Productivity puzzle revisited: what the latest official data tells us about the UK's biggest economic issue

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About the Office for National Statistics

The Office for National Statistics (ONS) is the largest producer of official statistics in the UK and the recognised national statistical institute. It is a publicly funded body, independent of government. ONS produces official productivity statistics for the UK, using a range of methods and data sources.

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Introduction

Productivity growth in the UK, as in many major economies, slowed substantially from around the 2008 financial crisis and economic downturn. This has come to be known as the "productivity puzzle" since economists do not have a clear understanding of the causes.

One proposed explanation is that it is caused by "mismeasurement" – usually suggested to be on the output side. The argument is that, in an increasingly digital world, it is more difficult to measure value and price changes. Failing to do so risks 'missing' additional output, and/or failing to account for quality changes, such that real volume output growth is understated.

While it is true that measuring the digital economy is challenging, the UK Office for National Statistics (ONS) devotes significant resources to this challenge, especially following the Bean Review (Bean, 2016). Other national statistical institutes (NSIs) have done similarly[1].

As methods and data evolve, understanding of the productivity puzzle has also evolved, although with continued room for further improvement. However, it seems implausible that all NSIs around the world simultaneously (around 2008) got substantially worse at measuring the economy, such that all major economies recorded a slowdown in productivity growth.

This paper presents the latest official ONS productivity statistics to bring our understanding of the productivity puzzle up to date. ONS incorporated changes to the measurement of real gross value added (GVA) in its annual national accounts update in 2021 (known as Blue Book 2021), including so-called 'double deflation'. This improves estimates, and results in substantial revisions at industry-level. As such, we hope to repeat past analyses with new data.

Productivity – the long-term picture

Productivity, a structural feature of an economy, benefits from a long-run perspective. Productivity acts as a proxy for technological change, especially in the long-run, and

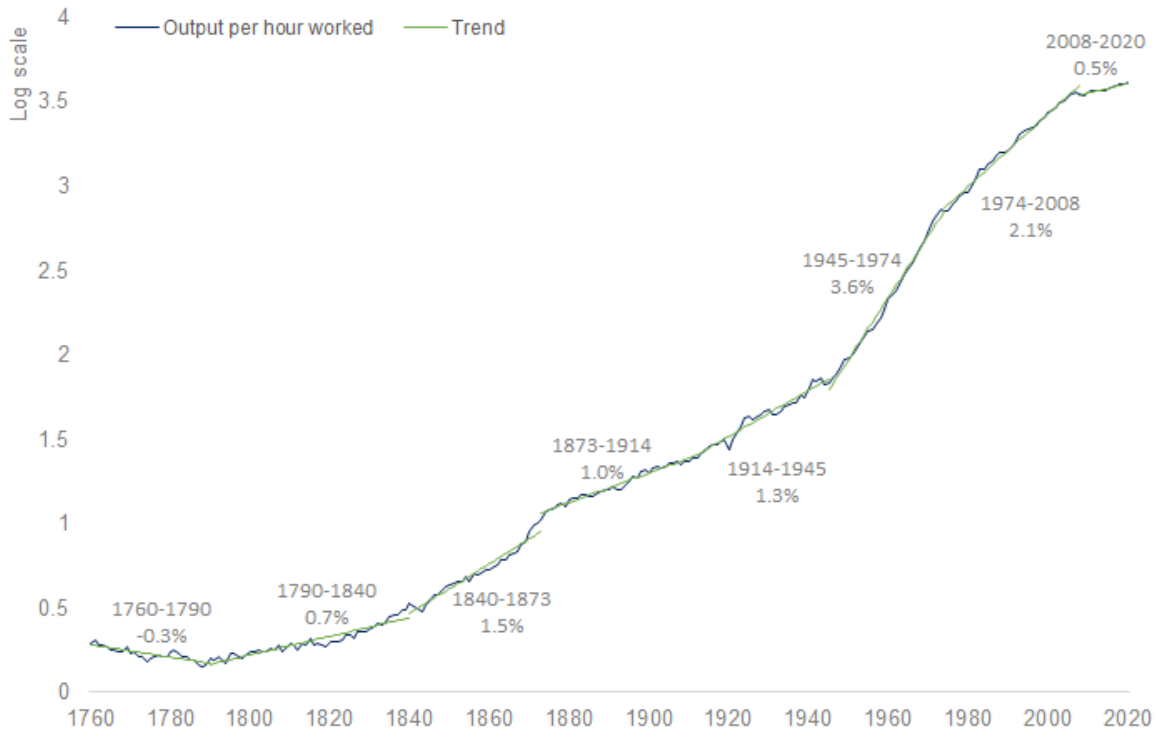
[1] See International Review of Productivity Statistics (London Economics, 2019) for details of what other NSIs do with regard to productivity statistics.

especially in certain measurement frameworks. The simplest measure of productivity – output per worker – is a less accurate proxy for technological change, since it can increase also from changes in average working hours, capital per worker, and market power, alongside other factors. However, it is the most easily measured and thus can be more robust over long periods of time.

Conceptually preferred measures include output per hour worked (which is still a single-factor productivity measure, but accounts for changes in working patterns over time) and multi-factor productivity (which accounts for capital as well as labour inputs).

Figure 1 shows output per hour worked for the UK, in 2019 prices. Given the huge changes over the past 250 years, it is shown on a log scale, and as such the slope of the line can be read as the growth rate. Period average growth rates are also included. In this context, it is easy to see that the growth in productivity between the Second World War and the 2008 economic downturn (especially up to 1974) was very rapid by historical standards. Growth in the post-financial crisis period of around 0.5% per year is comparable to the pre-Industrial Revolution age.

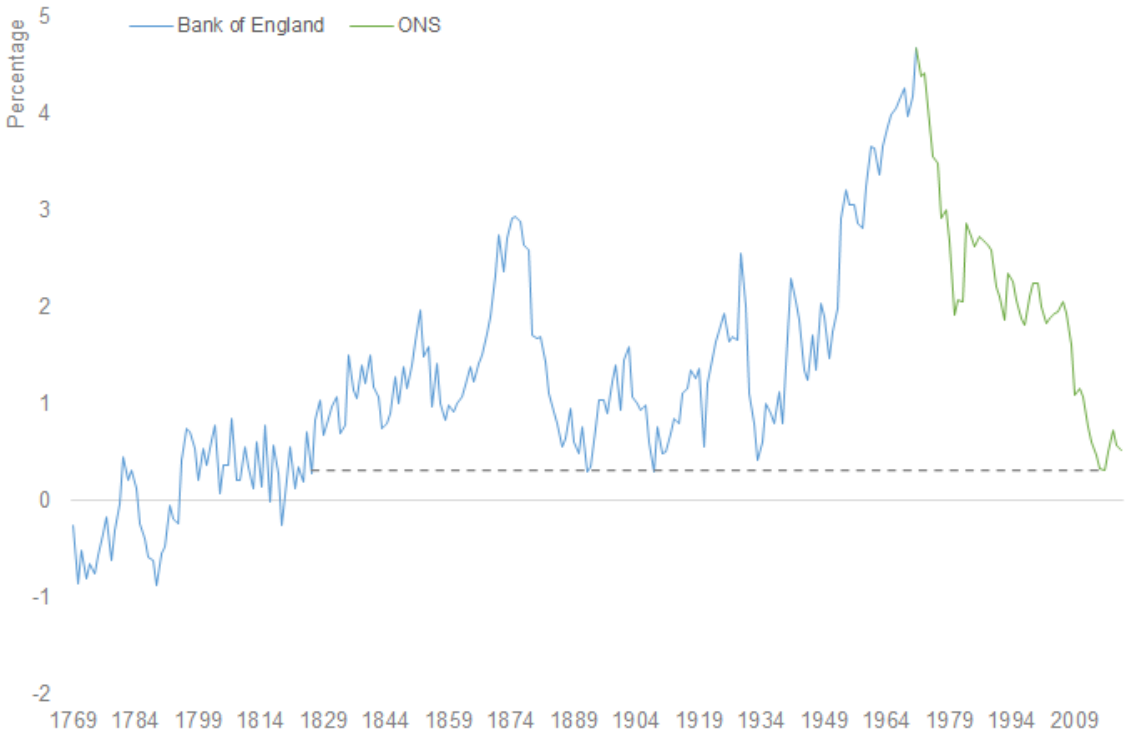
Figure 1 – Output per hour worked, UK (and Great Britain), 1760-2020



Source: Thomas and Dinsdale (2017) – Bank of England Millennium of macroeconomic data, and ONS – labour productivity
Notes: green lines are trend lines through periods; period average growth rates are compound annual averages.

Figure 2 shows a rolling-10-year average of the growth rate of output per hour worked[2] from Figure 1. This confirms that the past decade has delivered growth in productivity at a pace which has not been seen for a sustained period since the Napoleonic era.

Figure 2 – Growth in UK output per hour worked, rolling 10-year compound average annual growth rate, 1769 to 2020



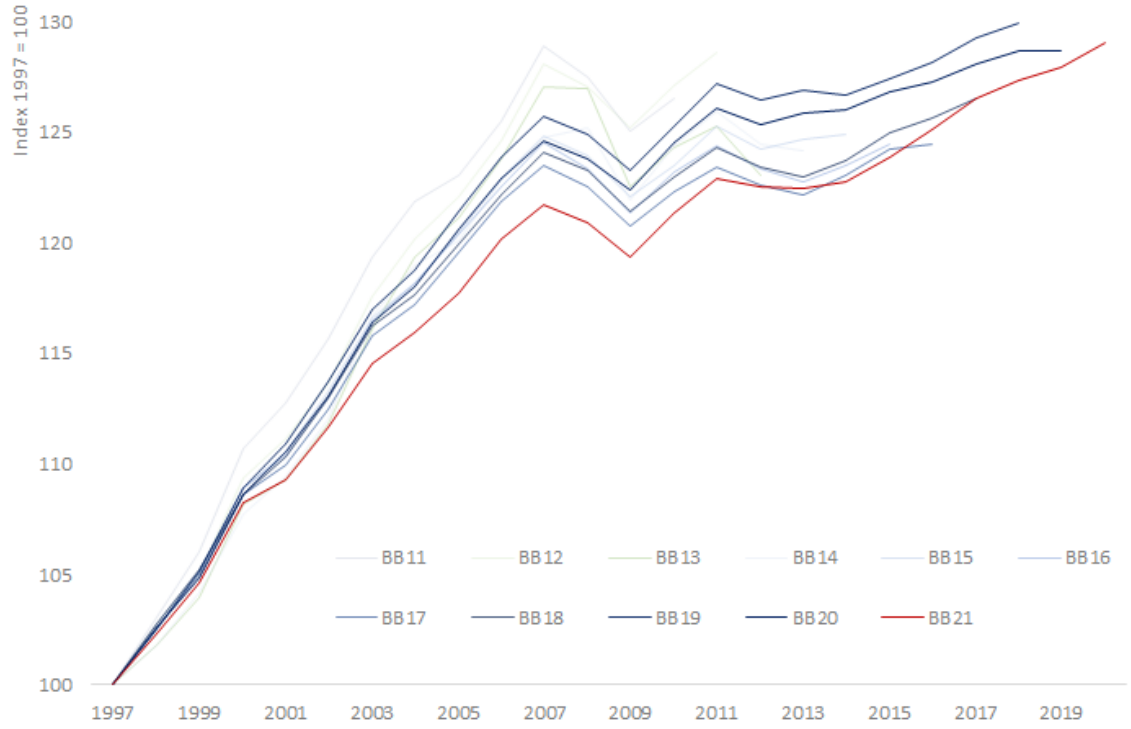
Source: Thomas and Dinsdale (2017) – Bank of England Millennium of macroeconomic data, and ONS – labour productivity
Notes: ONS data in green; Bank of England data in blue.

Our understanding of the "productivity puzzle" has evolved over time, as revisions to the official statistics have been released. Each year, ONS makes substantive methods and data revisions in its annual National Accounts process, known as the Blue Book. The revisions to methods in Blue Book 2021 were the largest in recent years, although there were also substantial revisions in Blue Book 2013 which brought the National Accounts onto a consistent basis with the European System of Accounts 2010 (the international guidance for national accounting of EU members).

Figure 3 shows how UK output per hour has been revised over time, after each successive Blue Book since Blue Book 2011. The revisions in the latest year, Blue Book 2021 (denoted in red), are larger than usual, and change the trend growth before and since the 2008 financial crisis somewhat.

[2] Similar charts for output per worker and MFP are shown in the Appendix.

Figure 3 – Output per hour worked, UK, various Blue Book vintages



Source: ONS – elaboration from Labour productivity revisions triangles

Table 1 shows the cumulative average annual growth rate before and after the financial crisis, and the slowdown between them, in each vintage of data. Revisions in Blue Book 2021 mean the slowdown in the average annual rate of growth is at its smallest of any vintage since Blue Book 2012 (when the post-downturn period covered just 2009 to 2011), due to both to a downward revision in pre-crisis growth, and an upward revision in post-crisis growth. This 'narrows' the productivity puzzle.

Table 1 – Average annual growth rates of output per hour worked, UK, various Blue Book vintages

Vintage	Average annual growth: 1997 to 2007	Average annual growth: 2009 to latest year	Change in average annual growth
Blue Book 2011	2.1%	1.1%	-1.0%
Blue Book 2012	2.5%	1.3%	-1.2%
Blue Book 2013	2.4%	0.1%	-2.3%
Blue Book 2014	2.2%	0.5%	-1.8%
Blue Book 2015	2.2%	0.5%	-1.8%
Blue Book 2016	2.2%	0.4%	-1.8%
Blue Book 2017	2.1%	0.4%	-1.7%
Blue Book 2018	2.2%	0.5%	-1.7%
Blue Book 2019	2.3%	0.6%	-1.7%
Blue Book 2020	2.2%	0.5%	-1.7%
Blue Book 2021	2.0%	0.7%	-1.3%

However, this still represents a slowdown in annual growth of productivity of more than 1 percentage point per annum, which has a substantial effect when compounded over a sustained period. Had productivity recovered to the level and trend it had before the financial crisis, it would have been some 20% higher in 2019 than it actually was. Assuming a constant labour share of income[3], then average annual earnings would be over £5,000 higher in 2019 than they actually were. It is not unreasonable to think that many decisions made by households and society might have been different, had average living standards risen by £5,000, rather than been essentially flat, which highlights the importance of understanding this phenomenon.

The drivers of the slowdown

Growth in output per hour worked can be decomposed in a growth accounting framework into three terms:

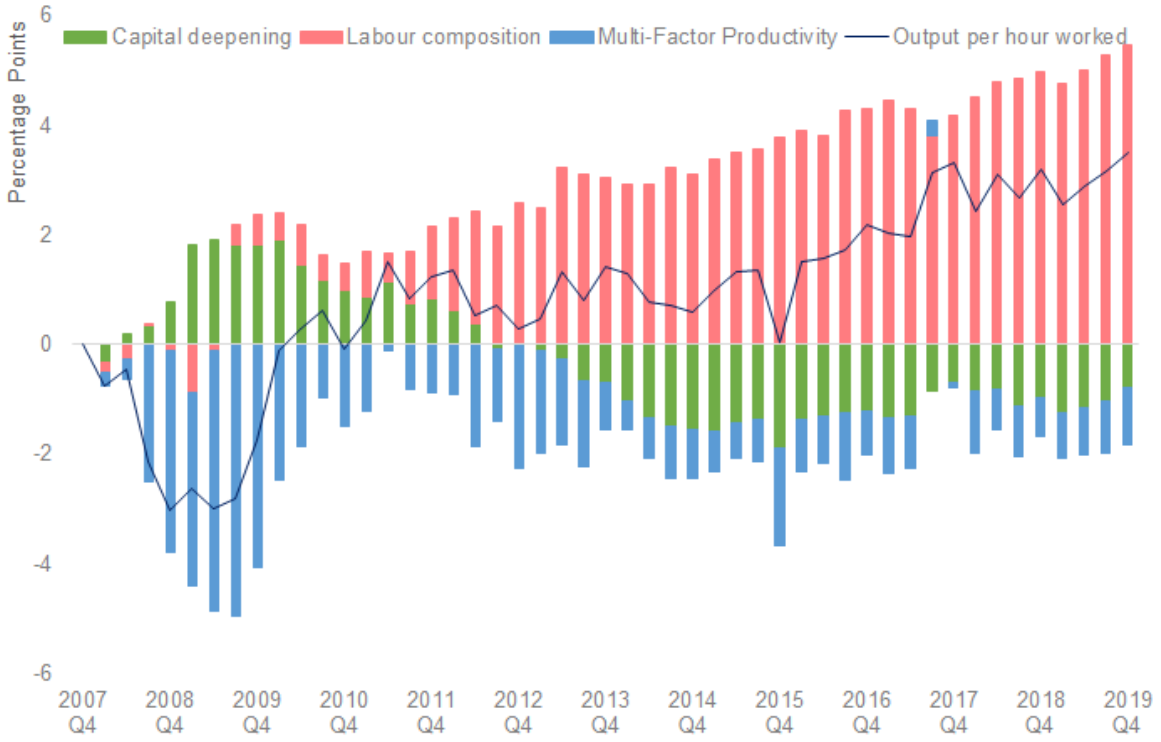
- Labour composition, representing the skills of the workforce
- Capital deepening, representing the availability of capital per hour worked
- Multi-Factor Productivity (MFP), the unexplained residual, representing technological progress, market frictions, and measurement error, amongst other things

Figure 4 decomposes growth in output per hour worked in the market sector[4] since 2008 into these components. This reveals, as has long been understood[5], that the "productivity puzzle" has been a puzzle of two parts: during the economic downturn, and immediately thereafter, MFP demonstrably failed to recover to pre-crisis levels, with weak (indeed negative) capital deepening playing a key role from 2012 onwards. By 2019, the puzzle was about half MFP and half capital shallowing (reduced availability of capital per hour worked).

Improvements in labour skills, reflected through labour composition[6], has played a key compensating role. One of the main drivers of improved labour composition over the past decade is the increase in the number of workers with university degrees. During the coronavirus pandemic, workers with university degree education increased their hours worked, while hours worked among less-educated workers fell. This reflects the industries most impacted by the pandemic, and the feasibility to work from home in different occupations. If the pandemic has lasting effects on the composition of the economy, this distinction could play an important role.

[3] Such that productivity gains passed one-for-one into earnings.
[4] ONS MFP estimates are for the market sector rather than the whole economy, since certain assumptions in the growth accounting framework work best in that context. The market sector excludes government and the non-profit sector.
[5] For instance, Goodridge, Haskel and Wallis (2015) suggested that the productivity puzzle was a TFP puzzle.
[6] Labour composition is derived from a measure of "quality-adjusted labour input", which splits the workforce into many 'cells' according to industry, education, age and sex. Hours worked are then weighted according to average pay in each cell, with higher paying cells having a larger weight, on the assumption that they are more productive.

Figure 4 – Output per hour worked, and cumulative contributions (percentage points), UK market sector, 2007 Q4 to 2019 Q4



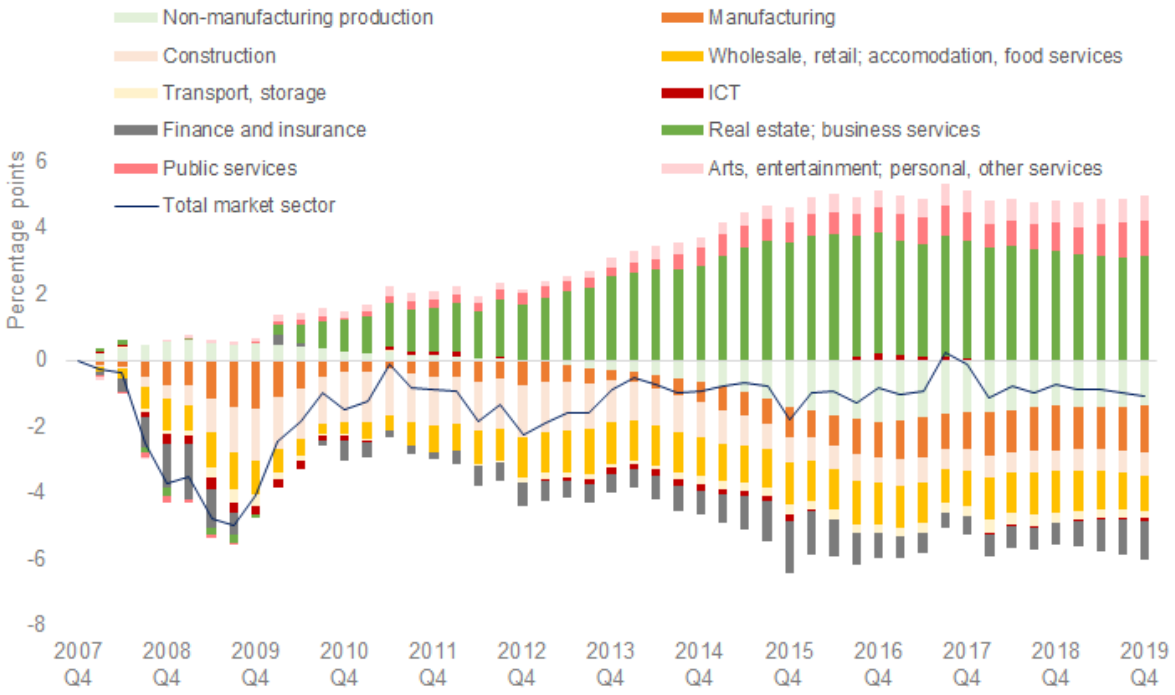
Source: ONS – Multi-factor productivity estimates

However, labour composition is a naïve measure, in that it can only proxy skills and experience by observable characteristics, namely education, age and sex. Increasing skills mismatches, falling on-the-job training[7], or decreasing relevance of taught curriculums could all lead the labour composition measure to overstate the true upward contribution of the skills of the workforce to productivity, whilst unequal gender pay would bias downwards the contribution of female labour participation. If labour composition were overstated, then MFP would be understated, and this might be sufficient for MFP to hit its 2007 levels in 2019. However, even if MFP recovered to its 2007 level, this still means no progress in the economic 'recipe' in over a decade.

Why then has MFP been so weak? It is not easy to answer this question because MFP is the residual in the equation and isn't driven by just one identifiable factor. Figure 5 shows cumulative contributions to total market sector MFP by industry, which might shed some light. While weak MFP appears broad-based across industries, it is not universal – the business services, (market) education and healthcare, and arts and entertainment sectors have all seen increasing MFP over the past decade. This may in part reflect measurement error further back, whilst the parts of the economy which are traditionally perceived as easier to measure have dragged on market sector MFP, particularly manufacturing, non-manufacturing production, and finance and insurance services.

[7] ONS estimates of firm-specific training investment in the market sector have indeed fallen in real terms since around 2009. See Martin (2021).

Figure 5 – Output per hour worked, and cumulative contributions by industry (percentage points), UK market sector, 2007 Q4 to 2019 Q4



Source: ONS – Multi-factor productivity estimates

The changing structure of the economy

To understand which industries have slowed most, we turn back to labour productivity, which offers greater industry granularity and ability to decompose changes in the aggregate. Using the UK Standard Industrial Classification (SIC) 2007, we consider three industry aggregations:

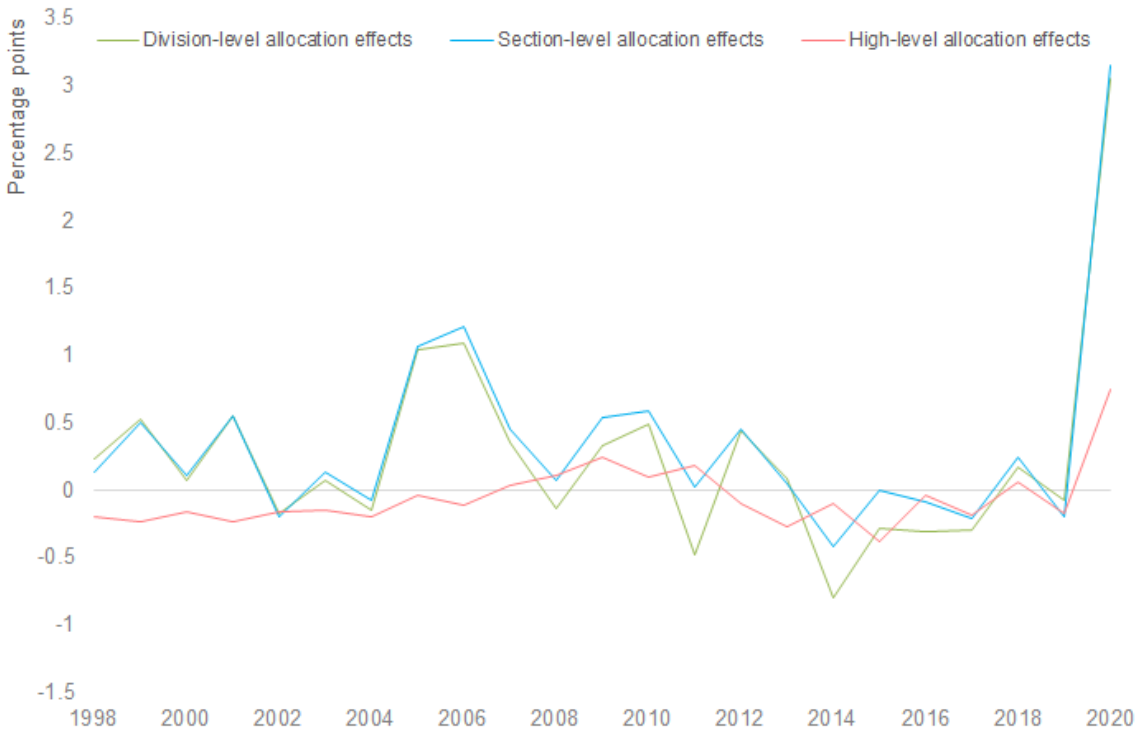
- High-level: Five industry groupings, using groups of industry "high-level sections" of SIC2007
- Intermediate: 19 industry "sections" of SIC2007 (and in some cases aggregations thereof)
- Detailed: 64 industry "divisions" of SIC2007 (and in some cases aggregations thereof)

Productivity of the economy as a whole can increase not only due to 'within-industry' productivity growth, but also from shifts in resources between industries with different levels of productivity. This 'allocation effect' is the result of changes in the composition or structure of the economy on aggregate productivity.

Measured allocation effects differs according to the level of industry granularity used. With more detail comes more opportunity for shifts in relative sizes, which can increase the measured allocation effect. At more aggregated levels, shifts within industry-groups are revealed as a 'within-industry' effect. Interpretation should, therefore, bear in mind the industry aggregation used.

Figure 6 shows the size of the allocation effect under the three aggregations detailed above. In the coarsest of these, the allocation effect is small and often negative. This largely reflects the slow shift away from the production industries, including manufacturing, and towards services; since manufacturing is generally a high-productivity industry and non-financial services (taken as a whole) is a lower-productivity industry, this shift drags on UK productivity. However, the finer aggregations reveal this to be somewhat a fallacy, since the services industries that have increased their shares of the economy tend to be higher productivity industries, like professional services. At this level, the allocation effect is larger, and more often positive. The finest of the aggregations is similar to the intermediate aggregation, suggesting that there is usually little difference in the level of productivity of industry "divisions" within each industry "section".

Figure 6 – Allocation effects at various levels of industry aggregation, year-on-year changes, UK, 1998 to 2020

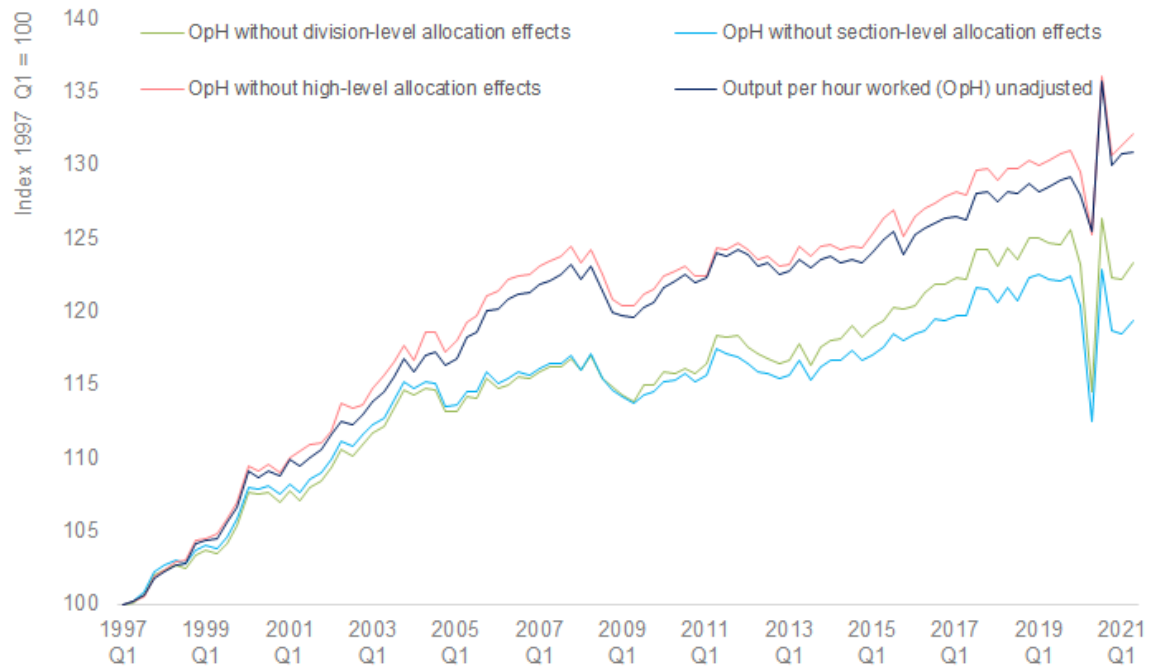


Source: ONS – Breakdown of contributions, whole economy and sectors and Labour productivity by industry division
Notes: 'Divisions' and 'sections' are layers of SIC2007. High-level are aggregates of sections, as described in text.

The most detailed allocation effect (which is likely to give the 'truest' sense of the allocation effect) added on average around 0.5pp per year to UK productivity growth between 1997 and 2007. This fell to around -0.2pp per year on average between 2009 and 2019, although it was a large positive contributor during the coronavirus pandemic in 2020. As such, in the decade between the financial crisis and pandemic the allocation effect stopped boosting productivity to the same degree as in the decade before the financial crisis.

Figure 7 shows what output per hour worked in the UK economy would have been in the absence of these allocation effects. In other words, holding the composition of the UK economy constant[8] at its make-up in Quarter 1 1997, this Figure describes how productivity has changed over time. There is a line for each variant of the allocation effect (using the three industry aggregations from above), along with the unadjusted series.

Figure 7 – Output per hour worked with and without various allocation effects included, UK, 1997 Q1 to Q2 2021, index 1997 Q1 = 100



Source: ONS – Breakdown of contributions, whole economy and sectors and Labour productivity by industry division
Notes: 'Divisions' and 'sections' are layers of SIC2007. High-level are aggregates of sections, as described in text.

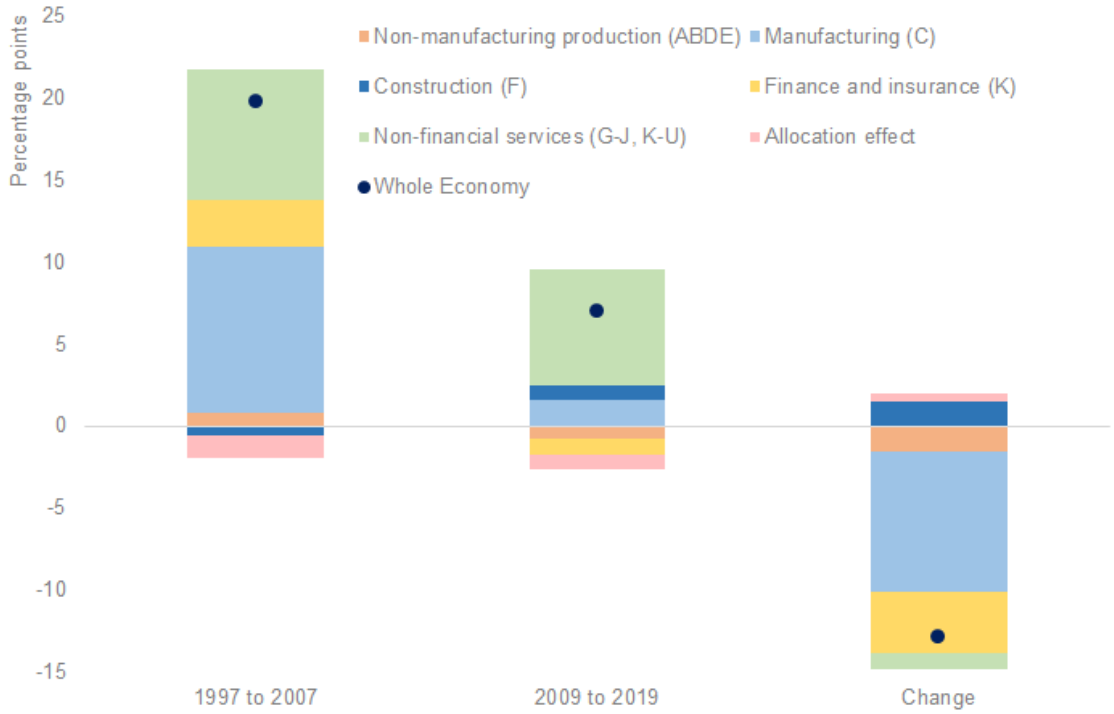
Productivity would have been around 5% lower in 2019 than it actually was in the absence of either of the two more detailed allocation effect terms. Thus, changes to the structure[9] of the economy over the preceding couple of decades pushed up UK productivity on average, especially around 2005 and 2006. This effect was even greater during the pandemic in 2020, when the allocation effect was a large positive contributor to growth.

[8] This is sometimes known as a 'base-weighted' index.
[9] This partly reflects the role of 'imputed rental' – the value associated with owner-occupied housing, which is included in GVA of the real estate industry in line with international guidance. Past ONS research showed that the allocation effect was little changed even after removing 'imputed rental'.

Industry slowdowns

Turning to industries with slowing productivity growth since the financial crisis, Figure 8 shows the contributions of high-level industry aggregates to productivity growth comparing the decade before the financial crisis, and the decade since[10]. The lower height of the second stack reflects the slower aggregate growth over that period. The final stack is the difference between the two periods, so can be read as contributions to the slowdown.

Figure 8 – Contributions to growth in output per hour worked, before and after the 2008-09 economic downturn, and the slowdown, aggregate industry groupings, UK



Source: ONS – Breakdown of contributions, whole economy and sectors

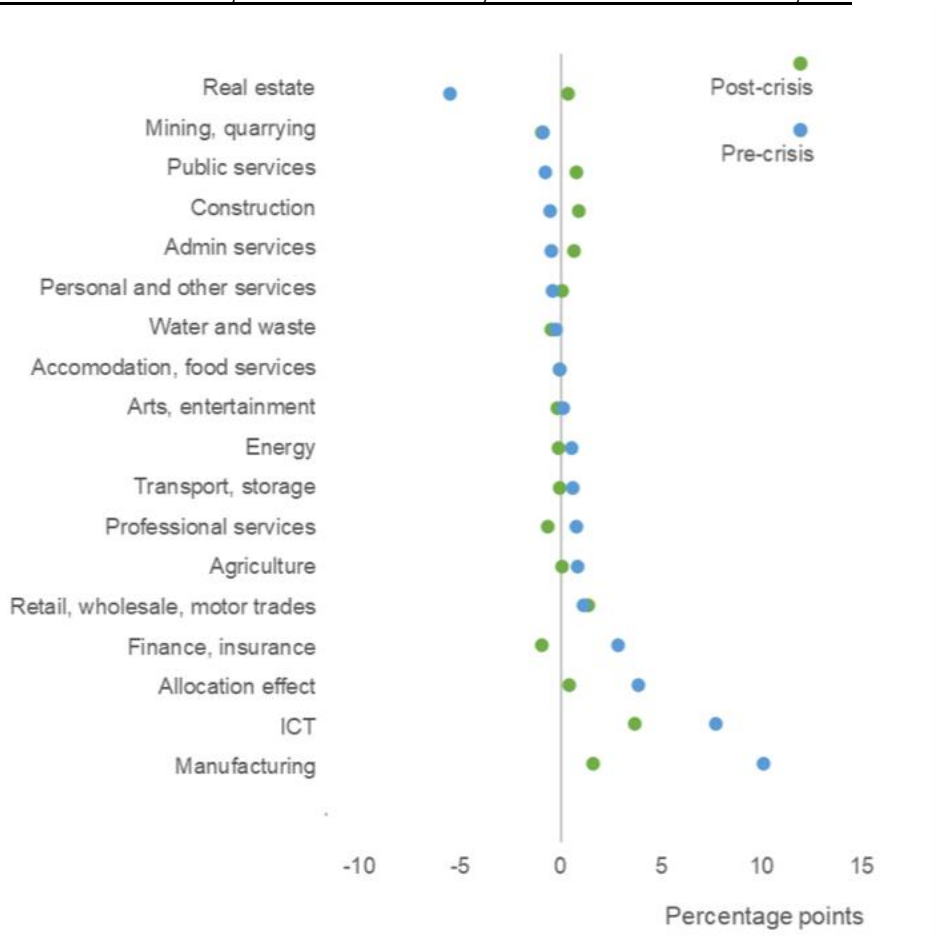
The slowdown is significantly driven by manufacturing (taken as a whole), which was the engine of growth before the financial crisis: whilst still positive, its contribution has fallen substantially. Finance also slows, from a positive contributor before to a small negative contributor after. Smaller negative contributions also come from non-manufacturing production and non-financial services (taken in aggregate). At this level, only construction and the allocation effect are positive contributors (although the allocation effect is still negative post-crisis, just less so than before).

Figure 9 is equivalent to Figure 8, but provides more industry detail, primarily in services. Manufacturing is the same as in Figure 8, and still a large contributor to the slowdown, along with finance, ICT (which grew strongly pre-crisis and less so thereafter), and the allocation effect (which is still positive post-crisis at this level, but less so than before). Countervailing effects (acting to reverse the slowdown in growth) come from real estate (which goes from steady decline pre-crisis to flat post-crisis), construction (as before), public services, and

[10] This style of chart is due to Tenreyro (2018), among others.

admin services. The small, negative contribution from professional services, which is often regarded as an innovative sector, is notable, especially given its relatively large size.

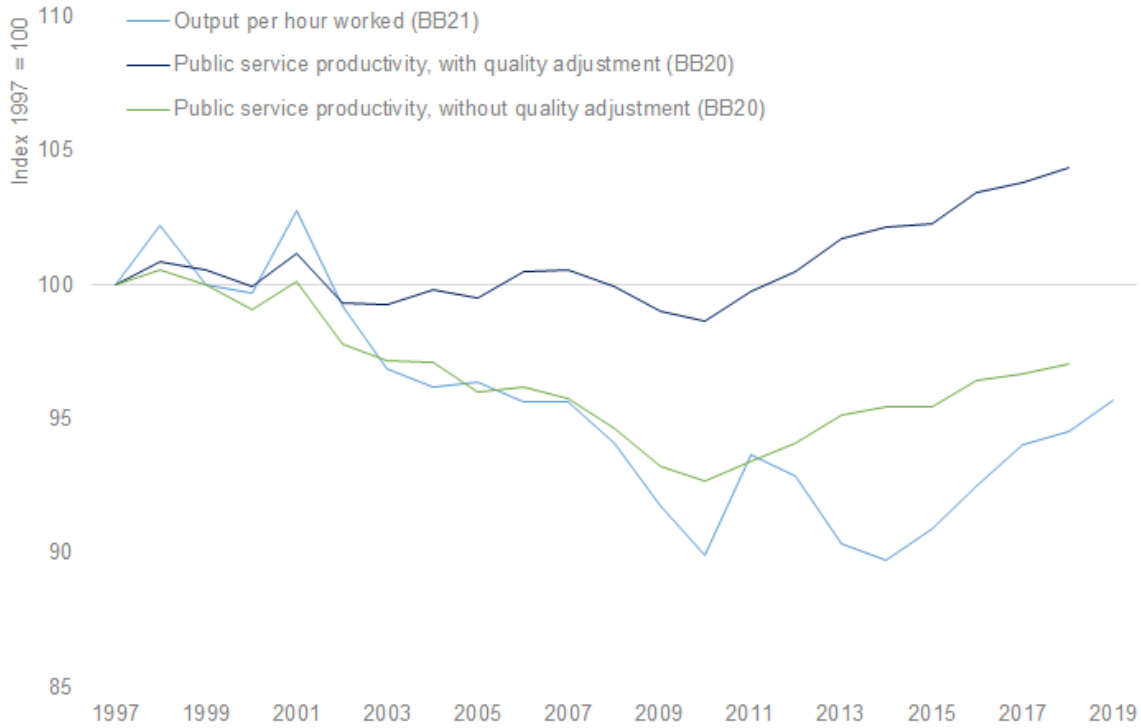
Figure 9 – Contributions to growth in output per hour worked, before and after the 2008-09 economic downturn, and the slowdown, section-level industries, UK



Source: ONS – Breakdown of contribution, whole economy and sectors

Figure 9 identifies a positive contribution from public services (public administration, education, and health and social care). Given challenges measuring public sector output, ONS produces estimates of public services productivity separately. This measure adjusts, where possible, for changes in the quality of services provided, so it differs from National Accounts measures used in labour productivity. National Accounts measures use volume (activity) indicators for around 60% of government final consumption expenditure. In other areas, output is measured by inputs, so there is little opportunity to measure productivity gains (although there can be labour productivity growth from increases in capital and intermediate inputs relative to labour). International guidance recognises this approach as failing to adequately capture quality change, which has generally had a positive effect on UK productivity growth in these sectors, as shown in Figure 10. In all cases, there is an increase in the trend after the financial crisis, confirming the result in Figure 9 even after improving measurement.

Figure 10 – Measures of the productivity of public services, UK, 1997-2019, index 1997 = 100

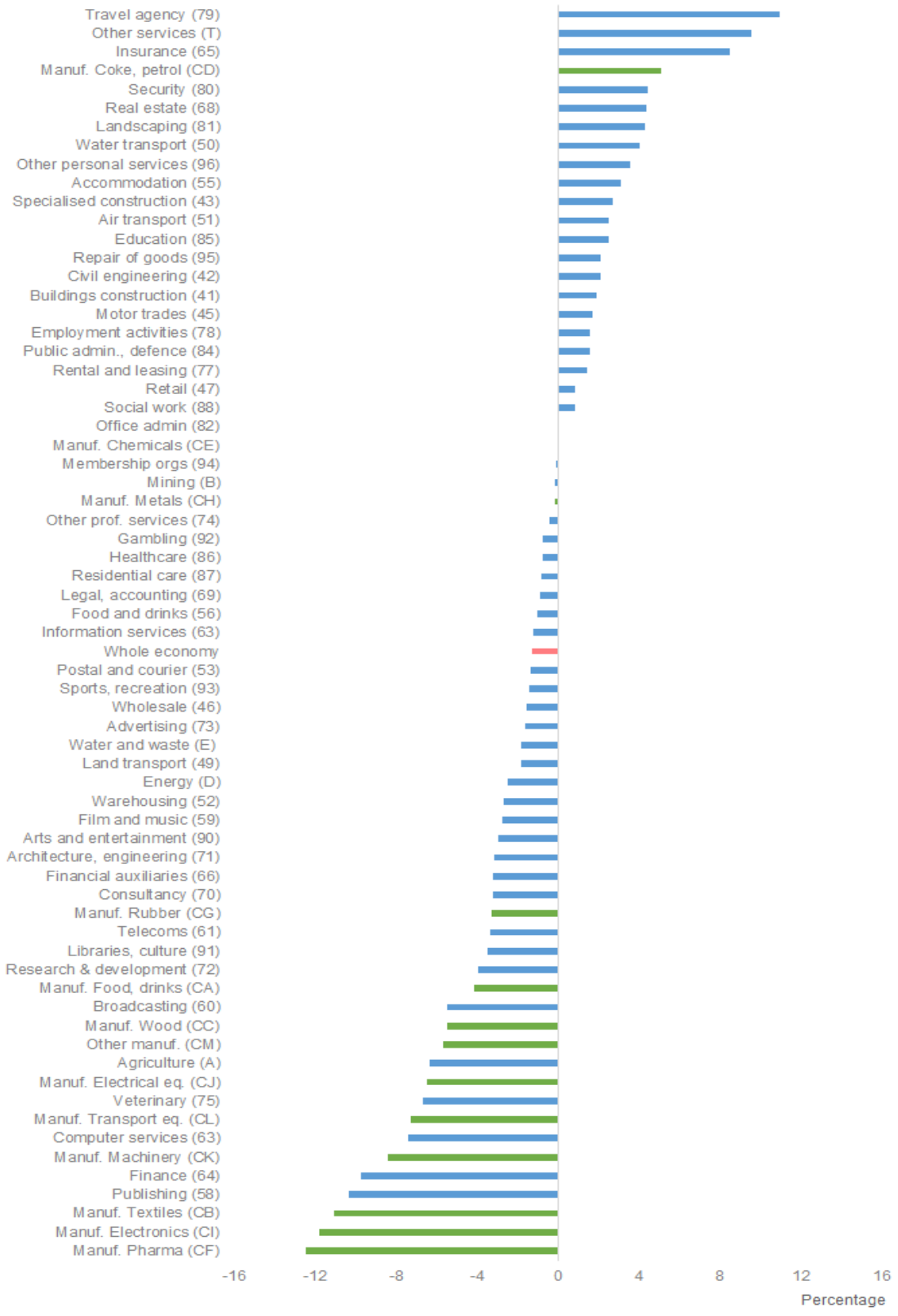


Source: ONS – labour productivity and public service productivity
Notes: public service productivity estimates are produced in KLEMS-style framework, so output is 'total output' rather than GVA. Thus the difference between output per hour worked and non-quality adjusted public service productivity is due to changes in the other measured inputs, namely intermediate goods and services and capital.

Figure 11 provides more industry detail[11]. At this detailed level of 'industry division', there are a wide range of slowdowns and 'speed ups'. Manufacturing sub-industries are highlighted yellow – almost all are negative, showing a slowdown in average annual growth since the financial crisis, and many quite substantially so. Services industries with the largest slowdowns are publishing (58) (both books and software), financial services (64), and computer programming (62). The industries 'speeding up' most are travel agency (79), activities of households as employers and undifferentiated goods and services (T), and insurance (65).

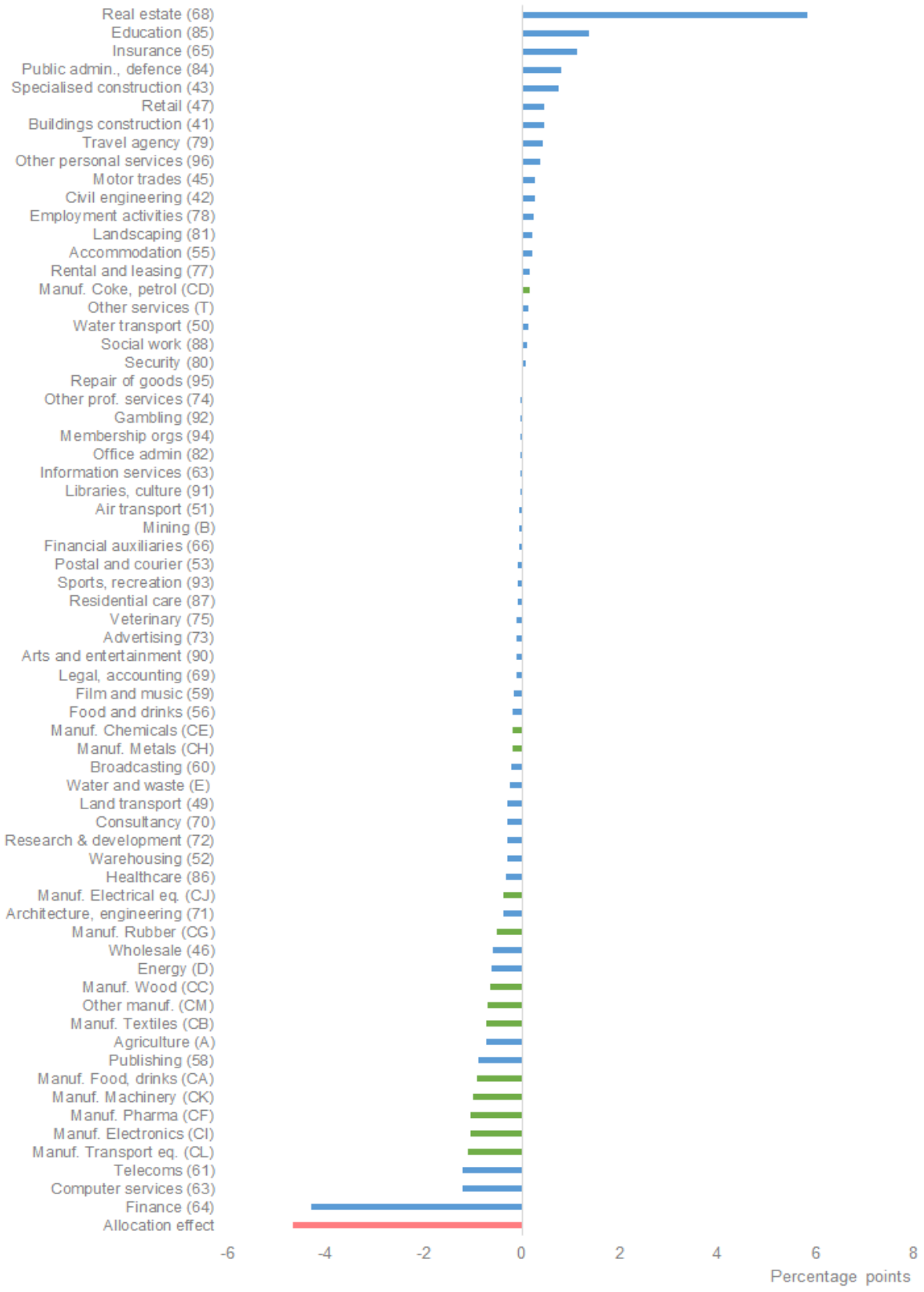
[11] This chart is based on Riley, Rincon-Aznar and Samek (2018).

Figure 11 – Difference between average annual growth in output per hour worked before financial crisis, and after, by industry division, UK



Source: ONS – labour productivity by industry division
Notes: industries are mostly 'divisions' from SIC2007, with some 'sections' and manufacturing 'sub-sections'. Manufacturing sub-sections highlighted green; whole economy highlighted pink.

Figure 12 – difference between cumulative contribution to growth in aggregate output per hour worked growth before financial crisis, and after, by industry division, UK

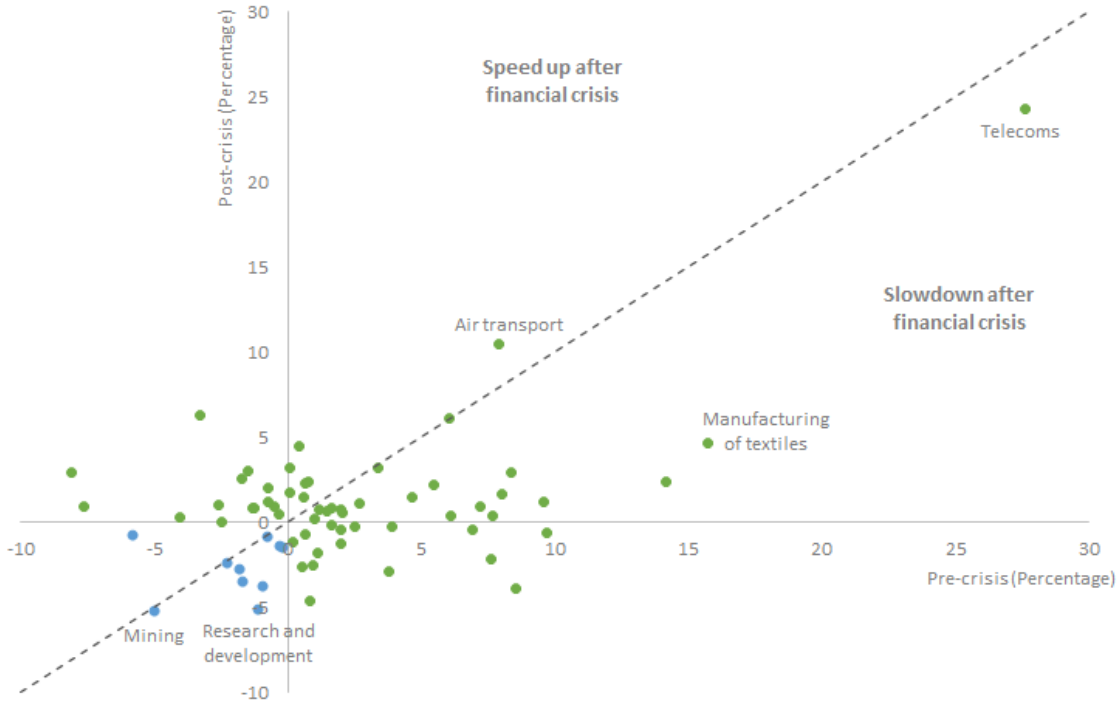


Source: ONS – labour productivity by industry division
Notes: industries are mostly 'divisions' from SIC2007, with some 'sections' and manufacturing 'sub-sections'. Manufacturing sub-sections highlighted green; allocation effect highlighted pink.

Figure 12 translates Figure 11 into contributions-space, by weighting industries according to their size. This is equivalent to the last stack from Figure 8, with more industry detail. In this case, the largest contributor to the slowdown comes from the allocation effect (measured at the industry-division level) and financial services activities (64), reflecting its large growth slowdown and large size. The telecoms industry (61), while still growing rapidly after the financial crisis, does so more slowly than before the financial crisis, and hence contributes to the aggregate slowdown – this is similar to most manufacturing industries.

To the extent that productivity growth reflects technological change, we do not expect sustained falls in productivity over time. Short-term negative growth rates are common for a variety of reasons, but sustained negative growth indicates either substantial regression in an industry, or measurement error. Figure 13 shows a scatter plot of the average annual growth rates in productivity by detailed industries, in the decade before the financial crisis and the decade thereafter. Ten industries (highlighted blue) see negative growth in both periods: mining and quarrying (B); R&D (72); warehousing and support services for transport (52); residential care activities (87); activities of membership organisations (94); information service activities (63); food and beverage services (56); office administration and support services (82); manufacturing of coke and petroleum products (CD). Several are candidates for measurement error, while persistent decline in mining and quarrying (B) and manufacturing of coke and petroleum products (CD) likely reflects structural decline.

Figure 13 – average annual growth in output per hour worked before and after financial crisis, by industry division, UK



Source: ONS – labour productivity by industry division

Conclusion

The latest official data suggest that the “productivity puzzle” is substantial and widespread. Growth after the financial crisis is historically slow, resulting in a large growing deficit against pre-crisis trends. Few industries have sustained or accelerated positive productivity growth over the past 20 years. Positive allocation effects before the financial crisis have vanished, and resources now seem to move away from more productive opportunities.

Despite improvements to measurement, challenges remain. The persistently weak productivity growth in many service industries is surprising. The persistently negative growth in some – even more so. It seems likely that quality improvements are under-reported in official data, leading volume output growth, and hence productivity growth, to be understated.

Challenges in measuring the public services, making up a non-trivial fifth of the economy, are also substantial. Adjusting for quality changes, as recommended in the Atkinson Review (Atkinson, 2005) substantially improves the picture, and would have a notable effect on UK productivity if implemented in GDP.

Meanwhile in manufacturing and production, once the engine of productivity growth, if increasing resources are devoted to environmental protection, then true output may also be understated. This is difficult to quantify, but as is now widely accepted, GDP does not capture everything of interest.

ONS will continue to improve its economic statistics. Improvement in all parts of the economic statistics landscape will improve our productivity estimates, and these estimates are only as good as the source data.

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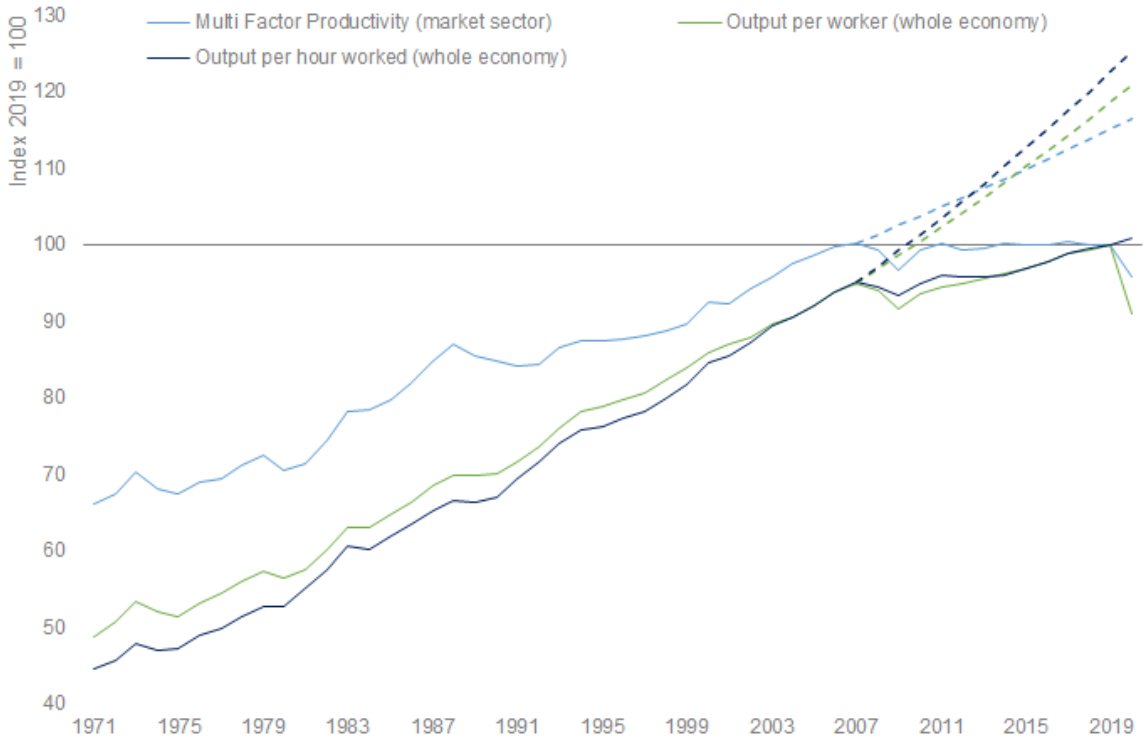
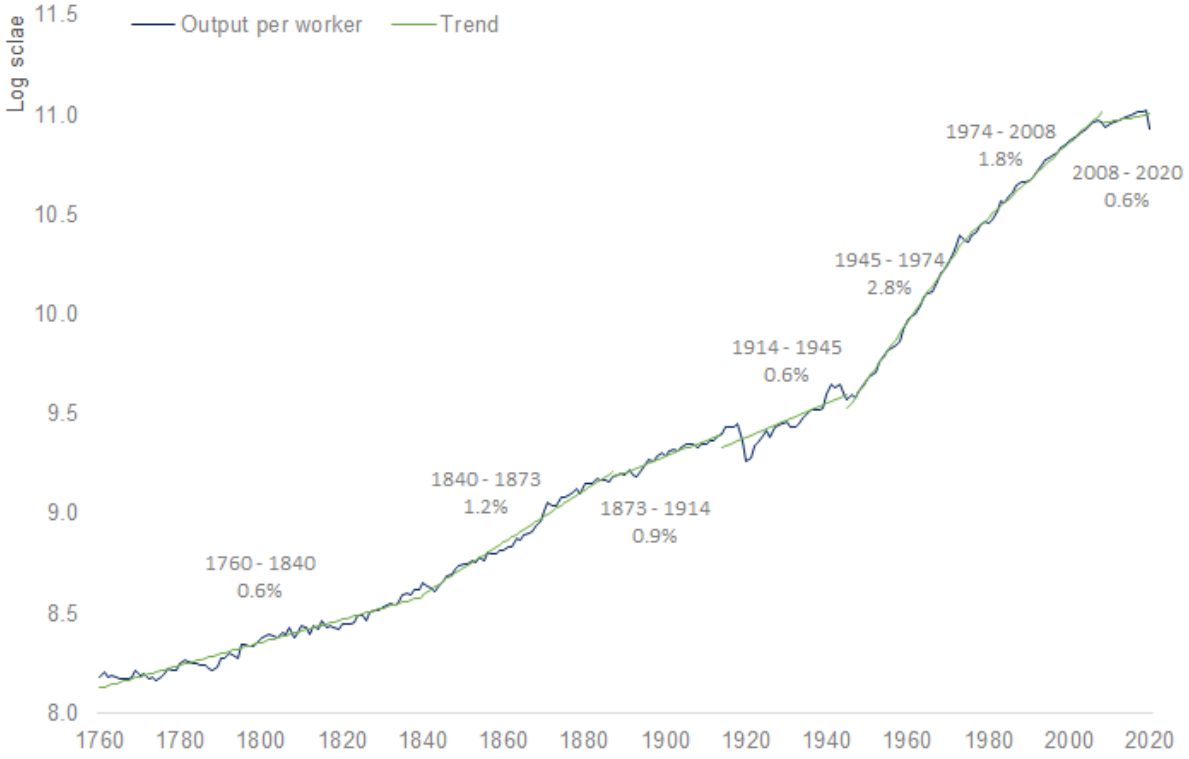
Appendix

Various productivity measures, UK economy and market sector, 1971 to 2020 with trend lines from 2007



Output per worker, UK (and Great Britain), 1760-2020



Growth in UK output per hour worked, rolling 10-year compound average annual growth rate, 1770 to 2020