Office for National Statistics

UK Centre for the Measurement of Government Activity

February 2009

Labour Inputs in Public Sector Productivity: Methods, Issues and Data

Summary

This paper provides an overview of the methodology currently used in the production of labour input measures, with a specific focus on how these affect estimates of public service productivity published by the UK Centre for the Measurement of Government Activity (UKCeMGA) in the Office for National Statistics (ONS). It highlights ongoing work to improve labour input measures and draws attention to both the theoretical literature and empirical work on labour measures as a way of highlighting key conceptual and practical issues with existing methods and data. In addition, it provides an update on the implementation of the Atkinson review recommendations on the measurement of labour inputs to production.

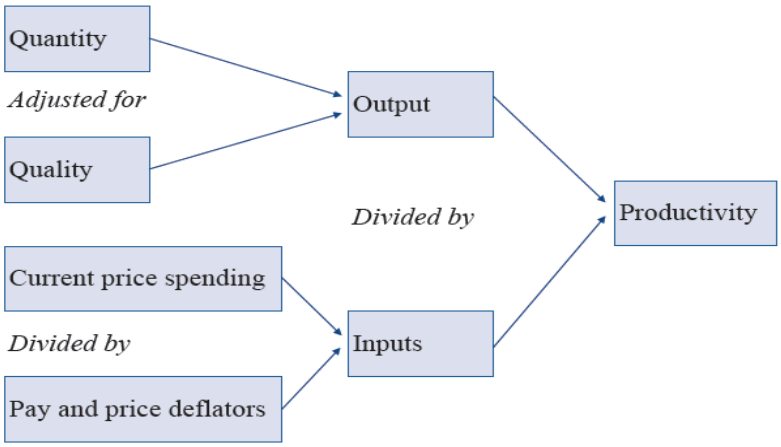
1. Introduction

1.1 Total output of an economy or sector of the economy is determined partly by the quantity of factor inputs (labour, capital, etc) and partly by how these factors are used. Different sectors of the economy may achieve different volumes of total output using similar quantities of factor inputs because of the variations in productivity. Therefore productivity is a concept that relates output to a given input or inputs.

1.2 In the UK, the Centre for the Measurement of Government Activity is tasked with measuring public service productivity. Essentially, this means measuring the effectiveness with which government produces and delivers services by measuring the relationship between outputs and the inputs (capital, labour, and intermediate inputs) used to produce them[1] – see Figure1.1. In essence, this measures the productivity of government spending (a GDP expenditure approach) rather than government production (a GDP output approach).

[1] Recognise that productivity ≠ efficiency

Figure 1.1: Components of productivity change



1.3 Measures of both the output and inputs components of the productivity equation should ideally be adjusted for quality. In the case of output, this means an estimate of change in the quality of service. For inputs, this means measuring the changes or differences in the quality of the resources that are used in producing or delivering that service. Issues around how best to estimate the changes in the quality of outputs are not the focus of this paper[2]. This paper addresses the inputs component of the productivity equation, specifically measurement of labour as a subcomponent of the overall inputs measure[3]. It discusses how best to estimate the volume of different types of labour (direct or indirect) and, in each case, how best to account for changes in the quality of labour.

1.4 Labour remains the single most important input to many production processes (OECD 2001). Of the inputs, labour expenditure makes up a significant portion of total public service expenditure and hence needs to be measured accurately and consistently over time. The simplest estimate of labour input is a summation of hours of all workers; however, this does not take into account the heterogeneity of labour. Employees with differing traits should be treated as separate and distinct inputs in the measurement of labour inputs. The measures of labour inputs in the production process should reflect the time, effort, and skills of the workforce. Any changes in these characteristics, or in the accuracy with which the characteristics are measured, will affect the productivity estimates produced. However, this is a considerable challenge because of the difficulty in measuring the variation in skills within a workforce.

[2] This is not to say that the issues and challenges in measuring outputs are not important. These are dealt with by various UKCeMGA publications which can be found on our website.
[3] Other input components are capital and intermediate consumption

1.5 Issues discussed further in this paper, with reference to UKCeMGA's work, are whether current labour input measures fully reflect labour input in the productive process, whether wages are a good measure of the marginal productivity of an individual[4], and whether current measures account for differences in the quality of labour inputs.

1.6 The paper is structured as follows: the next sections discuss multifactor productivity and labour input measures (direct and indirect), and outline some of the challenges that UKCeMGA is dealing with in trying to develop better labour input measures. This is followed by a discussion of the importance of quality adjusting labour and the various approaches to doing this. The latter part of the paper addresses the various skills parameters including the most commonly used indicator of skills – wages. This is followed by a discussion on ways in which both direct and indirect labour measures can include labour quality indicators. The new Education direct labour input measure is introduced and the results discussed. The paper concludes with a look at developments underway within UKCeMGA to improve current labour input measures for Defence, Police and Healthcare.

2. Labour in productivity estimation

2.1 Productivity is often expressed in terms of labour (labour productivity), frequently defined as output per person employed. This definition does not take into account the contribution of other factors such as capital in the production of that output. An alternative measure of productivity that relates output to both labour and capital inputs is Total Factor Productivity (TFP), sometimes referred to as Multifactor Productivity (MFP).

2.2 Labour and capital are the most common components of multifactor productivity analysis although some productivity studies (Diewert and Lawrence 1999) have included additional variables such as land and inventories. Others have included intermediate inputs as a third variable in MFP measurement (US National Academy of Sciences 1979, and Gallop 1979 and 1981). They argued that the correct treatment of MFP variables depends on whether the task at hand is to measure MFP at a highly aggregate level or at the level of detailed industries. Gallop (1979)

[4] Marginal productivity is the increase in the value of output that can be produced by adding in one more unit of the particular input while holding other inputs constant.

argued that if the productivity analyst's interest was focused on final product (highly aggregate level) this would call for a measure of MFP that only accounts for capital and labour as the key inputs[5].

2.3 Conversely, at detailed industry level, Gallop suggests that it would be a mistake to ignore intermediate inputs (that is, those purchased from other industries). For any industry of sector, the key is to define output to include products or services delivered to other sectors while defining inputs to include intermediates purchased from other sectors. At the same time, within the industry or sector, intermediate transactions occurring between establishments should be excluded from both outputs and inputs, in line with National Accounts. Therefore gross output, defined as total services or products delivered adjusted for inventory change, should be compared to measures of capital, labour and intermediate inputs (Gallop 1981).

2.4 The current UKCeMGA approach to MFP measurement follows the Gallop interpretation by accounting for capital, labour, and intermediate input components in the MFP measure, given that the productivity work is undertaken at functional level – that is, Health, Education, etc. This approach is similar to what is known as the KLEMS approach which classifies inputs into capital (K), labour (L), energy (E), material inputs (M), and purchased services (S). Often the last three categories of inputs are aggregated to form a single 'other input' category commonly referred to as intermediate consumption. The advantage of using this type of MFP as a measure of productivity is that it incorporates the effects of changes in all three inputs, whether they are due to improved skills, more efficient capital usage, more efficient procurement or a change in the composition of labour, capital or intermediate inputs.

3. Labour input measures

3.1 UKCeMGA uses two ways to measure labour inputs – direct and indirect. A **direct** measure involves counting the volume of inputs: the number of hours worked by different employees within a sector, accounting for their different skills. The **indirect** measure involves removing the effects of inflation from the compensation of employees' expenditure by dividing the expenditure by a pay cost index. This produces estimates of volume of labour inputs at constant prices, which allows for comparison over

[5] At a highly aggregate level with a focus on final output, GDP estimation would exclude intermediate inputs in order to avoid double counting.

time. Ideally, using either method should result in the same estimate of labour input but in practice this is not the case due to a number of reasons – for example data availability and accuracy. The *Atkinson Review* advocated improvements to both indirect and direct measures when estimating labour inputs for public service productivity analysis. Our experience in estimating public service productivity has shown that in many cases the variation in the results using either method is principally down to data availability, the quality of the data, and the degree of granularity of the data. UKCEMGA would ideally like to publish results using both measures as recommended by the *Atkinson Review* (see Box 1); however, given data constraints, on occasions only one method can be used. In cases where both direct and indirect measures can be produced, the choice of which one to use in the final productivity calculation is based on the quality and robustness of data.

Box 1: Atkinson Review on Labour Inputs

Principle F: the measurement of inputs should be as comprehensive as possible and in particular should include capital services; labour inputs should be compiled using both direct and indirect methods, compared and reconciled.

Principle G: criteria should be established for the quality of pay and price deflators to be applied to the input spending series; they should be sufficiently disaggregated to take account of changes in the mix of inputs and should reflect full and actual costs.

Recommendation 5.8: we recommend that ONS should continue to develop its estimates of labour inputs using both the direct and indirect approaches, exploring issues on data availability and interpretation in the light of comparisons between the results of both methods. For the **direct** approach, ONS should expand the analysis by function, introduce a public/private split and incorporate information on changes in skill mix. On the **indirect** approach, ONS should improve the quality of the deflators used for public spending on labour services.

Source: Atkinson 2005 p 50-51, 71

3.2 For example, the 2006 Education Productivity article presented both an indirect and direct measure. The direct measure used teacher numbers (full-time equivalents (FTE)) but it was thought this might fail to capture changes over time in actual hours worked, knowing that there had been deliberate expansion in support staff numbers to relieve pressures on teachers. The indirect measure was used in the productivity calculation. Since then, UKCeMGA has researched survey data from the Office of Manpower Economics on teacher working hours which has made it possible to produce a more robust direct labour input series, presented later in this paper. A review of labour input measures for public service areas in UK National Accounts and from UKCeMGA's work on public sector

productivity provides some examples of the problems faced with both methods and the need to improve these.

3.3.1 The National Accounts direct volume measure for Defence labour inputs uses FTE employees multiplied by an average wage across the entire military defence workforce in the year 2000 (ONS 2008a). The drawback here is that it doesn't account for skill: all MOD employees are treated as having the same level of skill given that an average wage is used. Secondly, by using weights fixed to the year 2000, this means that the estimates will not change to reflect the spending patterns in the given year (ONS 2008a).

3.3.2 For Police labour inputs, the current National Accounts indirect measure uses a very basic deflator derived from police expenditure on labour, collected through the Subjective Analysis Returns (SAR), based on average pay increases with a base year at 2000 (ONS 2008b). This has a number of flaws given that it includes both volume and price changes and doesn't account for skill. For example, it would be difficult to ascertain whether the change in the deflator is due to an increase in police numbers (volume change) or an increase in wages (price effects). In both areas (Police and Defence), forthcoming UKCeMGA publications will propose new methods to improve current measures, as outlined in the 'Conclusion and Next Steps' section of this paper.

3.3.3 For social security administration (SSA) inputs, the 2006 productivity article highlighted one of the weaknesses of using a department specific pay deflator to deflate the Department of Works and Pensions (DWP) component of labour expenditure and the Average Earnings Index (AEI) to deflate non-DWP labour expenditure for SSA (ONS 2006). Neither deflator accounts for changes in skill or experience of staff. The assumption in the DWP deflator is that the year-on-year changes are due to price changes and not changes in skills mix. Simply put, an increase in the quality of the labour force represents a bigger volume input than if labour quality is unchanged. The subsequent publication (ONS 2008c) uses an Index of Labour Costs per Hour (ILCH) to deflate both DWP specific and non-DWP labour expenditure, which is an improvement on the AEI index as it takes into account non-wage costs.[6] However, as with the method in the 2006 publication, this does not account for change on

[6] Such as national insurance contributions; employee pension contributions; and sick, maternity and paternity pay.

the skills mix. Neither article used a direct labour input measure as data on FTEs was not available.

3.3.4 For Education labour inputs, the current measure uses a suite of deflators for local authority and central government labour expenditure. For local authority expenditure, they are respectively based on teachers' remuneration data from the Department of Children, Schools and Families (DCSF) and a composite of the Annual Survey of Hours and Earnings (ASHE) series for support staff. Central government expenditure is deflated by an Education AEI from 2000 onwards; up to 1999, the public sector AEI is used. While these deflators have been recently reviewed and, in certain cases, improved, they are not ideal. For example, DCSF remuneration data is based only on salary averages for full-time staff rather than full-time equivalents, while the ASHE series used to deflate support staff expenditure are in many cases rough proxies for very specific types of education employment. Measuring labour indirectly with imperfect deflators gives rise to the possibility that the real impact of changing staff proportions and levels is not being picked up.

3.3.5 The current Health direct labour input measure splits employees into different professions, that is consultants, nurses, ambulance staff, and support staff, with FTE numbers for each category for the period 1995–2006 (ONS 2008d: 29). A Laspeyres index of the change in the volume of staff (by FTE) weighted by the average earnings of each category of staff is then calculated, which goes some way towards accounting for quality as it takes into consideration differences between staff categories/skills. Nevertheless, it may not fully account for changes in the quality of staff within each category if more highly qualified individuals are employed or current employees add to their skills set. There may also be salary differences between those employed by the NHS and agency staff. Furthermore, by using average earnings as weights, rather than total labour costs, it fails to account for changes in the relative cost of different staff that is different national insurance/pension contributions. Staff earnings from 2002 are used as a weight for all years prior to 2002. The method uses contracted hours not actual hours worked: as with teachers, there is a possibility that hours actually worked by staff such as doctors, have changed in a way not reflected in formal contracted hours. The index is based on England only with proxies for the other countries of the United Kingdom.

3.3.6 There is also an indirect measure of labour for Health which splits current price labour expenditure (England only) into several streams; Hospital and Community Health Services (HCHS), General and Personal Medical Services (GPMS), and Department of Health (DH) administration. Specific deflators are then used to deflate these streams – Overall DH Pay Cost Index to deflate expenditure on HCHS pay; NHS administration component of DH Pay Cost Index to deflate expenditure on DH administration pay; and a General and Personal Medical Services (GPMS) index constructed from the GP Earnings and Expense Enquiry Survey to deflate GPMS. This approach differentiates between different types of labour input in hospitals, but does not take account of possible salary differences between those employed directly by the NHS and agency staff. Similarly, the method is based on assumptions about the split between labour and non-labour costs in primary care, uses wages not total labour costs, and is based on England only data with proxies for the other countries.

4. A direct labour input measure

4.1 There are a number of options for calculating a direct labour input measure, each of which can be ranked along a continuum of conceptual correctness. The ranking, from lowest to highest is as follows.

4.1.1 Employment count: a straightforward measure of labour input and usually the easiest to obtain, but it does have some drawbacks: all workers are given the same weight regardless of whether they work full- or part-time.

4.1.2 Full-time equivalents (FTEs): preferred to a straight count measure as it takes into account the mix of full-time and part-time employment. An assumption is made about the relative input of part-time workers to full-time: commonly, that a part-time worker has a weight of one half that of a full-time worker.

4.1.3 Hours paid: improves on the FTE volume measure by not requiring an assumption about the relative input of part-time to full-time workers, but it does have some drawbacks: often workers are paid for a set number of hours, but it is common for workers to change the number of hours from week to week or work unpaid hours.

4.1.4 Actual hours worked: a more accurate measure of labour volume than hours paid. However, it treats hours worked by all individuals as equal, regardless of their 'quality'.

4.1.5 Quality-adjusted hours worked: the most accurate measure of labour volume is 'quality-adjusted' hours worked because differences among workers are explicitly recognised.

4.2 The next few sections discuss the most common measures in use in UK National Accounts and UKCeMGA productivity articles – full-time equivalents, actual hours worked and quality-adjusted hours worked.

4.2.1 **FTEs** or an employee year usually equals 2,080 hours, equivalent to working a 40 hour week for 52 weeks of the year, and includes all paid time such as overtime, vacation, holidays and sick leave. Part-time employees are usually converted to a full-time equivalent basis, pro rata to hours. Over time, this captures any shifts in working patterns. Any hours beyond the contracted week that are worked but not paid are not included. Conceptually, this time should be counted too because a measured productivity increase showing more output for the same input might actually reflect employees working more hours without remuneration, which is not a true productivity gain. Unless there is reason to suspect a significant change over time in work pressures and behaviours, this issue may not be important for analysis.

4.2.2 **Actual hours worked**, calculated as a sum of hours actually worked during normal periods of work plus overtime and any short periods of rest at work (for example, tea breaks). Ideally, the measure should exclude hours paid for but not worked, such as paid absences (annual leave, paid public holidays, paid sick leave); meal breaks; and time spent on travel from home to work and vice versa. While this measure is an improvement on the 'hours paid' volume measure, it does not include the quality of the labour input since the hours worked by all are treated as equal. Secondly, if data are measured on a sample from a particular week, it may not accurately reflect labour input, given that holidays and paid leave time may not be evenly distributed over the month.

4.2.3 **Quality-adjusted hours worked** are calculated as hours worked by workers at different skill levels, weighted together using expenditure on each of these categories. This is achieved by weighting hours worked/FTE within each job category by the average wages of the employees within that job category using information from surveys such as the ASHE survey and other job specific surveys (that is, DCSF data on teachers' earnings, NHS Earnings survey). Conceptually, this is an improved labour input method as it takes into account differences in quality, giving more

weight to units of relatively higher quality when aggregating units of labour input. However, it still does not differentiate between job categories. In doing this, changes in labour composition that affect output will be reflected in changes in labour contribution, and not as a change in productivity.

4.3 Constructing a direct labour input

4.3.1 Constructing a direct labour input measure requires up-to-date data on the number of full time equivalents or preferably actual hours worked, average earnings or specific information on compensation. A simple representation of a direct labour Laspeyres equation:

$$L_{t,t-1} = \sum_i w_{i,t-1}\left(\frac{h_{i,t}}{h_{i,t-1}}\right) \qquad (1)$$

Where

$w_{i,t-1}$ is the share that each type of labour occupies in total labour compensation.

$h_{i,t}$ represents the amount of actual hours worked in category *i* for year *t.*

4.3.2 From UKCeMGA's perspective, the selection of the appropriate direct input measure is dependent on the availability, coverage, and quality of the data available. In addition, a suitable time series of the sum of hours worked or the quality-adjusted measure of the hours worked is required. In the UK, there are a number of varied sources of this data. Table 2 in the Appendix provides a detailed summary of the various data sources both within ONS and externally. UKCeMGA uses data on FTEs directly from government departments: the Health and Social Care Information Centre (IC) for Health FTEs, Department of Children Schools and Families (DCSF) for Education FTEs, etc. The Labour Force Survey (LFS) provides extensive data on the number of people employed, earnings, and hours worked. As indicated in Table 2 in the Appendix, each of these data sources has its strengths and weaknesses. The impact of these various data sources on the attainment of quality-adjusted direct labour inputs are addressed in section 6.3 on quality adjusting labour.

5. Indirect labour input measures

5.1 An indirect labour input measure is produced by deflating expenditure on labour compensation using an appropriate wage index. This removes the effects of inflation/pay increases from expenditure and produces estimates of volume of labour inputs at constant prices, ideal for comparison of a direct volume of labour inputs over time. The simplest way of achieving this is to use a broad based deflator; however, a more accurate method would be to make use of a suite of deflators, specific to the components of labour expenditure – across sector, industry, job categories, etc.

5.2 Accounting for skill is important even in an indirect measure; otherwise, during deflation, it is automatically assumed that all year-on-year changes in price are due to inflation only. One of the Atkinson (2005) recommendations was to have sufficient disaggregation between types of labour to allow for changes in the input mix. That is a shift towards more highly skilled workers at higher earnings, or the reverse. As a result, the quality of the indirect estimates of labour inputs depends on the level of data disaggregation of both the labour force and deflators. This enables the development of high quality deflators but this must be in conjunction with a high-level expenditure breakdown on which the deflators will be applied. The criteria by which deflators are judged within ONS and UKCeMGA is provided by Atkinson (2005:72) – see Box 2.

Box 2: Quality criteria for deflators for government services		
Parameter	Description	Example
Comprehensiveness	The set of deflators should cover all components of expenditure to be deflated	UK expenditure should be deflated using UK, not just English deflators. Health deflators should cover the whole of the NHS not just hospitals
Coverage	The individual deflator should relate to all expenditure on the individual item to be deflated	Deflators for labour expenditure should cover NI contributions and pensions as well as earnings
Relevance	The deflator should correspond to the expenditure item to be deflated	
Sustainability	The deflator should be available for the foreseeable future and for a reasonable number of periods in the past	
Homogeneity	Deflation should be carried out at a level of disaggregation that maximises homogeneity of items within category	Significant differences in the movement of pay between staff grades would suggest that separate deflators are needed
Timeliness	The deflator should be available in good time after the end of the reference period	Estimating for missing periods may introduce bias
Periodicity	The deflator should be available on a quarterly basis	Annual figures may be satisfactory but only where there is evidence of insignificant short term change
Quality change	Where changes in characteristics of a good/service occur, price indices should reflect pure price changes only	
Availability of cost weights	Corresponding weights (of the same periodicity) for deflators should also be available	

Source: Atkinson (2005:72)

5.3 Constructing an indirect labour input

5.3.1 Constructing an indirect labour input measure requires expenditure on labour compensation by function (that is, Health) and a further breakdown by sub-function (Hospital services and Public health services), share of expenditure on staff categories by occupation in order to calculate the weights, and the average wage of each occupational

category, in order to calculate deflators specific to these categories. A simple representation of how the health indirect labour deflator is calculated is given below:

$$\frac{\sum \exp_{ti}}{\sum \left(\frac{\exp_{ti}}{def_{ti}} \right)} \qquad (2)$$

Where:

$\exp$ - England expenditure on category *i*

def - deflator specific to category *i*

t - time

i - occupational (sub-function) category

For each function or sub-function of expenditure, we deflate expenditure by the appropriate index for the same year. This is followed by an aggregation of the original (current price) expenditure and similarly an aggregation of deflated (constant price) expenditure. The next step is to divide the aggregated current price expenditure by the aggregated deflated constant price expenditure to produce an implied deflator. This implied deflator for England is then used to deflate UK current price labour expenditure. This is not ideal as it is possible that wage costs move differently in different parts of the UK.

5.3.2 For UKCeMGA's purposes of estimating public sector productivity, a breakdown of public sector expenditure is available in the National Accounts or, where more disaggregated information is needed, is obtained from government departments (for example, teacher salary data from DCSF). There are a number of broad sources of information on deflators. Data from the Annual Survey of Hours and Earnings (ASHE), Monthly Wages and Salary Survey (MWSS), Labour Force Survey (LFS), Quarterly Public Sector Employees Survey (QPSES), etc can be used to construct specific deflators from the earnings data collected. As indicated in Table 2 in the Appendix, each of these data sources has its strengths and weaknesses. The impact of these various data sources on the attainment of quality-adjusted direct labour inputs is addressed in the next section of this paper.

5.4 Comparing the two approaches

5.4.1 The selection of the appropriate labour input measure is dependent on the availability of the requisite data for each method. Productivity analysts prefer direct measures as wage indexes (indirect methods) are viewed as less reliable (OECD 2001). However, the direct method requires detailed information on staff numbers, hours worked or hours paid, which may be difficult to obtain. The indirect approach is easier to calculate since no additional data is required if appropriate deflators are available. However, accurate deflators also depend on the availability of disaggregated data.

5.4.2 The key, in either method, is to account for the heterogeneity of labour. Over time the composition of the labour force changes, which can be regarded as an increase or decrease in the average quality of labour input. For example, if a body contracts out functions with relatively low labour cost such as security and cleaning staff, retaining highly skilled staff such as accountants, the average quality of employed staff has risen (with equivalent security services now forming part of intermediate consumption rather than labour). Either method for measuring labour inputs should be sensitive to the possibility of such changes. Accounting for compositional changes of labour is important for a number of reasons: (i) it provides an accurate indication of the contribution of labour to production and (ii) the comparison of the adjusted and unadjusted estimates of labour input will illustrate how the compositional changes affect the productivity estimates. The next section provides a discussion on the various approaches to estimating quality-adjusted labour input.

6. Quality of labour inputs

6.1 This section of the paper deals with the various approaches to quality adjusting labour inputs and describes, with examples, the current methods used by UKCeMGA in the production of its productivity estimates of the UK public services.

6.2 Importance

6.2.1 The importance of accounting for quality within labour inputs has been extensively debated in the literature. Denison (1967) augmented labour input to reflect differences in the quality of labour by adjusting total employment for hours worked, age-sex composition, and level of

education. Jorgenson and Griliches (1967) showed that a substantial fraction of the Solow residual[7] could be explained by changes in the quality of labour inputs – growth accounting[i]. This allows us to better understand the factors that determine overall changes in productivity. The US Bureau of Labour Statistics (1993) used a regression approach to identify the impact of particular sources of change on labour composition.

6.2.2 More recently, the importance of labour quality has come to the fore given the widespread use of ICT capital and the increased investment in complimentary assets (including skills) to aid diffusion (O'Mahony et al 2005). O'Mahony and Vecchi (2005) argue that part of this complementary investment includes investment in labour force skills; therefore an evaluation of labour quality is a prerequisite if we are to distinguish between returns to ICT capital and returns to labour input. Jorgenson et al (2005) emphasise this further by asserting that both investments in ICT capital and education are key sources of growth at both economy and industry levels. Fosgerau et al (2001) have cited the growth in educational attainment across the developed world as a key driver for understanding and accounting for the quality of labour inputs. In addition, some have argued that for accurate cross-country productivity growth comparisons to be made, it is imperative that labour quality is incorporated into the growth accounting framework (Melka and Nayman 2004).

6.2.3 The European System of Accounts (1995:10.54) defines the quantity of employee labour as 'an hour's work for a given type and level of skill'. This definition, however, does not specify what types and levels have to be distinguished – that is education level, type of job, level of compensation, grade, etc – each of which may produce a different estimate of the labour input. The challenge here is how to define skill and hence how it can be measured. Eurostat (2001) offers a possible definition:

> The skill of a labour input reflects the physical and mental ability that an employee brings to a particular job.

There are two points of note with reference to this definition: (i) the definition of skill is specifically related to the job undertaken and (ii) the level of skill does not measure how much effort has been expended by a

[7] The Solow residual is a number describing empirical productivity growth in an economy from year to year and decade to decade – see endnote i

particular employee. Therefore, given the difficulty in defining a true measure of skill, a solution would involve a combination of measures that could best approximate the definition. Various options are discussed in the later sections of this paper.

6.2.4 The task for productivity analysts is to gauge the contribution to changes in aggregate output brought about by changes in human capital or the quality of labour inputs. This means accounting for differences in the quality of hours worked by different types of employees, and accounting for these separately when formulating productivity measures. For example, one hour worked by a new employee is not going to be of the same quality as one hour worked by someone with years of experience in the job (unless perhaps the new employee has significantly higher relevant qualifications). There might also be a change in the composition of the labour force over time - more qualified workers might be employed or existing workers might increase their skill by gaining more qualifications. If higher skilled employees are employed, then the total number of FTE workers or hours worked would not increase, but in volume terms the actual labour inputs have increased.

6.2.5 Labour compositional changes show the growth in labour input that is not attributable to the growth in hours worked; that is, the growth in labour input as a result of an increase in the education or experience of the workforce. Therefore the growth in labour composition can be derived as the growth in labour input minus the growth in hours worked. Consequently, an increase in the quality of labour over time would mean that a quality-adjusted labour input would rise faster than an unadjusted measure of labour input. For example, within the UK Education sector, the number of support staff doubled between 1996 and 2006 and this growth was significantly above that of teachers (ONS 2007). Failing to account for quality would result in the contribution of support staff being considered on a par with that of teachers. Hence they should be weighted by their respective relative pay to account for differences in skills.

6.3 Approaches to quality adjusting labour

6.3.1 From the literature there have been different approaches to quality adjusting labour input. The differences between these approaches are closely related to how **skills** are measured. One approach is to capture differences in labour input by looking at the differentiating characteristics of the labour force such as age, gender, class of worker, occupation or

education and cross-classify labour input by industry – the Jorgenson approach. The other option is to limit the number of differentiating characteristics so as to reduce the number of interaction effects between them. This is the approach adopted by the US Bureau of Labour Statistics (BLS) in which labour input is cross-classified by education and work experience. Alternatively, we could assume a direct relationship between skills and occupations, rank occupations by skills intensity and then derive differentiated measures of labour input. This is the approach taken by OECD (1998) and Lavoie and Roy (1998), and has been adopted as the current UKCeMGA approach. These three approaches are discussed in detail below.

6.3.2 The Jorgensen approach as described in his various collaborations (Jorgensen et al 1987 and Ho and Jorgenson 1999), closely mirrors the BLS approach except it uses as many as six characteristics to cross-classify labour. Jorgenson differentiates the number of hours worked into n types of workers ($h_1 \rightarrow h_n$) according to their characteristics (age, education, class of worker, gender, occupation, and industry) - the vector of variables that would be used as explanatory variables in the BLS method. Hours worked are disaggregated according to these characteristics in order to account for labour quality and to provide a measure of labour services. Labour services are derived from the aggregation of the growth rate of the hours worked, classified with reference to the above characteristics, with weights determined by the compensation share of each type of labour. Labour quality is indicated by the difference between labour services and the growth rates of the hours worked. Additionally, Baldassarini and Veroli (2007) note that the decomposition of the overall quality index into the contributions of its determinants provides some insights into the factors explaining changes in labour quality growth. On the contrary, some of characteristics might be correlated and, thus, the labour composition measure would reflect both the direct contribution of these characteristics to output growth and the interaction effect between them.

6.3.3 The BLS approach is premised on the notion that each worker possesses a unique set of skills that are matched in varying degrees to a firm's needs (Dean and Harper 2001). Labour hours are differentiated to account for some of the primary differences in skills among workers, in particular in those areas where these differences can be captured either as differences in the level of education or the number of years of work

experience. Information on the earnings of labour, more specifically the prices of different types of labour, is used to provide weights for combining differentiated labour inputs. The assumption is that factor inputs are paid the values of their marginal products[ii]. This takes into account Mincer's (1974) work on Human Capital with regard to the relationship between earnings and education/training. The framework recognises skills as the ultimate source of worker productivity and any investment (in skills) yields a direct relationship between earnings and education/training. Hence, Dean and Harper (2001) argue that because the labour input is inclusive of labour compositional changes, the BLS measures of labour productivity and MFP can be related directly to the compositional changes – a measure of the quality of labour.

6.3.4 **UKCeMGA's approach** as indicated earlier is based on the OECD interpretation of how skill could be included in a labour input measure. SNA 1993 (17.21) also provides similar guidance on how some level of quality can be included in a direct measure as indicated below:

> Alternatively, the data may also permit the direct approach of multiplying the current number of jobs in each job group by the base-period average annual compensation for jobs in that job group.

The approach taken assumes a direct relationship between skill and occupation, and ranks occupations by their skill intensity. Information on the occupational distribution of hours worked is then used to derive measures of labour input. Labour expenditure (compensation) is used to weight hours worked. The weighting goes some way towards accounting for 'quality' in the labour inputs, based on the assumption that highly skilled workers will be paid more than unskilled workers.

6.3.5 Under competitive market conditions, wages will reflect the marginal productivity of workers of different types since they are free to move between jobs in search of wages that reflect their productivity. However, many public service occupations do not operate in a fully competitive market since they are employed by monopsony employers such as NHS hospitals whose budgets are constrained by public spending decisions and specific salary scales set by public sector Pay Review Bodies (PRB). As such, market forces my not have a significant influence of the salary scales adopted (the PRB system does take some account of wider market factors).

6.3.6 The debate over which factors are most significant in determining wage rates is ongoing and is not the focus of this paper. However, the next few sections focus on the importance of two of these factors – level of education and years of work experience – and, in so doing, their relevance as a measure of the skills of a labour force.

6.4 Level of education / experience (skills) as a determinant of wage rates

6.4.1 Reilly et al (2005) contend that Human Capital theory shows that there is a positive relationship between wage levels and years of work experience. The age–earnings profile is concave, reflecting the concept of diminishing returns relative to work experience, and the profile is determined by employees calculating the costs and benefits of further investment in human capital. Therefore, an employee nearing retirement may opt to reduce their investments because the marginal benefits of further education are beginning to be outweighed by the marginal costs. To explain the relationship between wages and education attainment, Reilly et al (2005) offer the Screening Model (SM) and the Multi-period Implicit Contract Model (MICM) as alternatives to the Human Capital Model (HCM).

6.4.2 In the SM, productivity is determined by innate ability (which is proxied by education). The assumption here is that employers do not have perfect information about potential employees' abilities and thus use the level of education to screen the most able people into the various jobs and wage categories. This suggests that ability rather than education or training is the main determinant of the wage rate but, given that it is difficult to price this innate ability, a person's level of education offers a close approximation of this ability (skill).

6.4.3 MICM in contrast contends that the age-earnings profile is not an accurate representation of the relationship between wages, productivity or skills. Rather it partly reflects a deferred payment implicitly contained within the employment contract, whereby the employee agrees to take a wage lower than their value of marginal product early on in their career in order to receive a wage greater than the value of their marginal product later on in their career. A reason often cited for a firm's unwillingness to pay an employee their marginal productivity is that, in order to reduce labour turnover, they prefer to pay lower wages in the beginning and higher wages later in a job spell (Lazear 1979). Due to a limited degree of

certainty about individual productivity values, early in their career, a young worker might wish to hedge their bets by accepting employment under a less favourable pay scheme than could be achieved with full awareness of their own productivity (Frank 1984). Despite the competing models (SM, MICM or HCM), the Human Capital Model has been widely adopted in estimating labour inputs by a wide range of statistical organisations (US Bureau of Labour Statistics; Australian Bureau of Statistics; and Statistics New Zealand) and has been supported by empirical evidence in the literature.

6.4.4 The main critique of this approach would be: how closely do wages truly reflect the quality of the labour input? Frank (1984) contends that wages depend on a number of characteristics: employee and firm characteristics, wage policies, and market in which the firm operates. Working on the assumption of a competitive market,[8] wages would be a good proxy for quality of labour, however, this assumption does not hold true in the real world. For example, firms may follow strict pay formulae based on education, experience and length of tenure, even when there are apparently very wide differences in productivity among individual workers who are alike with respect to the characteristics specified in the pay formula.

6.4.5 It is costly for firms to measure individual productivity effectively enough for these differences to be reflected in wages. Since employees are more risk averse than firms, they are less willing to move around different employers in search of wages that reflect their marginal productivity. Moreover, frictions within the labour market can also mean that wages are not an accurate reflection of an employee's productivity[iii]. One can thus argue that wages may not be a true reflection of workers' marginal productivity, particularly in the public sector.

6.5 Selection of a skills indicator (for direct / indirect measure)

6.5.1 There are both theoretical and practical difficulties with each of the possible skill measures. For example, the use of wage compensation as a proxy for skills will tend to reflect prevailing supply and demand conditions and, therefore, should only be seen as an approximate long-

[8] Which assumes that: (i) workers are homogeneous, (ii) firms have no buying power, (iii) there are no trade unions, (iv) the productivity of each worker can be clearly measured, (v) the supply of labour is perfectly elastic. etc.

term indicator for skill. Eurostat (2001:77) therefore, offer the following guideline in the selection of the appropriate indicator for skill:

> Given the difficulties with job-specificity and the need to specify a harmonised approach the recommendation of this manual is therefore to use occupation as the variable to adjust labour hours for skill, unless it can be shown that education and occupation are strongly correlated, in which case education could be used as an indicator.

Quality in a direct labour measure

6.5.2 Accounting for quality in direct labour methods involves a direct measurement of the quantity of labour using either actual hours worked, hours paid, or full-time equivalent number of employees broken down by type of employee. The next step is to find a method that reflects the skill levels of employees so that the labour input data can be weighted appropriately and changes in the mix of skills over time can be reflected as a volume change. Box 3 offers a brief definition of the various skills parameter or variables.

6.5.3 Eurostat (2001) offers the Wage Rate (WR) method as a way of constructing a direct labour quality-adjusted index. The method requires the workforce to be classified into a number of different categories of employee. The hourly wage rate based on an official or industry-level rate is used for each category. Weighting is done using the wages for the category in the current year to obtain a Paasche-type index and, if a sufficient level of detail is available, a Laspeyres-type index can be calculated.

6.5.4 The WR method defines the price/volume decomposition in such a way that if a price change is not specified in the wage rate change for a certain category, it will end up in the volume component (Eurostat 2001). The method is ideally suited to industries or sectors of the economy where there are collective bargaining agreements that set common wage rates for large groups of employees. The method assumes that the collective wage increases give an indication of the actual changes in the price of labour, while all other wage increases are related to performance and hence are included in the volume component.

Box 3: Defining skills parameters

Level of Education: Education is used as a proxy for skill and is measured by the highest qualification attained. Holmwood et al (2005) suggest that the more educational categories included, the more effective the quality adjustment. The main concern with using this breakdown is that academic skills are given greater weight, and these may be less important amongst more experienced workers (Eurostat 2001).

Occupation: Using various labour force and structural earnings surveys, we can distinguish between different kinds of workers in the same industry.

Salary: Based on the rationale that workers with greater skills can command higher salaries with the assumption that there are no distortions or rigidities in the labour market that could cause relative salaries to imperfectly reflect relative skills (see the arguments outlined in sections 4.6 and 4.7).

Grade: Ideally suited for those organisations or sectors where there is a common, established career structure. A good example is the public service sector, where there is often a common grading structure across the service. Grade is often closely linked with salary, so similar results might be expected to using salary as a skill indicator.

Age groups: Taken as a proxy for work experience as older workers are thought to be more productive due to their greater level of work experience. Holmwood et al (2005) suggest that younger workers can be more creative and dynamic than their older colleagues provided that labour markets are competitive; then they should be paid their marginal productivity and hours will be weighted accordingly. The Australian Bureau of Statistics prefer to model experience as current age less five formative years less the number of years spent in education (Reilly et al 2005). A further adjustment is made for women to allow for the number of children that they have. This is probably a better proxy for work experience rather than just using age.

Gender: Included as a characteristic due to pay differences that remain between men and women. By examining hourly earnings excluding overtime for full-time employees, ONS (2007) analysis of the ASHE survey finds that the gender pay gap was 17.4 per cent in 1997 which has since narrowed to 12.6 per cent in 2007. The choice of gender as a variable also represents characteristics such as increased tendency for women to take career breaks.

Industries: To account for differences in skill between industries

Compiled from: Eurostat (2001), Holmwood et al (2005) Reilly et al (2005), ONS (2007)

Quality in an indirect labour measure

6.5.5 If there is insufficient or limited disaggregation of data on the hours worked, hours paid, or number of FTEs, then the alternative is to use an indirect approach to labour input estimation; that is, to use wage indices to deflate the value of wages and salaries. For these wage indices to offer some level of quality adjustment, they would have to meet some criteria: they should be broken down in sufficient detail to provide a deflator for groups of staff of homogenous skill. This presents some difficulty, given the structure of the labour market. Eurostat (2001) offers the Average

Wage (AW) method as a way of constructing an indirect labour quality-adjusted index.

6.5.6 The AW method uses average wages for categories of employee, based on the assumption that the total number of hours worked is not available. The starting point is an exhaustive set of data on numbers of employees and their salaries, in a detailed breakdown of grades and activities. The average wage increase per employee is determined for each of the detailed categories of employees, so that the wages of each category can be deflated separately. The breakdown into price and volume is implicit in the classification of grades, activities, etc, and the detail of those classifications. Shifts between the categories are reflected in the volume component, while wage increases within categories are included in the price component (Eurostat 2001). Consequently, the coverage of the volume component is increased when a more detailed stratification is used. The method is much more data-intensive than the WR method, and is most applicable to deflating the wages and salaries of government employees (Eurostat 2001).

7. Measuring the quality of labour inputs in Education

7.1 The Public Service Productivity Article: Education (2007) explored a direct measure of labour inputs as an alternative to the published indirect labour measure described in section 3.2. The new measure was intended to improve the capture of changes in the volume of labour by using a more detailed breakdown of staff numbers and salaries. While it did so, it did not take account of actual hours worked. This was of particular concern in the Education sector due to rapid growth in the number of support staff from the late 1990s onwards, a change which was thought likely to have been at least partly offset by a reduction in teachers' working hours. As a result, the indirect labour measure was retained within the overall input calculation.

7.1.1. The revised direct measure addresses the hours issue by adjusting teaching staff numbers by their actual working hours, and shows that an offsetting effect did in fact occur: between 1996 and 2007, support staff numbers more than doubled while the average teacher worked around 2 per cent fewer hours per week. In chained volume terms, with the revisions, the direct measure of education labour input growth over this period falls from 24.1 per cent to 22.5 per cent once teachers' working hours are taken into account. More detail of the new method follows.

7.2. Revised direct labour measure for Education inputs

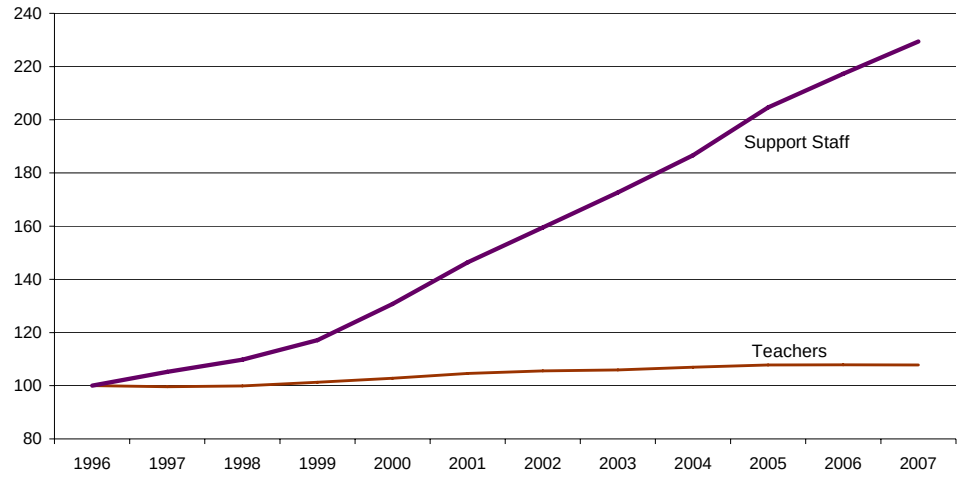
7.2.1 Recent government policies and reforms have aimed to reduce unpaid overtime worked by teachers by increasing support staff[9]. This is not the only purpose of employing extra support staff; numbers began to increase in the mid-1990s. On an academic year basis, support staff numbers in the UK are estimated to have risen by 229.4 per cent between 1996 and 2007. Figure 1 shows the trends in support staff and teacher numbers over this period.

Figure 1: Index of Teachers and support staff numbers [1, 2] in the UK

United Kingdom

1996=100

Index Numbers



[1] Academic year basis

[2] NI figures are estimated

Sources: DCSF, SG, WAG, DENI

7.2.2 The revised direct labour measure takes account of this issue by accounting for teachers' paid and unpaid working hours, using data from the Office for Manpower and Economics (OME) Teachers' Workloads Survey.

7.2.3 The Teachers' Workloads Survey provides independently collected data on the hours and working patterns of around 2000 randomly selected teachers in primary, secondary and special schools in England and Wales who returned useable questionnaires. The survey uses a multistage

[9] For example, 'Raising Standards and Tackling Workload: a National Agreement', introduced by DfES in 2003

stratified random sample, drawn from a comprehensive listing of all schools in England and Wales provided by the Department for Children, Schools and Families (DCSF) and the Welsh Assembly Government (WAG). There have been eight surveys to date examining teachers' workloads, carried out in 1994, 1996, 2000, and annually from 2003.

7.2.4 The survey is completed by teachers during a single week in March and may not necessarily provide an accurate guide to the working patterns in other weeks of the year, but the week selected is generally felt to be representative of typical term-time weeks. The survey has average total hours broken down by school type (primary, secondary and special school) and staff type (head teachers, deputy heads, heads of department and classroom teachers).

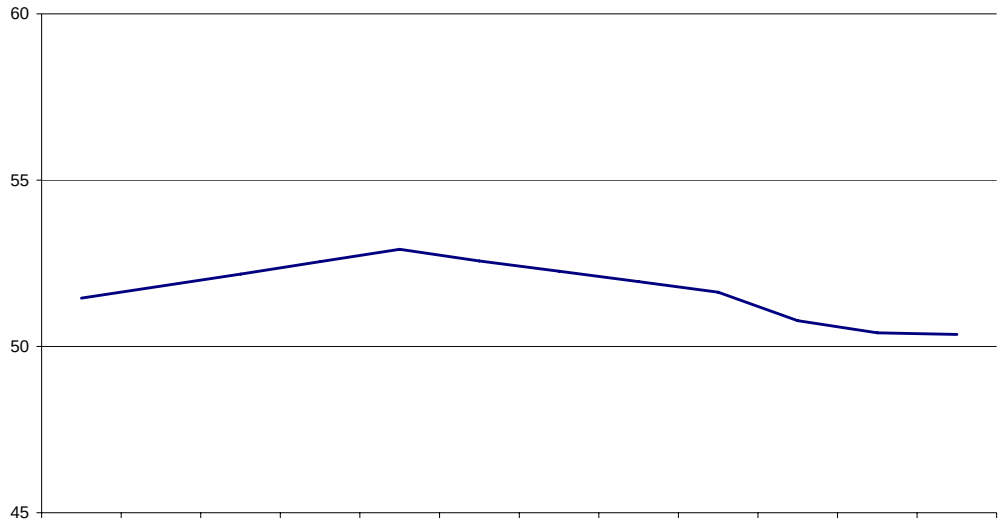
7.2.5 Figure 2 shows the pattern of teachers' working hours from 1996 to 2007. Average teachers' working hours increased from 51.5 hours to 52.9 hours during the period 1996 to 2000 then fell to 50.4 hours in 2007, a fall of 2.1 per cent over the whole period.

7.3 The revised direct labour measure also incorporates two further methodological improvements. Firstly, it uses regional full-time equivalent staff data for teachers for England, Scotland, Wales and Northern Ireland and full-time equivalent support staff data for England, Scotland and Wales, broken down by type of institution and teacher level where possible; the method previously presented covered England and Scotland only and aggregated by type of institution only. Secondly, it uses lower-level salary data to weight region-specific salary data which is then used to weight support staff, whereas the previous measure used UK figures.

Figure 2: Average teachers' working hours for England and Wales

England and Wales

Hours



Source: OME

7.4 The assumption made in the direct labour measure is that salary is a proxy for skill; salary data is used in the weighting of staff categories to account for skill level. For the proposed measure, salary data has been differentiated by staff type and school type for England and Wales. The source of the salary data for England and Wales is DCSF data on teacher earnings. England and Wales teachers' full-time equivalent staff numbers and average salary data were available in the following staff categories: head teachers, deputy heads and classroom teachers and these were further differentiated by school type: pre-school and primary, secondary schools and special schools. This detailed breakdown was not available as time series for Scotland or Northern Ireland so staff were categorised into pre-school and primary school teachers, secondary teachers and special teachers and weighted for skill using Annual Survey of Hours and Earnings (ASHE) data for pre-school and primary professionals, secondary professionals and special school professionals. As with staff data, where necessary salary data provided on an academic year have been adjusted to a calendar year basis.

7.5 For full-time equivalent support staff in England and Wales it was possible to identify specific staff groups, for example teaching assistants, administrative staff and technicians. In some cases these categories have been further differentiated. ASHE data was used to weight the different

support staff categories. For Scotland this breakdown was not possible so, instead, total support staff numbers were used and weighted using ASHE data for support staff categories. No support staff data were available for Northern Ireland therefore the direct labour index for support staff in Wales was used as a proxy.

7.6 The ASHE data used in this method is country specific - with the exception of a few categories for support staff where UK ASHE data was taken - to take account of regional differences in average wages. This improves on the previous direct labour method, in which UK average earnings data was used. The direct labour measure is calculated by combining individual country volume labour indices using expenditure weights for England, Scotland, Wales and Northern Ireland.

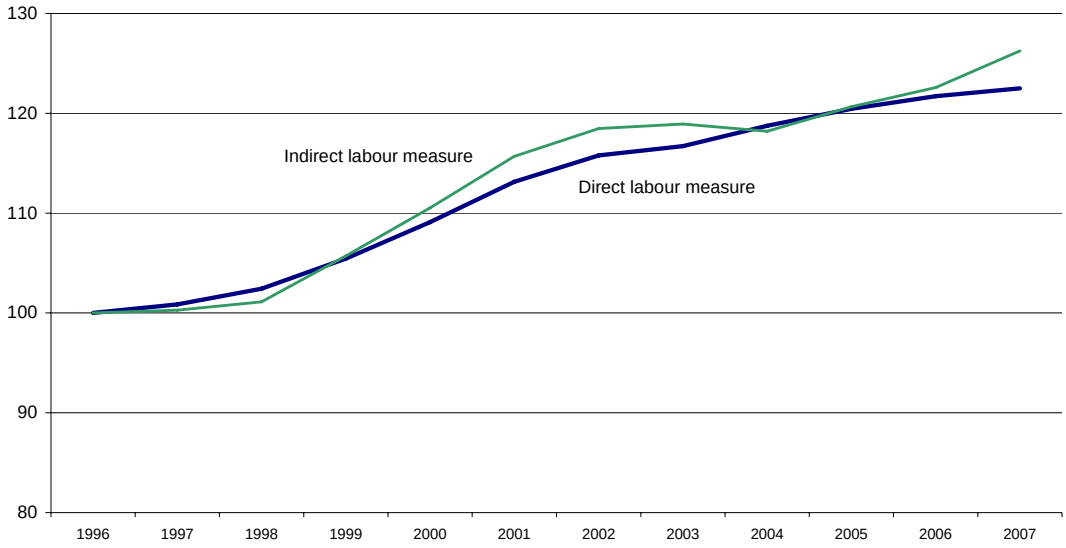
7.7 Revised direct measure versus published indirect measure

7.7.1 Using the direct measure, it is estimated that volume of education labour input in the UK increased by 22.5 per cent over the period 1996 to 2007, an average of 1.9 per cent each year. This compares with the indirect measure of education labour which had growth of 26.2 per cent, an average of 2.1 per cent each year, for the same period. Figure 3 compares the revised direct measure of labour input to the indirect labour measure used in the *Public Service Productivity Article: Education (2007)* showing also new data for 2007.

Figure 3: Comparison of indirect and new direct measure of labour input for Education

1996 = 100

Index Numbers



Source: ONS

7.7.2 Conceptually, an indirect and a direct measure should provide identical results if the same data sources are used. However, there are three key data differences between the revised direct labour measure and the previously published indirect measure:

- The direct measure shows lower growth than the indirect measure as it uses actual teachers' working hours for England and Wales, rather than paid hours worked. Actual working hours fell by 2.1 per cent between 1996 and 2007
- The direct measure accounts for skill level by using a finer breakdown of teaching staff salary data than the indirect measure, which uses average full-time equivalent staff remuneration to deflate expenditure on teachers
- The indirect measure for support staff does not take into account the different categories of support staff for each country as the composite ASHE deflator is based on England support staff categories only

7.8 Revised direct labour versus previously proposed direct measure

7.8.1 The previous direct labour measure, outlined in 2007, used data spanning from 1996 to 2006. Over this period, the volume of direct labour on the revised method increased by 21.7 per cent for the period 1996 to 2006 compared to growth of 24.0 per cent on the previous measure (Figure 4). Around half of the difference is attributable to the inclusion of teachers' working hours, with the remainder resulting from the use of more detailed staff number and salary data and their conversion from academic to calendar years where appropriate.

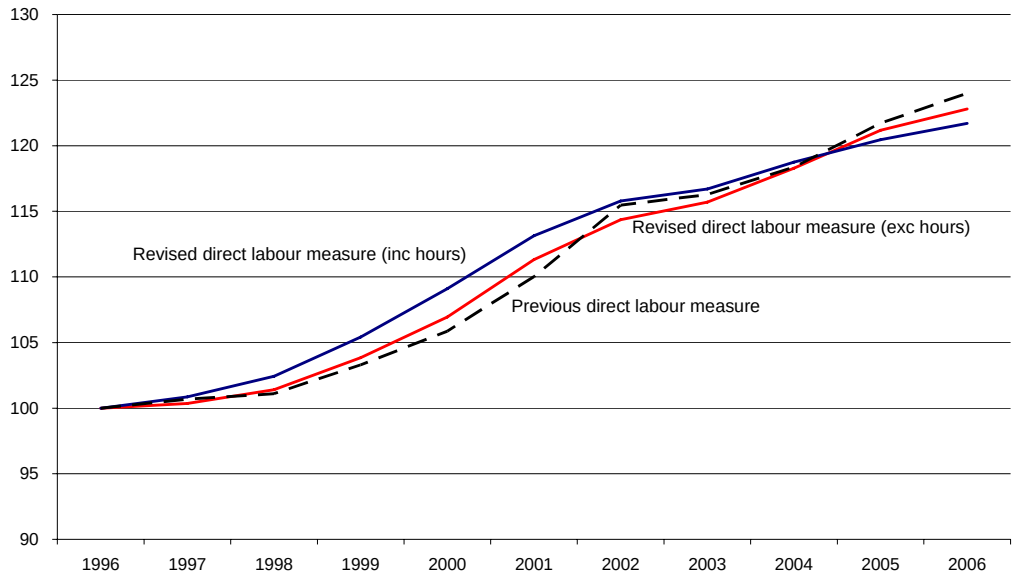
7.9 In conclusion, the revised direct labour measure addresses the main concerns with the previous method, by taking account of teachers' working hours in England and Wales, by using more detailed data on staff numbers and salaries, and by broadening coverage from England and Scotland only to a UK-wide basis. However, a number of measurement issues still remain that could be resolved in future should data become available:

- The Teachers' Workload Survey only covers England and Wales. There is not an equivalent survey conducted in Scotland or Northern Ireland, therefore the measures for these countries are based on full-time equivalent staff numbers only
- Using average salary to account for skill level may not truly reflect the level of skill as the assumption made is that higher wages reflect higher skills, which may not be completely accurate within the publicly-funded education sector
- As there are no data for support staff numbers in Northern Ireland, Wales was used as a proxy. However, the two education systems are different and there could be over- or underestimation for support staff for Northern Ireland
- For Scotland, a consistent time series showing the breakdown between support staff categories was not available for full-time equivalent staff numbers

Figure 4: Comparison of revised and previous direct labour measures for Education

1996 = 100

Index Numbers



Source: ONS

8. Conclusion and Next Steps

UKCeMGA is taking forward other work to address some of the issues highlighted in this paper.

8.1 Defence labour inputs

8.1.1 The recently published *Defence Scoping Paper* outlines the proposed changes to improving the current direct and indirect labour input measures. The proposed direct measures will break down FTE staff into 'service and civilian personnel by rank/grade, weighted by wage; or service personnel by trade, weighted by Job Evaluation Scores[10], and civilian personnel weighted by wage' (ONS 2008a). The proposed indirect measure will split defence labour expenditure into service and civilian personnel, which will be further broken down by rank or grade respectively for the service or civilian personnel and then deflated using rank or grade specific pay indices (ONS 2008a).

8.1.2 The changes have been made possible by the combination of varied sources of data from the MoD - Defence Analytical Services and Advice

[10] Job Evaluation (JE) Scores are used by the Armed Forces to ensure service personnel are assigned into a particular pay band (ONS 2008a).

(DASA) on the number of FTEs for civilian staff by grade, average service pay by rank, service strength by rank and a military salary index. Additional data from ONS surveys such as the Index for Labour Cost per Hour (ILCH) for Public Administration and Defence (PAD) and the Annual Civil Service Employment Survey for median civilian staff salaried for the MoD by grade. In both cases, the proposed changes offer a significant improvement from the National Accounts measure outlined in section 3.3.1 of this paper. The *Defence Scoping Paper* also highlights two potential issues that still need to be addressed: (i) treatment of reservist payments and (ii) special allowances paid to service personnel on active deployment (see ONS 2008a pg 12).

8.2 Police labour inputs

The proposed improvements to the police labour input measure are mainly focused on the improvement to the method of deflation. There are two possible deflators: one based on Office Manpower Economics (OME) average pay based on a sample of police forces in England and Wales, and the other based on average earnings from the ASHE. So far, the best measure is that using the OME deflator as it is based on a more detailed breakdown of average salary which thus introduces some element of quality (breakdown based on ranks and occupation grade). A direct measure is also planned, using data on police service strengths FTEs from the Home Office. Together with the new data from the OME on the average pay of police forces in England and Wales by rank, it is possible to estimate a new direct labour inputs measure. The forthcoming publication on police inputs will outline the changes to both methods.

8.3 Health labour inputs

Development work on health care labour inputs in the future will include work on increasing the number of categories of labour, quality adjusting categories of labour and increasing coverage by obtaining data from Scotland and Northern Ireland. It may be possible to include the number of categories for later years using data already available from current sources - NHS Staff Earnings Survey and NHS Staff Census. It may also be possible to obtain more highly differentiated categories from other sources such as the Labour Force Survey. Quality adjusting labour categories would necessitate not only having data on variables such as experience but also estimating the marginal impact of these variables on labour quality. Receiving data from Scotland and Northern Ireland will

depend on collections in those countries and co-operating with the work programme of the governments there.

8.4 Way forward

8.4.1 In concluding, the choice between the direct or indirect measures of labour and the quality of labour input is dictated by the availability of data to support either measure. The ideal requires data on total number of hours, disaggregated by the skill level composition of labour. Categories in the labour force should be distinguished by occupation, experience, age, level of education, and industry for use in making appropriate adjustments for quality differences in the labour input. Alternatively, where a direct measure is not available, a detailed breakdown of labour compensation expenditure either by occupation, grade, or class of worker and the subsequent development of relevant deflators to adjust the expenditure in the specified categories thus providing a quality adjusted indirect labour input measure.

8.4.2 This paper has outlined how labour inputs in productivity analysis can be measured, the various data sources for each method and a way in which measures of labour quality can be incorporated. It has also presented a new Education direct labour input estimate made possible by use of new data on teacher working hours from the Office of Manpower Economics. Going forward, there are a number of strands of work common to all areas of public sector productivity:

1. Detailed staff and earning figures for all four countries: England, Wales, Scotland, and Northern Ireland – this would improve coverage.
2. Improve function and country specific deflators for an indirect measure of labour.
3. Investigate the use of measures of labour quality (skill) other than occupation and, where possible, further breakdown of occupational categories; however, this may be limited by availability of a consistent time series.
4. Locate reliable time series data on actual hours worked (AHW).

End notes

[i] Growth accounting allows us to break down the growth of output into the growth of the factors of production – capital and labour, and the growth of the efficiency in the utilisation of these factors. The measurement of this efficiency is referred to as Total Factor Productivity (TPF). Consider a production function:

$$Y_t = A_t f(K_t, L_t)$$

Where: Y_t - aggregate output, K_t - the stock of physical capital, L_t - the labour force and A_t - represents TFP.

By taking natural logarithms and differentiating both sides with respect to time (t) the TFP growth is computed from the residual and referred to as the Solow residual. The Solow residual is a number describing empirical productivity growth in an economy from year to year and decade to decade. Robert Solow defined rising productivity as rising output with constant capital and labour input. It is a 'residual' because it is the part of growth that cannot be explained through capital accumulation.

[ii] The marginal product of labour (MPL) is the additional output produced by one more unit of labour with the marginal assumed to fall as long as all other inputs to production are held constant. In the neoclassical theory of competitive markets, the marginal product of labour equals the real wage, as wages are assumed to constitute the individual's reward for their personal contribution to output (Forth and O'Mahony 2003). In the market sector, a profit maximising firm will seek to equate marginal revenue and marginal cost all other things being equal. Changes to output may occur if workers raise their marginal product to account for wage increases. Additionally, an increase in marginal product may occur because of effort intensification (i.e. an increase in the quantity of labour unit per head or per hour) or an increase in the quality of labour input per head or per hour resulting from either better training or an investment in education. This concept underpins the debate on the importance of quality adjusting labour inputs in productivity analysis.

[iii] Other factors in play include:

- Geography - limits employees' willingness to travel in search of a wage that reflects a person's productivity
- Efficiency wages - an employer might pay an employee a wage above their equilibrium level as an extra incentive to work hard. The worker that is paid in excess may not be different to any other worker with the same ability and human capital investment who earns an equilibrium wage. The payment is an inducement to work more efficiently
- The pervasiveness of unions affects wages. Union workers earn approximately 20 per cent higher wages than comparable non-union workers, according to studies by Hirsch and Macpherson (2002), and Pierce (1999).

References

Atkinson, T., (2005), *Atkinson Review: Final Report*. (Basingstoke: Palgrave Macmillan)

Baldassarini, A., & N. Di Veroli, (2007), 'Labour Productivity: Comparative Measures and Quality Issues' *STATISTIKA* Vol 5, 347-367. Available at: http://panda.hyperlink.cz/cestapdf/pdf07c5/baldassarini.pdf

Black, M., M. Guy, & N. McLellan, (2003), 'Productivity in New Zealand: 1988 to 2002', *NZ Treasury Working Paper 03/06*, (June), New Zealand Treasury.

BLS (1993), 'Labour Composition and U.S. Productivity Growth, 1948-90', *Bulletin 2426,* U.S. Department of Labour - Bureau of Labour Statistics.

Dean, E.R., & M.J. Harper, (2001), 'The BLS Productivity Measurement Program' in C.R. Hulten, E.R.Dean, & M.J. Harper, *New Developments in Productivity Analysis : Studies in Income and Wealth: Volume 63* (NBER: University of Chicago Press).

Denison, E. F., (1967), Why Growth Rates Differ (Washington D.C.: The Brookings Institution).

Diewert, E., & D. Lawrence, (1999) 'Measuring new Zealand's Productivity' *Treasury Working Paper No 99/5, March*

ESA (1995) European System of Accounts; Chapter 11: Population and Labour Inputs. Available at: http://circa.europa.eu/irc/dsis/nfaccount/info/data/esa95/en/een00463.htm

Eurostat (2001), *Handbook on Price and Volume Measures in National Accounts* (Luxemburg: Eurostat)

Frank, R. H, (1984), 'Are Workers Paid Their Marginal Products?', *The American Economic Review,* Vol 74, No.4, 549-571.

Forth, J., & M.O'Mahony, (2003), 'The Impact of the National Minimum Wage on Labour Productivity and Unit Labour Costs': A Report to the Low Pay Commission. Available at: www.lowpay.gov.uk/lowpay/research/pdf/forth.pdf

Fosgerau, M., H. Jensen & A. Sorensen (2002), 'Measuring Educational Heterogeneity and Labour Quality: A note', *Review of Income and Wealth,* Vol 48 No2, 251-259.

Gallop, F.M., (1979), 'Accounting for Intermediate Input: The Link between Sectoral and Aggregate Measures of Productivity'. In *Measurement and Interpretation of Productivity*: pg 318-333 (Washington D.C.: National Academy of Sciences)

Gallop, F.M., (1981), 'Growth Accounting in an Open Economy', Boston College Department of Economics, Working Paper, March.

Hirsch, B. T., & D. A. Macpherson, (2002), *Union Membership and Earnings Data Book: Compilations from the Current Population Survey*. (Washington, D.C.: Bureau of National Affairs).

Ho, M.S., & D.W. Jorgenson, (1999). *'The Quality of the U.S. Work Force, 1948-1995'*, (Harvard University, Manuscript).

Holmwood, R., E, Lau, C. Richardson, & Wallis G (2005), 'An Experimental Quality-Adjusted Labour Input Measure', *Economic Trends* No. 624, pp 30–41. Available at: www.statistics.gov.uk/cci/article.asp?ID=1298

Hulten, C., E. Dean, & M. Harper, (2001), *New Developments in Productivity Analysis: Studies in Income and Wealth: Volume 63* (NBER: University of Chicago Press).

Jorgensen, D.W., & Z. Griliches, (1967)**,** 'The Explanation of Productivity Change' *Review of Economic Studies*, Vol. 34, No. 3: 249-283

Jorgenson, D. W., F. M. Gallop, & B. M. Fraumeni (1987), *'Productivity and U.S. Economic Growth'* (Cambridge, Harvard University Press).

Jorgenson, D.,Ho, M.S., & Stiroh, K.J. (2005), 'Growth of US Industries and Investments in Information Technology and Higher Education', in Corrado, C., Haltiwanger, J., & Sichel, D. (eds.) *Measuring Capital in a New Economy*. (Chicago: University of Chicago Press).

Lazear, E. P., (1979), 'Why is there Mandatory Retirement?' *Journal of Political Economy*, Vol 87, 1261-84.

Lavoie, M, & R. Roy (1998), *Employment in the Knowledge-Based Economy: A Growth Accounting Exercise for Canada*, Applied Research Branch, Human Resources Development Canada, R-98-8E.

Melka J. & Nayman L. (2006), 'Growth Accounting and Labour Quality in France, 1982-2001', In M. Mas & P. Schreyer, (eds.) *Growth, Capital and New Technologies* (Foundation BBVA).

Mincer, J., (1974), *Schooling, Experience and Earnings*, (New York: National Bureau of Economic Research).

National Academy of Sciences (1979), *Measurement and Interpretation of Productivity* (Washington D.C.: National Academy of Sciences)

OECD (1998), *The OECD Jobs Strategy - Technology, Productivity and Job Creation: Best Policy Practices* (Paris: OECD) Available at: www.oecd.org/dataoecd/39/28/2759012.pdf

OECD (2001), *Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth*, (Paris: OECD). Available at: www.oecd.org/dataoecd/59/29/2352458.pdf

O'Mahony, M., C. Robinson, & M. Vecchi, (2005), 'Heterogeneity of the Labour Input: Methodological Issues in Constructing Labour Quality Measures'. Paper presented at EUKLEMS consortium Meeting, Helsinki 9th -11th June 2005. Available at: www.euklems.net/meetings/CM_Helsinki/omahony_et_al_(2005).pdf

O'Mahony, M., & M. Vecchi, (2005), 'Quantifying the Impact of ICT on Output Growth: A Heterogeneous Dynamic Panel Approach', *Economica*, Vol 72, No 288, 615-633,

ONS (2006), *'Public Service Productivity: Social Security Administration'* (UK Centre for the Measurement of Government Activity). Available at: www.statistics.gov.uk/articles/nojournal/1596.pdf

ONS (2007), *'Public Service Productivity: Education'* (UK Centre for the Measurement of Government Activity). Available at: www.ons.gov.uk/about-statistics/ukcemga/publications home/publications/archive/public-service-productivity--education.pdf

ONS (2007), *The ONS Productivity Handbook: A Statistical Overview and Guide*, (Palgrave MacMillan, Basingstoke and New York).

ONS (2008a) *'Scoping Paper on Possible Improvements to Measurement of Defence in the UK National Accounts'* (UK Centre for the Measurement of Government Activity). Available at: www.statistics.gov.uk/articles/nojournal/Defence08v1.pdf

ONS (2008b), '*Criminal Justice System: Scoping Document*' (UK Centre for the Measurement of Government Activity). Available at: www.statistics.gov.uk/articles/nojournal/CriminalJusticeSystem_190308.pdf

ONS (2008c), *'Public Service Productivity: Social Security Administration'* (UK Centre for the Measurement of Government Activity). Available at: www.statistics.gov.uk/articles/nojournal/SSA.pdf

ONS (2008d), *'Public Service Productivity: Healthcare'* (UK Centre for the Measurement of Government Activity). Available at: www.statistics.gov.uk/articles/nojournal/HealthCare_290108.pdf

OME (2008) 'Teachers Workloads Dairy Survey' a report produced for The School Teachers' Review Body by The Office of Manpower Economics. Available at: www.ome.uk.com/downloads/2008%20Teachers%20Report%20FINAL.pdf

Pierce, B., (1999), 'Compensation Inequality' *Department of Labour, Working Paper No. 323* Office of Compensation and Working Conditions.

Reilly, R., W. Milne, S., Zhao, (2005), 'Quality Adjusted Labour Inputs', *ABS Research Paper No 1351.0.55.010*, (November) Australian Bureau of Statistics.

System of National Accounts (1993), Co-published with The European Commission, United Nations, International Monetary Fund (IMF). (New York: United Nations)

Appendix

Table 2: Sources of labour input data

Source	Description
Annual Survey of Hours and Earnings (ASHE)	ASHE provides information about the levels, distribution and make-up of earnings and hours paid for employees within industries, occupations and regions. The ASHE tables contain UK data on earnings for workers by sex and full-time/part-time workers. Further breakdowns include by region, occupation, industry, region by occupation and age groups. **Sample**: 142,000 employees **Strength**: A good source of information on employee wages collected from employers pay systems **Weakness**: Uses wages not total labour costs and categories of employees are not disaggregated to a low level. **Changes:** There has recently been a change in the sample size, with the 2007 ASHE being reduced by almost 20 per cent. The ASHE sample was cut by using an algorithm to apply either a 0 per cent, 10 per cent, 20 per cent or 30 per cent cut to each two digit industry. The cut was then made based on the digit preceding the 14 in the NI number. Northern Ireland, Special Arrangements and those employees new to the labour market were not cut. The biggest reductions were targeted on those industries that exhibited the least variation in their earnings patterns, resulting in the sample size being the same as it was back in the 1980s. The sample cut has a very small impact on the quality of highly aggregated figures. Automatic Occupational Coding is now being utilised by ASHE, which is used for assigning Standard Occupational Classification codes to ASHE. Automatic coding by text recognition can lead to an improvement in the quality and consistency of ASHE results.
Monthly Wages and Salary Survey	The Monthly Wages and Salary Survey (MWSS) is a survey conducted by the Office for National Statistics where commission, bonuses and pay award arrears are measured in addition to pay. It is used to construct the Average Earnings Index and experimental statistics such as Average Weekly Earnings (AWE) and the Index of Labour Costs per Hour (ILCH). **Sample**: 8,500 businesses in Great Britain, covering 11 million employees. **Strength**: It is a comprehensive measure of earnings across industry, collected from employers. **Weakness**: Absence of small employers.

Average Earnings Index	The AEI is the key indicator of how fast earnings, or pay, are growing in Great Britain. It measures how earnings in the latest month compare with those for the last base year when the index took the value of 100. The current base year is 2000. **Sample**: Based on information obtained from ONS Monthly Wages and Salaries Survey of 8,500 employers. **Strength**: Indices are published for the whole economy and public and private sector earnings. **Weakness**: It does not include information on occupation or hours worked. No adjustment is made for changes in hours worked, ie overtime. It was recommended by Martin Weale that ONS should replace AEI with AWE once some further work has been completed.
Labour Force Survey	The Labour Force Survey (LFS) is a quarterly sample survey of households living at private addresses in Great Britain. The survey seeks information on respondents' personal circumstances and their labour market status during a specific reference period, normally a period of one week or four weeks (depending on the topic) immediately prior to the interview. **Sample**: 60,000 households. **Strength**: A source of information on a number of characteristics, ie earnings, hours worked, educational attainment, employment info. **Weakness**: Self-classification of respondents. Proxy responses. **Changes**: The micro datasets have been weighted to the latest (2007/08) population estimates whereas previously they were based on population totals published in 2003. Users should also be aware that the underlying weighting methodology was changed for the 2007 re-weighting exercise, which is another factor that has contributed to changes in the re-weighted estimates. The raking ratio estimation method used prior to 2007 has been replaced with calibration weighting within a Generalised Regression (GREG) framework using the Statistics Canada Generalised Estimation System (GES). The change in methodology has had a minimal impact on estimates at higher levels of geography but changes may be apparent when estimates at lower levels (such as local authority) are examined. Due to differences in the population totals used and changes in the underlying weighting methodology adopted for the 2007 re-weighting project, estimates generated using the micro data published on 14 May 2008 should not be compared with those produced from micro datasets released prior to this date. An article describing the changes in the weighting methodology together with a detailed examination of the impact of re-weighting on key estimates at the local authority level was published in the Economic and Labour Market review in November 2008.

European Labour Cost Survey	As part of EU regulations, ONS produces a survey of labour costs once every four years. This is called the European Labour Cost Survey (ELCS). In the UK, estimates are produced by combining information from existing sources, the ASHE being the main source of information.
Whole of Government Accounts	A possible source of information for the future might be WGA, which are currently under construction. Their main benefits relate to improving capital measures however, as they are making departments more accountable for their figures by removing transfers between different departments of government. As a result more accurate and reliable figures relating to labour might also be produced.
The Information Centre for Health and Social Care	The IC is a special health authority that provides facts and figures to help the NHS and social services run effectively. It collects data from across the sector, analyses them, and convert them into useful information. **Sample**: The 2005/06 GP Earnings Expense Enquiry is based on a sample of 17,581 contracted GPs and 2,743 salaried GPs. The data source for the survey is HM Revenue and Customs tax self-assessment database. **Strength**: This is a useful source of information for the health team within UKCeMGA and was used for staff numbers in the NHS and to construct wage deflators for the General Practice Medical Service using information from the GP Earnings and Expense Enquiry. **Weakness**: Some elements of GP private work is included as well as NHS work.
Quarterly Public Sector Employees Survey	QPSES was introduced in 2004 and builds on the existing quarterly local authority survey (for England and Wales) by extending its coverage to include GB government departments, their agencies and public sector bodies. The variables for which data are being collected are the number of permanent/casual employees in full- and part-time jobs by the employee's sex. Information is required on both a headcount and full-time equivalent basis. **Coverage**: There are approximately 850 respondents to the survey in total. **Weakness**: For local government work there is still a degree of development work to be carried out to ensure full coverage.