

# Public service productivity estimates: Education

## 1. Summary

This note sets out the sources and methods used to construct estimates of productivity in publicly funded education, most recently presented in *Public service productivity estimates: Education 2010* ([ONS 2012a](#)).<sup>1</sup> It contains (a) a summary of the data sources employed, (b) a breakdown of how ONS calculates estimates of productivity in education, (c) a description of recent methodological changes, and (d) a discussion of the strengths and weaknesses of this approach.

At the most aggregate level, ONS estimates of education productivity are based on the ratio of output to inputs. Adopting  $p$ ,  $O$  and  $I$  to indicate productivity, output and inputs respectively, and including a subscript  $t$  for time-periods:

$$p_t = \frac{O_t}{I_t} \quad [1]$$

Estimates of the volume of education output are calculated using the number of students in several learning sectors. Data are gathered from Central government and the devolved administrations for nine different education services, including schools, the Higher Education training of teachers and health professionals and Further Education. Changes in the number of students in each sector are adjusted for absenteeism and quality, weighted by their share in aggregate education expenditure and converted into a single volume of education output series.

Estimates of the volume of education inputs are calculated using data on education expenditure and direct measures of school inputs. Data are gathered on (a) Labour input, (b) Goods & Services purchased by Central and Local government and (c) Capital services. As with education output, an aggregate index of inputs is produced by weighting the growth of each component by their respective share in aggregate education expenditure.

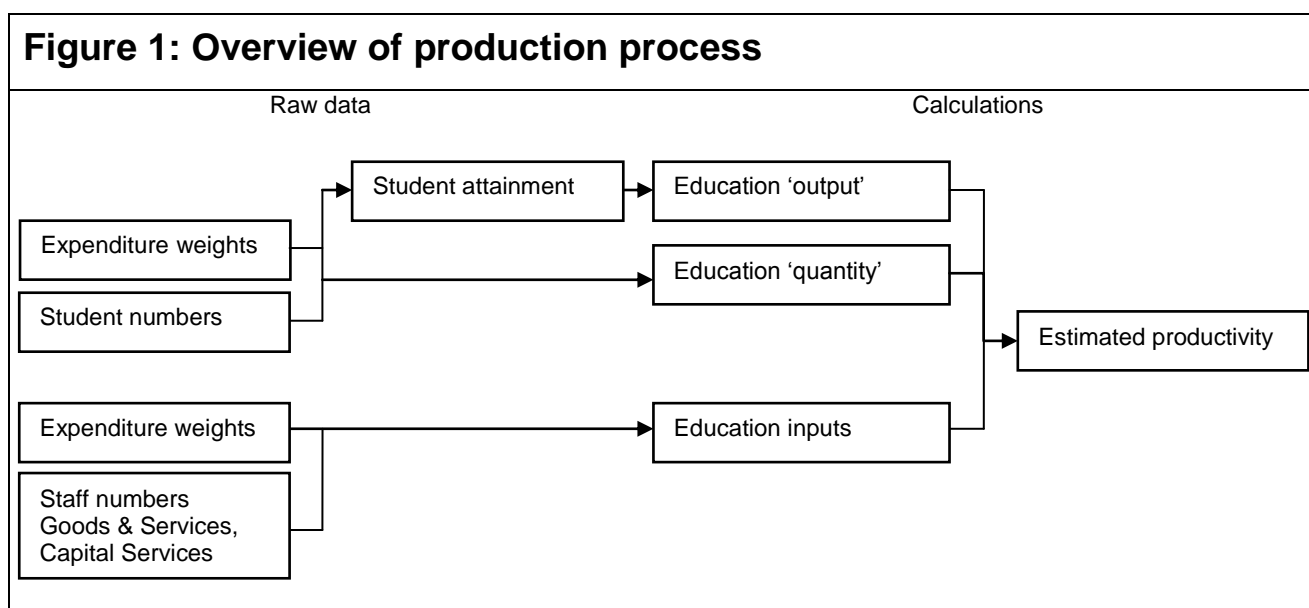
The methodology for calculating aggregate education inputs, output and productivity involves several stages. An overview of the process is provided in Figure 1.

In common with [ONS \(2012a\)](#), this note is focussed on measuring productivity in publicly-funded education. As a consequence, independent schools and Higher Education – other than the training

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<sup>1</sup> The remainder of this article will refer to the method ONS uses to calculate productivity in publicly funded education as [ONS \(2012a\)](#).

of teachers and some health professionals – are excluded from ONS estimates and fall outside the scope of this document.



The remainder of this note proceeds as follows. Section 2 presents the data and the methods used to calculate the quantity of delivered education. Section 3 outlines the data and methods used to quality-adjust measures of education quantity, both within the National Accounts framework and for the purposes of productivity estimates. Section 4 outlines the sources of data and the methods used to calculate measures of education inputs, while Section 5 offers a description of recent changes and improvements made to the calculation of both inputs and output. Section 6 presents a worked example of education productivity estimates, Section 7 discusses how this methodology meets user needs and Section 8 discusses the strengths and weaknesses of the [ONS \(2012a\)](#) approach, as well as setting out plans for future development.

## 2. Education output

ONS publishes two annual estimates of publicly-funded education delivered in the UK from 1996 onwards. The first of these – education ‘quantity’ – reflects changes in the numbers of students, attendance and their respective shares in aggregate expenditure. The second – education ‘output’ – adjusts the quantity series for changes in the quality of student outcomes. Both measures use data on student numbers and expenditure in nine educational sectors across England, Wales, Scotland and Northern Ireland to generate chained volume estimates of delivered education.

The sectors included in [ONS \(2012a\)](#) are all publicly-funded and comprise:

- Pre-schools
- Publicly funded Private, Voluntary and Independent (PVI) Pre-school places
- Primary schools

- Secondary schools
- Special schools
- City Technology Colleges and City Academies (CTCs and CAs)
- Further Education (FE)
- Higher Education training of Teachers (Initial Teacher Training (ITT)) and
- Higher Education training of Health Professionals

The coverage of [ONS \(2012a\)](#) broadly follows the treatment of education within the National Accounts methodological framework. The primary difference in coverage arises from the separate inclusion of Further Education. In [ONS \(2012a\)](#), FE is included as a stand-alone sector and includes all adult FE which is publicly funded. Within the National Accounts, the definition of education volume is to change due to a reclassification in 2010 to make FE expenditure a part of Central government expenditure ([ONS 2010](#)).

The measure of education quantity in [ONS \(2012a\)](#) is calculated using data on student numbers and expenditure in each of the nine sectors listed above. Table 1 provides information about the sources of these data. Further information is available in the [statement of administrative data sources](#).

**Table 1: Sources of education output data: 1996–2010**

	England	Wales	Scotland	Northern Ireland
<b>Schools</b>				
Students				DENI
Expenditure	DfE	WG	SG	-
Attainment				-
<b>Initial Teacher Training</b>				
Students	DfE	WG	SFC	DELNI
Expenditure				
<b>Health Professional Training</b>				
Students	DH	WG	SG	DHSSPSNI
Expenditure				
<b>Further Education</b>				
Students	The Data Service	LLWR	Infact	DELNI
Expenditure	LSC		SFC	-

**Notes:**

1 DfE: Department for Education, DH: Department for Health, WG: Welsh Government, SG: Scottish Government, LSC: Learning and Skills Council, LLWR: Life-long Learning Wales Record, SFC: Scottish Funding Council, DENI: Department of Education Northern Ireland, DELNI: Department for Employment and Learning Northern Ireland, DHSSPSNI: Department for Health, Social Services and Public Health.

2 Student data are provided on an academic year basis, while expenditure data are provided on a financial year basis. Data in academic and financial years are converted to calendar years by applying a cubic spline process.

The methodology used to produce estimates of non-market output is governed by [ESA \(1995\)](#), [SNA \(2008\)](#) and is set out in [Atkinson \(2005\)](#). As there is no effective price index for education, [ONS \(2012a\)](#) adopts a volume-based approach to education quantity, the methodology for which can be broken into several steps:

- 1 Time series data for England, Wales, Scotland and Northern Ireland are compiled examining (a) the number of students and (b) the level of expenditure in each educational sector. Pupil numbers in Primary, Secondary and Special schools, as well as CTCs and CAs is adjusted to account for student absence.
- 2 A chain-linked Laspeyres volume index of output is produced for each educational sector at a UK level such that:

$$l_{i,t} = l_{i,t-1} \cdot \left( \sum_j \left( \frac{a_{i,j,t} - a_{i,j,t-1}}{a_{i,j,t-1}} \cdot \frac{x_{i,j,t-1}}{\sum_j x_{i,j,t-1}} \right) + 1 \right) \quad [2]$$

where:

- $i, j$  and  $t$  index educational sectors, geographical areas and time respectively
  - $l_{i,t}$  is a chain-linked Laspeyres index of education quantity
  - $a_{i,j,t}$  is the number of students
  - $x_{i,j,t}$  is the level of expenditure in current price terms
  - output in the initial period,  $t=0$ , is set equal to 100
- 3 A UK-level, chain-linked Laspeyres volume index of education quantity is calculated using the individual sector indices and relative cost weights, such that:

$$L_t = L_{t-1} \cdot \left( \sum_i \left( \frac{l_{i,t} - l_{i,t-1}}{l_{i,t-1}} \cdot \frac{x_{i,t-1}}{\sum_i x_{i,t-1}} \right) + 1 \right) \quad [3]$$

where:

- $i$  and  $t$  index educational sectors and time respectively
- $L_t$  is a chain-linked aggregate UK Laspeyres index of education quantity
- $l_{i,t}$  is a chain-linked Laspeyres index of education quantity
- $x_{i,t}$  is the level of expenditure in current price terms
- output in the initial period,  $t=0$ , is set equal to 100

The result of this process is a chain-linked, UK-level, Laspeyres index of education quantity. There are several equivalent methods of generating this result. In particular, this approach is equivalent to first calculating the indices for geographical areas and then aggregating over educational sectors. Appendix A demonstrates that this approach is also equivalent to a methodology which weights activity by unit costs.

### 3. Quality-adjustment

Estimates of education quantity produced by [2] and [3] above reflect changes in the quantity of education delivered, but take no account of changes in the quality of education services provided. Following [ESA \(1995\)](#), [SNA \(2008\)](#) and [Atkinson \(2005\)](#), ONS incorporates additional steps to explicitly account for changes in the quality of provision in estimates of education output.<sup>2</sup>

In National Accounts methodology, output in Primary and Secondary schools, CTCs and CAs is adjusted upwards by 0.25 per cent each year to reflect changes in the quality of provision. This is based on historical improvements in General Certificate of Secondary Education (GCSE) exam scores in England.

In [ONS \(2012a\)](#), output in Primary and Secondary schools, CTCs and CAs is adjusted using the average point score (APS) per student in GCSE level examinations which are normally taken during the student's eleventh year of schooling. Education output in Scotland – where the Standard exams are taken in place of GCSEs – is quality-adjusted using the APS associated with these examinations. Growing average point scores are deemed to reflect greater scholastic attainment arising from improvements in the quality of education delivered.

The delivered quantity of Initial Teacher Training (ITT) courses is also adjusted for quality in [ONS \(2012a\)](#). In this case, the proportion of students who achieve Qualified Teacher Status (QTS) each year is used as a quality indicator.

As exam performance varies across geographical areas, the APS quality-adjustment is applied to Primary and Secondary school, CTC and CA output in each country separately. The APS at GCSE level for England and Wales are provided by the Department for Education and the Welsh Government respectively, while the APS associated with the Standard exams in Scotland are provided by the Scottish Government. For reasons of data comparability and availability, the level of education quantity in Primary and Secondary schools in Northern Ireland is quality-adjusted using the APS of English schools. ITT quantity in each geographical area of the UK is adjusted using the QTS award rate for England, which is also provided by the Department for Education. Here the implicit assumption is made that changes in quality in ITT in Wales, Scotland and Northern Ireland follows the trend in England.

Estimates of quality-adjusted output are produced in a similar manner to quantity measures of delivered education. As before, the process is carried out in several steps:

- 1 Time-series data are compiled using (a) the number of students, (b) the level of expenditure in each educational service and (c) the APS at GCSE level for England and Wales, the APS for Standard examinations in Scotland and the Initial Teacher Training QTS award rate in England. Attendance at Primary, Secondary and Special schools, as well as CTCs and CAs is adjusted to account for student absence.
- 2 The quality-adjustment measures for schools and ITT are converted into indices such that:

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<sup>2</sup> See [Atkinson \(2005\)](#) and [SNA \(2008\)](#) for a summary of the conceptual arguments surrounding the quality-adjustment of non-market services. See [ONS \(2012b\)](#) for a discussion of different methods of quality-adjustment.

$$q_{i,t} = q_{i,t-1} \cdot \left( \frac{APS_{i,j,t} - APS_{i,j,t-1}}{APS_{i,j,t-1}} \right) \quad [4]$$

As before,  $q_{i,t=0}=1$

- 3 A chain-linked Laspeyres volume index of quality-adjusted output is produced for each educational sector in such that:

$$l_{i,t}^Q = l_{i,t-1}^Q \cdot \left( \sum_j \left( \frac{a_{i,j,t} \cdot q_{i,t} - a_{i,j,t-1} \cdot q_{i,t-1}}{a_{i,j,t-1} \cdot q_{i,t-1}} \cdot \frac{x_{i,j,t-1}}{\sum_j x_{i,j,t-1}} \right) + 1 \right) \quad [5]$$

where:

- $i, j$  and  $t$  index educational sectors, geographical areas and time respectively
  - $l_{i,t}^Q$  is a chain-linked Laspeyres index of quality-adjusted education output
  - $a_{i,j,t}$  is the number of students
  - $q_{i,t}$  is the level of quality achieved in delivery
  - $x_{i,j,t}$  is the level of expenditure in current price terms
  - output in the initial period,  $t=0$ , is set equal to 100
  - for educational sectors which are not quality-adjusted,  $q_{i,t}=q_{i,t-1}=q_{i,t=0}=1$
- 4 As before, a UK-level, chain-linked Laspeyres volume index of quality-adjusted output is calculated using the individual sector indices and the relative cost weights, such that:

$$L_t^Q = L_{t-1}^Q \cdot \left( \sum_i \left( \frac{l_{i,t}^Q - l_{i,t-1}^Q}{l_{i,t-1}^Q} \cdot \frac{x_{i,t-1}}{\sum_i x_{i,t-1}} \right) + 1 \right) \quad [6]$$

where:

- $i$  and  $t$  index educational sectors and time respectively
- $L_t^Q$  is a chain-linked, aggregate UK, Laspeyres index of quality-adjusted education output
- $l_{i,t}^Q$  is a chain-linked Laspeyres index of quality-adjusted education output
- $x_{i,t}$  is the level of expenditure in current price terms
- output in the initial period,  $t=0$ , is set equal to 100

The use of the APS at GCSE level as a quality-adjustment has come under scrutiny in recent months. A discussion of the relative merits of this approach is included in [ONS \(2012b\)](#).

## 4. Education inputs

ONS publishes estimates of publicly-funded education inputs in the UK from 1996 onwards. The inputs index is an aggregate of three elements: Labour, Goods & Services and Capital, broken down by the accountable level of government as follows:

- Local authority Labour
- Central government Labour

- Local authority Goods & Services
- Central government Goods & Services
- Capital services

Changes in these elements are added together using their relative shares in total government expenditure on education, to form a chain-linked Laspeyres volume index. This is the same approach used to calculate the output series which is described in Section 2 above.

Table 2 provides information about the sources of data used in [ONS \(2012a\)](#). Further information is available in the [statement of administrative data sources](#).

**Table 2: Sources of education inputs data: 1996–2010**

Description	Source
<b>School Staff Numbers</b>	
England	Department for Education
Wales	Welsh Government
Scotland	Scottish Government
Northern Ireland (teaching staff only)	Department of Education Northern Ireland
<b>Teacher Hours &amp; Earnings</b>	
England & Wales	Department for Education
Scotland & Northern Ireland	ONS Annual Survey of Hours and Earnings
Earnings data for school support staff	ONS Annual Survey of Hours and Earnings
<b>Labour, Goods &amp; Services &amp; Capital Expenditure</b>	
Local authority Labour expenditure	Expenditure: ONS National Accounts Deflator: ONS National Accounts
Central government Labour expenditure	Expenditure: ONS National Accounts Deflator: ONS Average Earnings Index (public sector/education)
Goods & Services expenditure incurred by Local Authorities	Expenditure: ONS National Accounts, Deflator: Derived from s251 LA expenditure summary (England)
Goods & Services expenditure incurred by Central government	Expenditure: ONS National Accounts Deflator: Composite derived from ONS National Accounts
Capital services	ONS Volume Index of Capital Services

Notes:

1 LA: Local Authority

2 Data in academic and financial years are converted to calendar years by applying a cubic spline process

## Labour

The majority of Labour input is measured directly using teacher and school support staff numbers disaggregated into occupational groups such as head teachers, classroom teachers and teaching assistants. Teacher numbers for England and Wales are also adjusted for actual hours worked.



Teacher and support staff numbers are multiplied by average salaries to give implied total expenditure on school staff. Annual rates of growth in staff numbers (by occupational group) are added together using their relative shares in school staff expenditure, to form a chain-linked Laspeyres volume index. This is the same statistical technique as used for the output series (described in Section 2 above).

For each of the UK's four countries, separate input indices are calculated for teaching and support staff. These are added together using their relative expenditure shares to give an overall schools Labour index for each country. The UK schools Labour index is then calculated by adding together the four country indices using their relative shares in total UK school staff expenditure.

A small proportion of Labour input is measured indirectly using deflated expenditure. This relates to administrative work carried out by staff in Central government. A proportion of Further Education expenditure is also added, to represent Further Education Labour input.

It is assumed that administrative Labour input from local authorities moves in the same way as school staff input, as insufficient data are available to separately measure local authority administrative Labour.

An overall UK Labour input index is calculated by combining the direct and indirect elements, using Central and Local government shares in employee-remuneration expenditure.

## Goods & Services

Goods & Services are measured indirectly using deflated expenditure; calculations are at a UK level. This expenditure comprises the following elements:

- Goods & Services expenditure incurred by local authorities (e.g. schools equipment, energy costs, Pre-school education provided by the Private, Voluntary & Independent sector)
- Goods & Services expenditure incurred by Central government (e.g. office costs, Higher Education courses for health professionals, Initial Teacher Training)
- Further Education (Local & Central government procurement)

A composite Paasche deflator is calculated for both Local and Central government expenditure on Goods & Services using expenditure breakdowns from schools and Central government and identifying appropriate deflators for each expenditure category.

An overall Goods & Services index is calculated by combining the above elements, using Central and Local government shares in total Goods & Services expenditure.

## Capital

Capital is measured using the ONS Volume Index of Capital Services (VICS). This represents the flow of services provided by the capital stock within the education system each year, which primarily comprises buildings. Including data for both Central and Local government Capital, a five year moving average of the constant price capital services index is taken, to smooth out some of the volatility in the series. This is converted to an index.



## Total inputs

A chain-linked Laspeyres volume index of total inputs (across educational sectors and geographical areas) is calculated using the individual components and their relative cost weights, such that:

$$L_t = L_{t-1} \cdot \left( \sum_i \left( \frac{f_{i,t} - f_{i,t-1}}{f_{i,t-1}} \cdot \frac{x_{i,t-1}}{\sum_i x_{i,t-1}} \right) + 1 \right) \quad [7]$$

where:

- $i$  and  $t$  index inputs components and time respectively
- $L_t$  is a chain-linked aggregate UK Laspeyres index of education inputs
- $f_{i,t}$  is the volume of input by component
- $x_{i,t}$  is the level of expenditure in current price terms
- output in the initial period,  $t=0$ , is set equal to 100

## 5. Revisions to methodology

The three main methods changes introduced in [ONS \(2012a\)](#) are as follows:

- Data for Scottish school support staff were taken from the teacher census published by the Scottish government for the first time. This provides a greater level of disaggregation than the public sector employment survey previously offered.
- The salary weights used for some school support staff occupations were amended to more closely match the salary levels for these occupational groups.
- In 2010, most of the deflators used in Goods & Services inputs calculations moved to a new classification basis ([Standard Industrial Classification 2007 – SIC07](#)). As a result, calculations were updated to reflect the new SIC07 deflators.

Further information can be found in ([ONS 2012c](#)).

## 6. Worked examples

To provide a sense of how education developments affect the calculation of inputs, output and productivity, ONS has produced a simplified spreadsheet model of the process, published alongside this document. This spreadsheet includes information about a fictional education system in a country with two geographical areas (East and West), two educational sectors (Lower and Upper), and two inputs to production (Labour and Goods & Services). As such, it retains many of the complexities of [ONS \(2012a\)](#), while the reduced number of dimensions makes it more tractable.

The primary objective of the worked example is to illuminate how educational developments affect the calculation of productivity. The example allows users to change the growth rates of key series –

including the growth rates of student numbers, the growth rates of inputs and the rate of change in student attainment – and to observe how these alterations affect the evolution of aggregate education inputs, output and productivity. Users who are interested in the more detailed calculation steps can also follow these using the included worksheets. This section introduces the example's simplifying assumptions. The results of three customised scenarios devised using the accompanying spreadsheet are described in Appendix B.

At the most aggregate level, changes to inputs and outputs have a largely predictable impact on productivity: if inputs rise without a corresponding increase in output, productivity declines. If output increases without a corresponding rise in inputs, productivity goes up. However, the precise impact of a specific change – a 10% increase in the number of teachers, for example – depends on the input mix and the relative size of different educational sectors in different parts of the country. Changes which affect more important inputs, in larger educational sectors will have a greater impact on overall productivity than changes affecting less important inputs, in relatively small educational sectors.

To help to illuminate these effects, the model presented here incorporates two education sectors, with two inputs in two regions. Several important sectoral and regional characteristics determine the magnitude of the effects which users can customise. Specifically:

- the Eastern region is almost three times the size of the Western region, as measured by the number of students in Lower and Upper school in the initial year, 1995. Consequently, changes in the Eastern region will have a larger impact on productivity than changes in the Western region
- Upper school is almost 15% larger than Lower school. As a consequence, changes in Upper school will have a larger impact on country-wide totals than changes in Lower school
- the mix of inputs to education is held constant across regions and sectors and the growth rates of each element are assumed constant over the model's horizon. These simplifications help to illuminate the main effects of the approach of [ONS \(2012a\)](#)<sup>3</sup>

In addition to these initial conditions, a 'baseline' scenario is customised to provide an effective point of comparison. The assumptions of this baseline are set out in the spreadsheet, and include:

- faster student numbers growth in Upper school than in Lower school, and faster growth in both types of school in West than in East
- faster Goods & Services input growth than Labour input growth
- starting from a higher initial level of performance, point scores from examinations in the West grow more slowly than in the East

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<sup>3</sup> Where the ratio of inputs differs across educational sectors or geographical regions, and where the growth rates of these inputs varies either between sectors or regions, the results of the [ONS \(2012a\)](#) process are more complex. Specifically, a change in the growth rate of an input can influence the growth rate of output through its impact on the relative expenditure weights. For instance, holding all else constant, stronger growth of Labour input will tend to increase the weight assigned to a relatively Labour intensive activity, giving that activity a greater influence over aggregate outcomes than previously. To avoid this result, the worked example assumes that the Goods & Services: Labour ratio is constant across sectors and regions and that there is a single, national rate of growth for each input.

Finally, to simplify the model, it is assumed that unit input costs are fixed. These assumptions are designed to reflect the multiple dimensions of heterogeneity which the education system in the UK exhibits without over-complicating the calculation process.

This fictional, baseline scenario predicts (a) growing inputs, (b) rising education quantity and output and (c) productivity growth. This result arises from the faster combined growth of student numbers and attainment than the growth of inputs. This baseline is invariant to the changes specified by the user and therefore provides an effective base case against which to judge a customised scenario. The results of three customised scenarios devised using the spreadsheet are described in Appendix B.

## 7. User and stakeholder needs

ONS actively seeks feedback from users of its public service productivity statistics in order to inform its future work priorities. We are particularly interested in user views on the value of these statistics to inform policy debates and research projects within the academic and National Accounts fields. The updated Quality and Methodology Information (QMI) for the Education productivity article ([ONS 2012d](#)) includes a section on user needs and perceptions.

The QMI outlines the various methods we have used to gain feedback from users about our statistics, including (a) ONS work programme consultations, (b) functional board meetings, (c) workshops discussing the range of productivity estimates produced by ONS and (d) a user survey (via Survey Monkey) attached to the latest Education productivity article. The results of the workshops in public service productivity measures are published in [ONS \(2012e\)](#).

In addition, ONS has produced a document containing a series of frequently asked questions that provides users with a short explanation of the key concepts relating to public service productivity ([ONS 2012f](#)), including how they relate to other issues such as 'efficiency' and 'value for money'. This document also provides an overview of methods used to create the statistics and guidance on how they should be used.

## 8. Strengths and limitations

The approach adopted by [ONS \(2012a\)](#) is designed to provide accurate, consistent and timely estimates of productivity in publicly-funded education in the UK. It covers activity in nine educational sectors and a detailed array of different education inputs. However, there are several shortcomings which are the subject of continuing improvement efforts. These can be categorised as (a) data issues, (b) methods of quality-adjustment, (c) institutional differences and (d) timing. The following sections briefly review each of these areas.

### Data issues

One of the key contributions of [ONS \(2012a\)](#) is the production of estimates of education inputs and output which are comparable across countries, sectors and through time. This represents a

significant data processing challenge, as the relevant series are published at different times of year, on different calendar bases and often measure significantly different quantities across countries. Additional complexities arise from shifts in policy or educational innovations, as the existing published series may be modified to reflect new priorities.

In this respect, [ONS \(2012a\)](#) adopts a range of policies designed to ensure the comparability of the data series through time. Firstly, data are requested directly from the Department for Education and the devolved administrations in a format which ensures that both the most recent data and any revisions are included in the final estimates. Secondly, the data request is designed to match, as closely as possible, across geographical areas. Thirdly, where a complete time-series is not available, or where the coverage of an established indicator has been changed, ONS make a set of assumptions designed to estimate the missing data.

Specific data issues affecting [ONS \(2012a\)](#) include (a) a change in the methods by which attendance data are collected in England and (b) missing data arising from the suspension of data collection on the Higher Education training of health professionals in Scotland. In the former case, data on absence in England was previously provided for the breakdown of schools included in [ONS \(2012a\)](#): Primary, Secondary and Special schools, as well as City Technology Colleges and City Academies. Data on absence rates by school type in England has more recently combined absence in Secondary schools, City Technology Colleges and City Academies into a single category. As a result, ONS has used the trend of the combined series to project earlier, disaggregated absence rates. English absence data in the future will be published in line with new types of school arising from recent education reforms.

The Scottish government now collects a more limited array of information about publicly-funded students on medical courses than previously, affecting several series which are incorporated in [ONS \(2012a\)](#). Although information about the two largest elements of Allied Healthcare Professional training programmes is still being collected, data for several more specialised courses is no longer available. Alternative data sources are being investigated.

## Methods of quality-adjustment

The quality-adjustments applied to education output in [ONS \(2012a\)](#) are based on the APS of students in exams at the end of their eleventh year of schooling, and the proportion of students on Initial Teacher Training courses who attain Qualified Teacher Status each year.

As set out in [ONS \(2012b\)](#), the behaviour of the quality-adjustment based on the APS attained by students in GCSE and equivalent examinations has changed as the coverage of this indicator has evolved over time. The [Wolf Report \(2011\)](#), for example, presents evidence on the impact of vocational qualifications on school performance measures in England. As a result, the Department for Education has announced significant reforms to the classification of examinations and school performance measures which will take effect in 2014.

To address this and other data issues, ONS has undertaken to review alternative methods of quality-adjustment, with a view to generating a new method of accounting for changes in the standards of delivered education in the UK.

## Institutional differences

Alongside issues arising from missing data or from conceptual problems of quality-adjustment, there are a small number of problems which arise from differing education policies and data collection across different jurisdictions within the UK. Of these, the most high profile concerns differences in examination systems at the end of school year eleven, between students in Scotland and students in England, Wales and Northern Ireland.

While students in the rest of the UK sit GCSE or equivalent examinations at the end of their eleventh year of school, in Scotland students sit 'Standard Grade' examinations. The two systems differ both in terms of the tariff points awarded to students who achieve at different levels and in terms of the trend in average point scores through time. Specifically, while English average point scores have risen steadily over the last five years, students in the Scottish system have seen a much lower rate of increase.

Differences in institutional arrangements between jurisdictions represent a significant issue for comparability across geographical areas of the UK. The impact of these differences in the future depends on the extent of policy reforms in the devolved administrations. ONS is monitoring these developments and will take appropriate, pre-announced action as policy choices are made.

## Timing

The timing of data releases on student and teacher numbers and education expenditure represents a constraint to both (a) more frequent and (b) more timely examinations of productivity in publicly-funded education. As the central datasets used in productivity publications are published on an annual basis, ONS will continue to publish annual articles. ONS will keep the timeliness of the productivity articles under review in consultation with users.

## Appendix A:

Estimates of education productivity can be calculated by two equivalent methods, either (a) using unit-costs to weight the change in activity or (b) using aggregate expenditure share weights. In the following sequence these two methods are shown to be equivalent, in which:

- A and B indicate two different education sectors, t indexes time periods
- W is weighted education output
- V is the level of education activity
- P is the unit cost associated with a specific activity
- E is total expenditure

$$W_{t-1} = \frac{(V_{A,t-1} * P_{A,t-1}) + (V_{B,t-1} * P_{B,t-1})}{(V_{A,t-1} * P_{A,t-1}) + (V_{B,t-1} * P_{B,t-1})} \quad [1a]$$

$$W_t = \frac{(V_{A,t} * P_{A,t-1}) + (V_{B,t} * P_{B,t-1})}{(V_{A,t-1} * P_{A,t-1}) + (V_{B,t-1} * P_{B,t-1})} \quad [1b]$$

$$\%W_{t,t-1} = \frac{V_{A,t}P_{A,t-1} + V_{B,t}P_{B,t-1} - V_{A,t-1}P_{A,t-1} - V_{B,t-1}P_{B,t-1}}{(V_{A,t-1}P_{A,t-1}) + (V_{B,t-1}P_{B,t-1})} \quad [2]$$

$$\equiv \frac{(V_{A,t} - V_{A,t-1})P_{A,t-1} + (V_{B,t} - V_{B,t-1})P_{B,t-1}}{E_{t-1}} \quad [3]$$

$$\equiv \frac{1}{E_{A,t-1} + E_{B,t-1}} * ((V_{A,t} - V_{A,t-1})P_{A,t-1} + (V_{B,t} - V_{B,t-1})P_{B,t-1}) \quad [4]$$

$$\equiv \frac{1}{E_{A,t-1} + E_{B,t-1}} * \left( (V_{A,t} - V_{A,t-1}) * \frac{E_{A,t-1}}{V_{A,t-1}} + (V_{B,t} - V_{B,t-1}) * \frac{E_{B,t-1}}{V_{B,t-1}} \right) \quad [5]$$

$$\equiv \frac{V_{A,t} - V_{A,t-1}}{E_{A,t-1} + E_{B,t-1}} * \frac{E_{A,t-1}}{V_{A,t-1}} + \frac{V_{B,t} - V_{B,t-1}}{E_{A,t-1} + E_{B,t-1}} * \frac{E_{B,t-1}}{V_{B,t-1}} \quad [6]$$

$$\equiv \frac{V_{A,t} - V_{A,t-1}}{V_{A,t-1}} * \frac{E_{A,t-1}}{E_{A,t-1} + E_{B,t-1}} + \frac{V_{B,t} - V_{B,t-1}}{V_{B,t-1}} * \frac{E_{B,t-1}}{E_{A,t-1} + E_{B,t-1}} \quad [7]$$

## Appendix B:

To provide a sense of how education developments affect the calculation of inputs, output and productivity, ONS has produced a simplified spreadsheet model of the process, published alongside this document. This spreadsheet includes information about a fictional education system in a country with two geographical areas (East and West), two educational sectors (Lower and Upper), and two inputs to production (Labour and Goods & Services). As such, it retains many of the complexities of [ONS \(2012a\)](#), while the reduced number of dimensions makes it more tractable. This section describes the results of three customised scenarios devised using this worked example.

### Example 1: Increasing teacher numbers

To examine the effect of a change in staff numbers on education productivity, the national growth rate of Labour input was increased by two percentage points – from two per cent per annum to four per cent per annum – using the ‘Control Box’ worksheet.

The impact of this change on aggregate inputs can be gauged using the ‘Input Results’ worksheet. A doubling of the growth rate of Labour input relative to the baseline scenario increases aggregate inputs by 1.8 per cent in 1996, 3.6 per cent in 1997 and by 30.7 per cent by 2010. Note that aggregate inputs change by a smaller proportion than the change in Labour input – the magnitude of this effect is governed by the relative importance of different inputs in production. The levels of education quantity and output are unchanged (see ‘Output Results’ worksheet).

As the level of inputs in this scenario has risen without a corresponding increase in output, productivity should decline. This can be seen in the ‘Productivity Results’ worksheet. The quantity-based measure of productivity (which does not account for the changing quality of education delivered), declines from 100 in the base period, to 99.4 in 1996, to 92.5 in 2010, reflecting a 7.5 per cent fall in the level of productivity over this period. The output-based measure of productivity is similarly lower, rising 1.7 per cent between 1995 and 1996 (compared to the baseline change of 3.5 per cent), and by 29.1 per cent between 1995 and 2010 (compared to a baseline change of 68.7 per cent).

### Example 2: Rising student numbers

To examine the effect of a change in the number of students on education productivity, the growth rate of the Lower school population in the Western region was increased by three per cent – from three per cent to six per cent per annum – using the ‘Control Box’ worksheet.

The impact of this change on aggregate output can be seen using the ‘Output Results’ worksheet. Comparing this scenario with the baseline, the scenario quantity of education delivered is 0.3 per cent higher in 1996, 0.6 per cent higher in 1997 and 4.5 per cent higher in 2010. Note that this magnitude is significantly smaller than the simple percentage change would suggest. As West is significantly smaller than East in terms of student population, and as Lower school is smaller than Upper school, the growth in student numbers is concentrated in a relatively small sector of the whole system. The increase in output is therefore correspondingly smaller. The volume of Inputs remains unchanged (see ‘Input Results’).



As education output has risen without a corresponding increase in inputs, the level of productivity should rise. This can be seen in the 'Productivity Results' worksheet. Relative to the baseline case, quantity-based productivity in the scenario is 0.3 per cent higher in 1996, 0.6 per cent higher in 1997 and 4.6 per cent higher in 2010. The output based measure of productivity – which accounts for changes in the quality of delivered education – is similarly higher as a result of the change in student numbers. The quality-adjusted education productivity index rises from 100 in 1995 to 103.8 in 1996, and to 176.4 by 2010, compared to 100, 103.5 and 168.7 respectively in the baseline scenario.

### **Example 3: Rising student attainment**

To examine the effect of a change in the rate of attainment on education productivity, the annual percentage change in the exam point score of students in the Eastern region are increased by 1.5 per cent – from 2.5 per cent per year to 4.0 per cent – using the 'Control Box' worksheet.

The increase in the growth rate of student attainment has no impact on education inputs (see 'Inputs Results' worksheet) or the quantity of education delivered, but does affect the volume of education output. Compared to the baseline, education output in the customised scenario is 1.1 per cent higher in 1996, 2.2 per cent higher in 1997 and 17.7 per cent higher in 2010. In this case, the change applies to a relatively large segment of the school population in the larger region, resulting in a correspondingly larger change.

As in the previous examples, the effect of this shift in attainment on productivity is largely predictable. While the quantity-based measure of productivity is unchanged, the quality-adjusted, output measure of productivity is significantly higher in the customised scenario than in the baseline. Output based productivity is 1.1 per cent higher in 1996, 2.2 per cent higher in 1997 and 17.7 per cent higher in 2010.

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