The median number of days of paid leave a person is entitled to rise slightly in most occupations between the ages of 20 and 30 – but this is a typical feature of annual leave entitlement schemes.

V. The final element which facilitates the calculation of ALTR for each occupation before and after the pension reforms which took all public sector jobs from Final Salary DB schemes to CARE schemes is all the precise rules which govern the size of each pension in each job. These details are provided in Table A4 in the Appendix A.
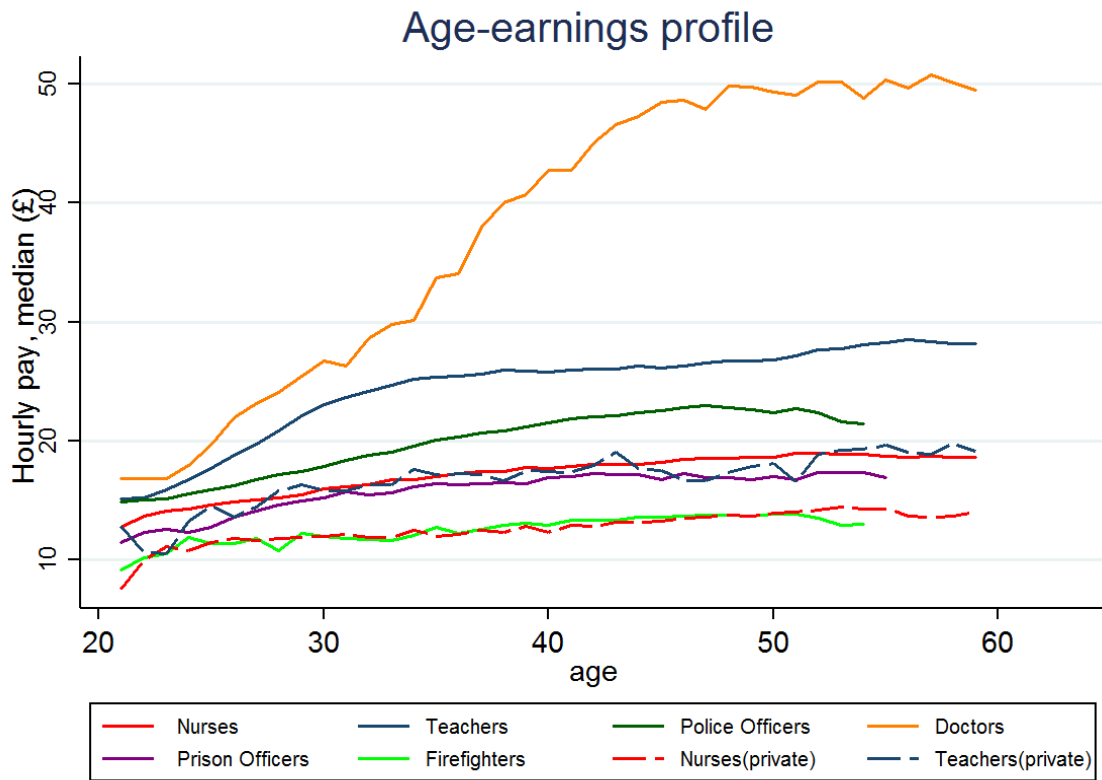
Figure 2: Age-earnings profile

Age-earnings profile

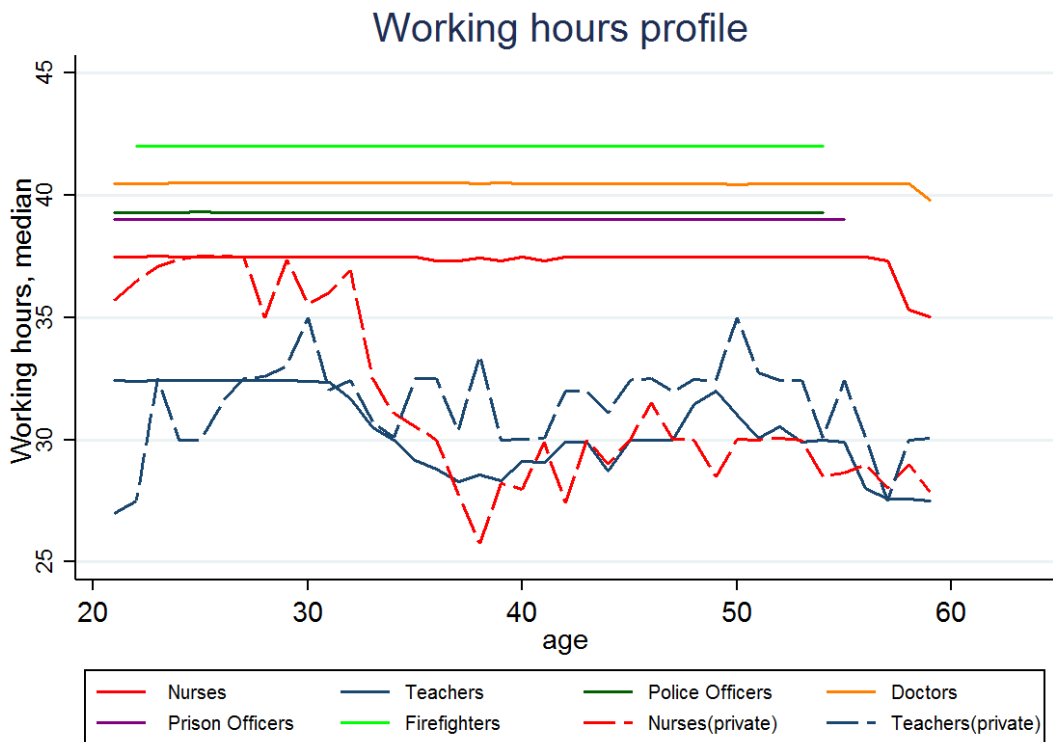**Figure 3: Working hours profile**

Working hours profile

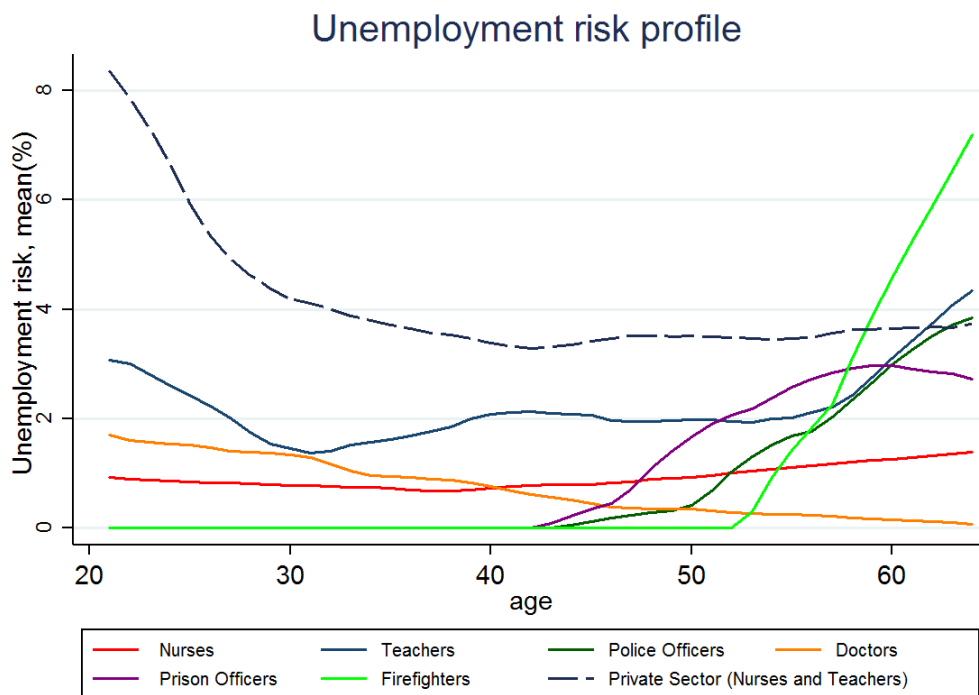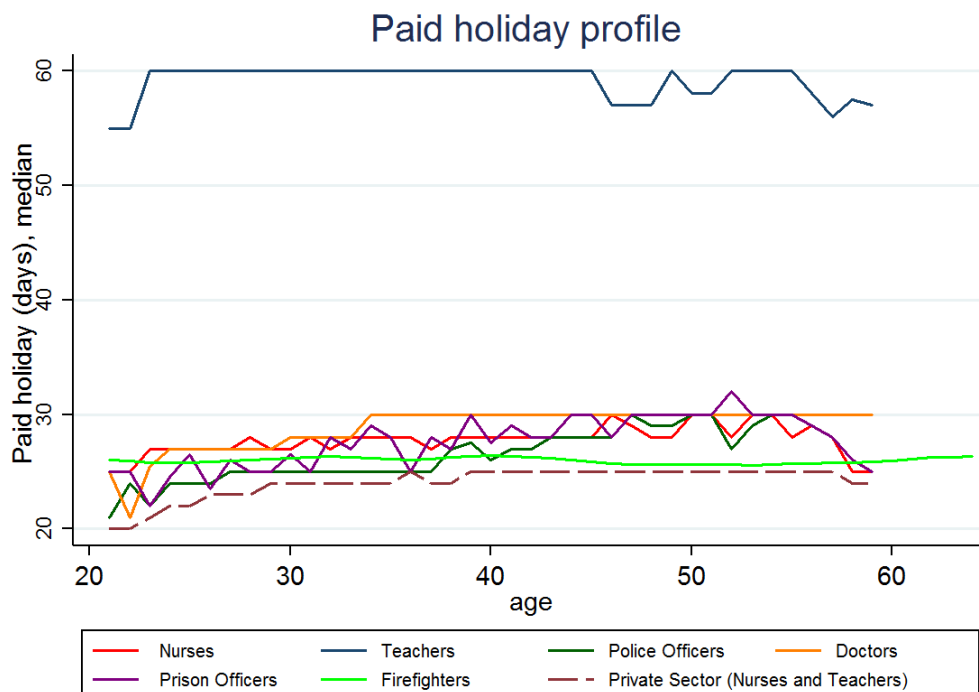**Figure 4: Unemployment risk profile**

Figure 5: Paid holiday profile

7. Results

The simulation results presented in the remainder of this report have been made possible by access to all the data we describe using the methodology we set out above. Much of the details of these computations – in terms of the constituent parts – were made available to the OME at an earlier stage of the analysis as appendices. But, specifically the summary form of the data on: hourly wages, annual holidays, weekly hours of work, and the probability of unemployment or being made redundant across the lifecycle by gender and region – the building blocks of our simulation were set out in the previous section. This gave a visual interpretation of the main patterns in the data and upon which the results are derived. But, it should also be appreciated that the rules of each occupational pension scheme are different and complex across different occupations. We set this out in Appendix A, Table A4.

7.1 The Stages of the Analysis

Our main analysis is done in five steps.

First, we compute ALTR assuming that in the 2015 schemes workers retire at NPA (for NHS staff, Teachers, Nurses, and Doctors at age 65 and for, Police, Prison and Fire Services at age 60). This facilitates a pre-reform FS with a post reform CARE comparison of pension conditions in each occupation. What we actually do is calculate the pension element of ALTR for Pre 2015 assuming they all retire at 60 except police and firefighters who retire at 55. (See Table A4.) We then keep the same retirement ages for each occupation for the CARE scheme in computing their pension element to ALTR. (This is despite the fact that people in this CARE scheme will now actually retire at the SPA).

We do this because we need to compute ALTR for the same 'representative individual' who works the same number of years in either of our two comparator pension schemes. In reality, of course the person who retires under the CARE scheme will have had the extra years of working wages but less years of retirement. Our framework does not allow us to make the comparison of the (person specific) utilities involved in this trade-off. So, we restrict our comparison to the 'representative worker' who has worked the same number of years in the FS or CARE scheme.

A further necessary simplification forced on us by sparsity of data on earnings at the older years of age is that the wage element of ALTR only accumulates when we have valid wage

data. We therefore assume they don't work when we have no valid hourly wage data. We therefore use the wage data up to age 60 for Doctors, Teachers, Nurses, and up to age 55 for Police, Firefighters and Prison Officers. (Note the ALTR is still accumulated because the value of their pension element to ALTR.) This is all that the data allow us to do, in terms of their earnings and pension contributions between their age at 50 and 60.

How might this procedure impact on our calculations? For the FS scheme our age restriction will mean that the ALTR is under-reported as the extra years of the FS will not be included at a slightly higher final salary. In contrast for the CARE scheme it will have less effect as it is the average wage which is used for CARE comparisons - but the accrual will still be under-accrued as the years not working will not count.

We suggest that our assumptions will not make much difference in the advantage of ALTR because we are assuming the same work and earning pattern of this 'representative workers' in both the FS and CARE schemes and years lost from FS and CARE will balance each other out.

In the second step of the analysis, we compute ALTR assuming that those in the 2015 schemes retire at the same age as those in the pre-2002 schemes (for NHS, Teachers, Civil Service, Police and Firefighters at age 55). We do this by simply taking the DB pension wealth in the 2015 CARE schemes computed in the first step and multiplying it by the discount factor for retirement 5 years before NPA as reported in Table A4. This allows us to make a more consistent comparison between the old and newly introduced pension schemes. Such a foreshortened pension calculation naturally has implications for the valuation of both FS and CARE schemes. This means that the move from FS to CARE could be even worse than our calculations suggest if the average worker works until 65, 67 or older.

The third step is to make comparisons within the same occupation across the public and private sectors. Specifically, we are able to compare public and private sector Nurses; public and private sector Teachers and make a selective comparisons between Firefighters, Police and Prison Officers. This comparison is a useful guide to how those pursuing the same occupation in different sectors fare.

The fourth step is to allow comparisons in the ALTR position between men and women doing the same job. It is relevant to ask how the ALTR reward of a male Teacher compares with a female Teacher for example.

The final part of the analysis is to make comparisons within the same occupation across two broad geographical areas. We examine the position in London and the South East and compare it with the rest of GB.

7.2. Comparison of FS Pre-Reform with CARE Post Reform Pensions

In Figures 6 and 7 below we graph the ALTR in the Pre-reform DB Final salary schemes and the Post-Reform CARE schemes for each occupation according to the method set out in the previous two sections of this report.

A most important fact to note is the important change in the Police and Firefighters pension conditions which changed a lot after the post 2015 reforms. Specifically, both groups were considerably affected by the removal of the double accrual rate after 20 years of service – as detailed in Table A4. This huge shift can be clearly seen graphically by comparing Figure 6 and Figure 7 for the ALTR in these two occupations after age 40. This marked shift has already been documented in the preceding analysis of Danzer et al. (2016). We will see again in the present report that these changes matter considerably for our simulations of the changes in ALTR in percentage terms and cash premiums in our before and after comparisons.

Figure 8 then graphs the difference in these two ALTR figures for each age over the lifecycle for each occupation expressed as a proportion. So, Figure 8 shows the proportionate changes in the relative value comparing value in CARE (post-reform) with FS (pre-reform) ALTR over the working life ***within*** each occupation scheme. (Formally, this is detailed in equation 10 in the Technical Appendix B). The figures focus on our final set of results (i.e. the second step of analysis). Here we take into account of the fact that a worker under the old pension scheme retires 5 years earlier than someone under the 2015 reformed systems. Police and Firefighters are certainly losing the most due to these reforms, with a decline of average accumulated pension wealth of around 35%. Next worst off in terms of relative changes are the Doctors who experience around 12% less ALTR under CARE than FS schemes at around the age of 45. Teachers and Nurses variously are up to 5-10% worse off under CARE schemes depending on the point in the life cycle which is considered.

Figure 9 performs the same relative calculation but does it in absolute money terms. It is immediately clear from both figures that Fire and Police Services are made substantially worse off under the new pension schemes across their whole career but markedly so after

the age of 40. For Nurses and Teachers, they are around 5-10% worse off under CARE than the old FS schemes for most of their working lives. Doctors are much worse off – to the tune of around 13% in mid career. This translates to Doctors being made up to £100k or more, worse off towards the end of their careers in ALTR terms.

Figure 6: ALTR (pre-reform)
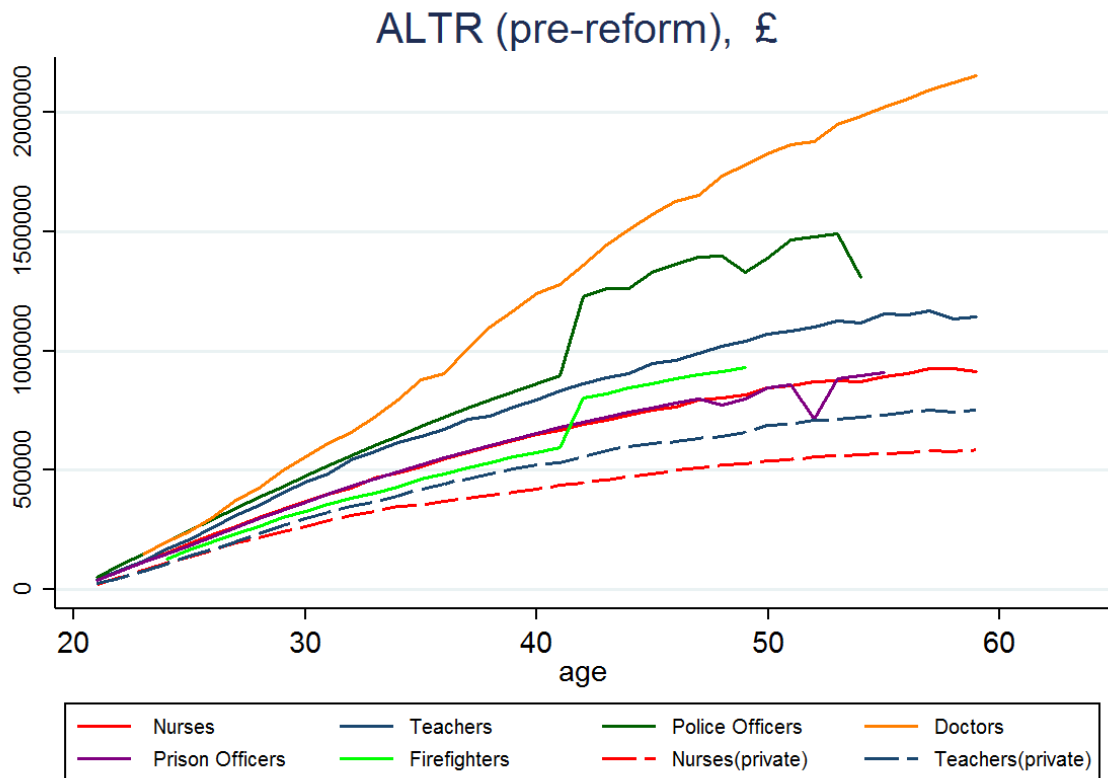
Figure 7: ALTR (post-reform)

ALTR (post-reform), £

Legend: Nurses, Teachers, Police Officers, Doctors, Prison Officers, Firefighters, Nurses(private), Teachers(private)
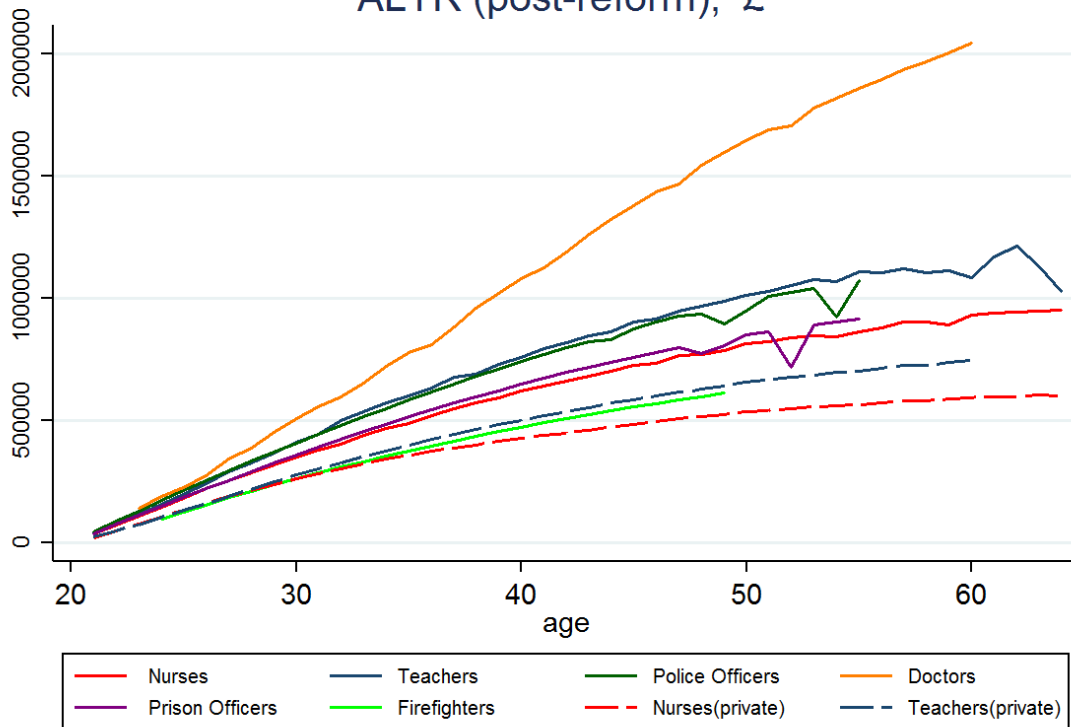
Figure 8: Advantage of ALTR

Advantage of ALTR (%)

Legend: Nurses, Teachers, Police Officers, Doctors, Prison Officers, Firefighters, Nurses(private), Teachers(private)

Figure 9: Premiums of ALTR

Figure 10: ALTR (dis-) advantage of 2015 schemes

Figure 10 graphs some of the same information as Table 1 in relative (dis) advantage percentage terms for each occupation by gender by region (wherever possible). So figure 10 graphically presents how much worse off in percentage terms our representative worker is under CARE than FS at their retirement date by occupation by gender by region. The eye is drawn in the figure to the Firefighters and the Police position where they have lost over 30% of the vlaue of their ALTR under the CARE scheme compared to the old FS scheme. Nest worse off are doctors who have lost around 10% of the corresponding relative value in the ir ALTR.

7.3.   Final DB Pension Wealth Analysis

Table 1 translates the proportionate changes in the relative value of occupational pension schemes into monetary values and evaluates them at the normal retirement age. So Table 1 sets out the premium of the FS scheme over the CARE schemes within an occupations at the normal retirement age. The purpose of making a special point about this cash evaluation is that this is the average age at which a person stops working and so, in some sense, the ALTR at that point represents the amount that the person will be worse off into their retirement.
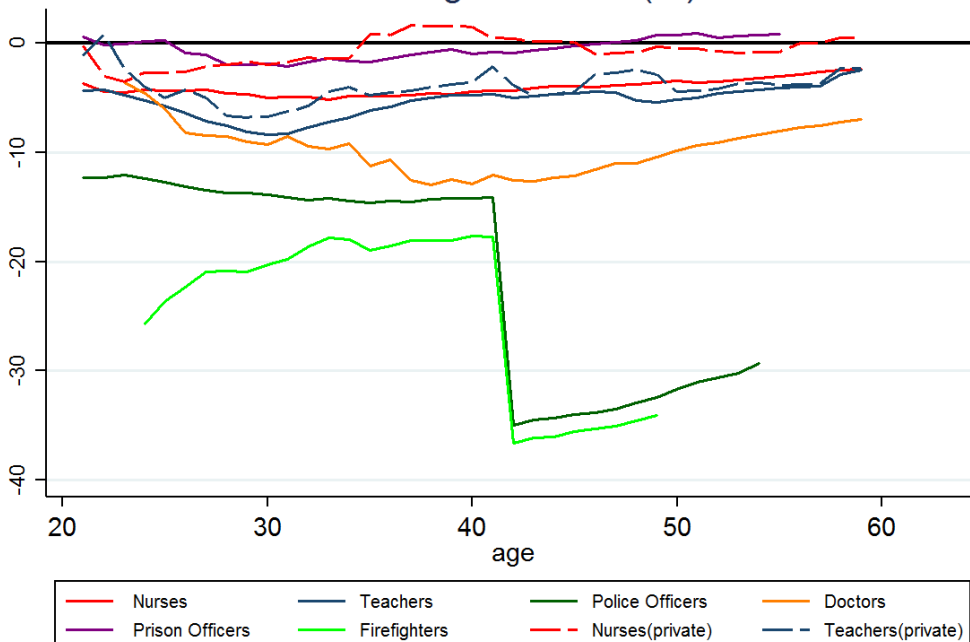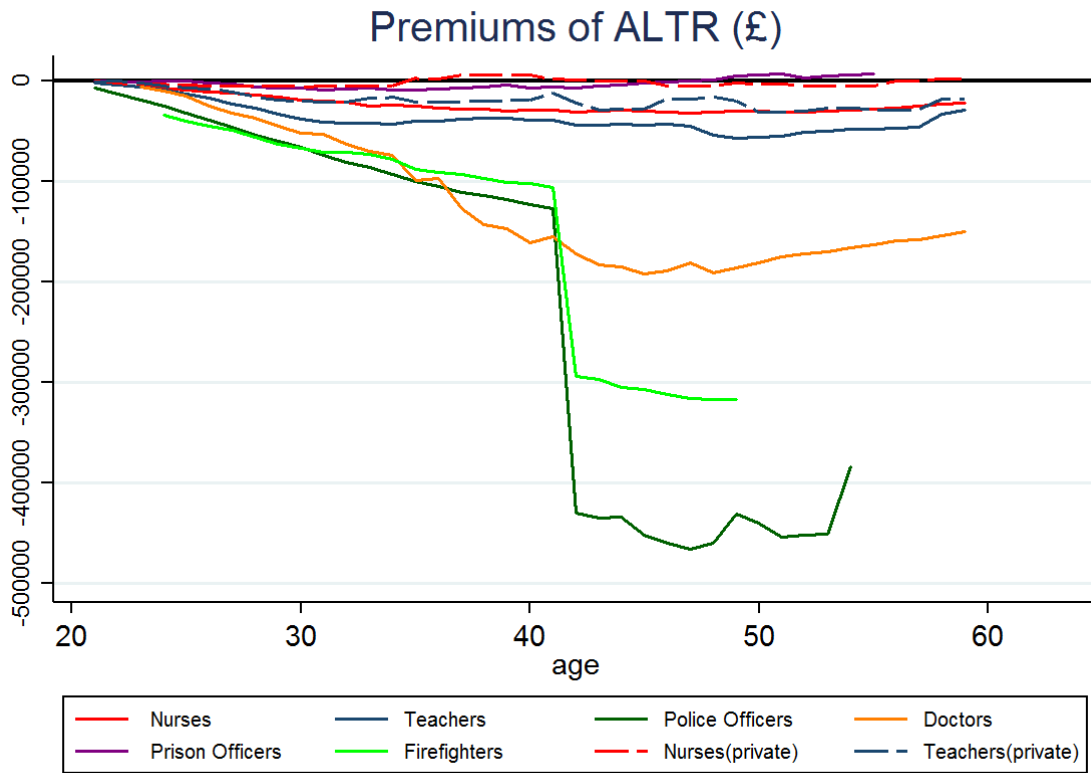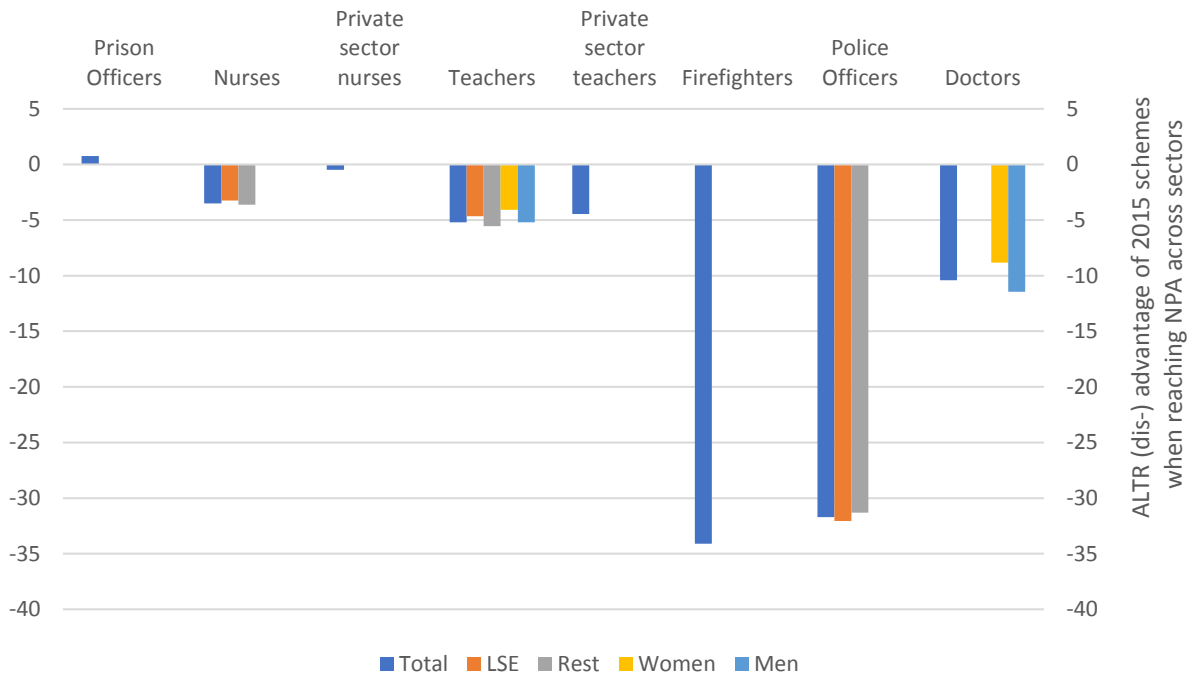
NHS Nurses are around £30k worse off, Doctors around £185k worse off, state school Teachers around £55k worse off, and Police and Firefighters around £440k and £315k worse off respectively. Prison Officers are the closest to being unaffected as they are £6k better off in ALTR terms.

Fire and Police Forces are the most penalized as we are *de facto* comparing the very generous pension schemes, respectively of 1992 and 1987 with the 2015 reformed one. These old schemes were offering a low NPA. They also had a unique feature: a two-tier accrual rate by which pension rights accrued at an annual rate of 1/60th for the first 20 years, following by rights accrued at 1/30th for each year thereafter, providing for a very rapid accrual of rights later in the career. It should also be pointed out that the assumption behind the old pensions' schemes for the Police and the Fire Service was they would typically retire from the job before the age of 55 and may or may not have a second career. In practice since many continued to work in alternate careers then the new CARE pension schemes attempted to reflect this. Hence, the default working assumption under

the new scheme, with individuals having longer working lives is that they will be most likely to have a second career.

Table 1: ALTR(dis-) advantage of 2015 scheme in £ at pension age

Occupation	Total	Regions		Gender	
		London/ SE	Rest	Women	Men
Nurses	-29,600	-28,900	-30,100	N/A	N/A
Teachers	-55,700	-51,200	-58,800	-41,500	-59,500
Police Officers	-439,900	-486,700	-417,400	N/A	N/A
Doctors	-185,200	N/A	N/A	-142,700	-212,500
Prison Officers	6,300	N/A	N/A	N/A	N/A
Firefighters	-316,600	N/A	N/A	N/A	N/A
Private sector nurses	-2,600	N/A	N/A	N/A	N/A
Private sector teachers	-30,600	N/A	N/A	N/A	N/A

Notes: N/A – not estimable due to insufficient sample size.
    Total figures are based on a larger age range sample than Region or Gender columns.
    Figures in £UK pounds at 2018 prices rounded to the nearest £100.

An important final point to make is that the figures presented in this report evaluate the change in pension wealth among various occupational groups after the current reforms. It is worth stressing that this does not necessarily imply that the *level* of pension wealth accumulated over the lifetime after the reform is lower for a Police officer or a Firefighter than for a Prison Officer, for example. In fact, the *change* in pension wealth due to the reform has affected Police and Fire Services most. In point of fact, comparing Figure 6 and 7 we see that the Police and Firefighters still have an ALTR which is more generous than Prison Officers and Nurses post 2015 (Figure 7) although they have fallen behind Teachers who they were ahead of in the pre-reform period (Figure 6).

7.4. Comparisons across Public and Private Sectors.

In a previous contribution D&D (2012) examined how graduate careers in the public and private sectors as a whole fared in terms of ALTR across the lifecycle. In this report we have performed the same calculation across different public sector jobs and compared the old pre-reform FS style pension scheme with the 2015 CARE pension scheme. Most

explicitly we are able to compare Teachers and Nurses in the public and private sectors. The logic of this comparison is quite persuasive as people who work in these occupations are able to (and frequently do) switch sectors. The jobs are the same but there may just be slightly different conditions of work in the two sectors.

What Figure 11 shows is that public sector Nurses are around 5% worse off after the CARE reforms. Private sector Nurses are better or worse off at different ages after these reforms. The difference is due to two reasons. Firstly, it is partly because around 20-30% of Nurses are in private sector pension schemes outside of the NHS scheme but around 60% of private Nurses are in the NHS scheme. [49] This NHS scheme was open to them from 2013. Looking at Figure 12, this relative disadvantage of the private sector Nurses between the two schemes are similar compared to public sector Nurses who could be only around £30,000 worse off. The second predominant reason is because of the difference in average working hours. Figure 3 clearly shows that private sector nurses work around 6-8 hours less per week after the age of 30 compared to a public sector NHS nurse. Figure 2 also shows that private sector nurses earn less pay per hour than NHS nurses.

Examination of Figure 11 also shows us the relative position of Teachers in both sectors. Public sector Teachers are around 5% worse off in ALTR under the CARE scheme but this is very similar to the position of private sector Teachers.[50]

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[49] 61% of private Nurses are in the NHS pension schemes, 12% are in DC, and 26.5% are in other schemes. Private Nurses make up 20% of all Nurses, and public Nurses account for 80% of the profession. We assume that a private Nurse faces the same pension parameters as an NHS public sector Nurse who is in the same NHS pension scheme.

[50] Private teachers only make up 6% of all teachers, and public teachers account for 94% of the profession. We assume that a private teacher faces the same pension parameters as a public sector teacher.
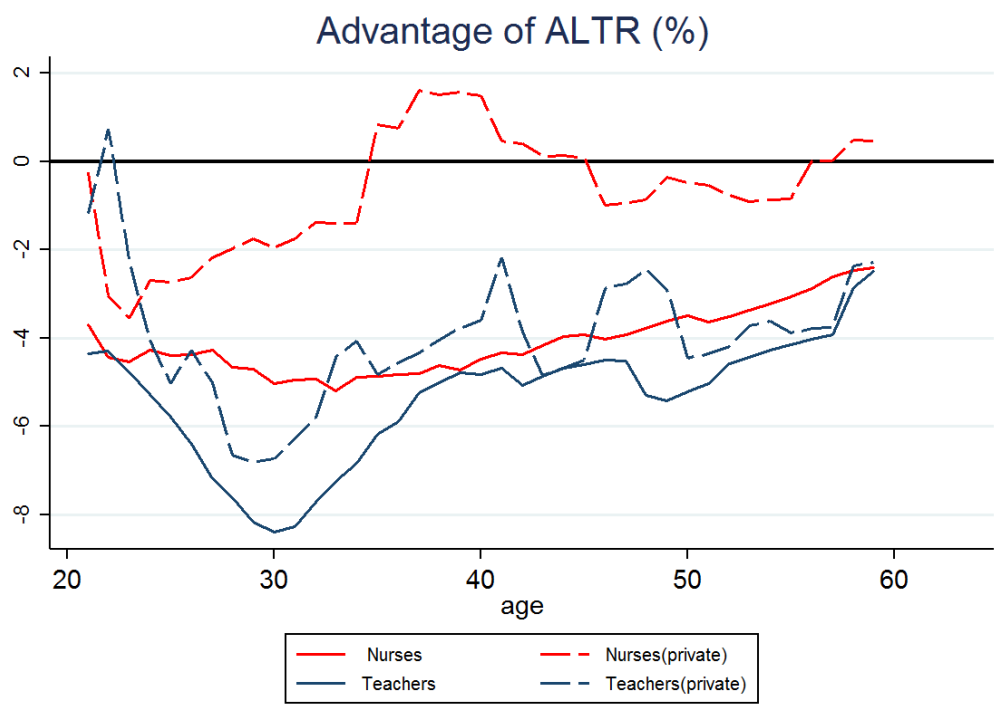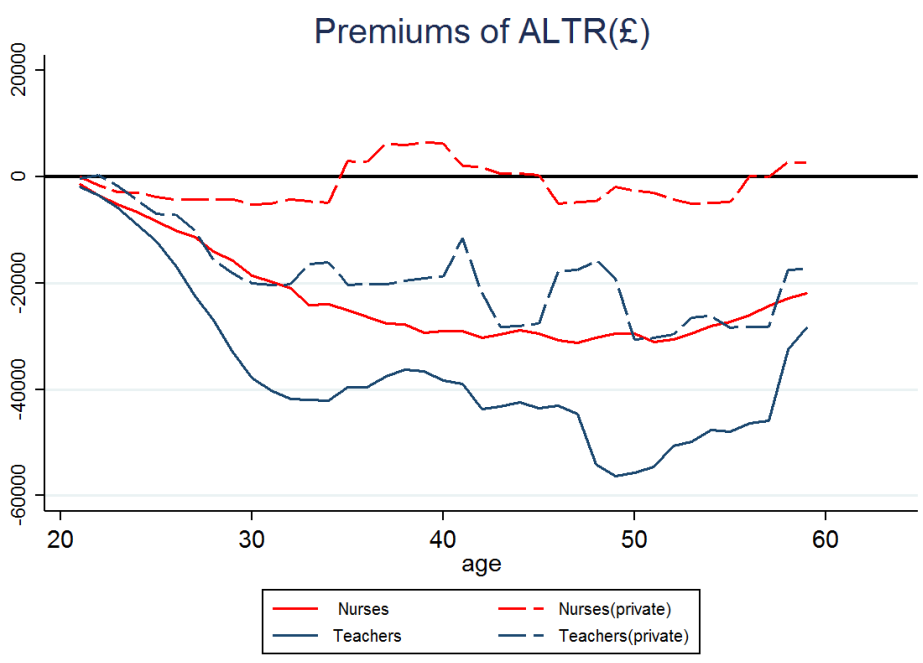
Figure 11: Advantage of ALTR, Nurses and Teachers

Advantage of ALTR (%)

Figure 12: Premiums of ALTR, Nurses and Teachers

Premiums of ALTR(£)

7.5. Comparisons by Gender within Occupations

Another margin policy makers are interested in is the extent to which these same public sector occupations treat men and women differently in terms of TR. Due to sample size data limitations, we can only compare the ALTR premium by occupation and by gender in two occupations, namely: Teachers, and Doctors. This is because there are not enough male Nurses or female Police, Firefighters or Prison Officers in the ASHE to make meaningful comparisons. The ALTR position of male and female Teachers and Doctors is graphed in Figure 13. From this figure it is clear that both female Doctors and female Teachers do not fare as badly as their male counterparts as a result of the 2015 pension reforms moving from Final Salary to the CARE schemes.

We find that male Teachers and Doctors were more adversely affected than their female counterparts, at least in part, due to their longer working hours and higher earnings. Remember that a CARE scheme will always end up being less advantageous for those earnings at the extreme end of the earnings distribution. We also found that male Teachers have lost around 5% of ALTR since the reforms and women Teachers close to half that figure (see Figure 16). This translates approximately to around £59k loss for men and a £41k loss for women. Specifically, male Doctors are 10-12% worse off under the post-2015 CARE scheme than they were under the pre-reform FS scheme. This translates into around £212k in ALTR terms compared to women who are around 8% worse off or £143k in ALTR terms.

It is important to stress that these gender comparisons of pension schemes are, at least in part due to a combination of hours and pay differences across the lifecycle for men and women. (Of course, if men gain promotion faster to a higher grade on better pay this will also be a factor.) What we know from our data though is that women work fewer hours than their male counterparts and earn less. This means that as pension conditions worsen men are affected proportionately more than women.

Figure 13: Premium of ALTR, Male and Female Teachers
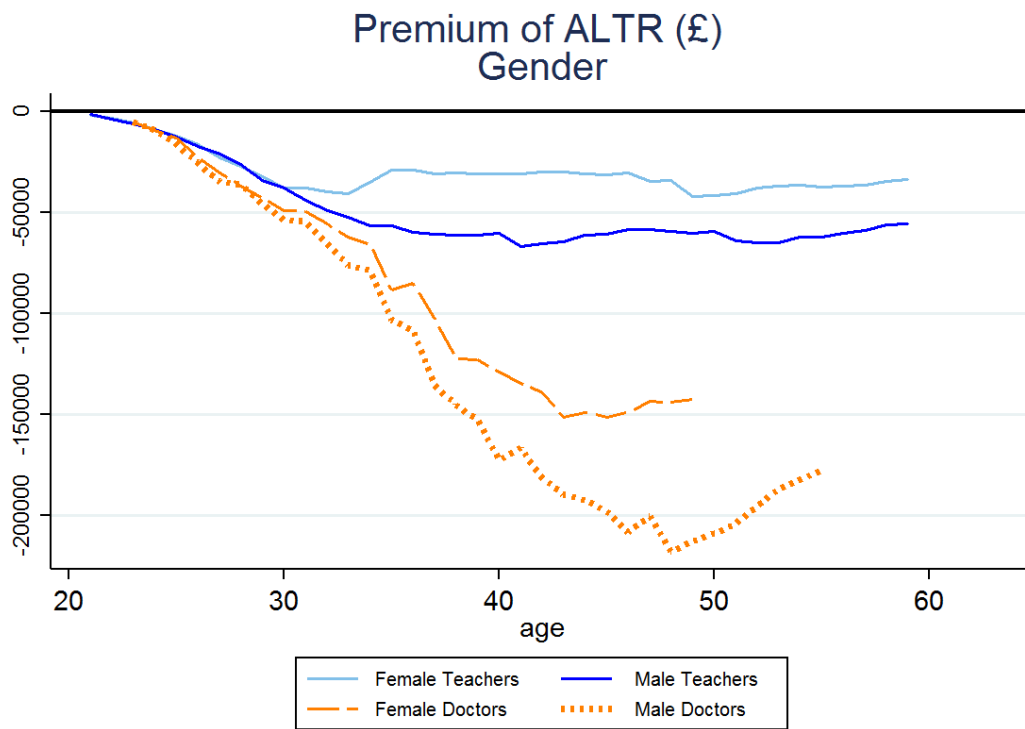
Figure 14: Advantage of ALTR, Doctors
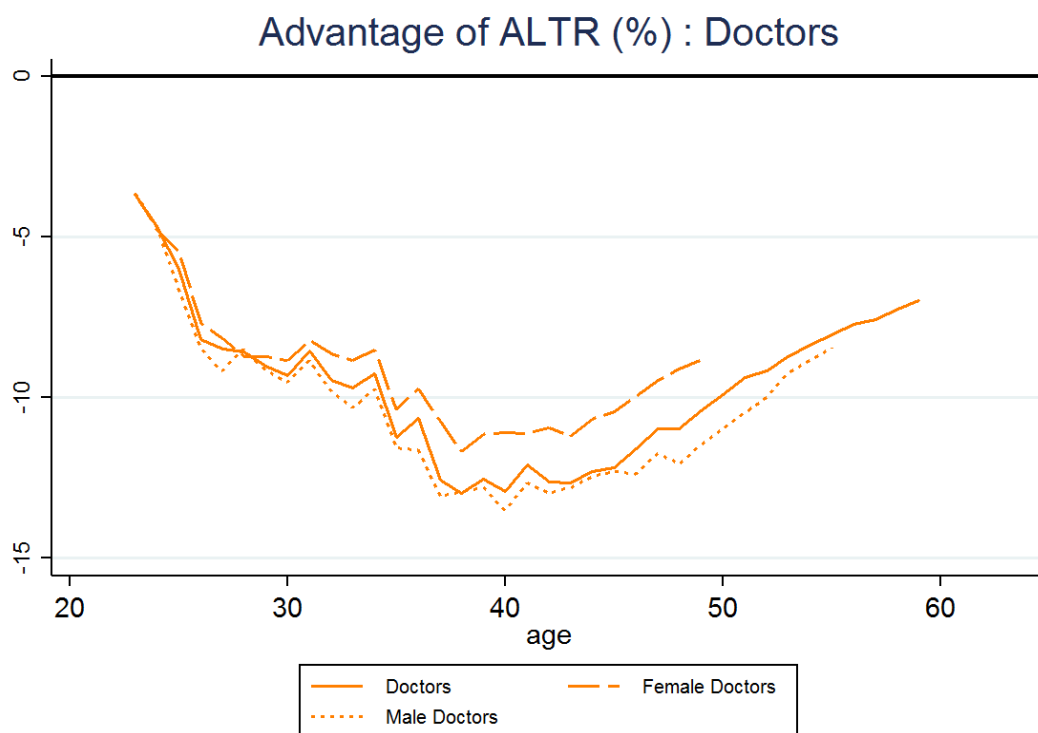
7.6. Comparisons by Region within Occupations.

A final area of some policy relevance is how people in the same job fare in different parts of the country. We have big enough sample sizes in ASHE to be able to examine regional differences by occupation for Nurses, Teachers and the Police.

In Figure 15 we can see that in terms of ALTR there is very little difference within each of these occupations between London and the South East and the rest of the UK. In Figure 16 we focus in on the relative ALTR of teachers by gender and geography. Note that the scale of the vertical axis in Figure 16 is quite different from Figure 15 but this allows us to compare the effects of gender and geography in more detail. From this figure there is evidence of some ALTR premium for female Teachers in London and the South East over their counterparts in the rest of the country when comparing the movement from FS to CARE schemes. Male teachers are relatively worse off under CARE than FS in terms of how these changes affect their relative ALTR.

In our regional comparisons, we found that Teachers in the rest of the country have fared slightly worse than those inside London and the South East. In the case of Nurses by the time they retire there is no substantial regional effect.

Figure 15: Advantage of ALTR, Region
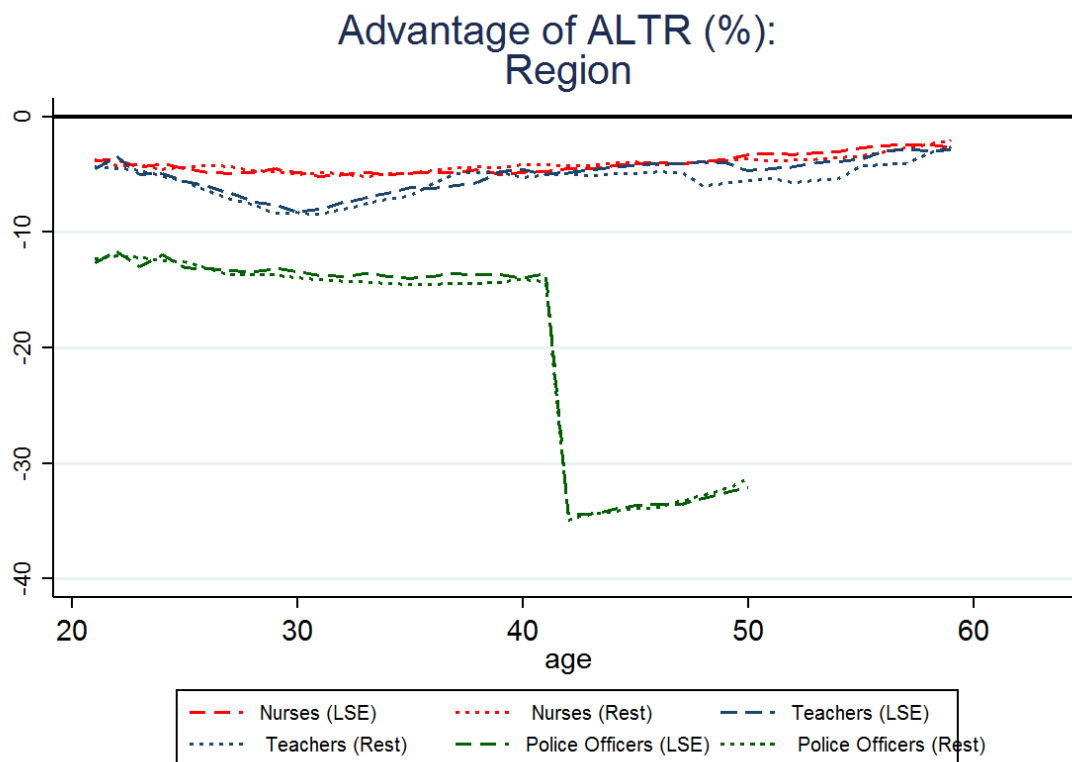
Figure 16: Advantage of ALTR, Teachers

Advantage of ALTR (%): Teachers

Legend: Teachers — Teachers (LSE) — Teachers (Rest) — Female Teachers (LSE — Female Teachers (Rest) — Female Teachers — Male Teachers
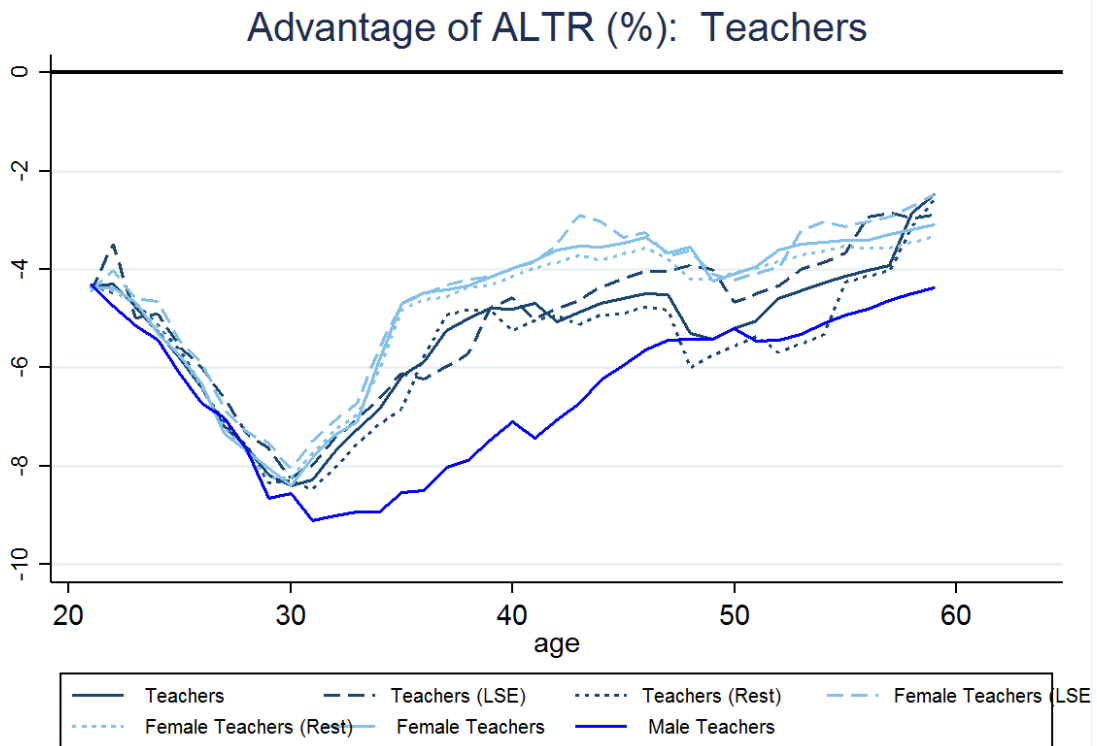
Figure 17: Advantage of ALTR, Nurses by Region

Advantage of ALTR (%) : Nurses

Legend: Nurses — Nurses (LSE) — Nurses (Rest) — Female Nurses (LSE) — Female Nurse (Rest)
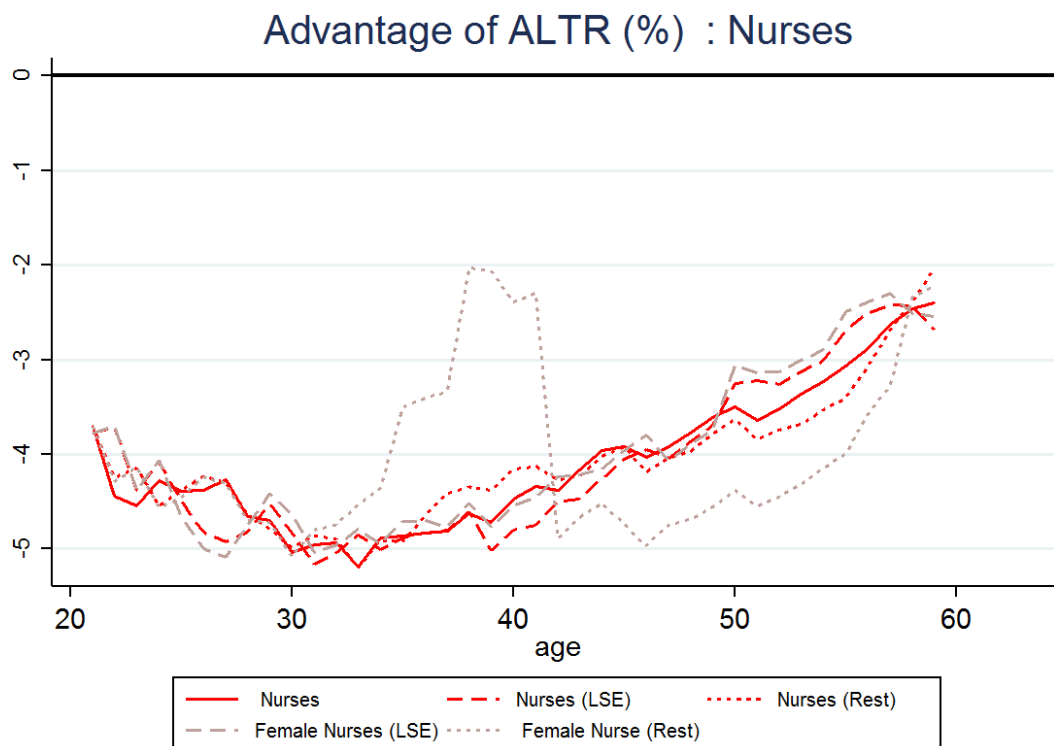
Study of Figures 17 and 18 shows us the relative position of female nurses compared to all nurses in geographical areas. Figure 17 makes this comparison in terms of percentage ALTR disadvantage and Figure 18 shows the premium cash calculations. The figures show that there is not much difference by geographical location although female nurses in the Rest of the UK fair slightly better in their late 30s and early 40s. It is likely that this is due to differences in hours of work.

Figure 14: Premiums of ALTR, Nurses

Premiums of ALTR (£) : Nurses
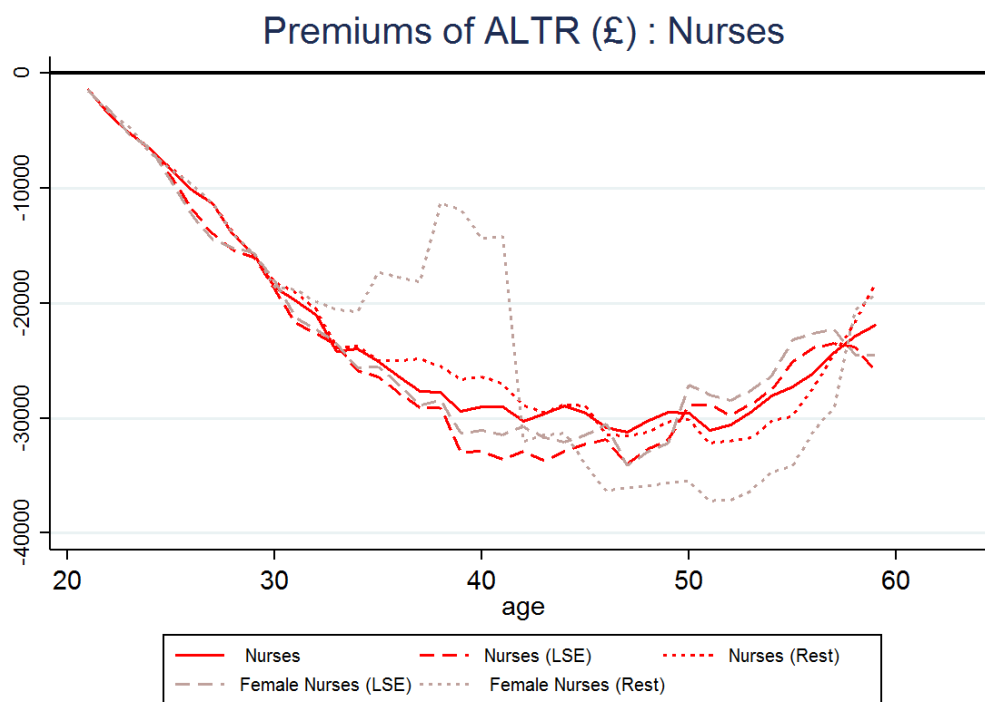
7.7 Regression Modelling of Conditional ALTR Advantage over the Lifetime.

So far in our analysis we have either graphically summarised the ALTR Premium or percentage advantage in money terms (in 2018 prices) over the lifecycle for each occupation and interest group (where the data permit) or we have evaluated the end point – at retirement – in cash terms. It is also relevant to ask what the average advantage or disadvantage is over the whole life cycle controlling for age (and non-linear age effects). This we can do with a simple regression analysis using our aggregate data. This also affords us the opportunity to examine these percentage advantage effects of different occupations relative to different reference groups and to make an explicit overall average comparison of sector, gender and region effects.

To this end we ran several OLS regressions to explain the advantage of ALTR using our age cell data set. That is, we have a unit of observation which is by each year of age by occupation and in some cases by gender and region. An age squared term is included to capture the non-linear effect on the advantage of ALTR. Typically, the ALTR is negative but non-linear and so this structure means that the extent of ALTR disadvantage becomes less negative as age advances after the middle years. Accordingly, we would expect the ALTR regression to be linearly negative in age and positive in age squared. The private and public sector's ALTR are included in some regressions in order to capture how advantageous the specific occupations are comparing with the sector. It is possible to include various alternative interaction terms in our regression – but care needs to be exercised in attributing and interpreting such coefficients. Hence, we presently do the analysis at the most simple level without interaction terms. To standardize our comparisons with the whole public sector or the whole private sector, we need to make some further assumptions. We assume and apply an accrual rate of 1/80 in a FS scheme for the public sector and 1/60 in a DC scheme for the private sector (D&D, 2012). For the CARE scheme, we use the accrual rate of 1/49 for the public sector, the same as occupation "Local government" in Danzer et al. (2016). These assumptions are made to facilitate a comparison of individual occupations with the sectors as a whole.

Table 2 provides the estimations presenting the occupation effect and public sector effect on the advantage of ALTR. Column 1 uses the sample from Nurses, Teachers, Doctors, Police Officers, Prison Officers, Firefighters with private sector (excluding teachers) as reference group. Nurses and Teachers have no significant advantage compared with the private sector. Police Officers, Firefighters, and Doctors have a significant ALTR disadvantage (16.5%, 19.9%, and 5.13% respectively), while the Prison Officers have 3.85% ALTR advantage.

Column 2 to Column 4 in Table 2 illustrate the sector effect in the ALTR advantage. We use public and private Nurses and Teachers with the public sector as reference to investigate the sector effect in the ALTR advantage. When the occupations are controlled for in the estimation (Column 2), the public Nurses (-5.78%) have a bigger disadvantage than the private Nurses (-2.4%). If we use a dummy variable to capture the sector effect (Column 3), the result suggests that the general whole public sector (not including teachers and nurses) has an insignificant advantage ALTR compared to the whole private sector. When we consider both occupation effect and sector effect together (Column 4),

we find that the whole public sector effect has risen to a 5.% ALTR advantage. Notice that column 2 is simply a reframing of the reference group compared to column 4 to allow us to identify separate effects. [51]

Table 2: Advantage ALTR % with occupation and sector effects

	Aggregate	2 - Public Only	3- Public Only
Age	-0.008***	-0.001	-0.001*
	(0.002)	(0.001)	(0.001)
Agesq/1000	0.095***	0.022**	0.022**
	(0.020)	(0.008)	(0.008)
Nurses	0.002	-0.058***	-0.058***
	(0.005)	(0.001)	(0.001)
Teachers	-0.010*	-0.071***	-0.071***
	(0.005)	(0.002)	(0.002)
Police Officers	-0.165***		
	(0.015)		
Doctors	-0.051***		
	(0.005)		
Prison Officers	0.039***		
	(0.005)		
Firefighters	-0.199***		
	(0.015)		
Private Nurses		-0.024***	0.033***
		(0.002)	(0.004)
Private Teachers		-0.057***	Omitted
		(0.002)	
Public			0.057***
			(0.002)
Constant	0.123***	0.030**	-0.026**
	(0.033)	(0.014)	(0.015)
Reference Group	Private (excl.Teachers)	Public Sector (excl.Teachers)	Public Sector (excl.Teachers)
Observations	249	195	195
R^2	0.787	0.876	0.876

Table 3 provides the estimations of gender and regional effects. Column 1 and 2 are for gender effects, and Column 3 and 4 are for the regional effects. We use the gender samples of Teachers and Doctors with the public sector as reference group in Column 1. We also provide the estimation excluding the public sector in order to get comprehensive results

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[51] Reference group is a group to which another group is compared. The function of reference group is to illustrate how the ALTR of a different group, compares with reference group. In Table 1, column 1 presents the effect of each public occupation, compared private sector, on the advantage ALTR. We reframe the reference with public sector in column 2 and 4 to show how the ALTR of the teacher and nurse occupations are affected.

and robustness. The estimation suggests that women have 1.6% significant ALTR advantage than men, regardless of whether we include the broad sector sample or not. The regional data of Nurses, Teachers, and Police Officers are applied to look into the regional effect. This study includes the public sector sample in Column 3 of Table 3 and further provides the estimation without the public sector in Column 4 for the robustness check. The results suggest that people in London and the South East do not have a significant ALTR advantage compared to the rest of the country.

Table 3: Advantage ALTR with gender and regional effects

	Gender/Public	Gender	Region/Public	Region
Age	-0.006***	-0.009***	-0.008***	-0.010***
	(0.001)	(0.001)	(0.001)	(0.002)
Agesq/1000	0.076***	0.110***	0.088***	0.106***
	(0.010)	(0.014)	(0.015)	(0.020)
Nurses			-0.057***	0.155***
			(0.002)	(0.011)
Teachers	-0.070***	0.036***	-0.070***	0.142***
	(0.002)	(0.003)	(0.003)	(0.012)
Police Officers			-0.211***	
			(0.011)	
Doctors	-0.108***			
	(0.003)			
London & S.East			0.001	0.003
			(0.005)	(0.006)
Women	0.016***	0.016***		
	(0.002)	(0.003)		
Constant	0.109***	0.052**	0.169***	-0.005
	(0.016)	(0.025)	(0.027)	(0.031)
Reference Group	Public Sector (excl.Teachers)	Doctors	Public Sector (excl.Teachers)	Police Officers
Observations	216	138	294	216
R^2	0.926	0.738	0.770	0.684

8. General Conclusions.

The findings of this report are diverse and based on a detailed econometric simulation framework which has been appropriately caveated. In addition, the simulations we presented are potentially sensitive to the time period of the data we use. It is also the case that the data used in this analysis from a variety of sources required a considerable investment.

Notwithstanding these circumstances and the importance of a general health warning there are some clear conclusions which come directly from this research.

1. Comparisons of remuneration should be based on the principles of Total Reward which adequately take account of the value of pensions, and different working conditions relating to working hours, holidays and the probability of unemployment.

2. Total Reward principles and methods should be used to compare workers' jobs both within and between occupations. Within occupation pension conditions should be compared – for example between grades, ranks or ages of workers based on TR principles.

3. Total Reward principles and methods can be used to compare jobs across sectors - both for jobs that are directly comparable – like NHS nurses and private nurses and state school teachers and private school teachers and within and between occupations.

4. The overall general results (from the regression analysis) point to the fact that public sector workers as a whole, in terms of their ALTR, are now worse off relative to private sector as a consequence of the introduction of the CARE reforms by around 3.5%. This figure should be a cause for concern at a time when real (inflation adjusted) relative salaries of public servants have fallen systematically over the last 10 years due in large part to the Government's pay restraint policies. Within this average figure of 3.5%, there are larger ALTR reductions in some specific occupations where major changes in the pension conditions of the workers (e.g Police and Firefighters) have made these groups considerably worse off.

5. We suggest that the occasional evaluations that the OME commissions on behalf of the Review Bodies to value occupational pensions for specific occupations need to be broadened out to take account of all pay and conditions using TR methods.

6. These ALTR calculations presented in this report impact on the working conditions of younger workers in public sector jobs relatively to the levels of TR enjoyed by older workers over their lifetime. This may have important implications for recruitment, retention and motivation of future generations of public servants.

7. The methodology of using TR calculations provides a framework for making more general comparisons between generations of workers and their total remuneration conditions. This means we have a method for investigating inter-generational inequality and with the potential for making suggestions as to how anomalies can be rectified. This can be achieved by running the simulation models with different underlying assumptions on any of the parameters in question – e.g accrual rates, inflation adjustment rates, lump sums, or retirement ages. We recommend that the Review Bodies use the TR methodology set out in this report as part of their assessment of remuneration conditions for their remit groups. This also applies to simulating how potential PRB recommended uplifts might impact on different groups of workers.

Detailed conclusions for specific occupations:

1. The standout figures on ALTR disadvantage are the large sums for Police Officers and Firefighters – with the current CARE scheme workers between £300k and nearly £500k worse off relative to their older counterparts in the FS DB pre-2012 scheme. We have set out how these large differences occur due to changing retirement ages and accrual rates. These large sums are stark and suggest there may be a need for further review and reform.

2. The next largest difference between the TR package for workers under the old pre-2012 FS scheme and the new CARE scheme is that affecting hospital doctors/dentists. A thorough on-going review of the extent to which pension changes lie at the heart of recruitment and retention problems in the

profession along with the effects of the lowering of the tax-free pension pot allowance needs to be undertaken urgently.

3. As far as gender comparisons of TR go it is clear that women teachers and doctors/dentists fair better than their male counterparts. Notwithstanding that part of this difference is due to different working hours profiles over the lifecourse.

4. Somewhat reassuringly, when comparison is made between public and private sector counterparts of directly comparable groups (i.e. teachers and nurses) it is shown that the public sectors workers are in fact slightly better off in terms of ALTR. This is mainly due to the lower working hours undertaken by the private sector workers (note that private sector nurses and teachers are predominantly in the same pension schemes as their public sector counterparts).

5. Where regional comparisons of TR within an occupation are possible it is clear that the regional differences in the ALTR dis-advantage are not substantive, nor are they statistically significant.

6. Whilst TR calculations in our analysis were not possible for the Armed Forces these techniques could be used to rigorously evaluate ALTR for the members of the Armed Forces by using the administrative data on payroll held by the Ministry of Defence. This analysis should be conducted to provide a robust way of comparing Armed Forces personnel.

7. Whilst TR calculations in our analysis were not possible for GPs and General Dental Practitioners (due to the self-employed not being in the ASHE data) these techniques could be used to rigorously evaluate ALTR for these professions by using HMRC data if they could be made available for this purpose. This analysis would provide a robust way of comparing GPs and General Dental Practitioners with other doctors and dentists mostly working in hospitals.

9. Discussion

Recent events mean that we all need to pay careful attention to what is happening to our pension, especially those in the public sector. Due to the size of the Public SAecotr Borrowing Requirement and the earlier recession, the current government and the previous coalition government have chosen to cut the size of the public debt. These changes are predicated on the view that public sector pay and pensions have been allowed to rise too high relative to the private sector and that the burden of taxation to fund public sector pay and pensions needs to be reduced. At the same time, due to increasing life expectancy there has been growing concern about the demographic balance of the population and the burden of the pension obligations to public sector workers in the future, given that most public sector pension schemes are unfunded.

This report followed a previous literature in defining and calculating what is meant by DB pension wealth accumulated over the lifetime for each public sector pension scheme and examined what the ratified changes to the pension system mean in various public sector schemes. The report finds that public sector workers are, on average, worse off in the recently introduced CARE pension schemes. However, the average masks substantial occupational variation: those in the Prison Service, Teaching and NHS Nurses schemes fare less badly under the pension reforms than those in the Police and Fire Services pensions schemes who are much worse off. We also found that Doctors/Dentists are also substantial losers in the move from Final Salary to CARE schemes.

This report also examined the relative impact of the 2015 CARE reforms on occupations in the public and private sector, the differences in generosity across geographical regions and between men and women.

In our sector comparisons, we found only relatively small differences between public and private sector Teachers although we found out that private sector Nurses are less adversely affected by the move to CARE pension schemes than their public sector counterparts. This is mainly as a result of lower hours of work, lower hourly rates of pay and a lower fraction of people in the FS pension scheme in the private sector. In our gender comparison, we found that male Teachers and Doctors/Dentists were more adversely affected than their female counterparts due to their longer working hours and

higher earnings. Remember that a CARE scheme will always end up being less advantageous for those whose earnings are at the high end of the scale. We also found that male Teachers have lost around 5% of ALTR since the reforms and women Teachers close to half that figure. Over a lifetime, at current prices, this translates approximately to around £59k loss for men and a £41k loss for women.

In our regional comparisons, we found that Teachers in the rest of the country have fared slightly worse than those inside London and the South East. In the case of Nurses by the time they retire there is no substantial regional effect.

The implications of our findings are potentially wide-ranging and pose many important public policy questions. As the time interval between the reforms and the withdrawal of their pension benefits is considerable, many policy questions of interest will have a long-time dimension. Amongst them are: was it fair to impose these pension changes on workers retrospectively when they actually entered these occupations under very different contractual conditions? Did the government mean for there to be such a large redistribution of pension wealth away from such key workers as the Police, Firefighters and Doctors? Will these changes have no adverse effect on the recruitment of young people into these occupations? Did the government consider potential problems in the retention of high fliers in the public sector towards the end of their career? If the answer to most of these questions tends to be "No", will these adverse pension changes require appropriate adjustments in salaries of the affected workers to restore compensating pay differential? These are all questions that will inevitably have to be faced by future governments who need to recruit, retain and motivate the right calibre of people within these key public sector occupations.

References

Balsam, S. 2002. *"An Introduction to Executive Compensation",* London: Academic Press.

Bardasi, E. and Jenkins, S. 2010. "The gender gap in private pensions", *Bulletin of Economic Research*, 62(4): 343–363.

Barr, N. and Diamond, P. (2008) *"Reforming Pensions: Principles and Policy Changes",* Oxford. Oxford University Press.

Banks, J. and Smith, S. 2006. "Retirement in the UK", *Oxford Review of Economic Policy,* 22(1): 40-56.

Bell, D. Elliot, R. Scott, A. Ma, A. and Roberts, E. 2006. "Comparing the New Earnings Survey (NES) and the Labour Force Survey (LFS): An Analysis of the differences between the data sets and their implications for the pattern of geographical pay in the UK", *Regional Studies,* 40(6): 645-665.

Belman, D. and Heywood, J. S. 2004. "Public-sector wage comparability: The role of earnings dispersion", *Public Finance Review*, 32(6): 567-587.

Bhuller, M. Mogstad, M. and Salvanes, K. 2017 "Life Cycle Earnings, Education Premiums and Internal Rates of Return", *Journal of Labor Economics*, 35(4), 993-1030.

Blackaby, D. Murphy, P. and O'Leary, N. 1999. "The Payment of Public Sector Workers in the UK: Reconciliation with North American Findings", *Economic Letters,* 65: 239-43.

Blake, D. 2003 *"Pension Schemes and Pension Funds in the United Kingdom"*, 2nd ed, Oxford, Oxford University Press.

Blake, D. 2006. *"Pension Economics"*, Pensions Institute, Wiley and Sons.

Borland, J. and Gregory, R. G. 1999. "Recent developments in public sector labor markets" In *Handbook of Labor Economics Volume 3C*, ed. Orley C. Ashenfelter and David Card, Ch. 53. Amsterdam: Elsevier Science Publishers BV.

Brown, C.. 1980. "Equalizing Differences in the Labor Market", *Quarterly Journal of Economics,* 94(1): 113-134.

Burtless, G. 2010. "Lessons of the Financial crisis for the design of national pension systems", *CESifo Economic Studies*, 56(3):323-49.

Cannon, E. and Tonks, I. 2004. *"UK Annuity Rates and Pension Replacement Ratios 1957-2002"*, CRAM Bristol Working Paper.

Cappellari, L. 2002. "Earnings dynamics and uncertainty in Italy: how do they differ between the private and public sectors?", *Labour Economics,* 9(4): 477-496

Chan, S. and Huff Stevens, A. 2001. "Job loss and employment patterns of older
  workers", *Journal of Labor Economics,* 19(2): 484-521.

Crawford, R., Emmerson, C. and Tetlow, G. 2010. "*Occupational Pension Value in the
  Public and Private Sectors*", IFS Discussion Paper 10/03.

Crawford, R. and Disney, R. (2014). "Reform of police pensions in England and Wales",
  Journal of Public Economics, 116: 62-72

Danzer, A.M. and Dolton, P. 2012. "Total Reward and pensions in the UK in the public
  and private sectors", *Labour Economics*, 19: 584–594.

Danzer, A.M. and Dolton, P. and Rosazza-Bondibene, R. 2016 "Who Wins?: Evaluating
  the Impact of UK Public Sector Pension Scheme Reforms", *National Institute
  Economic Review*, Vol 237, R38-R46.

Dillon, E. 2017 "*Risk and return tradeoffs in lifetime earnings*", Arizona State University
  Mimeo.

Disney, R. 1995. "Occupational Pension Schemes: Prospects and Reforms in the UK",
  Fiscal Studies, 16(3): 19-39.

Disney, R., Emmerson, C. and Wakefield, M. 2008. "Pension Provision and Retirement
  Saving: Lessons from the United Kingdom", *Canadian Public Policy*, 34: 155-175.

Disney, R., Emmerson, C. and Tetlow, G. 2009. "What is a public sector pension worth?",
  Economic Journal, 119: F517-F535.

Disney, R., and Gosling, A. 1998. "Does it Pay to Work in the Public Sector", *Fiscal Studies,*
  19: 347-374.

Disney, R., and Whitehouse, E. 1996. "What are Occupational Pension Plans Entitlements
  Worth in Britain", *Economica,* 63: 213-38.

Dolton, P. 1990. "The economics of UK teacher supply: the graduate's decision,"
  Economic Journal, 100(400): 91-104.

Dolton, P. , Makepeace, G. and Marcenaro-Gutierrez, O. 2014. "Public Sector Pay in the
  UK: Quantifying the Impact of the Review Bodies", *Manchester School*, 86(6):701-
  24.

Duncan, G. 1976 "Earnings functions and non-pecuniary benefits", *Journal of Human
  Resources,* 11: 462-483.

Greenhill, R. 1990. "*Performance Related Pay in the 1990s".* Cambridge: Director Books.

Gustman, A. L., Mitchell, O. S. Samwick, A. A. and Steinmeier, T L. . 2000. "Evaluating
  Pension Entitlements" In *Forecasting Retirement Needs and Retirement Wealth,*

ed. Olivia S. Mitchell, P. Brett Hammond and Anna M. Rappaport. Philadelphia: University of Pennsylvania Press.

Heywood, J. S. 1991. "Government employment and the provision of fringe benefits", *Applied Economics,* 23: 417-423.

HM Treasury 2011. "*Public Service Pensions: Good Pensions that Last*".

Ippolito, R.A. 1985. "The labor contract and true economic pension liabilities", *American Economic Review*, 75: 1031–1043.

Independent Public Service Pension Commission (2011). "*Final Report*".

Leslie, D.. 2008. "*Pay Comparability for the Defence Medical Services and the National Health Service using a TR Approach*". Mimeo.

Lumsdaine, R. L., and Mitchell, O. S. 1999. "New developments in the economic analysis of retirement" In *Handbook of Labor Economics Volume 3C*, ed. Orley C. Ashenfelter and David Card, Ch. 9. Amsterdam: Elsevier Science Publishers BV.

Meadows, P. 2003. "*Retirement ages in the UK: a review of the literature*", Employment Relations Research Series No.18.

Mitchell, O. S. 1982. "Fringe benefits and labor mobility", *Journal of Human Resources,* 17(2): 286-298.

Montgomery, E. B., Shaw, K. and Benedict, M. E. 1992. "Pensions and wages: An hedonic price theory approach", *International Economic Review,* 33(1): 111-128.

Montgomery, E. B., and Shaw, K. 1997. "Pensions and wage premia", *Economic Inquiry,* XXXV: 510-522.

Nybom, M. 2017 "The distribution of lifetime returns to college", *Journal of Labor Economics*, 35(4): 903-52.

Ormerod, C. and Ritchie, F. 2007. "Linking ASHE and LFS: can the main earnings source be reconciled?", *Economic and Labour Market Review,* 1(3): 24-31.

Pension Policy Institute (PPI). 2008. "*The Pension Primer*", [Internet source] www.pensionspolicyinstitute.org.uk, accessed 06 May 2009

Pesando, J. E. 1984. "Valuing pensions (annuities) with different types of inflation protection in total compensation comparisons", *Canadian Journal of Economics,* 17(3): 569-587.

Postel-Vinay, F. and Turon, H. 2007. "The Public Pay Gap in Britain: Small Differences That (Don't?) Matter", *Economic Journal,* 117: 1460-503.

PPI 2015. "*The Pension Primer: A Guide to the UK Pension System*". PPI report, June 2015. London.

PPI 2013. "*The Implications of the Coalition Government's public service pension reforms*", PPI Report, May 2013. London.

PPI 2005. "*Occupational Pension Provision in the Public Sector*". PPI report, March 2005. London.

Quinn, J. F. 1982. "Pension wealth of government and private sector workers", *American Economic Review,* 72: 283-287.

Rosen, S. 1974. "Hedonic prices and implicit markets: Product differentiation in pure competition", *Journal of Political Economy,* 82: 34-55.

Rosen, S. 1986. "The Theory of Equalizing Differences" In *Handbook of Labor Economics Volume 1*, ed. Orley C. Ashenfelter and Richard Layard, Ch. 12. Amsterdam: Elsevier Science Publishers BV.

Steventon, A. 2008. "*An Assessment of the Government's Reforms to Public Sector Pensions*" Policy Studies Institute.

Thurley, D. 2009. "*Local Government Pension Scheme: Rule of 85*", House of Common Standard Note 4002.

Von Weizsacker, R.K. 1993 "*A Theory of Earnings Distribution"*, Cambridge University Press, Cambridge.

Willis, R. J., and Rosen, S. 1979. "Education and Self-Selection", *Journal of Political Economy,* 87(5): S7-36.

Woodbury, S. A. 1983. "Substitution between wage and nonwage benefits", *American Economic Review,* 73(1): 166-82.

Appendices

A1: Data Appendix

Data sets used:

We use the maximum number of available quarterly LFS data and pool them for obtaining measures of the following variables:

- Public holiday entitlement: October to December quarters from 2005 to 2018.

- For the computation of unemployment rates (ILO definition), we exploit the pooled five-quarterly short panels of the LFS from 1997:Q1 to 2018:Q3 (with the exception of 2005:Q3 and 2008:Q4, in both of which the information on economic activity status is missing). Unemployment risk is defined as the probability of moving from dependent employment in quarter one to unemployment in one of the subsequent four quarters.

In order to estimate age-earnings profiles, the most reliable (employer-reported) earnings data are in the Annual Survey of Hours and Earnings (ASHE), of which we use the years 1997 to 2018. Our earnings measure includes bonus payments and our hours of work measure includes basic paid hours as well as average overtime hours worked.

In the 2005-2015 ASHE data, employers report employer and employee pension contributions alongside the pensionable pay. From this information, it is straightforward to compute the pension contribution rates on behalf of the employer and the employee. Due to small sample in some cases, pension information has been averaged across age bands. Age-earnings profiles are deflated to the base year 2018 and are computed after netting out annual average sector growth (cp. Disney et al., 2009).

During the observation period, the occupational coding frame changed from SOC(2000) to SOC(2010) between 2010 and 2011. This discontinuity was addressed by using the Office for National Statistics occupational look-up table, which shows how the two classifications map onto one another at different group levels and for different surveys by gender. We used the Unit Group (four-digit) level and weights derived from the 2001 Census sample, which is considered to be most reliable due to its large sample size, to show the SOC(2000) contribution towards the composition of each specific SOC(2010) Unit Group. The coding frame is shown in Table A1.1 below:

TABLE A1.1

Groups	Occupation	SOC 2010	SOC 2000	Region
Doctors/ Dentists	• Medical practitioners • Dental practitioners	2211 2215	2211 2215	GB excl. NI
Nurses	• Nurses	2231	1181, 3211	GB excl. NI
Police	• Senior police officers • Police officers (sergeant & below)	1172 3312	1172 3312	England, Wales
Prison	• Senior officers in fire, ambulance, prison & related services • Prison officers	1173 & SIC03 75.23 3314	1173 & SIC07 84.23 3314	England, Wales
School Teachers	• Secondary education teaching professionals • Primary & nursery education teaching professionals • Special needs education teaching professionals	2314 2315 2316	2314 2315 2316	England, Wales

To compute retirement ages by sectors, we pool all four available waves from the English Longitudinal Survey of Ageing (ELSA) and the waves G (1997) to Q (2007) from the British Household Panel Survey (BHPS). Note that we were obliged to use this data as Understanding Society only asks about age expected to retire and not actual age of retirement. In the BHPS the appropriate question is asked but only at two waves of the data. In the LFS data the vast majority of respondents are between the ages of 16-64 and therefore we cannot use this data to infer retirement age.

In the BHPS, public vs. private sector affiliation is reported by the respondents. As sector affiliation is missing in the ELSA data, we mapped sectors according to occupations.

For occupations that have more than 75% public sector affiliation in ASHE, we coded the entire occupation in ELSA as public, while we coded occupations with more than 75% private sector workers in ASHE as entirely private in ELSA. Occupations that were more equally distributed between sectors were omitted from the ELSA sample.

Similarly, employer-sponsored health insurance plans were retrieved from ELSA. It should be noted that these data sample only individuals aged 50 and above.

Sample:

The target sample for our valuation exercise are full- and part-time employed men and women, aged 21 to 60. The public and private sector definition is as defined by the ONS.

Further Assumptions

a. In our data, we use the 'average total paid hours per week including overtime'. This is as reported in ASHE by the employers. So, this does not include unpaid overtime hours that workers themselves may claim they work.

b. We assume all Prison Officers are in DB scheme. The sample size of Prison Officers is quite small, causing confidentiality issues so the SRS did not agree to release the data.

c. The unemployment risk and the number of paid holidays is the same for women and men within each occupation.

d. The unemployment risk is adjusted by Kernel-weighted local polynomial smoothing for each occupation.

e. We assume the proportion of private health insurance paid by employer is 3.4%, and it costs £237.723 for all occupations. This assumption is based on Danzer et al. (2016).

f. We assume that Doctors' profiles at age 21 and 22 are the same as age 23. We can only obtain the Doctors' data from age 23 because its professional training period is much longer than other occupations. However, we need the data from age 21 for all occupation to calculate the accumulated lifetime total reward (ALTR).

What is Possible in terms of earnings and working hours data:

OPTIONS (focus)	1 (Age)	2 (Region)	3 (Gender I)	4 (Gender II)
Prison Officers	Both Genders together All regions together Up to 55			
Police Officers	Both Genders together All regions together Up to 50	Both Genders together London & SE, Other Up to 50	Only Men London & SE, Other Up to 50	Men, Women All regions together Up to 50
Teachers	Both Genders together All regions together Up to 65	Both Genders together London, SE, Other Up to 60		Men, Women London & SE, Other Up to 60
Nurses	Both Genders together All regions together Up to 60	Both Genders together London, SE, Other Up to 60	Only Women London & SE, Other Up to 60	
Doctors	Both Genders together All regions together Up to 60	Both Genders together London & SE, Other Up to 60		Men, Women All regions Up to 50

COMPARATORS

	1 (Age)	2 (Region)	3 (Gender I)	4 (Gender II)
Firefighters	Both Genders together All regions together Up to 50			
Private sector Nurses	Both genders together All regions Up to 60			
Private sector Teachers	Both genders All regions Up to 65			
SOC2010 major group 2 (excl. Teachers)	Both Genders together All regions together Up to 65	Both Genders together London, SE, Other Up to 65	Only Men/Women London & SE, Other Up to 65	Men, Women London & SE, Other Up to 65
SOC2010 major group 2 (excl. Nurses)	Both Genders together All regions together Up to 65	Both Genders together London, SE, Other Up to 65	Only Men/Women London & SE, Other Up to 65	Men, Women London & SE, Other Up to 65

Table A2: Overview of pension schemes

Name	Contractual arrangement	Type
Defined benefit (DB)	Trust based	Run by the organisation, benefits are determined by the scheme rules, for example based on final or average salary
Defined contribution (DC)	Trust based	Run by the organisation, benefits are determined by contributions and investment returns, also known as money purchase
Group personal pension (for simplicity subsumed under DC)	Contract based	Facilitated but not run by the organisation, an arrangement made for employees to participate in a personal pension scheme on a grouped basis. This is not a single scheme, it is a collecting agreement
Stakeholder pension (for simplicity subsumed under DC)	Contract based	Facilitated but not run by the organisation, must meet certain conditions and be registered with The Pensions Regulator (TPR). Include employer-sponsored and other stakeholder pensions. Employers with 5 or more employees generally have to make a stakeholder pension available to their staff since 8th October 2001 in case they do not offer any of the other schemes).
State Graduated Pension, State Earnings Related Pension, State Second Pension (all for simplicity assumed as SERPS)	Implicit contract	The additional state pension was introduced to support the many employees who were not covered by any occupational scheme and thus left solely with the Basic State Pension. Through the payment of NI contributions, employees implicitly purchase pension 'rights'.

Source: The Pensions Regulator (http://www.thepensionsregulator.gov.uk/employers/different-kinds-of-pension-scheme.aspx)

Table A3: Parameter assumptions

Parameter	Disney et al. (2009)	Leslie (2008)	Main specification
Life expectancy	Age-gender cohort life expectancies (1997-2001); adjustment for differences in life expectancies by social class	85 (Pension multiplier at age 65 is 20)	Age-gender cohort life expectancies (2002-2006); adjustment for differences in life expectancies by social class
Wage growth	NA	0.02	0.02
Discount rate	0.03	0.04	0.03
Employee contributions	For final salary plans: Private: 4.6% Public: 3.9%	NA	From data
Discount back to age	NA	18	21
Real annual rate of return	NA	NA	0.02 (see Crawford et al., 2010)
Accrual factor	Public DB: 1/80th Private DB: 1/60th		We use all the occupational rules as specified in Table A4.
Additional lump sum	Public DB: 3/80th Private DB: 0		Public DB: 3/80th Private DB: 0
Inflation rate		0.02	We use the ONS CPI index to reflate all earnings data.
Retirement age	Private: 65 Public: 60	65	60; State pension age (SPA) 65
Vesting period	2 years (not used)	—	DB: 2 years
Job Tenure	12.2 (public), 9.5 (private) mean uncompleted pension plan tenures (self-reported BHPS)	Life cycle employment without unemployment risk (max. 48)	Life cycle employment adjusted for unemployment risk

Table A4. Changes in pension parameters

Nurses	before 2002	from 2015
Scheme type	Final salary	CARE
Accrual rate	1/80	1/54
NPA	60	SPA
Revaluation of active members benefits		CPI + 1.5%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3 * annual pension	optional in exchange for reduced pension
Widow's pension	50% of your pension in payment	33.75% of the pension in payment
Early retirement discount		0.767 for retirement five years before
Teachers	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/80	1/57
NPA	60	SPA
Revaluation of active members benefits		CPI + 1.6%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3*annual pension	optional in exchange for reduced pension
Widow's pension	50% of your pension in payment	37.5% of your pension in payment
Early retirement discount		0.770 for retirement five years before
Doctors	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/80	1/54
NPA	60	SPA
Revaluation of active members benefits		CPI + 1.5%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3 * annual pension	optional in exchange for reduced pension
Widow's pension	50% of your pension in payment	33.75% of the pension in payment
Early retirement discount		0.767 for retirement five years before
Prison Officers	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/80	1/43.1
NPA	60	SPA
Revaluation of active members benefits		CPI
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3*annual pension	optional in exchange of reduced pension
Widow's pension	50% of your pension in payment	37.5% of your pension in payment
Early retirement discount		0.769 for retirement five years before

Table A4. (Continued)

Private Sector Nurses	before 2002	from 2015
Scheme type	Final salary	CARE
Accrual rate	1/80	1/54
NPA	60	SPA
Revaluation of active members benefits		CPI + 1.5%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3 * annual pension	optional in exchange for reduced pension
Widow's pension	50% of your pension in payment	33.75% of the pension in payment
Early retirement discount		0.767 for retirement five years before
Police Officers	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/60 up to 20 years - 2/60 after 20 years (capped at 40/60)	1/55.3
NPA	55	60
Revaluation of active members benefits		CPI + 1.25%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	Optional in exchange for reduced pension	Optional in exchange of reduced pension
Widow's pension	50% of your pension in payment	50% of your pension in payment
Early retirement discount		0.775 for retirement five years before
Private Sector Teachers	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/80	1/57
NPA	60	SPA
Revaluation of active members benefits		CPI + 1.6%
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	3*annual pension	optional in exchange for reduced pension
Widow's pension	50% of your pension in payment	37.5% of your pension in payment
Early retirement discount		0.770 for retirement five years before
Firefighters	**before 2002**	**from 2015**
Scheme type	Final salary	CARE
Accrual rate	1/60 up to 20 years - 2/60 after 20 years (capped at 40/60)	1/59.7
NPA	55	60
Revaluation of active members benefits		Average Earnings
Revaluation of pensions in payment	RPI up to April 2011	CPI
Lump sum	Optional in exchange for reduced pension	Optional in exchange of reduced pension
Widow's pension	50% of your pension in payment	50% of your pension in payment
Early retirement discount		0.782 for retirement five years before

Note that we assume that all private sector teachers and nurses have the same pension conditions as their public sector counterparts as the majority of teachers and nurses are in the relevant public sector schemes and we do not have details on what the minority of those private sector nurses and teachers who are in other pensions schemes or who have opted out of a pension scheme altogether.

Appendix B: Technical Methodology

Deriving ALTR for DB and DC Pension Schemes

The total value of a person's wage payment in a given year, at age v (including pension) is:

$$w_v(1 - e_v - N) + (CP_v^{\mathrm{K}} - CP_{v-1}^{\mathrm{K}}) \tag{1}$$

where: w_v is wage at age v, e_v is the rate of employee contribution to pension at v, N is the rate of National Insurance and other statutory stoppages and CP_v is the present discounted value of accumulated pension rights at age v. [52] Let the K superscript denote whether a person is in a DB scheme or a DC scheme – where here we take DB to mean the pre 2012 DB scheme which was based on Final Salary. A brief overview of pension schemes is given in Table A2 of the Appendix. We take the perspective of a representative individual in each of the sectors and assume for simplicity that the fraction of private and public sector workers in DB, DC schemes accords to the overall membership fractions in each sector [53]. Hence the average TR function for the both sectors is computed as a weighted average of workers in the DB and DC schemes, averaged over the period 1997 to 2018.

Assuming a person is in a DB pension scheme which is based on their final salary value at time T, the accumulated value of such a pension at V, where V is the final period of work, is:

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[52] So $(CP_v^{\mathrm{K}} - CP_{v-1}^{\mathrm{K}})$ is the discounted incremental value added to a person's pension in the last year. We also abstract here from the issue of pension indexation (for a sector comparison, see Pesando, 1984).

[53] Public sector enrolment in different pension schemes is 90.1% DB, 2.5% DC and 6.3% SERPS, while the corresponding private sector numbers are 31.4%, 31.4% and 36.2%. The SERPS has a small proportion in each occupation, which is less than 4%. The main contribution of this research is to compare the advantage/difference of DB scheme and CARE scheme. When we compare the advantage of pension scheme changes, the SERPS does not play an important role in the evaluation of total reward and pension wealth. Additionally, SERPS does not occupy a certain proportion in public or private sector. Therefore, this study does not take into account the SERPS scheme.

$$CP_V^{DB} = \sum_{r=1}^{D_1} \delta^r \gamma \ell w_T \; + \; \sum_{s=D_1+1}^{D_2} \frac{1}{2} \delta^s \gamma \ell w_T \; + \; \sum_{t=1}^{D_1} \delta^t SP_t \; + \; \delta^r \beta \gamma w_T \qquad (2)$$

where: D_1 is the member's years of life after retirement (indexed by r) [54,55], D_2 is the partner's years of life (indexed by s) in retirement in excess of the member (i.e. where $D_2 > D_1$), δ is the discount rate, SP_t is the level of State Pension at time t (indexed from the 65th year when the State pension is eligible), γ is the cumulated years in the scheme, ℓ is the accrual rate in the scheme and the last term in equation (2) is the lump sum paid in most DB schemes where β is the lump sum fraction. It should be noted that the terminal salary was the best out of the previous three years, which is the standard rule in most DB schemes. [56] The basic State Pension becomes payable in full after 30 qualifying years; below this threshold, every year pays 1/30th of the full entitlement. [57,58]

Now consider the person who pays into a DC scheme. Their accumulated value of their pension at the date of the year of retirement, V is:

$$CP_V^{DC} = \sum_{r=1}^{D_1} \delta^r \varrho \left[\sum_{v=1}^{V} [e_v + m_{tv}] w_v \{1 + x\}^{(V-v)} \right] + \sum_{v=1}^{D_1} \delta^t SP_t \qquad (3)$$

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[54] We assume that a partner's pension would start instantly from the time of death of a spouse.

[55] For the time being we assume that there is no difference in the longevity of public or private sector workers. Life expectancies are gender-specific cohort values that are up-rated by a premium fraction for social class I and II. We intend to investigate this using occupation specific mortality rates in the future.

[56] In our computations, this rule applies from age 23.

[57] The number of qualifying years was reduced to 30 on the 6th April 2010. Earlier, and for persons born before 6 April 1945 (men) and 6 April 1950 (women), 44 (men) and 39 (women) years were required.

[58] Workers (quite typical for public sector workers) whose pension schemes were (before 1 April 2016 when opting out ceased) formerly opted out of SERPS and who therefore paid lower rate National Insurance Contributions are unlikely to be entitled to a full State Pension after this stated qualifying period.

where: D_1 is the person's years of life after retirement, e_t is the rate of employee contribution to pension at time t, m_t is the rate of employer contribution to pension at time t, ϱ is the sex specific indexed annuity rate, x is the real annual rate of return on the investment income derived from the DC pension contributions, and, D_1, δ, SP_t, and v are defined as in equation (2). It is assumed that members of a DC scheme take out their contract at age 21 and will buy an annuity at age 60. At this age, they are entitled to draw 25% of their final transfer value as a tax-free lump sum. The remaining three quarters of the fund buy an annuity which is assumed to be the second-best open market gender-specific annuity available at the market.[59] To reduce further complications, we assume that members are non-smokers and that all annuities are single-life products which do not contain provision for partners. The ratio of the NPV of the pension stream over the value of the annuity is very close to 1, but women's pension stream seems to earn them some returns from buying the annuity.[60]

Now we can add in the other components to TR. Let the person in question work a different number of hours per year. If we now specify the wage rate as the real hourly wage rate[61] then we can write the total pay equation from (1) as:

$$H\{w_t(1 - e_t - N)\} + CP_t^K \tag{4}$$

Where, H is the median total hours worked per year and w_t is the median hourly wage rate.[62] Now adding in the value of benefits in kind, paid holidays and health insurance—denoted BK_t, as well as the possibility that the person in question could be made unemployed at any time t, the value of Current TR (CTR) is:

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[59] The fund value is rounded to the nearest pound. Annuity rates change over time. The annuity tables are taken from the Consumer Financial Education Body.

[60] This could be due to the fact that we are assuming 'single' contracts for married women (in order to reduce complexity); pension providers might assume shorter life expectancies for single women thus providing them with slightly higher returns.

[61] Notice that we perform all our calculations adding up total remuneration for the hours of work actually chosen in the week.

[62] Note that in principle (5) could be rewritten to be expressed in net of tax terms by using $w_t(1 - e_t - T - N)$ where T is the average tax rate.

$$CTR_t = E_t[H\{w_t(1 - e_t - N)\} + BK_t] + E_t\, CP_t^K \tag{5}$$

where E_t is the probability of remaining in employment at time t.

We now finally define what we mean by TR. We suggest that TR at each given age τ , should comprise *accumulated* earnings up to that time plus the *accumulated* wealth of a pension scheme (up to any given age τ), evaluated from the career start (v=21). So we can define the ALTR in money terms at age τ as:

$$ALTR_\tau = \sum_{v=21}^{\tau} \delta^{(\tau-v)}\, E_v[H\{w_v(1 - e_v - N)\} + BK_v] + \delta^{(\tau-v)} E_v\, CP_v^K \tag{6}$$

The asset value of a DB pension is evaluated as the sum of the discounted DB benefit stream from retirement until death. For this computation, knowledge about retirement dates and the remaining life expectancy at retirement is required. The actual benefit value will depend on the pension plan details provided by different employers (i.e. accrual rates, accrual base, NPA, initial vesting period, lump sum options, survivors' benefits, and indexation) as well as specific employee details like levels of past earnings and number of years in service.

Comparing CARE and Pre-2012 DB FS Total Reward.

Assuming a person is for their entire working life in a pre-2002 DB pension scheme *i,* which is based on terminal salary (w_{Ti}). Then accumulated value is given in equation (2), for each occupation or PRB remit group separately (i.e. NHS, Teachers, Doctors, Police and Fire Services)*.*

Assuming instead a person is for their entire working life in a 2015 reformed pension scheme *i,* which is now based on career average salary $\overline{w}_i$, and deflating by the (ONS) CPI, then the accumulated value of such pension at pension age *r* is:

$$\widehat{DB}_{ri}^{CARE} = \sum_{r=1}^{D_{1i}} \delta^r \sigma^{CPI} \gamma_i \ell_i \mu_i \overline{w}_i \; + \sum_{s=1}^{D_{2i}} \theta_i \delta^s \sigma^{CPI} \gamma_i \ell_i \mu_i \overline{w}_i \quad (8)$$

An important aspect to note is that DB pension wealth in equation (8) is no longer a final salary scheme, based on the salary at the end of the career w_{Ti}, but it is a CARE pension scheme based on the average salary $\overline{w}_i$ (an average of the salaries received in each year of work after each year's salary has been appropriately revaluated by μ_i).

The idea of the report is to simulate the impact of the various public sector pension reforms. We do this by comparing the NPV of accumulated lifetime DB pension wealth in the pre-2002 pension schemes $\sum_v^\tau \delta^{(\tau-v)} \; CP_V^{DB^d}$ with the one of the schemes introduced in 2015, $\sum_v^\tau \delta^{(\tau-v)} \widehat{DB}_{ri}^{CARE}$. Hence, at each given age τ we evaluate the DB wealth as if this was the first year of pension withdrawal, discounting back to the career start at age v. The DB pension (dis-)advantage of the 2015 scheme over the 2002 scheme for each occupation i can be calculated from:

$$PA_{ri}^{new} = \frac{\sum_v^\tau \delta^{(\tau-v)} \widehat{DB}_{ri}^{CARE} - \sum_v^\tau \delta^{(\tau-v)} \; CP_V^{DB}}{\sum_v^\tau \delta^{(\tau-v)} \; CP_V^{DB}} \quad (9)$$

Negative values of PA_{ri}^{CARE} reflect a deterioration of the NPV of accumulated pension wealth under the reform.

It is also possible to make comparisons of how a public sector CARE scheme, now in place for Nurses and Teachers, compares to their private sector counterparts. The logic of this comparison is analogous to that above except the comparator is now people doing the same (or broadly similar jobs) in the private sector who we will assume will receive a DC pension. We may express the public sector CARE advantage (or disadvantage) relative to their private sector control counterpart as:

$$PA_{ri}^{con} = \frac{\sum_v^\tau \delta^{(\tau-v)} \widehat{DB}_{ri}^{CARE} - \sum_v^\tau \delta^{(\tau-v)} \; CP_V^{DC}}{\sum_v^\tau \delta^{(\tau-v)} \; CP_V^{DC}} \qquad (10)$$