Quarterly multi-factor productivity: progress and next steps

Methodology used to compile quarterly multi-factor productivity and the plans to reduce time taken in producing estimates and increasing industry granularity.

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1 . Introduction

This article provides a high-level description of the derivation of quarterly estimates of multi-factor productivity (MFP) published for the first time in a companion article and provides some information about the next steps for our Growth Accounting suite. MFP measures the change in real (inflation adjusted) economic output that cannot be accounted for by changes in the measured inputs of labour and capital. As such, estimates of MFP complement other ONS productivity metrics such as Labour productivity which measures only the relationship between economic output and hours worked.

Productivity metrics are important for policy makers. The UK Government's Productivity Plan published in 2015 states that "Productivity is the single most important determinant of average living standards and is tightly linked to the differences in wages across countries." In a speech earlier this year, a member of the Bank of England's Monetary Policy Committee noted that "Productivity matters for welfare. Over time and across countries, higher productivity is reliably associated with higher wages, higher consumption levels and improved health indicators …" (Tenreyro, 2018).

ONS have published annual MFP estimates for several years. However, an ONS-commissioned international survey of national statistics institutes (NSIs) recently revealed a gap between ONS' MFP publications and those of leading NSIs in terms of both the speed and the coverage of our statistics.

On our current annual cycle, MFP estimates have been published around 15 months after the end of the period to which they refer, and contain estimates for only a small number of industries. By contrast, the US Bureau of Labor Statistics publishes annual MFP estimates three months after the end of the year, and subsequently publishes MFP estimates for 86 manufacturing industries and 33 non-manufacturing industries. The Bean Review (Bean, 2016) also suggested that ONS pursue quarterly estimates of MFP as a complement to our existing suite of labour productivity metrics.

The first quarterly MFP estimates published alongside this article respond to these recommendations. They are preliminary and will likely be subject to more revision than usual as our methodology is refined. We welcome feedback on our methods and data, on the potential uses for and usefulness of these estimates as well as on our future development priorities. Feedback can be sent to productivity@ons.gov.uk.

2 . Input data for the multi-factor productivity framework

The compilation of multi-factor productivity (MFP) estimates is relatively data-intensive, drawing on a range of data from the National Accounts and elsewhere. In general, ONS' growth accounting model requires the following inputs:

- hours worked and labour composition

- capital services

- gross value added

- factor income weights

As MFP draws on each of these input datasets, the granularity with which MFP can be published – either in terms of the level of industrial granularity, or in terms of the frequency of the estimates – is determined by the granularity of the least detailed set of input data. On an annual basis, ONS' MFP suite consequently required estimates for the aggregate UK market sector and a set of industry components for each year. Over the past two years, in preparation for the move to a set of quarterly estimates, ONS has been developing new methods and datasets to deliver the required industrial and temporal granularity. This section reviews each of the components above, providing a high-level guide to the key data inputs used in the accompanying estimates.

Hours worked and labour composition

While hours worked – both in total and by industry – are taken from the main labour productivity release, the estimation of quarterly movements in labour quality has been more involved. This work has focused on methods to combine the strength of different survey sources – including the Labour Force Survey and the Annual Survey of Hours and Earnings – and improving our estimates of market sector hours worked. These improvements have been documented in previous releases in July 2017 and October 2017.

The quality adjusted labour input (QALI) estimates, a companion to the quarterly MFP release were first published in October 2017 and include quarterly estimates of hours worked and labour composition for the UK market sector and 19 component letter-level industries for the period Quarter 1 (Jan to Mar) 1994 to Quarter 1 2017. Since then we have made some small improvements to our methodology which are summarised below and will be set out in more detail in a follow-up article in July 2018.

Improvements to the market and non-market split

Hours worked splits between the market and non-market sectors have been adjusted to achieve greater consistency between labour market statistics and national accounts: primarily by ensuring that non-market sector estimates of hours worked are zero where there is negligible non-market sector output. The largest effect from this change is that housing associations are now designated to the market sector and this has resulted in an increase in hours worked in the market sector for Real Estate Activities.

Changes to the Annual Survey of Hours and Earnings benchmarks and added New Earnings Survey

The annual pay variable in the Annual Survey of Hours and Earnings (ASHE) is now used where it is available to produce annual pay benchmarks, as opposed to pay within a reference week. This ensures that in industries such as Financial and Insurance Activities larger bonus payment outside the reference period are included in pay estimates. These pay estimates now extend back to 1994 using the New Earnings Survey (NES), the predecessor to ASHE.

Imputation of missing hours

For Labour Force Survey (LFS) respondents that do not answer how many hours they have worked, there is now an imputation of hours worked. This minor change to calculating hours worked involves using average hours in a QALI category where the LFS respondent did not answer how many hours that they worked in the reference period. This has a small effect on labour composition by industry, as some categories of workers appear to be more likely not to report hours worked.

Changes to the simulation of earnings in LFS

Where there are no pay estimates for LFS pay by QALI categories (age, sex, education, industry) by occupation group, educational pay premiums are estimated using a regression (a detailed explanation of estimating educational pay premiums can be found in a previous release Developing improved estimates of quality adjusted labour inputs using the Annual Survey of Hours and Earnings: a progress report. This minor change involves running the analyses over a five-year period and to include occupation group in the regressions, as opposed to using regressions for each occupation group. This change has a negligible impact on QALI and ensures that industry coefficient estimates have smaller confidence intervals, which is particularly important when increasing industry granularity.

The QALI system has also been extended to Quarter 2 (Apr to Jun) 2017, and we have seasonally adjusted the labour composition series where the unadjusted series display seasonality according to our standard criteria (estimates of hours worked are already seasonally adjusted). Ten of the 19 letter-level industries are affected by sectorisation into market and non-market components, one of which (industry O – public administration and defence) is entirely non-market.

Capital services

Estimates of capital services – which record the contribution of the market sector capital stock to production each period – have also been developed on a quarterly basis for a relatively granular breakdown of industries. We published quarterly estimates of capital services for the UK market sector, for 16 letter-level industries and 57 2-digit industries up to Quarter 2 2017 in our [Volume index of capital services (VICS) release](#) in February 2018. The letter-level industry components go back to Quarter 1 1951, and the 2-digit industry components go back to Quarter 1 1997. Letter-level estimates for industries P (Education) and Q (Health and social care) were suppressed from the VICS release for quality assurance reasons. Users will appreciate that both these industries are predominantly non-market, so the market sector components are small and volatile.

These data form the primary capital data for the release of quarterly MFP alongside this release. The only development since February 2018 is that we have seasonally adjusted those quarterly letter-level capital services estimates which display seasonality according to our standard statistical criteria.

Gross value added

Estimates of quarterly gross value added for the UK market sector and detailed industry components are available from our National Accounts production systems. These estimates are available from Quarter 1 1997 and are seasonally adjusted.

Factor income weights

Quarterly factor income weights are calculated using returns to labour from QALI and returns to capital from VICS. In our annual MFP system, income weights are averaged over the current and previous year. In our quarterly MFP system, we echo this approach but use the average of the present and previous quarter. Income weights vary by industry and have the property that the capital weight is 1 minus the labour weight.

These data sources are combined to deliver the preliminary quarterly MFP estimates for the UK market sector and 10 letter-level (and aggregates of letter-level) industries which are published alongside this article. These estimates cover the period Quarter 1 1994 to Quarter 2 2017, and will be developed further over the coming months.

3 . Future developments

In the months ahead, we plan to develop these estimates in two ways. First, we plan to shorten the time lag between the reference period and publication from approximately nine months for this first publication, moving in stages to a publication schedule in which we publish quarterly multi-factor productivity (MFP) on the same time scale as our main labour productivity estimates, that is just over three months after the last quarter. This would be among the fastest publication schedules for MFP internationally, as well as being unique in terms of its quarterly frequency.

Second, we plan to increase the level of industry granularity of our MFP statistics. Here the binding constraint is our redeveloped capital services system, where the bottom-level industry granularity spans 62 separate industries (National Accounts does not identify investment in two of the industries in the international A64 taxonomy, T (97-98) and U (99)). This level of disaggregation consequently represents the maximum level of detail at which ONS could feasibly look to produce MFP statistics.

The key barrier to increasing the industry granularity of MFP is estimating quality adjusted labour input (QALI) at a more granular level of industries. This will be the principle focus of our development work, which will fall into three groups:

Industry conversion

To produce estimates for quality adjusted labour input (QALI) from 1994 to 2017 it is necessary to convert industries into a common standard industry classification (SIC). Relationships between industry classifications are produced by examining the frequency that workers or businesses are classified to a new SIC code from a previous SIC code. The current methodology maps industries on a one-to-one basis, so that the previous SIC code is mapped to the industry with the most frequent relationship. This method works well for 19 letter-level industries, however at a more granular level a one-to-one mapping creates discontinuities in the series for several industries. To produce a greater level of industry detail, it is necessary to use proportional mapping of SIC codes as detailed in [Division Level Labour Productivity Estimates](#).

Calculating earnings weights for QALI worker "types" for more detailed industries

The greatest barrier to producing greater industry granularity is in estimating hours worked for different worker types for more detailed industries. Given that QALI groups workers in each industry into 36 categories (sex (two), age (three), education (six)), direct estimates of earnings weights for smaller industries have small sample sizes and result in a large amount of variance in estimates of labour composition, and some missing values. As QALI is calculated through changes in hours worked multiplied by income weights, any change to and from an estimate of zero cannot be calculated and is replaced with a value of zero.

The smallest industry that we currently produce QALI estimates for is Mining and Quarrying, which has a larger variance in quarterly changes in labour composition estimates than for other industries. A simplified example in Table 1 demonstrates issues that greater industry granularity creates. In this example there is no overall change in hours worked and each category of worker gets paid the same amount, therefore there should be no change in QALI. With no estimate of hours worked for the lowest education category for women under the age of 41, this methodology produces inaccurate estimates for QALI. The problem of small sample sizes is not confined to missing estimates, as small sample sizes will result in estimates of changes in QALI that are unlikely to be representative of the population. A relatively simple solution to producing estimates of QALI for smaller industries, is to reduce the number of categories where the LFS cannot support this level of detail. In the simplified example dropping sex, which is a relatively weaker predictor of pay, would increase sample sizes and remove the problem of log changes of zero.

Table 1: Simplified example of problems with small sample sizes

QALI category	Hours worked		Pay weight		Change in QALI
	1st quarter	2nd quarter	1st quarter	2nd quarter	
HQ1 female 16 to 40	0	25	0.00	0.11	0.00
HQ1 female 41 to 99	25	20	0.11	0.09	-0.02
HQ1 male 16 to 40	40	35	0.17	0.15	-0.02
HQ1 male 41 to 99	25	30	0.11	0.13	0.02
HQ2 female 16 to 40	30	25	0.13	0.11	-0.02
HQ2 female 41 to 99	35	40	0.15	0.17	0.02
HQ2 male 16 to 40	45	20	0.20	0.09	-0.11
HQ2 male 41 to 99	30	35	0.13	0.15	0.02
Total	230	230	1	1	-0.11

Source: Office for National Statistics

Notes:

1. QALI category in the format of education group, sex and then age group.

2. HQ1 No education/GCSEs, HQ2 A-levels or higher.

3. The change in QALI is calculated by taking the log change from the 1st quarter to the second quarter and multiplying by the average pay weight of both quarters.

To preserve the existing 36 QALI categories within each of 64 industries, it would be necessary to estimate the number of hours worked in 2,304 QALI categories. The benefit of producing a robust framework for estimating hours worked at a more granular level is that this approach could be extended in the future to further breakdowns of QALI, for instance potentially producing a regional QALI.

A further cause of volatility when expanding industry granularity, is that the present system of benchmarking quarterly pay estimates to annual pay estimates, rescales quarterly pay to meet the annual benchmark. This methodology can result in volatility in pay weights between quarters, considerably changing the weighting of changes in hours that are unlikely to reflect changes in pay. Improvements could also be made in the treatment of outliers, where we currently only remove very large pay estimates.

Producing consistent time-series

Finally, current estimates of quality-adjusted labour input prior to 1994 use EU-KLEMS data, which do not fully support a 19-industry breakdown. As the Labour Force Survey (LFS) did not collect information on pay prior to 1992, we are planning to use the New Earnings Survey to provide pay weights to produce a longer time series of quality adjusted labour input.

4 . Links to related statistics

- [UK productivity introduction: October to December 2017](#) draws together the headlines of the productivity releases into a single release, providing additional analysis of our productivity statistics (published 6 April 2018).

- [Labour productivity: October to December 2017](#) contains the latest estimates of labour productivity for the whole economy and a range of industries, together with estimates of unit labour costs (published 6 April 2018).

- [Quarterly UK public service productivity (experimental statistics): October to December 2017](#) contains the latest experimental estimates for quarterly UK total public service productivity, inputs and output (published 6 April 2018).

- [International comparisons of UK productivity (ICP), final estimates: to 2016](#) presents an international comparison of labour productivity across the G7 nations, in terms of growth in GDP per hour and GDP per worker (published 6 April 2017).

- [Introducing industry-by-region labour metrics and productivity](#) presents new, experimental industry-by-region productivity metrics; this includes measures of hours worked, jobs, and accompanying productivity measures for the SIC letter industries in the NUTS1 regions (published 6 April 2018).

- [Quarterly Multi-factor productivity (MFP), (experimental estimates): to Q2 2017](#) decomposes output growth into the contributions that can be accounted for by labour and capital inputs; the contribution of labour is further decomposed into quantity (hours worked) and quality dimensions (published 6 April 2018).

- [Management practices and productivity in British production and services industries - initial results from the Management and Expectations Survey: 2016](#) Results from the second wave of a pilot survey, the Management and Expectations Survey, which gathered information on British management practices and firms' expectations for future growth (published 6 April 2018).

- [Public service productivity estimates: total public service, UK: 2015](#) presents updated measures of output, inputs and productivity for public services in the UK between 1997 and 2014, in addition to new estimates for 2015 (published 5 January 2018).

- [Public service productivity estimates: healthcare, 2015](#) presents updated estimates of output, inputs and productivity for public service healthcare in the UK between 1995 and 2014, in addition to new estimates for 2015 (published 5 January 2018).

- [International comparisons of labour productivity by industry: 2014](#) uses new production-side PPPs to present estimates of labour productivity for 29 European countries across 10 industries on a GVA per hour worked basis (published 6 October 2017).

- [Quality adjusted labour input: UK estimates to 2016](#) presents updated estimates of quality adjusted labour input (QALI) for the whole economy and for the market sector (published 6 October 2017).

- [Foreign direct investment and labour productivity: a micro-data perspective: 2012 to 2015](#) examines the composition of firms with foreign direct investment (FDI) in Great Britain between 2012 and 2015, and their productivity outcomes compared with firms with no FDI relationships (published 6 October 2017).

- [Introducing division level labour productivity estimates](#) provides an overview of new and experimental estimates of labour productivity at the two-digit SIC industry level for the UK and provides some initial analysis demonstrating trends in the data (published 5 July 2017).

- [Understanding firms in the bottom 10% of the labour productivity distribution in Great Britain: "the laggards", 2003 to 2015](#) examines the characteristics of businesses in the bottom 10% of the labour productivity distribution in terms of their size, age, industry and location, between 2003 and 2015 (published 5 July 2017).

- [Multi-factor productivity estimates: Experimental estimates to 2015](#) decomposes output growth into the contributions that can be accounted for by labour and capital inputs; the contribution of labour is further decomposed into quantity (hours worked) and quality dimensions (published 5 April 2017).

- [Developing new measures of infrastructure investment: July 2017](#) is the first in a series of papers on infrastructure statistics, focusing on definitional and data challenges in measuring infrastructure investment (published 5 July 2017).

- [Volume index of UK capital services (experimental): estimates to Quarter 2 (Apr to Jun) 2017](#) provides estimates of the contribution of capital inputs to production in the market sector, split by asset and industry (published 7 February 2018).