Multi-factor Productivity - Indicative Estimates, 2010

Author Name(s): John Appleton and Mark Franklin (ONS)

Abstract

This article presents indicative estimates of multi–factor productivity (MFP) using estimates of quality adjusted labour inputs and capital services. Using a growth accounting framework, output growth can be decomposed into contributions due to changes in labour and capital inputs, and a residual component variously described in the literature as 'disembodied technical change', the 'Solow residual', total factor productivity (TFP) or – as in this article - MFP. This approach complements traditional measures of productivity, which focus only on one factor of production – labour – and take account only of changes in volumes (that is, hours worked) but not changes in the composition of labour input over time. Capital services have been estimated using data consistent with Blue Book 2011. Data for 2010 show a small positive contribution to UK output growth from MFP in 2010, following sharply negative contributions in 2008 and 2009. There are a number of methodological changes since the last publication of MFP estimates in May 2011, of which the most significant is a change in the industrial breakdown to reflect a revised Standard Industrial Classification (SIC).

About this release

This is the latest in an annual series of MFP releases, containing indicative estimates of MFP growth for 1998 to 2010 consistent with Blue Book 2011. Data are presented for the whole economy, the market sector and ten industry groups. MFP measures the change in real (inflation adjusted) economic output that cannot be accounted for by changes in measured inputs of labour and capital.

Importantly, the measurement of labour and capital inputs attempts to adjust for compositional changes. This is most apparent in the case of labour inputs, where the MFP framework distinguishes between pure volume changes in hours worked and a "labour composition" component. For more information on measurement of labour inputs, see Acheson (2012).

Within an MFP growth accounting framework, movements in capital inputs are captured by capital services. Conceptually this is analogous to the treatment of labour input insofar as weights are given to different forms of capital to reflect their estimated contribution to the production process, although unlike labour there is no equivalent of a pure volume measure of capital.
The weights used in this capital services framework differ from those used in measuring the value of capital in the national accounts. Intuitively this is because the monetary value of an asset can differ from its contribution to the production process.

Changes since the last release

The growth accounting framework has been extended forwards by an additional year since the previous release (Acheson, 2011). Additionally, the following methodological changes have been introduced since the last release:

1. Change to SIC (2007)

Table 1 shows the differences in industry breakdown as a result of the industrial classification change from SIC (2003) to SIC (2007). Although the two breakdowns are similar, it is not possible to make like-with-like comparisons with the last release due to changes in classification below section level. For example, some detailed activities classified to manufacturing under SIC(2003) are classified outside manufacturing under SIC(2007).

In addition, two industry sections (G and I) which were separately identified in the previous release have now been amalgamated. This allows the identification of a new industry, information and communication (J).

The industry breakdown used in this release is consistent with that used in the Quality-adjusted labour input release Acheson (2012).
### Table 1: Industry categories under SIC(2003) and SIC(2007)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>ABDE</td>
<td>Agriculture; forestry and fishing; mining and quarrying; utilities</td>
<td>ABCE</td>
<td>Agriculture, hunting and forestry; fishing; mining and quarrying; utilities</td>
</tr>
<tr>
<td>C</td>
<td>Manufacturing</td>
<td>D</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>F</td>
<td>Construction</td>
<td>F</td>
<td>Construction</td>
</tr>
<tr>
<td>GI</td>
<td>Wholesale and retail trade; accommodation and food services</td>
<td>G</td>
<td>Wholesale and retail trade</td>
</tr>
<tr>
<td>H</td>
<td>Transportation and storage</td>
<td>H</td>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>J</td>
<td>Information and communication</td>
<td>I</td>
<td>Transport, storage and communications</td>
</tr>
<tr>
<td>K</td>
<td>Financial and insurance activities</td>
<td>J</td>
<td>Financial intermediation</td>
</tr>
<tr>
<td>LMN</td>
<td>Real estate activities; professional and scientific activities; administrative and support activities</td>
<td>K</td>
<td>Real estate, renting and business activities</td>
</tr>
<tr>
<td>OPQ</td>
<td>Public administration and defence; education; health and social work</td>
<td>LMN</td>
<td>Public administration and defence; education; health and social work</td>
</tr>
<tr>
<td>RSTU</td>
<td>Arts and entertainment; other services</td>
<td>OPQ</td>
<td>Other social and personal services</td>
</tr>
</tbody>
</table>

Table source: Office for National Statistics

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(41.5 Kb)

#### 2. Calculation of capital services

Owing to the unavailability of low level data on gross fixed capital formation on a SIC(2007) basis, the capital services estimates used in this release are not qualitatively equivalent to those previously published by ONS ([Appleton & Wallis (2011) (117.3 Kb)](#)). For more information on the derivation of the capital services estimates used in this release, see Appendix 1.
Interpreting these statistics

Using a growth accounting framework, as first developed by Solow (1957), growth in output can be decomposed into contributions from growth in labour inputs (in terms of both its quantity and composition) and from growth in capital services. The residual output growth that cannot be accounted for by growth in labour and capital inputs is hence an estimate of multi-factor productivity (MFP). This term is sometimes referred to as the ‘Solow residual’ or total factor productivity (TFP).

Alternatively, the growth accounting framework can be expressed as a decomposition of labour productivity growth, by dividing all of the elements by the volume of labour input, actual hours worked in this case, into the contributions of weighted labour composition (the difference between the growth of quality adjusted and unadjusted labour inputs), capital deepening (defined as the weighted growth in capital inputs per hour worked) and MFP growth.

Conceptually the MFP residual can be thought of as capturing technological progress, including the effect of changes in management techniques and business processes or more efficient use of factor inputs. It is important to note that improvements in the quality of capital are examples of ‘embodied technical change’. In principle, such quality changes are captured in the measurement of capital services and are not included in MFP. MFP is linked, therefore, not to an increase in the quantity or quality of measured factor inputs but rather to how they are employed.

In practice the MFP residual may also capture a number of other effects such as adjustment costs, economies of scale and measurement error in inputs and outputs. For example an improvement in the quality of the labour force not captured by the quality adjusted labour inputs or returns from expenditures that are not currently treated as capital formation within the national accounts framework, such as research and development, will be incorporated into the MFP residual.

The formal growth accounting methodology, together with more information on data sources, is set out in Appendix 2.

Note that due to the volatility of year on year MFP growth, some of the results are presented as averages over the periods. The results by year are presented in the Reference Tables (48 Kb Excel sheet) accompanying this article. Note also that due to the need for additional work arising out of the absence of disaggregated investment data on a SIC(2007) basis, this release comes after the publication of Blue Book 2012, which incorporates a number of revisions affecting the national accounts up to and including 2010.

In particular, 2010 growth rates of output and aggregate investment were revised down in Blue Book 2012 compared with the estimates in Blue Book 2011, see this article for more information. Subject to resourcing, ONS hopes to publish updated MFP estimates to 2011 (consistent with Blue Book 2012) in the first half of 2013, as part of a general initiative towards accelerating production of this release and its constituent elements – quality-adjusted labour input and capital services. For more information, see the Next Steps section below.
Results: Whole economy

As shown in Figure 1 MFP made a small positive contribution to output growth in 2010, after large negative contributions in 2008 and (especially) 2009. The main contribution to whole economy output growth in 2010 came from an increase in labour quality (0.9 percentage points, or around half of the 1.8 per cent growth recorded in Blue Book 2011).

As noted in Acheson (2012), the positive contribution from labour composition in 2010, when hours worked were unchanged, suggests a substitution in the composition of the workforce towards higher “quality” categories of labour, or alternatively that labour shedding has been weighted towards lower skilled workers.

The positive contribution from capital services to growth throughout the 2008-09 recession and indeed in every year in Figure 1 may seem surprising. However, it should be recalled that capital services flow from productive capital stocks which, for some long-lived assets such as structures, depend on investments over many prior years. It should be noted that ONS measures of capital services currently make no provision for accelerated scrapping of capital.

It is certainly possible that some productive capital has been prematurely scrapped over the recession, as has been shown to be the case in previous recessions (see for example Harris & Drinkwater, (2000)). Moreover, as noted in Appendix 1, the capital services estimates embedded in this release are subject to more than usual uncertainty due to gaps in the source data.

Figure 1: Whole economy: Decomposition of annual output growth

Source: Office for National Statistics

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(27.5 Kb)
As explained above, a decomposition of labour productivity growth can be used to inform analysis of the drivers of growth in the headline productivity measures. **Figure 2** decomposes labour productivity growth into the contributions from labour composition, MFP and the amount of capital per hour worked (known as capital deepening). The graph demonstrates changes in whole economy labour productivity growth through time, of which MFP growth is a clear influence.

**Figure 2: Whole economy: Decomposition of annual labour productivity growth**

![Graph showing decomposition of annual labour productivity growth](chart)

Source: Office for National Statistics

**Download chart**  
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Comparing Figure 2 with **Figure 1** there is almost no difference in 2010 (because hours worked were virtually unchanged). A striking feature of Figure 2 is the pronounced pro-cyclicality of MFP, which accounts for a good deal of the variation in labour productivity growth over this period. There is also some evidence that the contribution of labour composition is tending to increase over time, with the largest contributions coming in 2009 and 2010.

**Results: Industry breakdown**

**Figure 3** presents the decomposition of labour productivity group by industry, expressed as annual averages over the period 1998 to 2010. Categories on the x-axis correspond with those in Table 1 above. WE is the whole economy and MS is the market sector. The first point of interest is that the pattern of MFP contributions varies widely across industries, adding almost four percentage points to growth of industry J, and subtracting around 1.5 percentage points from growth of industries ABDE and RSTU.

This contrasts with the pattern of capital deepening, which makes positive contributions in all industries (albeit only marginally in the case of industry OPQ), and with labour composition, which
also makes positive contributions in all industries, albeit marginal in industries ABDE, F and H. As in
the case of the whole economy time series (Figures 1 and 2), variations in MFP account for much of
the variation in labour productivity growth across industries.

**Figure 3: Decomposition of annual average labour productivity growth by industry**

1998-2010

![Decomposition of annual average labour productivity growth by industry](source: Office for National Statistics)

The varying contributions of MFP across industries may reflect differences in the diffusion of
disembodied technological change, and perhaps also differences in the propensity of knowledge-
based activities such as spending on R&D and on human capital, which are not currently included in
the asset base in the system of national accounts and are not therefore captured in capital services.

**Figure 4** presents a cross section of the decomposition of labour productivity growth across the UK
economy in 2010. As stated previously, annual estimates of MFP are quite volatile and Figure 4
should mainly be used as a tool to illustrate the divergences in productivity across industries.
On an industry basis, the largest contribution to labour productivity growth from MFP occurred in industries F (construction) and J (information and communication), which are also the industries recording the fastest growth in labour productivity. Output in these industries also recovered strongly in 2010 according to Blue Book 2011.

In the case of industry F in particular, this followed steep falls in output and labour productivity, and a strongly negative MFP contribution, in 2009. It is likely that this swing in MFP reflects workers in construction being temporarily under-employed in 2009 during the period of weak activity, followed by more efficient utilisation of labour in 2010 as the rate of activity picked up.

There were large negative contributions to labour productivity growth in industries ABDE (mainly utilities) and K (financial and insurance activities) in 2010, and again these were the industries with the sharpest falls in labour productivity. Also of note are the negative contributions of MFP in industries LMN (other business services) and OPQ (mainly the public services), more or less cancelling out the impact of capital deepening and labour composition. This is significant because these are the two largest industry groups, together accounting for around 40 per cent of GVA.

Comparing Figures 3 and 4 it can be seen that MFP contributions in 2010 were typical of the period average (at least in terms of size) in the majority of industries. But in industries F and K, the MFP contributions were atypical of the average since 1998. This underlines the need for caution in interpreting estimates for a single year.
The causality of these changes is not evident as the debate over the slowdown in the UK’s productivity is not conclusive and includes both supply-side interpretations, such as tightening of credit conditions, and demand-side interpretations, focussing on weak aggregate demand. See for example Dale (2011) and Martin (2011) for a discussion of these and other arguments.

Revisions since last release

Revisions to the MFP results since Acheson (2011) arise from methodological changes since the last release and revisions to the component series. The former relate mainly to capital services and are described briefly in Appendix 1. The latter can be categorised into three broad groups:

- Revisions to the National Accounts data in Blue Book 2011, including those arising out of the change to SIC(2007).
- Revisions to quality-adjusted labour input estimates.
- Revisions to capital services estimates.

There were a number of changes in the structure of the National Accounts in Blue Book 2011, including a revised method of deflation. For more information, see Patterson et al. (2011).

Revisions to the quality-adjusted labour input series are driven by revisions to National Accounts Compensation of Employees data and annual benchmarking of the underlying LFS micro data. For more information see Acheson (2012).

Revisions to the capital services estimates are described further in Appendix 1.

To give an indication of the drivers of revisions to output growth, Figure 5 plots the average contributions at the whole economy level for the most recent and previous estimates. The data cover the period 1998 to 2009, over which comparable data are available. Over this period, average output growth has been revised upwards as explained in Blue Book 2011 and individual components have seen revisions, particularly due to the change to SIC07.

Compared to the previous estimates, the increase in output growth is roughly equally due to higher capital inputs (reflecting upward revisions to gross fixed capital formation in the expenditure breakdown of GDP), and due to MFP. Revisions to labour inputs, volume and composition, have been negligible.
Figure 5: Contributions to whole economy annual average output growth: 1998 to 2009

Current and previous estimates

![Figure 5: Contributions to whole economy annual average output growth: 1998 to 2009](chart)

Source: Office for National Statistics

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(26.5 Kb)

**Next steps**

This section describes forthcoming development work on the ONS growth accounting measures. ONS welcomes feedback on all aspects of the statistics produced. For information on how you can communicate this to us see the [Background notes section](#) of this release.

**New information from Blue Book 2012**

As noted above, the national accounts estimates used in the compilation of this release, from Blue Book 2011, has been superseded in [Blue Book 2012](#). In particular, the path of gross fixed capital formation has been revised between Blue Book 2011 and Blue Book 2012, and this will feed through into revised estimates of capital services. Subject to resourcing, ONS hopes to publish updated growth accounting estimates in the first half of 2013.

**Premature scrapping of capital**

ONS estimates of capital services do not currently account for the premature scrapping of assets. The impact of capacity scrapping on capital services is difficult to measure but important, particularly during a turning point in the economic cycle. One approach, used in the ONS wealth-based measurement of capital stocks, adjusts for capital scrapping using information on rates of business
insolvencies. Further information on this approach can be found in the Quality and Methodology Information paper for Capital Stocks and Capital Consumption (88.9 Kb Pdf).

However, insolvency rates do not appear to vary greatly over the economic cycle, and this methodology requires a number of assumptions to be made about the relationship between insolvencies and the capital assets of businesses that are becoming insolvent. In addition, ONS is not currently producing wealth-based measures of capital stocks.

The productivity branch of ONS intends to explore another approach to capital scrapping, as part of an integrated programme to measure stocks of productive capital in a consistent fashion between the national accounts and other data environments, including the ONS virtual micro-data laboratory. This builds on EU-funded research that is currently underway, to update and develop estimates of productive capital at the level of individual enterprises.

Following Harris & Drinkwater (2000), this provides a route to adjusting for scrappage using information on firm demographics – essentially by permitting the quantification of productive capital of firms that cease to exist, then making assumptions about the share of this capital that is re-allocated to other firms. We intend to report progress on this line of research at a productivity statistics user group workshop in early 2013.

**Quarterly growth accounting estimates**

Another objective is to shorten the time lag between publication of the UK national accounts and publication of growth accounting estimates, with the medium term aim of moving towards a quarterly framework for growth accounting.

Considerable progress has already been made in developing a quarterly process for quality-adjusted labour inputs. One application of this work is the development of consistent measures of unit labour costs below the whole economy level. ONS intends to publish an article on this subject in coming months.

Measurement of capital services on a quarterly basis is conceptually feasible but is some way off in practical terms. As noted elsewhere in this release, ONS is not currently publishing detailed investment estimates on a SIC(2007) basis, and the annual capital stocks release has been temporarily suspended. Capital services estimates used in this release have been based largely on previously published SIC(2003) estimates. Nevertheless, measurement of capital services is a requirement of the 2008 System of National Accounts and ONS has a work programme in place to meet this requirement.

One issue for consideration is the value of more frequent publication of quality-adjusted labour inputs to users, other than as component of a wider growth accounting framework. ONS welcomes comments from users on this issue.

**Background notes**

1. **User engagement**
ONS is keen to develop a greater understanding of the use made of productivity statistics. If you have any feedback please get in touch via productivity@ons.gsi.gov.uk.

A productivity statistics user group workshop will be held in London in early 2013. For more information email us at productivity@ons.gsi.gov.uk.

2. **Other information on productivity**

ONS publishes a quarterly Labour Productivity statistical bulletin. This provides more timely and periodic information regarding UK productivity, and uses a more disaggregated industry breakdown than this MFP release.

ONS publishes international comparisons of labour productivity in levels and growth rates for the G7 countries.

More international data on productivity are available from the OECD, Eurostat, and the Conference Board.

ONS also publishes a range of public sector productivity measures and related articles. These measures define productivity differently from that employed in the ONS Labour Productivity and MFP estimates. Further information can be found in Phelps (2010) (252.5 Kb Pdf).

More information on the range of ONS productivity estimates can be found in the ONS Productivity Handbook. In addition, ONS has recently published an article (Grice, 2012) on the “productivity conundrum”.

3. Details of the policy governing the release of new data are available by visiting www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html or from the Media Relations Office email: media.relations@ons.gsi.gov.uk

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This document is also available on our website at www.ons.gov.uk.
References


Appendix 1 - Derivation of indicative capital services

Disaggregated gross fixed capital formation (GFCF) data by asset and institutional sector are not currently available on a SIC(2007) basis. For the purposes of this article we have used SIC(2003) data consistent with the 2011 capital services release (Appleton & Wallis, 2011), converted to SIC(2007) using a standard ONS conversion matrix.

This conversion was carried out at the SIC(2007) group level, consistent with the 2012 quality-adjusted labour input release (Acheson, 2012). The conversion was carried out in value and volume terms, and the resulting asset and SIC(2007) group estimates have been benchmarked to the 2011 Blue Book aggregates.
For 2010 we have used internal ONS GFCF estimates at the SIC(2007) group level, again benchmarked to Blue Book 2011.

It should be emphasised that the resulting estimates of capital services are not official estimates and have been produced solely for the purpose of this growth accounting exercise. ONS does not intend to publish the underlying capital services data separately.

In addition we have made a number of methodological changes to the construction of capital services:

- Derivation of user cost weights now follows international best practice, as described in the OECD manual, *Measuring Capital, Second Edition*.
- User costs of capital are conditioned to estimates of returns on capital consistent with those used elsewhere across ONS. In particular, returns on capital now account in a consistent fashion for the recorded earnings of the self-employed, including that part of their earnings which is attributable to their ownership of capital assets.
- User cost weights are now applied at the SIC(2007) group level, that is, allowing returns on capital to vary by SIC(2007) group, according to the recorded distribution of income consistent with the national accounts.
- For the purpose of growth accounting we exclude investment in dwellings and the associated capital stock of dwellings, as these do not feed directly into recorded production. It follows that we have to make a corresponding adjustment to remove the income (actual and imputed) that arises from ownership of dwellings, and we have made a small change to this adjustment in this release.
- Tax adjustment factors are now applied ex post (in line with the OECD manual) rather than ex ante.
- As in previous releases we treat investment in computer hardware separately from investment in other plant and machinery. In this release we have benchmarked investment in computer hardware to published ONS estimates of business investment in computer hardware.

**Appendix 2 – Methodology, data sources and data issues**

**Methodology**

Following Solow (1957), the production function is assumed to take the following form:

**Equation (1)**

\[ Y = A(t) f(K, L) \]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.

Where \( A(t) \) represents disembodied technical change, \( K \) denotes the volume of capital inputs (measured by capital services), \( L \) denotes the volume of labour inputs (measured by quality-adjusted labour input) and \( Y \) denotes the volume of output, measured by gross value added. This production function embodies the assumption of neutral technical change, that is, the disembodied technological shift factor, \( A(t) \), leaves the marginal rates of technical substitution of the labour and capital inputs unchanged.
It is additionally assumed that factors are paid their marginal products. Given that all factor inputs are classified as either labour or capital, this implies constant returns to scale in the production function.

Taking the total differential with respect to time and dividing by output gives the proportionate growth in output (where dots denote time derivatives):

**Equation (2)**

\[
\frac{\dot{Y}}{Y} = A \frac{\partial f}{\partial K} \frac{\dot{K}}{Y} + A \frac{\partial f}{\partial L} \frac{\dot{L}}{Y} + \frac{\dot{A}}{A}
\]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.

If we denote the relative income shares of capital and labour as follows,

\[
\psi_k = \frac{\partial Y}{\partial K} \frac{K}{Y}
\]

and

... then (noting that:

\[
\frac{\partial Y}{\partial K} = A \frac{\partial f}{\partial K}
\]

etc.) we can express growth in output as an income share weighted sum of factor input growth and growth in disembodied technical change:

**Equation (3)**

\[
\frac{\dot{Y}}{Y} = \psi_k \frac{\dot{K}}{K} + \psi_l \frac{\dot{L}}{L} + \frac{\dot{A}}{A}
\]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.

Here, the assumption of constant returns to scale implies that the capital share of income is equal to one minus the labour share of income, that is:
\[ \psi_k = (1 - \psi_i) \]

Equation (3) implies that we can recover disembodied technical change as a residual.

In discrete time, equation (3) can be re-arranged and approximated as:

**Equation (4)**

\[
\Delta \ln Y(t) = \bar{\delta}_i(t) \Delta \ln L(t) + \left[1 - \bar{\delta}_i(t)\right] \Delta \ln K(t) + \Delta \ln A(t)
\]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.

where

\[ \bar{\delta}_i \]

represents the average labour share of total income between the current and previous period. This states that the growth in log GVA is equal to growth in log labour input weighted by the labour income share plus growth in log capital input weighted by the capital income share plus growth of the disembodied technical change parameter (the MFP residual).

This framework can be adapted in order to obtain a decomposition of growth that includes the contribution of labour composition. Letting \( H \) denote unadjusted labour inputs (measured by hours), we can re-write equation (3) as:

\[ \frac{\dot{Y}}{Y} - \frac{\dot{H}}{H} = \psi_k \frac{\dot{K}}{K} + \psi_i \frac{\dot{L}}{L} - \frac{\dot{H}}{H} + \frac{\dot{A}}{A} \]

which, after some re-arrangement, can be simplified to:

**Equation (5)**

\[ \frac{\dot{Y}}{Y} - \frac{\dot{H}}{H} = \psi_k \left( \frac{\dot{K}}{K} - \frac{\dot{H}}{H} \right) + \psi_i \left( \frac{\dot{L}}{L} - \frac{\dot{H}}{H} \right) + \frac{\dot{A}}{A} \]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.
In discrete time (5) can be re-arranged and approximated as follows:

\[
\Delta \ln \left( \frac{Y(t)}{H(t)} \right) = \bar{z}_1(t) \left[ \Delta \ln \bar{L}(t) - \Delta \ln \bar{H}(t) \right] + (1 - \bar{z}_1(t)) \left[ \Delta \ln \bar{K}(t) - \Delta \ln \bar{H}(t) \right] + \Delta \ln A(t)
\]

The description for this equation is currently unavailable. ONS apologises for any inconvenience caused.

This states that growth in log GVA per hour of labour input (that is, labour productivity as conventionally measured, for example in the ONS quarterly Labour Productivity Statistical Bulletin) can be decomposed into the contributions of weighted labour composition (the difference between the growth of quality adjusted and unadjusted labour inputs), capital deepening (defined as the weighted growth in capital inputs per hour worked) and MFP growth. The quality adjustment measure of labour input explicitly accounts for the heterogeneity of labour inputs by adjusting for changes in labour supply as reflected by education, gender and industry of employment. This is in contrast to a standard aggregation of labour which treats each hour of labour input as homogeneous.

**Data Sources**

The approach undertaken in this article to growth accounting is relatively undemanding in terms of data requirements. It uses gross value added (GVA) as an output measure and quality-adjusted labour input (QALI) and capital services as its factor inputs. In addition the income share of each factor of production, labour and capital, is required to determine its contribution to output growth.

The use of QALI allows for the contribution of labour inputs to be attributed to both an increase in the volume of labour, in terms of actual hours worked, and an increase in the quality of the labour, in terms of the skill composition of the workforce. QALI is mainly derived from quarterly Labour Force Survey (LFS) data. This allows information on the educational, industrial, age and gender composition of the labour inputs to be gained.

Making the assumption that factors are paid their marginal products, the hours worked by each of these compositional categories are weighted by their share in total labour income. For the most recent analysis of QALI, see Acheson (2012).

Capital services are analogous to QALI in capturing compositional changes in capital inputs more fully than alternative measures of capital input, such as changes in net capital stocks. Capital services differ from National Accounts capital stock measures as they weight together the growth in the net stock of assets using rental rather than purchase prices.

This is conceptually more appropriate for use in growth accounting analysis since, under the assumption that factors receive their marginal products; rental prices better reflect the marginal productivity of a given capital asset. Owing to current production issues with the measurement of capital in ONS this edition of the MFP release has been compiled using indicative estimates consistent with the high level aggregates published in Blue Book 2011. For more information see Appendix 1.
Output measures used in this MFP analysis are chained volume indices of GVA at basic prices, consistent with Blue Book 2011.

Labour and capital income shares are derived in a consistent fashion from the income presentation of the national accounts, and include a decomposition of the income of the self-employed, which is recorded in the national accounts as 'mixed income' and includes returns to both capital and labour. Capital income excludes that part attributable to ownership of dwellings, which are not deemed to be part of the productive capital stock.

An alternative approach to growth accounting is to use a gross output measure and calculate the contributions to growth not only from capital and labour inputs but from intermediate inputs as well, Phelps (2010). An example of this approach is the EUKLEMS project which additionally apportions output growth to the intermediate inputs of energy, materials and services. Whilst this approach to growth accounting is conceptually preferred, its data requirements are much more onerous. In particular, constant price supply use tables, which are not currently published by the ONS, represent a barrier to adoption of this approach.