Office for National Statistics

Article

Volume index of UK capital services (experimental): estimates to 2014

Capital services is a measure of capital input to economic production which takes account of the quality and use of the capital stock across time and different types of assets.

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1 . Abstract

This article presents new estimates of market sector capital services, which are the preferred measure of capital input into production and for use in analysing and modelling productivity, as well as growth accounting analyses. New estimates are provided up to 2014 and previous estimates have been revised, reflecting revisions to source data and methodological changes. Capital services estimates in this article will be incorporated in growth accounting estimates in a future article. Estimates for 2014 show that capital services grew at the fastest rate since 2008, but still well below rates of growth prior to the economic downturn. Average growth of aggregate capital services has been revised only marginally compared with previous estimates over the period since 1990, although there are significant revisions to growth rates of capital services for individual industries.

2 . Acknowledgements

The authors would like to thank Gavin Wallis of the Bank of England for providing Tax Adjustment Factors used in the underlying calculations. (“Tax Incentives and Investment in the UK” Forthcoming in Oxford Economic Papers)

3 . Introduction

About this release

This article represents the latest in a series of articles presenting experimental estimates of capital services. Estimates are presented for 10 industry groups, for 10 asset classes and for the aggregate market sector. This differs from previous publications in which estimates were published for the whole economy level alongside the market sector. This change reflects a fundamental re-parameterisation of the ONS capital services system and has implications for our estimates of multi-factor productivity (MFP), as discussed later in the article. There are also implications for comparisons between estimates of capital services and our official estimates of capital stocks . Capital services and capital stocks both use long runs of detailed estimates of asset accumulation, but with differences in coverage, compilation methods and aggregation. Conceptually, capital services measure flows of capital into production, whereas capital stocks measure wealth embodied in capital assets.

Capital services are informative in their own right, not least in terms of differences in time series properties compared with the widely used conventional measures of capital stocks [1]. However, the main motivation for their estimation is as an input to multi-factor productivity, within a growth accounting framework. This provides a decomposition of movements of growth of economic output and labour productivity into contributions due to changes in inputs of factors of production (labour and capital) and a residual component described as MFP. Movement in capital services rather than movements in the national accounts estimates of capital stocks are the preferred measure of changes in capital inputs in this framework (Harris and Drinkwater, 2000). MFP estimates will be published in a forthcoming article using the capital services estimates in this release.

Layout of article

The rest of this article is structured as follows. The following section describes what is new in this edition, summarising the main changes to sources and to the methodology.

The next section provides some context by drawing comparisons between movements in capital as measured by capital services and those implied from the capital stock estimates. This section also provides some technical material on differences in compilation between the 2 sets of estimates. The section will also compare the capital stock estimates against published capital stocks figures and discuss differences between methodologies.

Next, a results sections present results at the aggregate level, industry level, and asset level. Results are presented as cumulative contributions to percentage growth by the components of each index. These provide a convenient arithmetic decomposition of where growth is coming from, but should not be confused with indices, and cumulative percentage changes will not be equal to index changes. A full set of underlying estimates of growth rates and weights for all component industries and assets in the capital services system can be found in the dataset (Excel sheet) component of this release.

Following on from this, the article examines revisions from previous estimates. Stand-alone estimates of capital services were last published in January 2015. It is these estimates, of the market sector, that are the main comparator for the revisions section.

The last section in the main article is a short section on next steps. As always, feedback from users is welcome. Contact details are provided in the Background notes.

Notes for Introduction

1. Our estimates of capital stocks are presented in monetary units, in current prices and chained volume measures (CVMs), and gross and net of depreciation. Capital services are unit-less volume estimates and are presented as indices and changes in indices. The relevant comparison, as discussed further below, is between capital services and net CVM capital stocks. It is also worth noting that compilation of capital services requires compilation of net capital stocks (in volume and value terms) as an intermediate step. Some comparisons between these two sets of capital stock estimates are shown below and in an Excel table accompanying this release.

4 . What's new?

Coverage

The main change from previous editions is that this release focuses on capital services used within the market sector rather than, as previously, focusing on the whole economy. There are a number of reasons why we have made this change. First, the relationship between capital services and economic output is different between the market and non-market sectors:

- economic output in parts of the non-market sectors is measured exclusively by employment – so changes in capital inputs have no impact, and the conventional production function model which underpins multi-factor productivity (MFP) does not apply
- in the non-market sector, capital income (used in the capital services system in deriving user cost weights) includes only consumption of fixed capital (equivalent to depreciation in current prices in the capital stocks framework)

Second, much investment by the non-market sector is in the form of infrastructure assets which contribute to the productive potential of many parts of the economy, not just (or even predominantly) the industry conducting the expenditure. Investment in roads is a good example. In the national accounts framework such investment is largely conducted by industry O (public administration and defence), but this asset accumulation has no impact on the output of O whatsoever.

Converting the capital services system has meant ensuring consistency across the full set of source data, including asset accumulation (gross fixed capital formation, GFCF) by industry and asset, deflators, asset lives and returns to capital. There are also knock-on consequences as one of the main purposes of compiling estimates of capital services is to serve as an input into MFP. The MFP framework partitions output growth into contributions from labour inputs (quantity and quality), contributions from capital services and a residual MFP component (positive or negative) which is often interpreted as a measure of technical progress. Re-parameterising capital services around the concept of the market sector will necessitate some consequential changes to other components of the MFP framework, including adjustments to output (gross value added).

Previous editions have included estimates of capital services for the market sector as a whole, as well as estimates for the whole economy. However, these market sector estimates have been derived in a top-down fashion, by weighting each asset according to its estimated market sector proportion and summing across assets. This approach provides a single estimate for market sector capital services, but does not provide an industry breakdown. By contrast, the approach taken on this release does provide an industry breakdown below the market sector aggregate estimates, allowing more thorough analysis of productivity movements across the market sector as a whole, albeit at the expense of losing an aggregate for the whole economy [1].

Source data

Our principal source is a detailed breakdown of business investment by asset and industry in volumes and values. This dataset differs in some aspects from the detailed GFCF dataset underlying our official estimates of capital stocks, notably in terms of coverage and the degree of consistency with the UK National Accounts – Blue Book 2015. We have made 3 modifications to the business investment dataset:

- we have made an adjustment to undo the effect on business investment of an asset transfer in 2005 from British Nuclear Fuels Ltd (classified as a public corporation, included in the business investment coverage) to the Nuclear Decommissioning Authority (classified as a central government body and outside the scope of business investment) – otherwise this change would manifest itself in a large spike in manufacturing investment in plant and machinery in that year, reflecting a large negative value of the assets transferred
- we have adopted a revised deflator for mineral rights as used in the capital stocks dataset, the rationale for which is set out on our website
- for 3 tangible assets (buildings, transport equipment and plant and machinery excluding ICT) we have used deflators which vary across industry – these deflators are taken from legacy ONS systems, converted to SIC 2007 and benchmarked to the aggregate asset deflator in the business investment dataset

The detailed business investment industry x asset dataset is only available from 1997. For earlier years we have spliced to the nearest equivalent series in the dataset underlying our official capital stock estimates.

Additionally, the deflator for purchased software is now aligned between capital services and the ONS national accounts systems, including headline GFCF estimates and official capital stocks estimates. This reflects adoption of the long-standing capital services methodology in Blue Book 2015, although with some minor differences in compilation.

Methodology

(i) Rate of return

The rate of return is one component of the user cost of capital, alongside a component representing asset deterioration (that is, the loss in productive potential incurred over the time period in question) and a component to capture the real price change of the asset, relative to the average price level as reflected by the consumer price index. For further information on user costs, see Oulton and Wallis, 2015.

The previous edition compiled capital services for each industry using endogenous industry level rates of return, calculated using industry level returns to capital from the ONS supply-use tables. This represents a very challenging test of data consistency and gives rise to multiple examples of negative user costs (which are not economically plausible, being analogous to negative wages for labour) and undesirable volatility in the time series properties of the resulting capital services estimates. It also creates a practical issue prior to 1997, when supply-use tables are not available on a SIC 2007 basis.

For this release we retain an endogenous link to recorded returns to capital, but we have applied this constraint at the aggregate market sector level. That is, we are assuming a common rate of return across all industries and all assets. This is a reasonable assumption in economic terms, since one would expect differential rates of return to cause capital to flow from lower to higher returning uses. And for most industries, the relationship between industry level rates of return (using industry returns to capital) and the aggregated series is fairly similar. However, in a few industries, the effect of using an aggregated rate of return is dramatic. For example, industry-specific rates of return would be much higher than aggregated returns in industries G (wholesaling and retailing) and K (financial services), while industry-level rates of return would be below the aggregated estimates in industry P (the market sector element of education services).

One possible explanation is that recorded returns to capital in the national accounts framework include returns to land ownership. Land as an asset is not included in the capital services system (nor in the ONS capital stocks system), on the basis that land is a natural endowment and not a produced asset. Nevertheless it seems likely that the costs of land vary across industries, and it is not implausible that the costs of land are higher for land-intensive industries such as G (wholesaling and retailing) and K (financial services), where the industry-specific rates of return would be much higher than the aggregate estimates.

Additionally, discrepancies between rates of return in these alternative methodologies may reflect inconsistencies in the source data. In particular, extreme values for rates of return can arise in cases where the asset accumulation process generates high stock values for 2 or more assets with different user cost characteristics (short-lived versus long-lived for instance) or where asset values are large relative to industry level estimates of returns to capital.

(ii) Deterioration profiles

Following discussion with colleagues in our capital stocks branch we have decided to adopt declining balance rates of 2 for all assets. This has the effect of more closely aligning the age-efficiency profiles in the capital services system with the age-price profiles in the capital stocks system, although it remains the case that capital services uses geometric deterioration while the capital stocks system uses straight-line depreciation and a stochastic retirement function. For more information, see chapter 5 of the ONS Productivity Handbook.

Notes for What's new?

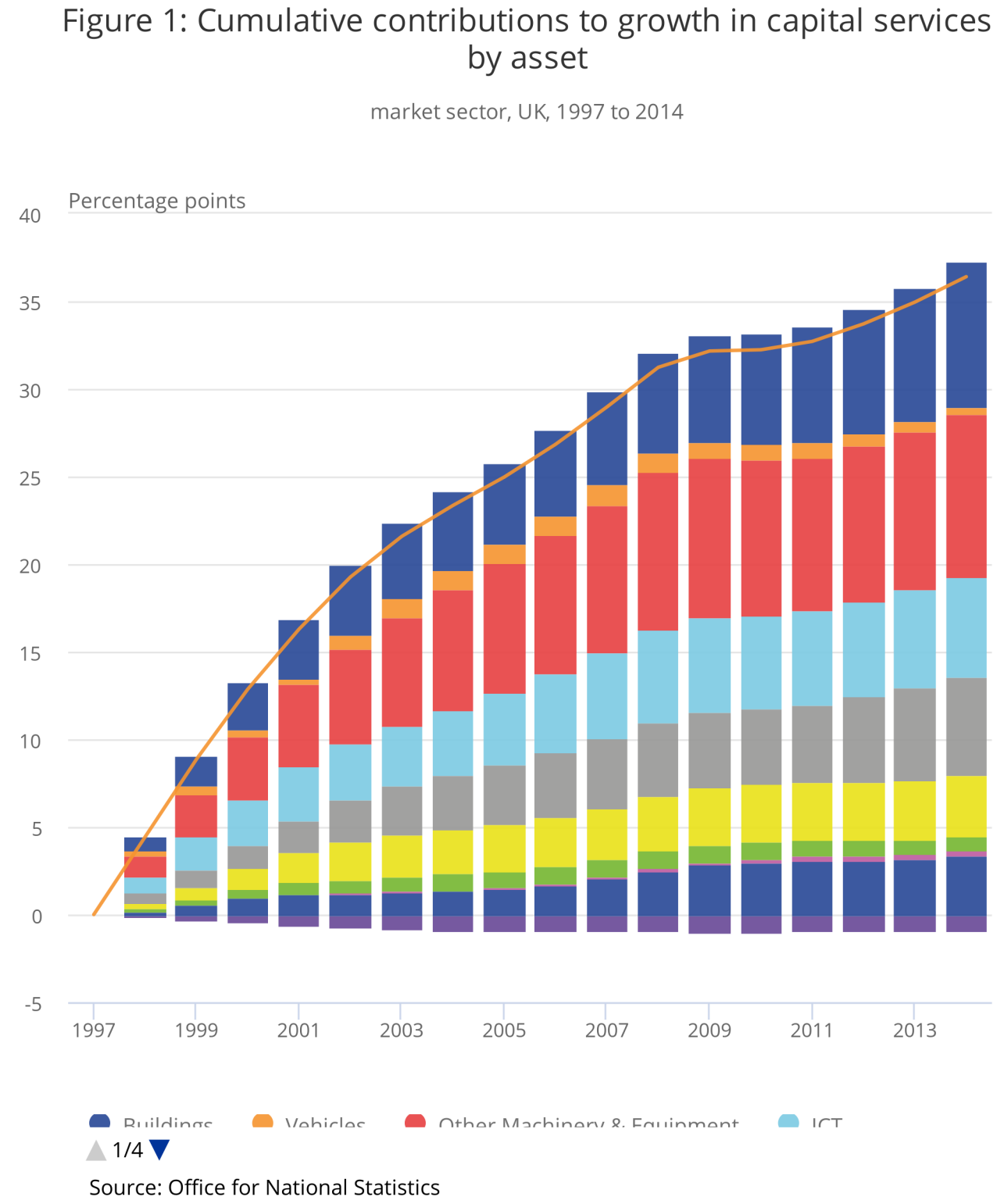
1. Readers may deduce that this approach also provides a route to an MFP breakdown of the non-market sector. This is feasible but is not pursued further in this article because, as noted earlier, the nature of the National Accounts compilation process means that MFP does not have a clear economic interpretation for the non-market sector.

5 . Results

Figure 1 shows how different assets have contributed to whole economy growth in capital services. The 2 largest contributions over time are from buildings and other machinery and equipment, but the 2 different types of software and information and communications technology (ICT) also contribute a significant amount over the time series. There is a small negative contribution to capital services from mineral exploration rights, likely reflecting North Sea oil. This however has minimal impact on the aggregate.

Figure 1: Cumulative contributions to growth in capital services by asset

market sector, UK, 1997 to 2014

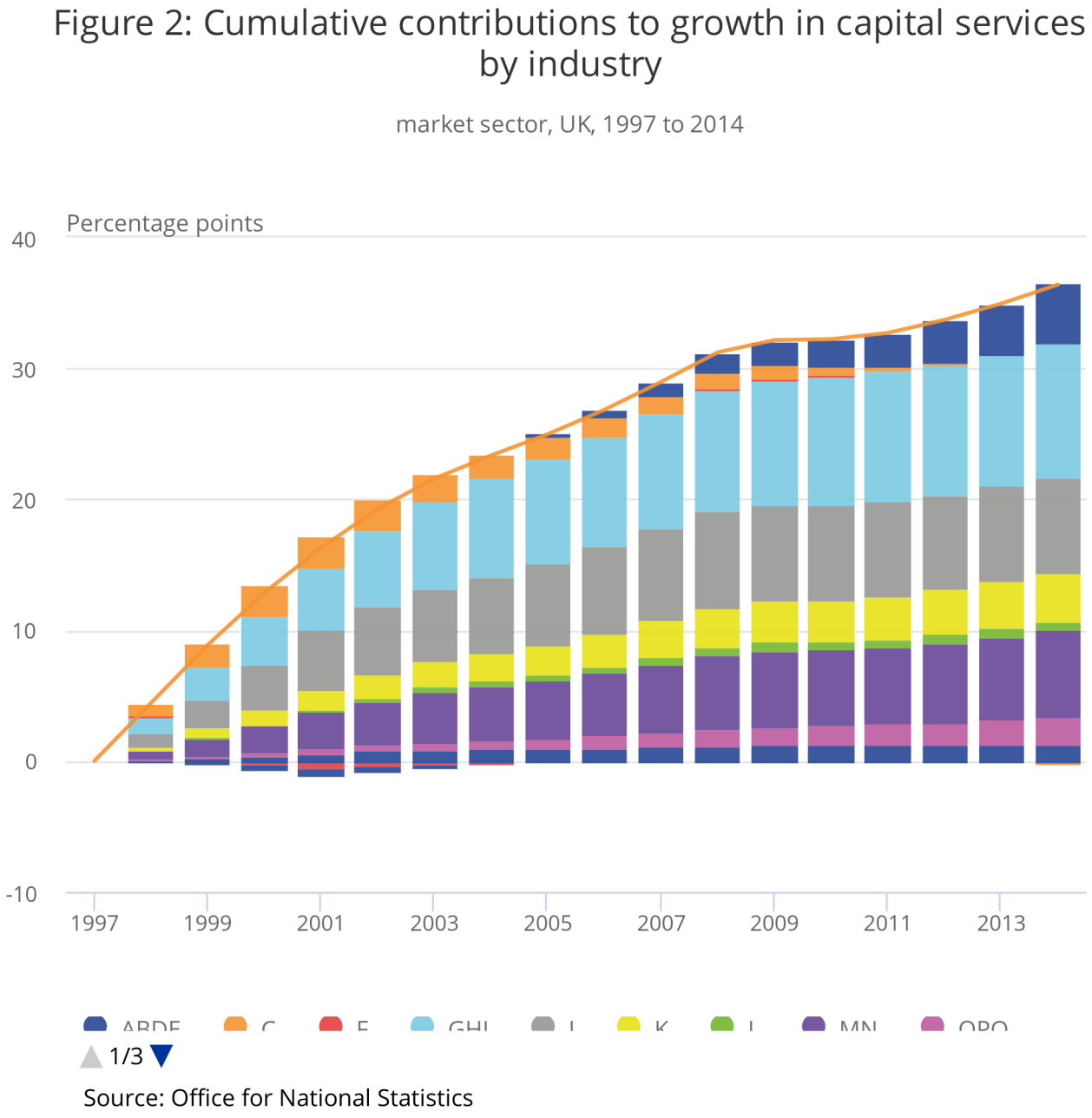


Source: Office for National Statistics

Capital services growth contributions from different industries are shown in Figure 2. These figures show that all industry groupings with the exception of the “other production” ABDE aggregate provide positive contributions over the whole period. The negative contribution of ABDE is only briefly experienced in the early 2000s before becoming a significant contribution again. The effect will be decomposed in the more detailed results to follow.

Figure 2: Cumulative contributions to growth in capital services by industry

market sector, UK, 1997 to 2014



Source: Office for National Statistics

Notes:

1. A refers to Agriculture, forestry and fishing, B refers to Mining and quarrying, C refers to Manufacturing, D refers to Electricity, gas, steam and air conditioning supply, E refers toWater Supply, Sewerage, Waste Management and Remediation Activities, F refers to Construction, G refers to Wholesale and retail trade; repair of motor vehicles, H refers to Transportation and storage, I refers to Accomodation and food services, J refers to Information and communication, K refers to Financial and insurance activities, L refers to Real Estate activities, M refers to Professional, scientific and technical activities, N refers to Administrative and support service activities, O refers to Public administration and defence; compulsory social security, P refers to education, Q refers to Government Services, RSTU refers to Other Services.

Rate of return

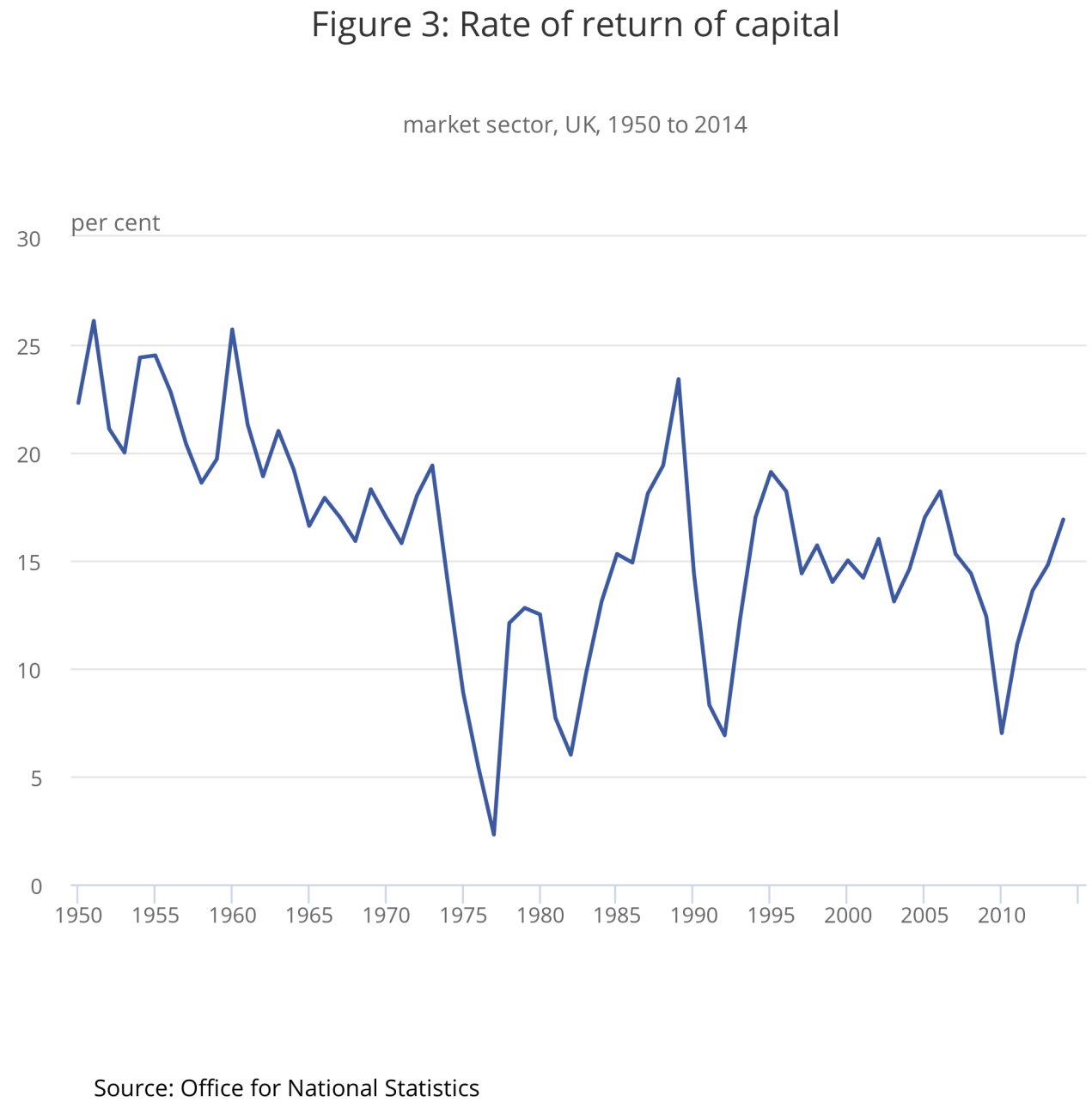
Figure 3 shows for the first time the estimated real rate of return of capital for the whole economy. The rate of return of capital is the risk adjusted market return or the opportunity costs of holding durable goods rather than financial claims (Jorgenson and Yun, 2001). The rate of return is for the market sector and is common across assets and industries in line with the OECD Productivity Manual.

The average rate of return on capital for the 60 year period is 15.9%. There has been a general decline in the rate of return of capital over the 60 year period with the trend clearly punctuated by the economic downturns in the UK economy, in which the rate of return declines sharply before swiftly rebounding. This relationship holds for the most recent downturn though the decline in the rate is relatively small in comparisons to most historical downturn within this period, despite the magnitude of this downturn in relation to the others.

This calculated rate of return is broadly in line with other comparable estimates, such as those in Oulton and Wallis, 2015. Both exhibit the same relationship between recessions and the rate of return of capital.

Figure 3: Rate of return of capital

market sector, UK, 1950 to 2014



Source: Office for National Statistics

Results by asset

Average growth in capital services has declined across asset groupings since the 1990s and this is a trend that continues further with the historical data barring mineral extraction rights and cultivated assets which have seen an increase in average growth rates in the recent period, post downturn. ICT alongside the 2 software splits have suffered the greatest falls in average growth rates, with purchased software falling from an average growth rate of 21.7% in 1990 to 2000 to 5.1% in 2008 to 2014 (Table 1).

Table 1: Average growth of capital services by asset, market sector, UK, 1990 to 2014

% per year	1990-2000	2000-2008	2008-2014
Buildings	2.8	1.1	1.0
Vehicles	0.3	1.0	-2.1
Other Machinery & Equipment	2.5	2.3	0.1
ICT	15.2	9.3	2.3
Purchased Software	21.7	8.4	5.1
Own-Account Software	12.4	3.9	1.0
Artistic Originals	5.8	1.9	-1.5
Mineral Extraction Rights	-5.6	-8.4	1.4
Cultivated Assets	2.6	1.5	5.1
Research & Development	2.2	2.3	1.5

Source: Office for National Statistics

Results by industry

The trend in average growth in capitals services across industries (Table 2) follows that of assets.. All industries barring AB (agriculture, forestry and fishing and mining and quarrying) and Q (Government Services) have lower average growth rates than the preceding periods. The best performing industry DE (electricity, gas, steam and air conditioning supply and water supply, sewerage, waste management and remediation activities) with an average growth rate of 4.3% is still much below its 1990 to 2000 average of 7.4%. The worst performing industries have been industries G (wholesale and retail trade; repair of motor vehicles) and J (information and communication), in which the average growth rates have declined by 6.1% over the period respectively.

Table 2: Average growth of capital services by industry, market sector, UK, 1990 to 2014

% per year	1990-2000	2000-2008	2008-2014
AB	-1.6	-1.0	1.9
C	2.4	-0.7	-1.4
DE	7.4	5.0	4.3
F	1.7	0.7	-0.7
G	7.0	2.9	1.9
H	3.9	4.0	-0.7
I	6.0	2.3	1.2
J	5.9	3.9	-0.2
K	6.3	4.5	2.2
L	3.2	1.9	0.0
M	5.6	4.3	2.1
N	6.9	5.0	1.2
P	1.5	2.7	1.6
Q	2.3	0.6	2.1
RSTU	5.1	3.6	0.9

Source: Office for National Statistics

Notes:

1. A refers to Agriculture, forestry and fishing, B refers to Mining and quarrying, C refers to Manufacturing, D refers to Electricity, gas, steam and air conditioning supply, E refers toWater Supply, Sewerage, Waste Management and Remediation Activities, F refers to Construction, G refers to Wholesale and retail trade; repair of motor vehicles, H refers to Transportation and storage, I refers to Accomodation and food services, J refers to Information and communication, K refers to Financial and insurance activities, L refers to Real Estate activities, M refers to Professional, scientific and technical activities, N refers to Administrative and support service activities, O refers to Public administration and defence; compulsory social security, P refers to education, Q refers to Government Services, RSTU refers to Other Services

6 . Comparing capital services and capital stocks

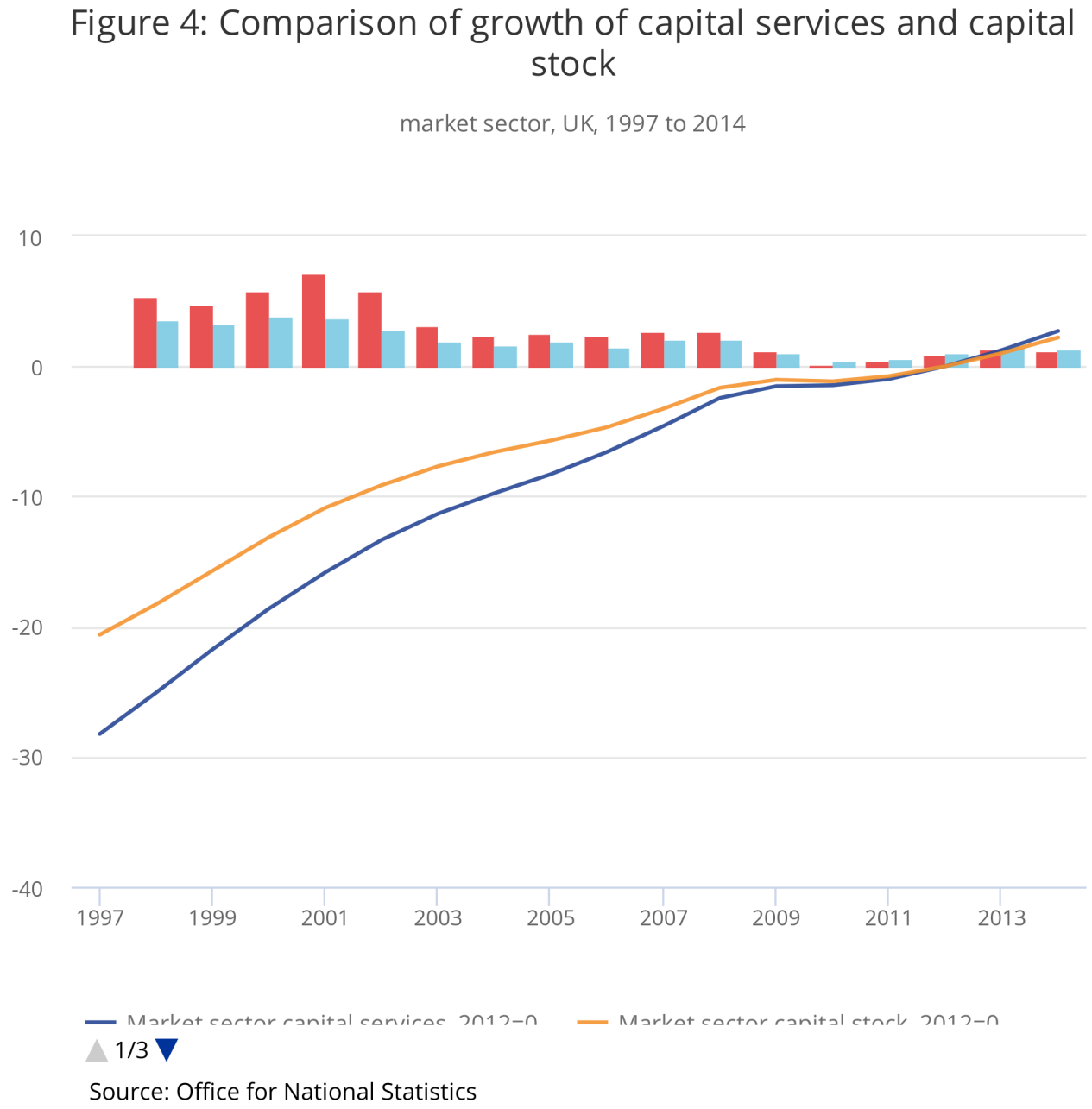
Capital services vs. capital stocks

The conceptual difference between capital service estimates and net capital stocks is that the former aims to directly identify the flow of services into production from capital goods, while the latter is primarily a wealth measure of the value or volume of capital goods and does not attempt to measure how they are used in productive activity. As a simple example, a building purchased for £1 million would be expected to contribute less to production over a single time period than £1 million of information and communications technology (ICT) equipment over the same period, because the ICT equipment will use its productive potential up much more quickly, and because its purchase price will likely fall dramatically.

Conceptually, capital services estimates are flow estimates which depend upon estimates of stocks of productive capital. Stocks of productive capital are compiled by assuming that past investments follow an age efficiency profile, rather than an age price profile, as is used in the ONS capital stocks framework. Further information on differences in methodology can be found in the previous edition of the release.

Figure 4: Comparison of growth of capital services and capital stock

market sector, UK, 1997 to 2014

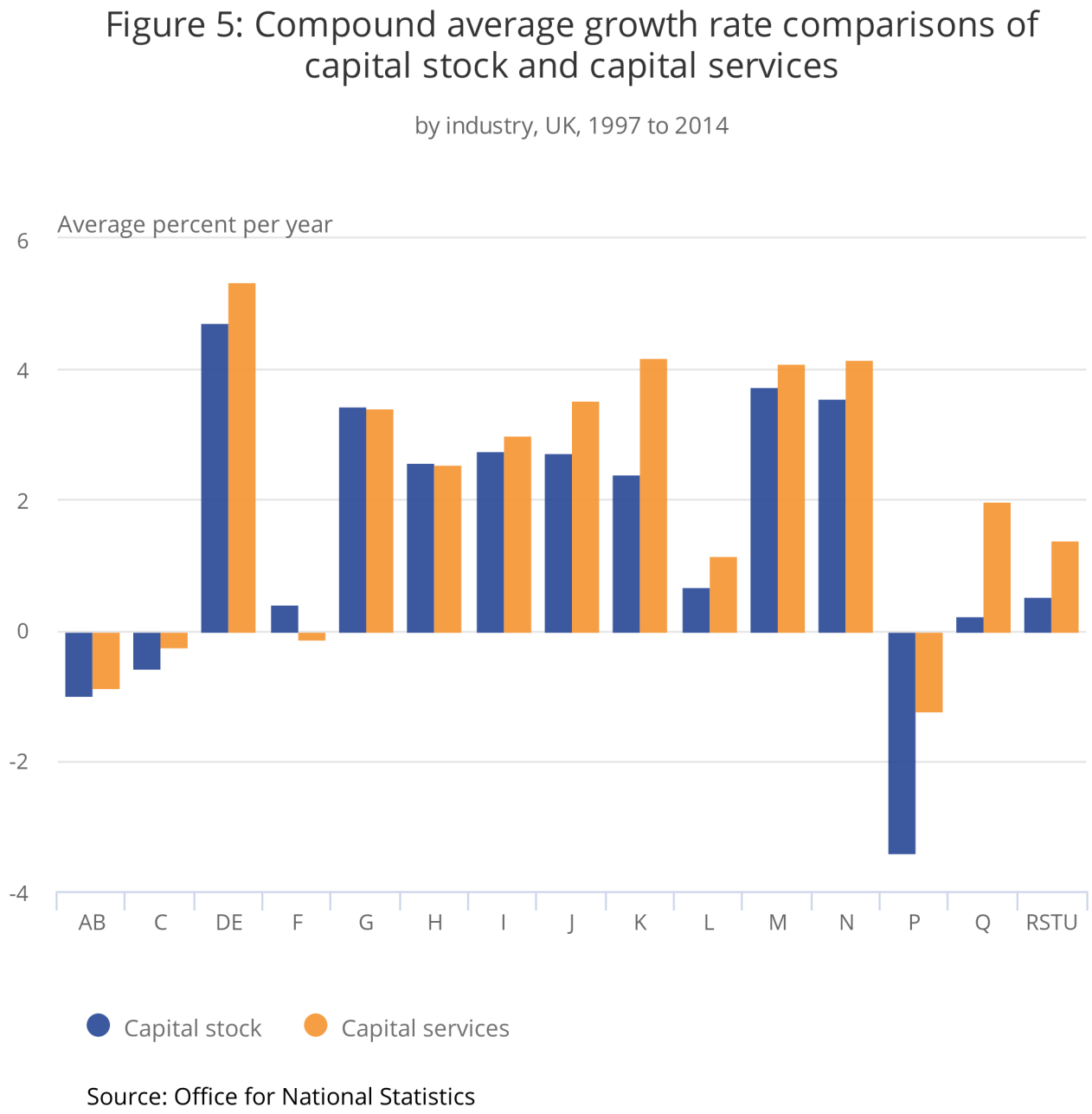


Source: Office for National Statistics

Figure 4 outlines the differences between conventional net capital stocks and capital services, showing that over the 1997 to 2014 period, capital services grow by more, however, over the downturn period (2008 to 2012), the difference in growth profiles is less pronounced. Figure 4 shows that both capital stocks and capital services post-recession have gradually recovered but are still well below pre-crisis growth levels.

Figure 5: Compound average growth rate comparisons of capital stock and capital services

by industry, UK, 1997 to 2014



Source: Office for National Statistics

Notes:

1. A refers to Agriculture, forestry and fishing, B refers to Mining and quarrying, C refers to Manufacturing, D refers to Electricity, gas, steam and air conditioning supply, E refers toWater Supply, Sewerage, Waste Management and Remediation Activities, F refers to Construction, G refers to Wholesale and retail trade; repair of motor vehicles, H refers to Transportation and storage, I refers to Accomodation and food services, J refers to Information and communication, K refers to Financial and insurance activities, L refers to Real Estate activities, M refers to Professional, scientific and technical activities, N refers to Administrative and support service activities, O refers to Public administration and defence; compulsory social security, P refers to education, Q refers to Government Services, RSTU refers to Other Services

Figure 5 shows how the different methods of calculation used in producing capital services estimates result in different growth rates from capital stocks by industry. Again the general trend of capital services growing at a faster rate of capital stocks is clear; however, the rates of growth vary significantly by industry. Industry G (wholesale and retail trade; repair of motor vehicles) and F (Construction) go against the trend with capital services growing more slowly or even shrinking while capital stock grow at a faster rate.

7 . Comparing estimated capital stocks against ONS capital stocks

This article publishes estimates of market sector net capital stocks by asset and industry and these can be compared to net capital stocks that we also publish within the capital stocks, consumption of fixed capital release.

Figure 6 compares levels of the 2 different levels of stocks. There are a number of differences between the 2 estimates which are due to differences in the methodologies and some differences within the source data. VICS net capital stocks figures are compiled using market gross fixed capital formation (GFCF) from our business investment release while comparable estimates for market sector capital stocks have been derived from whole economy stocks minus general government stocks. This should result in a broadly like for like comparator.

Beyond the source data differences there are differing methodologies used between the 2 estimates. The main difference between the 2 measures is within the PIM (perpetual inventory model) used. The VICS capital stocks are estimated using a geometric depreciation, while national accounts capital stocks use a linear depreciation method with an established distribution of depreciation at the end of each of the assets' life. The method of geometric depreciation used within VICS has been altered to bring estimates more in line with our published estimates but some differences still remain.

Different deflators are also used within the respective systems. The VICS capital stocks uses different deflators for the research and development (R&D) asset to allow for greater consistency along the VICS extended historical time series.

Capital stocks estimates also undergo further adjustments, such as for wartime capital losses that are not captured within the VICS system.

These factors contribute to differing levels of capital stocks within the 2 estimates, with the VICS system having a relatively higher level but average trends in stocks typically follow each other closely.

Figure 6: Comparison of Market Sector net stock estimates

UK, 1997 to 2014

Source: Office for National Statistics

8 . Revisions

Revisions to GFCF

The fundamental re-parameterisation of the capital services system described above has led to large differences in gross fixed capital formation (GFCF) estimates by asset and industry, although the average revision to GFCF aggregate is fairly small. This is as expected. In the previous edition, GFCF component data feeding into the market sector capital services aggregate were benchmarked to the business investment aggregate from the national accounts, but used only limited information on the asset distribution and none at all on the industry distribution across the market sector. For this release we have much more robust industry x asset source data below the market sector aggregate, albeit at the cost, for the time being at least, of no capital services estimates for the whole economy.

There have also been some sizeable revisions to deflators for certain assets. In particular, the deflator for information and communications technology (ICT) hardware has been revised upwards in the period up to 2000 (such that the average price fall of this asset has been reduced). And the deflator for mineral exploration rights has undergone a methods change with the effect of increasing the rate of price growth over much of the period but sharply reducing the rate of price growth since the economic downturn.

Revisions to capital services estimates

Figure 7 shows aggregate capital services in this release alongside the market sector aggregate from the previous release published in January 2015, both indexed to 2012. It is important to note that the market sector aggregate from the January 2015 release was compiled in a “top-down” fashion from proportions of aggregate GFCF attributable to the market sector, rather than “bottom-up” from detailed industry x asset GFCF components as in the current release.

The latest estimates grow less fast over the period up to 1990. Average growth rates are almost identical since 1990: the latest estimates grow a little faster prior to the economic downturn, but a little slower since the downturn.

Capital services by industry are not fully comparable due to the re-parameterisation noted above. Subject to this caveat, there are large across-the-board revisions to growth of capital services by industry, affecting industries that are ostensibly not affected by the re-parameterisation (because they lie entirely or predominantly in the market sector) such as manufacturing, construction, wholesaling and retailing and financial services, as well as industries which we would expect to be affected by removing the non-market components (including real estate, education services and health services).

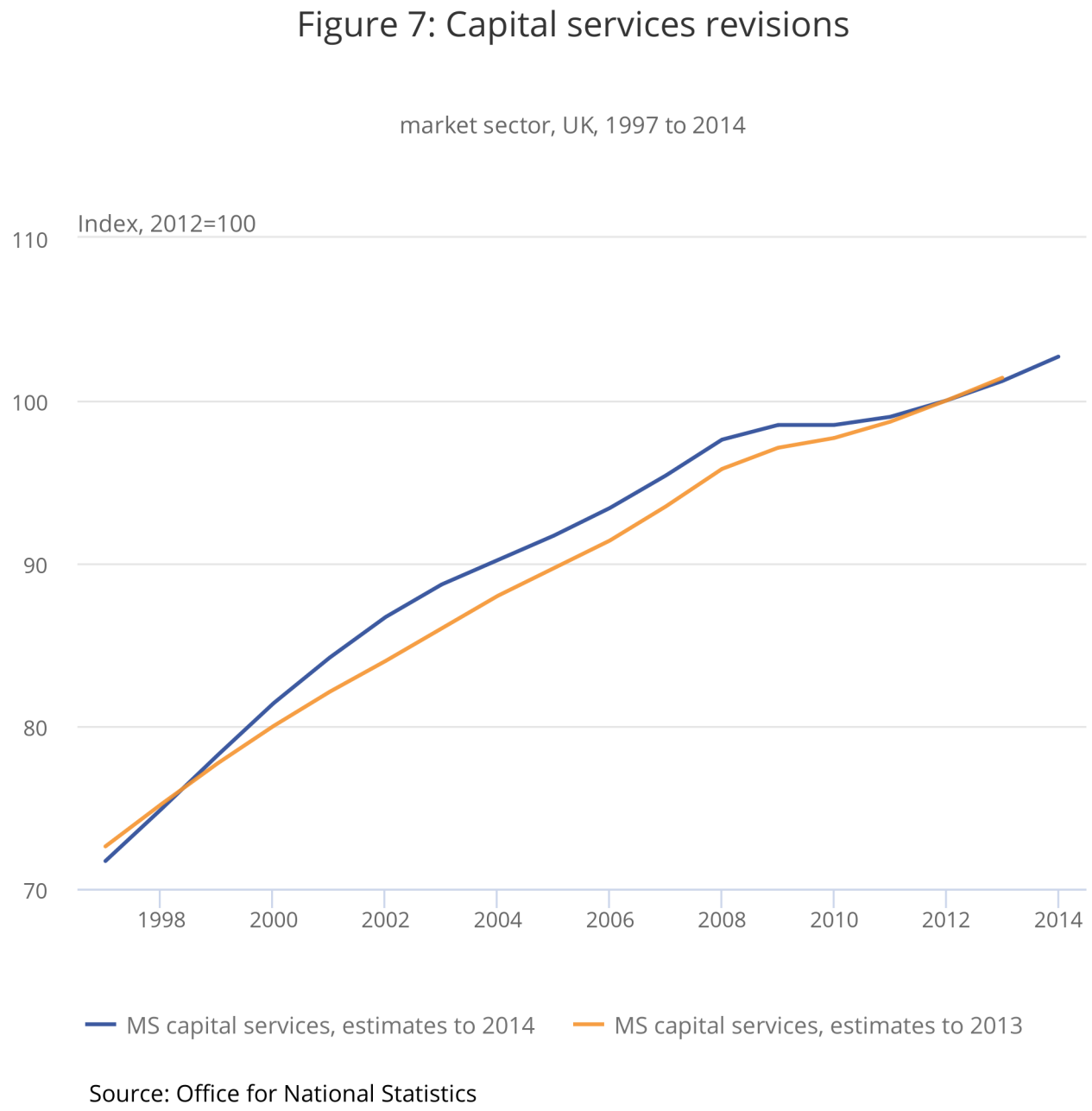
For example, growth of capital services since 1990 in manufacturing is now estimated to be 1.2% per year lower than in last year’s estimates, and growth of capital services in construction has been revised down by 1.0% per year. On the other hand capital services are now estimated to have grown significantly more rapidly in a number of service industries including information and communications (1.8% per year), financial services (1.8%) and professional and scientific services (1.2%).

Slower growth of capital services in manufacturing is a consistent feature of the latest estimate, spanning the period prior to the economic downturn as well as the post-downturn period. Faster growth of capital services in the information and communications industry is also common to the pre- and post-downturn periods. However, the latest estimates are more similar in growth rate terms to previous estimates for the post-downturn period for a number of industries including utilities, financial services, professional and scientific services and administrative and support services.

More information on revisions is available in the dataset.

Figure 7: Capital services revisions

market sector, UK, 1997 to 2014



Source: Office for National Statistics

9 . Next steps

Our next step is to combine these estimates with estimates of quality adjusted labour inputs (QALI) in order to compile multi-factor productivity (MFP) estimates on a Blue Book 2015 basis up to 2014. Following the re-parameterisation to the market sector, this will be a slightly larger task that in previous years, as we will also need to adjust estimates of gross value added by industry and factor income shares. Moreover, our existing QALI framework aggregates to the market sector by assuming that all non-market sector labour input is located in industries O-U. This is a simplification, which we will aim to address in the next QALI update. In the interests of timeliness we plan to use our existing QALI framework (updated only for Blue Book factor income constraints) in our forthcoming MFP estimates.

As for development of capital services, we are running a project to further improve gross fixed capital formation (GFCF) deflators and in particular to reinstate separate deflators by industry and asset. Our development agenda is part of a broader strategy for developing economics at ONS, further information on which is available on our website.

10. Background notes

1. Capital services calculations are based on the methodology recommended in the OECD Measuring Productivity manual and the OECD Measuring Capital manual. The OECD produces a spreadsheet which outlines the data sources and an example of how they combine to produce capital services estimates.

2. We are keen to develop a greater understanding of the use of productivity statistics. If you have any feedback, please get in touch via productivity@ons.gsi.gov.uk

3. We publish a quarterly Labour Productivity statistical bulletin. This provides more timely and periodic information on UK labour productivity, and is accredited as a National Statistic.

4. We publish 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.

5. We also publish a range of public sector productivity measures and related articles. These measures define productivity differently from that employed in the ONS labour productivity and multi-factor productivity (MFP) estimates. Further information can be found in Phelps(2010).

   More information on the range of our productivity estimates can be found in the ONS Productivity Handbook .

6. 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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