IARIW 2024

IARIW 2024

Thursday, August 22 – Friday, August 30

Are Software Assets Mostly Proprietary? Some Evidence Using UK and US National Accounts Data

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Paper prepared for the 38th IARIW General Conference
August 26-30, 2024

THEME 6: Output and Productivity Measures in Dynamic Industries
Time: Wednesday 28 August [17:30-18:30 GMT]

Are software assets mostly proprietary? Some evidence using UK and US National Accounts data

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This version: August 2024 – prepared for IARIW general conference 2024

Abstract

Most economic theory treats intangible assets as proprietary. In this paper we uncover patterns in software investment that challenge this view, suggesting that most of the rise in the last decade has been driven by purchased software. We focus on US and UK data that provide a decomposition of software investment into contributions of purchased and proprietary. We document a contrasting composition of software investment in both countries and explore reasons for these differences. Despite similar measurement frameworks, subtle differences in assumptions have large effects on official estimates of in-house software investment. Harmonising measurement closes over half of the apparent level difference. However, the contribution of purchased software to the rise of US software investment remains across different methodologies, and explains the faster rise in software investment relative to the UK in the last decade. We find that the US have had large productivity gains in the software development industry over the same period. While other European countries do not provide detailed data on investment by type of software, we find that the rise in software investment in the last decade was strongest in countries experiencing large productivity gains in the software industry. We suggest this is more consistent with a rise of software investment driven by purchased software across Europe as well.

Keywords: software investment, intangible assets, national accounting, economic measurement

JEL codes: E22, E01, O34

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We are grateful to Tommaso Bighelli, Marco Garofalo and Jonathan Haskel for valuable comments and discussions. We received helpful comments from participants at the ESCoE annual conference 2024, especially from Nick Oulton, Phil McCann, and Phil Wales. This paper uses ONS statistical research datasets. Outputs may not exactly reproduce National Statistics aggregates. Any errors are our own.

1. Introduction

The rise of intangible inputs has been dramatic over recent decades, and the focus of a large and increasing literature discussing their role in the economy. These intangible inputs, and software in particular, are usually thought of as proprietary (Aghion et al., 2023; de Ridder, 2024) – either because they are developed in-house or customized. Their proprietary dimension is the reason for much of the literature to suggest they have limited positive spillovers to competitors and contribute to the decline in innovation diffusion and business dynamism (see, among others, Bessen, 2020; De Ridder, 2024; Aghion et al., 2023; Bajgar et al., 2023).

In this paper, we focus on US and UK data to shed light on the nature of software investment, the second largest intangible asset capitalised in the national accounts, by looking into detailed data on the contributions of purchased and proprietary investment. We document a contrasting composition of software investment in the two countries. Overall, both the UK and the US have similar levels of software investment to GDP ratios in 2022. Yet, the US has a large contribution of purchased software investment, and this has driven a large rise in total software investment since the late-1990s. By contrast the UK has a large contribution of proprietary software investment, though this has been relatively flat since the late-1990s. We investigate reasons for these differences both in levels and trends. Despite similar measurement frameworks, subtle differences in assumptions have large effects on official estimates of in-house software investment. Harmonising measurement closes over half of the apparent level difference. However, the contribution of purchased software to the rise of US software investment remains, and explains the faster rise in total software investment in the US relative to the UK in the last decade.

We investigate potential reasons for the diverging purchased software investment trends. We find that the US has had large productivity gains in the software development industry while productivity in this industry was stagnant after 2010 in the UK. Finally, we investigate data from other European countries. We do not have detailed data on investment by type of software outside the US and the UK, but we do find that the rise in software investment in the last decade was strongest in countries experiencing large productivity gains in the IT services industry. We suggest this is more consistent with a rise of software investment driven by purchased software across Europe as well.

We conclude the paper discussing limitations of using national accounts for the measure of proprietary investment. In particular, the measure of purchased software in the US could hide intra-group transactions, where software is developed by a subsidiary selling its service to another subsidiary within the same business group, blurring the notion of purchased and proprietary investment. This calls for further research on how intangible investment is made within firms given the importance of the assumption that most of it is proprietary in the literature, and the lack of supporting evidence for this assumption in National Accounts.

While the issues of spillovers and proprietary knowledge potentially apply to many intangible asset types, we focus on software in this paper for three reasons. First, software is a large and important component of intangible investment currently capitalised in the national accounts. Software alone is responsible for 13% of US total investment in 2022, up from 6% in 1997 (based on current official data). Second, comprehensive data on software investment exist, in contrast to many other intangibles (note that we do not study investment in data). Since software is capitalised in the national accounts, considerable international guidance on its measurement exists, and thus official data could be expected to be reliable. However, as we'll point out through the paper, uncertainties about the quality of some of the data remain. Third, software and data have been the topic of previous work (e.g. Bessen,

2020) and renewed interest recently as artificial intelligence (AI) is also associated with software investment.

A few papers have already pointed to the important difference between proprietary and purchased investment. In particular, Bessen (2020, 2022) argues that firms increasingly use proprietary software as defensive tools against competition, resulting in reduced innovation diffusion across firms and slowed innovation. Coyle et al. (2022) compare the level of productivity for UK firms investing in digital tools in-house against firms purchasing digital tools. They find that firms employing software specialists (in-house investors) are more productive than non-investors, but that firms buying in software services (external investors) are less productive than non-investors, and that these trends hold at all employment sizes.

While these papers suggest a significantly different productivity impact of proprietary and purchased investment, little is known about aggregate trends in each type of investment. The contribution of this paper is twofold: 1) to document more precisely the composition of one of the largest components of capitalised intangible investment: software investment; and 2) to explore the comparability of current official measures of investment in proprietary software in the UK and US.

The paper proceeds as follows. Section 2 illustrates the trends in software investment in the UK and US using official data, highlighting the apparent disparity. Section 3 dives into own-account (proprietary) software investment, focussing on measurement issues. Section 4 explores the differential trends in purchased software investment, including with productivity of the software development industry. Section 5 discusses those findings and considers some explanations for the remaining differences. Section 6 concludes.

2. Comparing trends in software investment in the UK and US

Figure 1 shows the share of software[1] investment in GDP in the US and UK between 1997 and 2022, based on data from the US Bureau of Economic Analysis (BEA) and UK Office for National Statistics (ONS) respectively. The left panel, Figure 1a, shows the share when both software investment and GDP are in current prices, while the right panel, Figure 1b, uses both numerator and denominator in chained volume measures.

Contrary to what might be expected, the level of software investment in the UK (as a share of GDP) exceeds that in the US for the two decades prior to 2017. Over this period, both the UK and US see the software share of GDP increase, initially at a similar pace, but the US sees a faster increase from around 2010. In the UK, the share plateaus from about 2013 onwards, while the US share increases sharply from this point, and quickly surpasses the UK. A similar story emerges in both left and right panels of Figure 1, suggesting that software investment deflators are not a primary driver of this difference. Using total capital investment as the denominator instead of GDP also yields a similar story, though with the UK above the US throughout the time series (see Figure A.1 in the Appendix).

Despite the differences highlighted above, the average share of software investment in GDP over 1997-2022 as a whole are quite similar in the UK and US.

The differences in levels and trends motivates a closer look at software investment. Figure 2 splits software investment into two components: purchased investment (left panel, Figure 2a), and own-account investment (right panel, Figure 2b). In both panels, Figure 2 shows the

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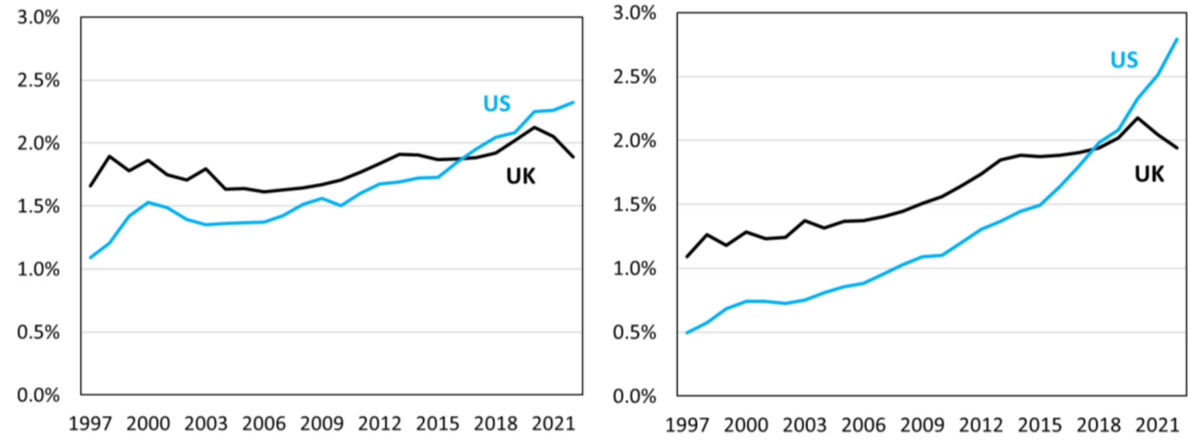
[1] Strictly, the asset class is “Software and databases” – see Appendix for discussion. We refer just to “software” throughout for brevity, and since database investment as measured is small.

relevant part of software investment as a share of GDP, with both investment and GDP in current prices (equivalent charts in chained volume measures in Figure A.2 in the Appendix).

Figure 1 – Share of software investment in GDP, UK and US, 1997-2022

Figure 1a – Current prices *Figure 1b – Chained volume measures*



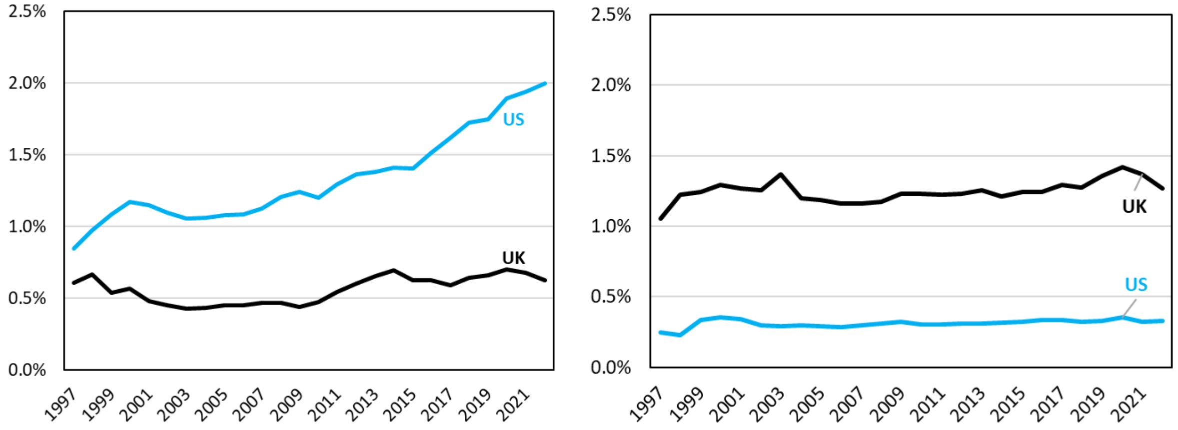
Source: Authors' calculations using ONS and BEA data.
Notes: In left panel, numerator and denominator both in current prices; in right panel, numerator and denominator both in chained volume measures.

Figure 2 reveals stark differences between the UK and US for both purchased and own-account software investment. In the case of purchased investment (Figure 2a), the US is much higher than the UK, and sees much faster growth, especially from around 2015 onwards. In 1997, purchased software investment accounted for around 0.6% of GDP in the UK, and 0.8% in the US – a small difference. In 2015, it was 0.6% in the UK and 1.4% in the US; in 2022, the UK was still at 0.6% and the US had increased to 2.0%.

In the case of own-account investment, the relationship is the reverse – the UK appears to invest about four times as much (as a share of GDP) in own-account software as the US does. The patterns over time are, however, similar – namely a very slow increase in the investment share of GDP, but close to flat.

Figure 2 – Share of software investment in GDP in current prices, UK and US, 1997-2022

Figure 2a – Purchased software *Figure 2b – Own-account software*



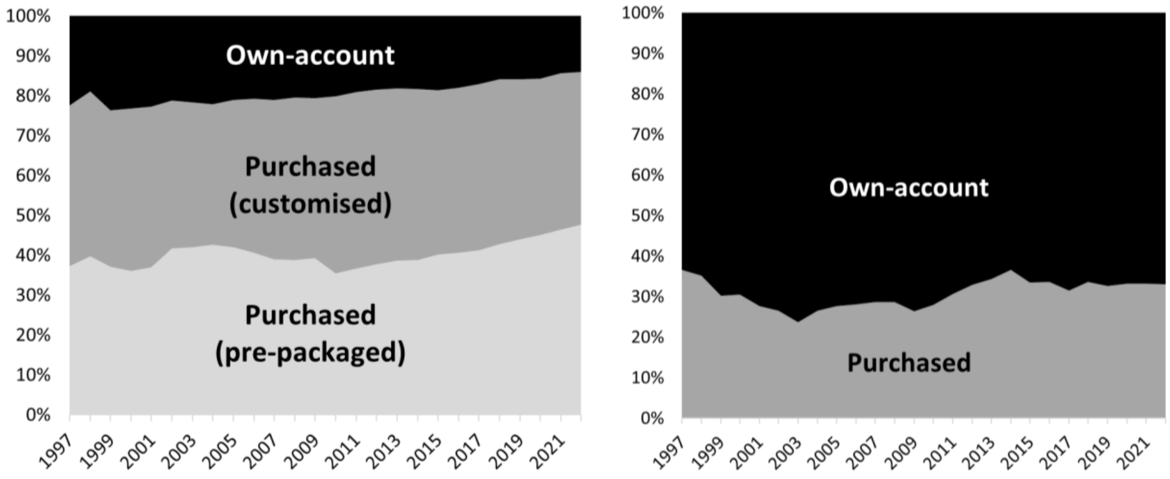
Source: Authors' calculations using ONS and BEA data.
Notes: In both panels, numerator and denominator both in current prices. Equivalent charts in CVMs in Figure A.2 in the Appendix.

Figure 3 combines these data to show the composition of total software investment, with the US in the left panel (Figure 3a), and the UK in the right panel (Figure 3b). Confirming the story from Figure 2, software investment is dominated by purchased investment in the US, and by own-account investment in the UK. Own-account investment accounts for only around 20% of total software investment in the US (and falling over time), compared with around 70% in the UK. This stark difference appears unintuitive.

Figure 3 also introduces an additional breakdown of purchased software for the US: pre-packaged and customised. Pre-packaged software, also known as generic or off-the-shelf software, are types that are not customised to the user, and the same software product can be purchased by many buyers. By contrast, customised software is developed externally to the investing business, but is customised and bespoke to the buyer. Of these two types, it is pre-packaged software that has increased most in the US, accounting for about 40% of software investment in the late 1990s, rising to nearly 50% in the 2020s.[2] The same breakdown is not available for the UK, but purchased software investment in the UK explicitly includes both customised and pre-packaged types.

Figure 3 – Composition of total software investment in current prices, 1997-2022

Figure 3a – United States *Figure 3b – United Kingdom*



Source: Authors' calculations using ONS and BEA data.
Notes: In both panels, total software and software components all in current prices (equivalent chart in CVMs in Figure A.3 in the Appendix). Split of purchased software investment into customised and pre-packaged not available for the UK.

We next look into the industry composition of total software investment, for which we have data covering 1997-2017. Figure 4a shows the share of each industry in total software investment in the US and UK in 2017. There are similarities and differences between the two countries. For both, three industries invest a lot in software: finance and insurance; IT services; and professional, scientific and technical services. Together, these industries accounted for about 60% of all software investment in the US, against 45% in the UK. In addition to these, the wholesale and retail industry accounts for a fairly large share, somewhat more so in the UK than the US. In terms of total software investment, the IT

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[2] Pre-packaged software shows a sharper increase over time when examined in chained volume measures, as shown in Figure A.3 in the Appendix, on account of sharp deflation relative to the other software types (see Figure A.8 in the Appendix for software investment deflators).

services industry is somewhat larger in the US than the UK. There is also commonality in which industries invest least: transport and storage; and utilities and mining.

A notable difference, however, is the role of own-account software, which appears larger in all industries in the UK than their US counterparts. So the stark difference in levels of own-account software seen in Figure 2b is not due to only one industry, but across all industries. Another difference is the concentration of software investment amongst a few industries in the US, compared with a more even split across UK industries.

Figure 4b shows the total growth in current price software investment by industry between 1997 and 2019. For the whole economy, current price software investment nearly quadrupled in the US in that period, while in the UK it approximately doubled. Across industries in the UK, the total growth was similar in most – the main exception being the professional services and science industry. And in most UK industries, the growth was driven by own-account software.

By contrast, in the US, investment rose unevenly – very sharply in some industries, and much less in others. The industries seeing the biggest increase (e.g. IT services) are largely the same industries that accounted for the biggest shares of software investment in Figure 4a. This suggests an increasingly concentrated industry distribution of software investment in the US over time. In contrast to the UK, most of the growth in software investment in US industries is driven by purchased software.

Together, these Figures present a fundamentally different role for software investment in the US and UK economies – in terms of its level, its composition, its distribution, and its trajectory. We turn now to explaining these differences.

Figure 4a – Share (%) of each industry and software type in total software investment, 2017

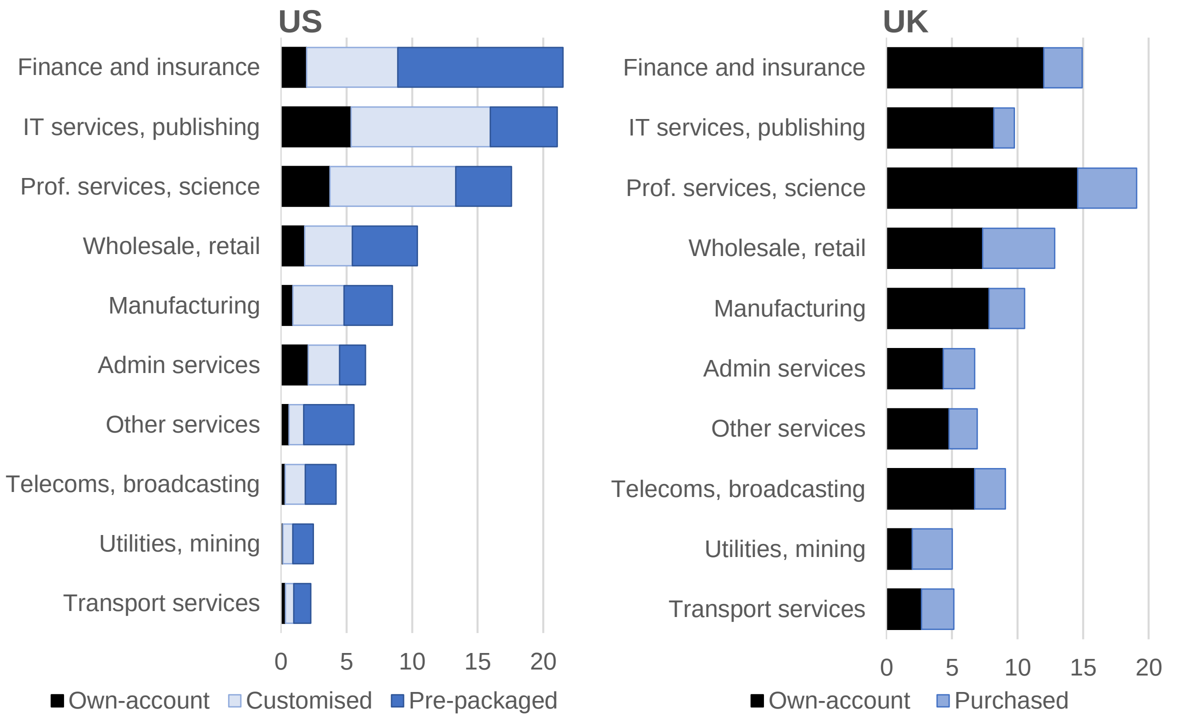
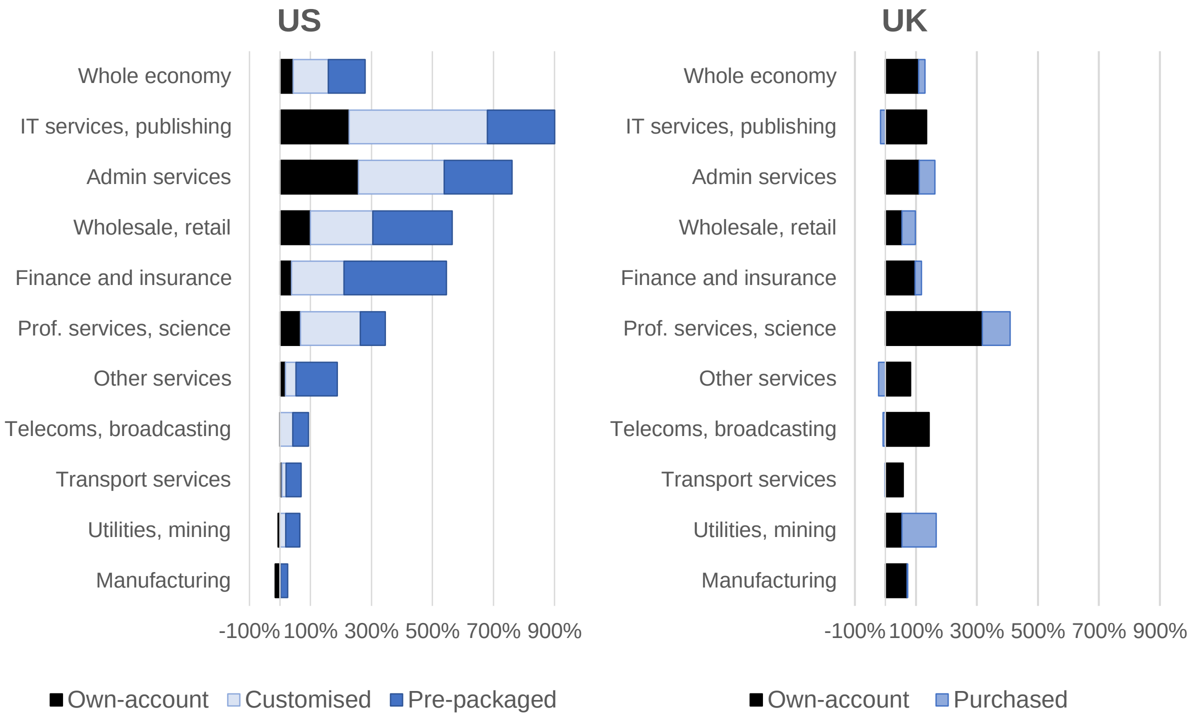


Figure 4b – Total growth in current price software investment (2017 vs 1997) by industry, and contribution of own-account and purchased software



Source: Authors' calculations using ONS and BEA data.
Notes: See Table A.1 in the Appendix for industry codes. Industries ordered high-to-low by US data in both panels. UK "purchased" is equivalent to sum of US "pre-packaged" and "customised".

3. Exploring differences in own-account software investment

Figure 2b revealed stark differences in the level of own-account software investment as a share of GDP in the US and UK. This section explores the reasons for that difference.

3.1. Measuring own-account software investment in the National Accounts

We start with measurement. Own-account software investment estimates are imputed in the national accounts, since data cannot be reliably collected via business surveys (Martin and Baybutt, 2022). As such, there is considerable scope for differences in methods and assumptions to lead to differences in estimates across countries. This is a topic that was explored in detail in the early 2000s, when software investment was first introduced into the national accounts in the late 1990s.[3]

Before assessing differences in methods between the UK and US, we first summarise the standard "sum of costs" method used to estimate own-account software investment in both countries. Users familiar with such methods may prefer to skip to section 3.2. The method for estimating own-account investment in software in the UK National Accounts is set out in considerable detail in Martin (2022); see also the OECD handbook on measuring intellectual property products (OECD, 2009).

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[3] Important work by, among others, Oulton (2001), Lequiller et al. (2003), and Ahmad (2003) led to increased international comparability and general adoption of the sum of costs method described in the text.

The general approach is to model the costs of producing software assets for in-house use, and add them up – the so-called “sum of costs” method. The method typically starts from labour costs, since the software production process is labour intensive, and because good data on labour are readily available. Other costs and adjustments are applied thereafter.

Labour costs

First, occupations involved in creating software in-house are identified from official classifications of occupations, such as the UK Standard Occupation Classification (SOC), the US Standard Occupation Classification (SOC), or the International Standard Classification of Occupations (ISCO). Some relevant occupation codes are perhaps obvious – in the case of software, those labelled as software developers or software programmers. Other IT-related occupation codes could clearly also be considered relevant to own-account software investment, such as IT managers, website developers, IT technicians, and so forth. There is relatively little evidence on this, and most estimates follow international guidance or precedent. Some country practices and research are set out in Lequiller et al. (2003), Ahmad (2003), OECD (2009), and Eurostat (2020).

Second, the fraction of time that each occupation type spends creating long-lived in-house software assets is assigned. For instance, if, on average, 50% of the time of software developers is spent creating long-lived software assets for use inside the business, then a time factor of 50% is assigned to the software developers occupation code. These are typically based on fairly limited an outdated evidence, and most NSIs follow international guidance or precedent. International guidance (e.g. OECD, 2009) suggests the use of 50% in the absence of other information. The UK ONS has conducted some original research, documented in Martin (2022). See also Eurostat (2020).

Non-labour costs

Next, an assumed uplift factor (or “blow-up factor”) to convert from labour costs to total costs is determined. The sum of costs method aims to estimate the full economic cost of producing in-house software assets. While the labour costs might be the largest and most easily-identifiable component of those costs, the costs of intermediate inputs (including a share of “overhead costs”), consumption of fixed capital (of, for instance, IT hardware and other software assets), taxes less subsidies on production and products, and (where relevant) a rate of return on capital also need to be added. A common approach to this is to use the ratio of total costs to wage costs that prevails in the software development industry, which is assumed to be representative of the software-creation process in all other industries. This ratio is typically around two, which is to say that labour costs account for around half of the total costs of producing software.

Double-counting adjustment

Finally, a factor is applied to avoid double-counting with purchased software investment. Recall that this method starts with software-creating occupations – these will be employed in some industries that produce software assets for sale, rather than for use in-house. Indeed, one might expect the majority of software development workers to be employed in the specialist software development industry, many of whom will be creating software for sale. To avoid double counting with estimates of purchased software investment from business surveys, a “sales adjustment” factor is applied to the own-account investment estimates in industries which are assumed to produce software for sale. If all software produced by an industry were for sale, the sales adjustment should entirely eliminate the own-account software investment estimate, and all of that investment would get picked up as purchased investment by other industries via business surveys. It is common to remove most, but not all, of the own-account software investment in the specialised software development industry, as well as some in the computer manufacturing industry (which often produces software to be embedded into their hardware, the value of which is bundled with the hardware and included in estimates of hardware investment).

Method in practice

The method can then be applied using labour market data that contains information on pay, occupations and industries. Ideally the pay variable would account for non-wage labour costs, such as payments in kind (e.g. company cars), and employers' social contributions (e.g. employers' pension and social contributions), since this reflects the full economic labour cost. If it does not, then a scale-up factor can be applied to wages to convert to total labour costs.

The labour costs of each relevant worker are multiplied by their time capitalisation factor (which can vary by occupation), sales adjustment factor (which can vary by industry), and non-labour cost uplift factor (which is usually the same across occupations and industries). If the data source is a sample survey, then survey grossing weights are also applied. The resultant values are summed by industry an/or sector. This gives an estimate of own-account investment which (in theory) avoids double-counting with the related purchased investment.

3.2. Classification differences

While both the UK and US follow international national accounting guidance to a large extent, there are subtle differences in concepts. One is on the treatment of software research and development (R&D).

With the capitalisation of R&D in the national accounts in the System of National Accounts (SNA) 2008 and European System of Accounts (ESA) 2010, an issue of potential double-counting between software and R&D arose – R&D for new software products could be captured as both software investment (most likely own-account software) and R&D. Prior to this, international guidance on measuring software investment (Lequiller et al., 2003; Ahmad, 2003) recommended including software R&D costs in the value of software investment, so this was likely common practice by the time that R&D was capitalised.

Conceptually, R&D that is done in the software development process which is entirely used up in a year or less, is embodied in the associated new software asset. In this case, the R&D costs are part of the costs of production of the new software asset, and so should be included in the value of software investment. Only if the R&D asset is expected to last for more than a year, perhaps being used in multiple software development projects, should a separate R&D asset be captured, and thus the R&D costs treated as investment in R&D instead of investment in software. In this case, some capital services from the new R&D asset should be included in the value of software investment.

Such distinctions are hard to make in practice. As such, in order to avoid double counting, many countries excluded R&D on new software products from official estimates of R&D investment when R&D was brought into the national accounts. The reasons for adjusting R&D, rather than software, was broadly those of precedence and practicality – since software had been in the accounts prior to R&D, it seemed preferable to bring R&D in at a lower number than to have to revise the incumbent software. The ONS (Ker, 2014) and BEA (BEA, 2013) both followed this approach when they first capitalised R&D.

However, the BEA have changed their approach since 2018, reclassifying R&D on software originals from own-account software investment to R&D. The motivation was to improve consistency between the source data for the R&D estimates, and the resultant estimates of R&D GFCF (Chute et al., 2018). Rather that subtract software R&D from the R&D source data, BEA now treats all R&D identified in the source data as R&D, and has adjusted their estimates of own-account software to exclude software R&D-type activities.[4]

Since the ONS still treats software R&D as software investment (specifically own-account software), this creates a discrepancy between the US and UK official data. Own-account software investment in the UK is likely to be (relatively) larger than in the US, since in the UK it implicitly includes R&D in software products, while in the US that is treated as R&D.

How big is this difference? It is difficult to be precise, as the BEA and ONS do not publish official estimates on the alternative basis in order to allow for a direct comparison. As such, we have estimated the effect using available data. For the US, we consider two approaches: 1) add up the relevant software R&D GFCF categories and add them onto currently measured own-account software GFCF, 2) use the estimates of own-account software investment from prior to the reclassification. For the UK, we estimate software R&D from the business expenditure on research and development (BERD) data, and subtract this from own-account software.[5] This comes with considerable uncertainties, since the BERD data are subject to major revisions and uncertainty at the time of writing (ONS, 2023). However, we hope it will give us a reasonable approximation.

Figure 5 shows the results of these adjustments, expressed for both countries as own-account software investment as a share of GDP in current prices (Figure A.4 in the Appendix shows the equivalent chart in chained volume measures). The two approaches for the US yield reassuringly similar results – including software R&D approximately doubles own-account software investment, from around 0.3% of GDP to around 0.6%.

For the UK the estimated effect is relatively small. Removing software R&D from own-account software investment would reduce OAS as a share of GDP from around 1.1% of GDP to around 1.0%. Note again that this adjustment is highly uncertain given significant data quality issues associated with the UK R&D data at the time of writing. It is also worth noting that most of the reported business R&D on software development is done by the computer programming industry (division 62) which is already adjusted heavily in OAS estimates to avoid double counting with purchased software (sales adjustment, as described in section 3.1).

Overall, it seems that classification differences can explain some, but far from all, of the difference in level of own-account software investment between UK and US.

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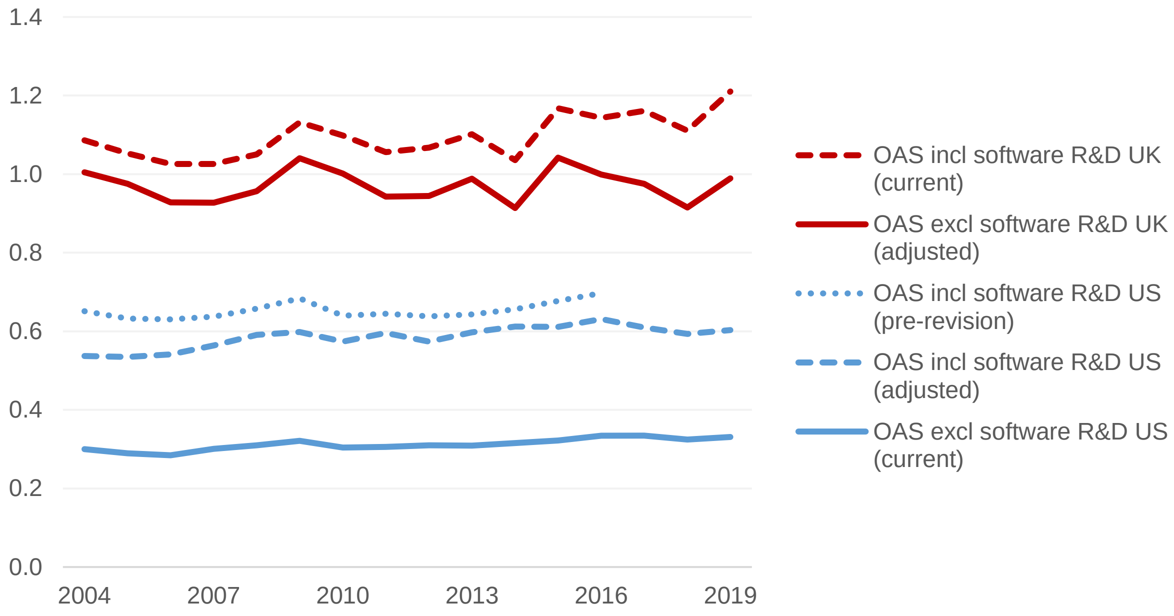
[4] See also Moylan and Okubo (2020) for an account of the evolving treatment of R&D in the US National Accounts.

[5] “Software development” was added as a separate BERD product in 2016, prior to which it was included in the broader product “Computer programming and information service activities”, which from 2016 has a narrower definition. For years where BERD on software development is available we use that. We backcast this using the broader product, maintaining the 2016 share of software development in the combined category, which is about a third. We also apply the uplift for under-estimation, published by ONS in 2023, which is available for the combined product, and we assume applies equally to Software development and Computer programming and information service activities.

Figure 5 – Own-account software investment as a share of current price GDP, including and excluding software R&D, UK and US, 2004-2019



Source: Authors calculations based on data from BEA and ONS.
Notes: Red lines are estimates for the UK; blue lines are estimates for the US. Solid lines exclude software R&D; dashed lines include software R&D. The dotted blue line uses data from the 2017 NIPAs, prior to the classification change in the 2018 comprehensive update. Thus, the red and blue solid lines have consistent scope and can be compared; and likewise the red and blue dashed lines can be compared. Numerators and denominators all in current prices (Figure A.4 in the Appendix uses CVMs).

3.3. Methodological differences

Since there remains a significant difference after harmonising classification and definition of own-account software, we turn to methodological differences in the estimation of own-account software. Both the ONS and the BEA follow the sum of costs method described in section 3.1. However, the implementation and assumptions at each stage of the method differ.

Labour input: occupations

In choosing the relevant occupations, the ONS follows the UK Standard Occupation Classification (UK SOC) and the BEA follows the US Standard Occupation Classification (US SOC). The codes and titles of relevant occupations are listed in Table 1, with UK and US codes loosely aligned. Table 1 uses the 2010 vintages of the UK SOC and US SOC, though equivalent codes are also used based on other vintages (see e.g. Martin (2022) for UK codes on the UK SOC 2000 and UK SOC 1990).

Table 1 shows that the ONS measures use a much wider set of occupations than the BEA measures, encompassing a number of occupations that play a more peripheral role in the software development process, such as IT managers and IT technicians. The ONS also includes some occupations explicitly to cover in-house database creation (shaded in grey in Table 1), which the BEA does not include.[6]

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[6] The 2023 comprehensive update (McCulla et al., 2023) expands the measurement of own-account software to include additional occupations, including those relating to “web developers and digital interface designers,

Table 1 – Occupation codes used in official own-account software investment estimates by ONS and BEA

UK SOC 2010 code	UK SOC 2010 code and description	UK time factor (%)	US SOC 2010 code	US SOC 2010 description	US time factor (%)
1136	Information technology and telecommunications directors	10			
2133	IT specialist managers	30			
2134	IT project and programme managers	30			
2135	IT business analysts, architects and systems designers	35	15-1121	Computer Systems Analysts	50
2136	Programmers and software development professionals	50	15-1131	Computer Programmers	50
			15-1132	Software Developers, Applications	50
			15-1133	Software Developers, Systems Software	50
2137	Web design and development professions	35			
2139	Information technology and telecommunications professionals n.e.c.	25			
2423	Management consultants and business analysts	10			
2425	Actuaries, economists and statisticians	10			
3131	IT operations technicians	20			
3132	IT user support technicians	15			
3539	Business and related associate professionals n.e.c.	10			
4217	Typists and related keyboard occupations	5			
5245	IT engineers	5			

Sources: Authors' elaboration of ONS (2019), Martin (2022), BEA.
Notes: UK codes included explicitly to capture databases shaded in grey.

While the ONS includes more occupation codes than the BEA in their own-account software investment estimates, they do so with relatively low time factors. The occupation codes which are broadly common to the ONS and BEA methods both use relatively high time factors, around 50%. This is consistent with international guidance (OECD, 2009; Eurostat, 2020), which suggests that in the absence of other evidence, a time factor of 50% should be applied to the wages of the most relevant occupations.[7]

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database administrators and architects, network and computer systems administrators, computer network architects, and computer and information research scientists". This revision is only taken back to 2013 (McCulla et al., 2023) but seems to have had surprisingly little effect on estimates of own-account software; indeed, there are downward revisions to own-account software in some years which seems inconsistent with the expansion of occupations included in the method. Given uncertainty over these new methods, we base our analysis on previously reported methods.

[7] Eurostat (2020) specifically recommends ISCO-08 occupation codes 251 (Software and Applications Developers and Analysts) and 2521 (Database Designers and Administrators). ISCO-08 occupation code 251 (Software and Applications Developers and Analysts) corresponds roughly to the overlapping codes of the ONS and BEA method.

The ONS method includes other occupations with lower time factors. Eurostat (2020) reports that these additional occupation codes account for only around 20% of total own-account software (and databases) investment estimates in the UK. Similarly, ONS (2019) report that the inclusion of occupation codes explicitly to account for own-account database investment adds around £1-3bn to total own-account software (and databases) investment estimates in the UK in most years from 1997-2016, equivalent to about 10% of the total.

Non-labour costs

In the UK this varies around 2, based on the ratio of total output to compensation of employees in the specialist software investment. Through correspondence with BEA staff, we believe the BEA uses a similar method to the ONS, with a scale-up factor of a similar magnitude.

Sales adjustment

The application of sales adjustment factors differs somewhat between the ONS and BEA. The ONS use sales adjustment factors in only three industries, documented in Martin (2022): the specialist software development industry (division 62), the computer manufacturing industry (division 26), and the electronics manufacturing industry (division 27). 90-95% of investment in software in these industries is assumed to be for sale and thus removed from the own-account investment estimates.

By contrast, the BEA uses sales adjustment factors in many more industries, but they are typically smaller. The BEA approach to sales adjustment factors are described in Chesson and Chamberlin (2006) and OECD (2009) as *2/(proportion of software professionals to total employment x 100)*, which we believe is still used. This approach applies sales adjustment factors in industries with the number of relevant occupations above a 2% threshold, with the factor varying according to the relative importance of software-related occupations in total employment in the industry. This has the effect of applying large adjustments in selected industries, and smaller adjustments in several industries.

Testing the impact

The net impact of these differences on investment estimates is fairly ambiguous. First, the ONS uses a broader set of occupation codes, likely to increase estimates of investment relative to the BEA. However, these have relatively small ‘time factors’, such that the effect is likely to be quite small. Second, the BEA applies sales adjustment factors to more industries that the ONS, which would tend to reduce their investment estimates. However, the adjustment factors are quite small outside of a few industries, such that the effect is likely small. In combination, the net effect is likely to depend on the distribution of relevant workers across occupation codes and industries in the UK and US labour market data.

To test whether the differences observed are primarily methodological, we attempted to implement the BEA method on UK microdata, and the ONS method on US microdata. This cannot be done precisely given the use of different occupation and industry classifications in each, and as such approximations were necessary. Tables A.3, A.4 and A.5 in the Appendix describe the choices in detail, informed by classification conversions.

Testing the impact: ONS method on US data

First, we applied the ONS method on US labour market data. We used the BLS’ Occupational Employment and Wage Statistics, which is the same source as used by the BEA to construct their OAS estimates. We followed the ONS method as far as possible, based on a conversion of occupation codes from the UK SOC to the US SOC (via ISCO) –

see Table A.3 in the Appendix for complete list of occupation codes used. Recall that the ONS method includes many more occupation codes than in the BEA method. We applied the same cost-uplifts as in the UK, and applied the same sales adjustment factors based on converted industry codes (see Table A.5 in the Appendix).

As a validation of our technology, we also attempted to replicate the BEA method on the US data. We have incomplete knowledge of the BEA method, but based on conversations with BEA staff we were able to replicate the official figures to a reasonable degree. Since these do not account for the reclassification of software R&D (section 3.2), our replication estimates are comparable in scope to the adjusted estimates from Figure 5 – that is, own-account software (as currently measured) plus software R&D.

Figure 6 shows that our replication of the BEA method on US data comes very close to our adjusted estimates from Figure 5. Thus, we can have some confidence in our methods. Applying the ONS method then leads to a substantially higher estimate of OAS in the US, increasing OAS as a share of GDP from around 0.6% (after the reclassification of software R&D, as seen in Figure 5) to around 0.9-1.0%. While the official data and the series adjusted for software R&D are broadly flat as a share of GDP over time, the ONS method trends notably up over time. This difference in trajectory is also consistent with the differences in trends seen in Figure 4.

Figure 6 – Comparing measurement approaches for US own-account software investment, 2004-2019

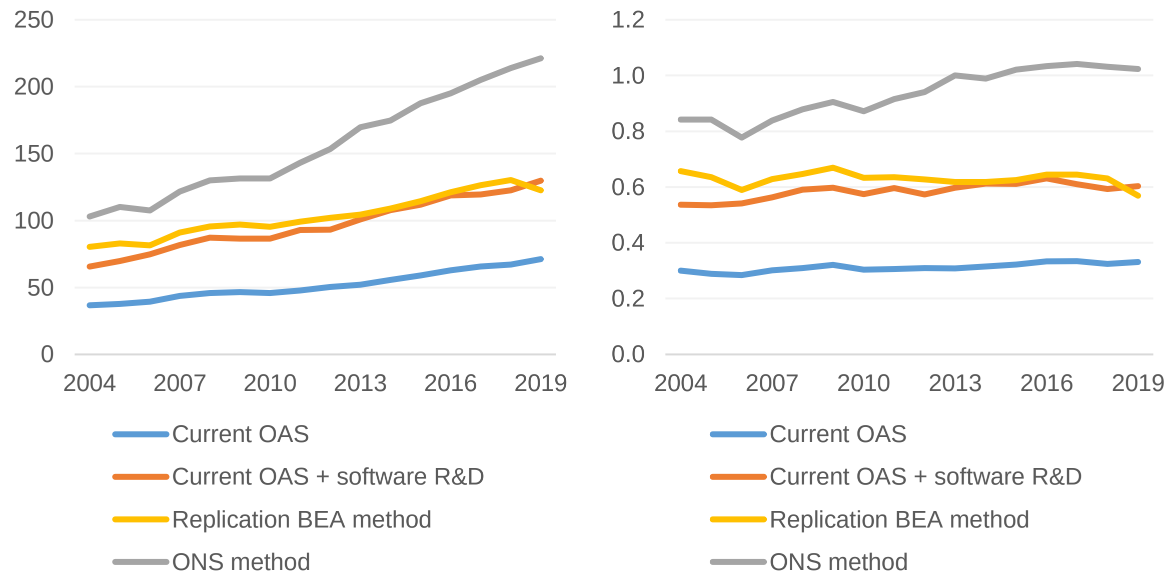


Figure 6a – Current prices, $bn

Figure 6b – Share of current price GDP (%)

Source: Authors' calculations using BLS OES, based on ONS, BEA.
Notes: Replication uses US SOC 2010 up to 2018, and US SOC 2018 for 2019, causing a minor discontinuity. Equivalent charts in CVMs in Figure A.5 in the Appendix. GDP adjusted for additional own-account investment in "ONS method".

Testing the impact: BEA method on UK data

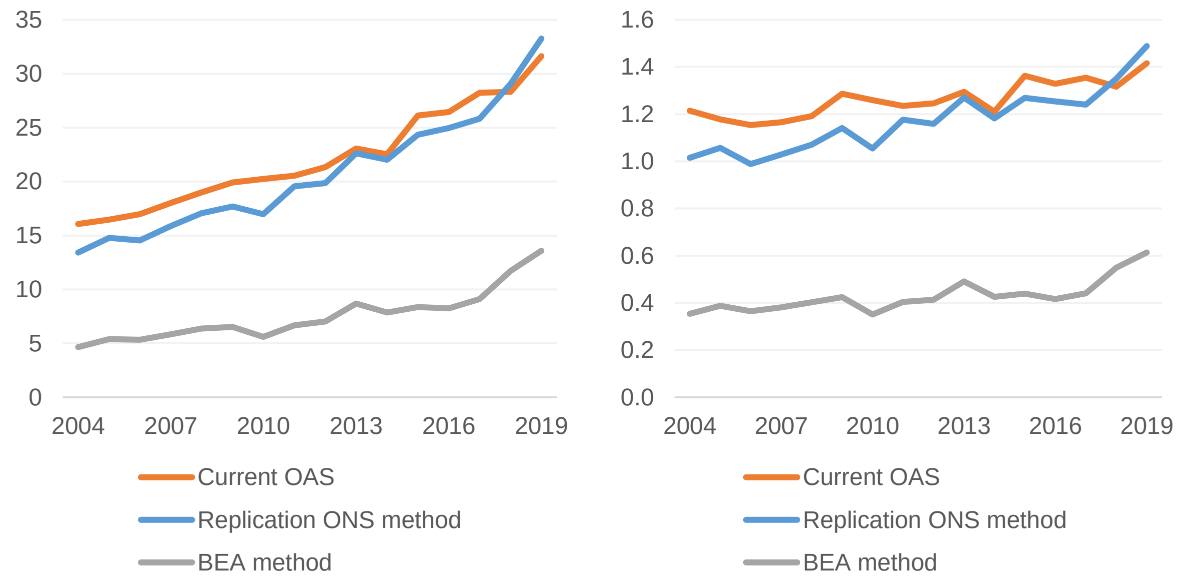
Second, we applied the BEA method to UK labour market data. It would be preferable to apply this to the Annual Survey of Hours and Earnings (ASHE), which is the source used by ONS for their official OAS estimates. However, due to access limitations, we apply it for now to the Labour Force Survey (LFS). Martin (2022) showed that the LFS and ASHE produce similar estimates of the level of OAS between 2002 and 2019, so we believe this is a reasonable test.

We followed the BEA method as far as possible, based on a conversion of occupation codes from the US SOC to the UK SOC (see Table A.4 in the Appendix). Recall that the BEA method includes only a few core software development occupations, while the ONS method includes more peripheral occupations. We applied a cost-uplift of 2 (i.e. doubling) in all years, broadly consistent with the BEA approach, though we do not have the precise cost uplifts for the US. For the sales adjustment, we attempted to apply the same "scalable employment ratio" method as in the BEA method (see above) – this makes adjustments to more industries than the ONS method, though in those industries that the ONS method does adjust (see above), a smaller adjustment. The sales adjustment method is an area of uncertainty.

Figure 7 shows the official UK estimates against our replication from the LFS and our estimates using the BEA method on UK data. The replication is close to the official data (as in Martin, 2022), while the BEA method gives markedly lower estimates – reducing OAS as a share of GDP from 1.3-1.5% to 0.4-0.6%. Both the official data and the BEA method give a series that trends up slowly over time.

Figure 7 – Comparing measurement approaches for UK own-account software investment, 2004-2019

Figure 7a – Current prices, £m *Figure 7b – Share of current price GDP (%)*



Source: Authors' calculations using LFS, based on ONS, BEA; Martin (2022).
Notes: "Replication ONS method" and "BEA method" use UK SOC 2000 up to 2010, and UK SOC 2010 from 2011, with the two series splices together in 2011. "Replication ONS method" data from Martin (2022). Equivalent charts in CVMs in Figure A.6 in the Appendix. GDP adjusted for lower own-account investment in "BEA method".

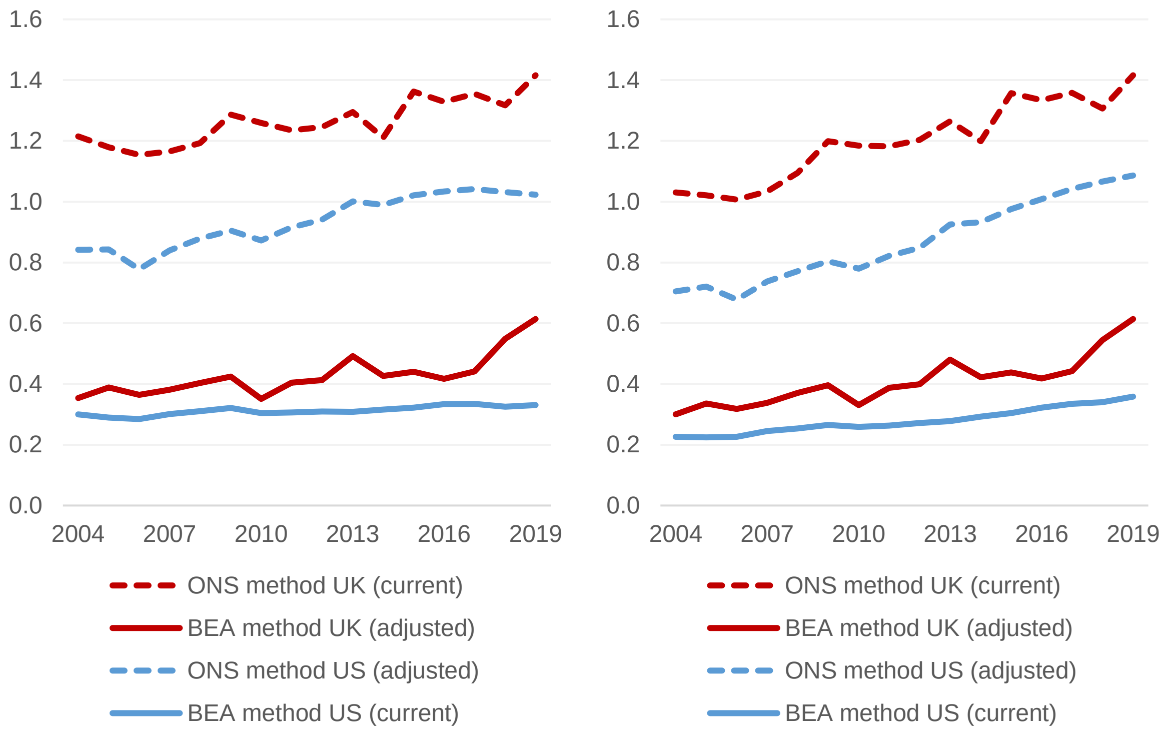
Testing the impact: Comparing results

Putting all of this together, Figure 8 shows how the adjustments bring the UK and US estimates closer into alignment, which are summarised in Table 2. In Figure 8, estimates for the UK are in red and for the US in blue; dashed lines show measurement using the ONS method, and solid lines using the BEA method. Thus, the red and blue solid lines have harmonised methods and can be compared; and likewise the red and blue dashed lines can be compared. The left panel of Figure 8 shows the data in current prices (as a share of GDP at current prices), and the right panel in chained volume measures (as a share of GDP in chained volume measures).

Based on official data from the ONS and BEA, OAS as a share of current price GDP is around four times higher in the UK (dashed red line, 1.2-1.4%) than in the US (solid blue line, around 0.3%). Adjusting for the classification of software R&D narrows the difference to about two times higher in the UK (Figure 5). Harmonising methodology narrows it further, to around 1.5 times higher in the UK (Figure 8). This holds similarly when using the BEA method for both countries (compare solid lines), which reduces the UK estimate, or when using the ONS method for both countries (compare dashed lines), which increases the US estimates. Thus, we can say that roughly three-quarters of the initial gap can be explained by measurement differences (including classification and methodology), and around one-quarter of the initial gap remains.

Figure 8 – OAS as a share of GDP, UK and US with measurement adjustments, 2004-2019

Figure 8a – Share of current price GDP (%) *Figure 8b – Share of GDP CVM (%)*



Source: Authors' calculations using data from ONS and BEA.
Notes: Red lines are estimates for the UK; blue lines are estimates for the US. Solid lines use BEA method; dashed lines use ONS method. Thus, the red and blue solid lines have consistent scope and can be compared; and likewise the red and blue dashed lines can be compared. GDP adjusted down in BEA method UK, and adjusted up in ONS method US.

Inspection of the trends in Figure 8, which are summarised in Table 2, suggest that the different methods principally affect the level of investment, though the ONS method also appears to give a modestly faster increase over time. For the UK, OAS as a share of GDP in chained volume measures increases between 2004-2006 and 2017-2019 by 0.3pp with the

ONS method, a little faster than 0.2pp with the BEA method. For the US, the difference is more stark, with an increase of 0.4pp using the ONS method, against just 0.1pp using the BEA method. The faster growth with the ONS method likely reflects relatively faster growth in the additional occupations included in the ONS method (Table 1), such as occupations associated web design and data science, which are not included in the BEA method.

Table 2 – Summary of own-account software investment measurement harmonisation, shares of GDP in current prices and chained volume measures, UK and US, 2004-2019 and sub-periods

	% of GDP CP				% of GDP CVM			
	2004-2019	2004-2006	2017-2019	Change	2004-2019	2004-2006	2017-2019	Change
UK								
ONS method (current)	1.3	1.2	1.4	0.2	1.2	1.0	1.4	0.3
Removing software R&D	1.0	1.0	1.0	0.0	0.9	0.8	1.0	0.1
BEA method	0.4	0.4	0.5	0.2	0.4	0.3	0.5	0.2
US								
BEA method (current)	0.3	0.3	0.3	0.0	0.3	0.2	0.3	0.1
Adding software R&D	0.6	0.5	0.6	0.1	0.5	0.5	0.6	0.2
ONS method	0.9	0.8	1.0	0.2	0.9	0.7	1.1	0.4

4. Explaining the divergence between US and UK patterns of software investment: structural drivers

After accounting for measurement differences, own-account software investment remains a little higher in the UK than the US (section 3), and purchased software investment remains substantially higher and growing faster in the US than in the UK (Figures 2-4). We next turn to potential explanations related to structural differences in software activity across the US and the UK, to try to explain these remaining differences.

4.1. Concentration of software professionals

We first investigate the distribution of software professionals across industries in the economy. Figure 9 shows the share that each industry accounts for in total employment of software occupations, defined as just the core software development occupations, largely in line with the codes used in the BEA method (Table 1). The left panel shows the average level of these shares in the post-financial crisis period (2012-2019 for the US and 2012-2021 for the UK), the right panel shows the change in these shares relative to their pre-financial crisis average (2004-2011).

We can see that the two countries have very similar distributions of software occupations. This is consistent with the more similar levels of own-account software investment after harmonising methodologies, and supports the view that such large differences in own-account software investment in official data are likely to be largely measurement artefacts. In both countries, the IT services industry[8] accounts for the largest share of software occupations, as would be expected, with the US having a slightly higher share in this industry. The UK has a higher share of workers in all of the bottom six industries in Figure 9,

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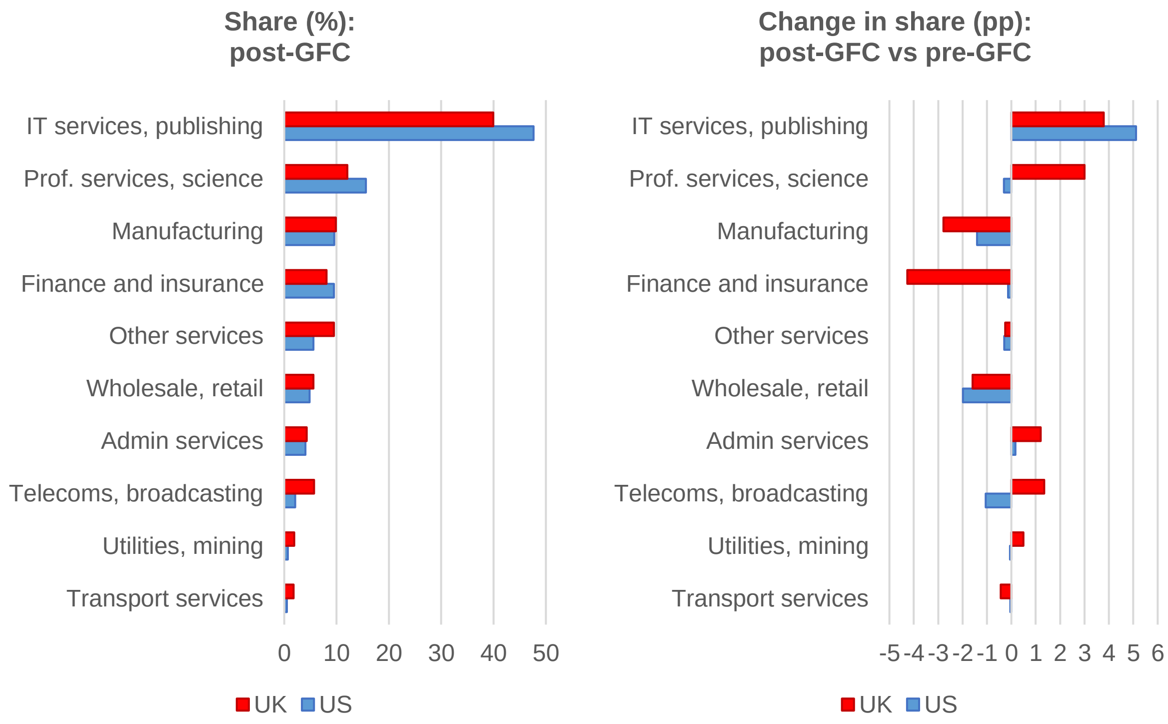
[8] We define the IT services industry as NACE industry divisions J58 (publishing, including software publishing), J62 (software development and computer consultancy), and J63 (information services). In the UK: UK SIC 2007 divisions 58, 62, 63. In the US: NAICS codes 511, 518-519, 5415.

consistent with somewhat higher own-account software investment even after measurement harmonisation.

In the right panel of Figure 9, we see a slightly faster rise in concentration of occupations in the IT services industry in the US over time. This could be consistent with the relatively stronger growth in purchased software investment seen in Figure 2a, since it will be the IT services industry that largely produces such software for sale. That said, the 'change' estimates should be treated cautiously due to potential confounding effects from changes to occupation and industry classifications over time.

Figure 9 – Share of each industry in total employment of software occupations, US and UK



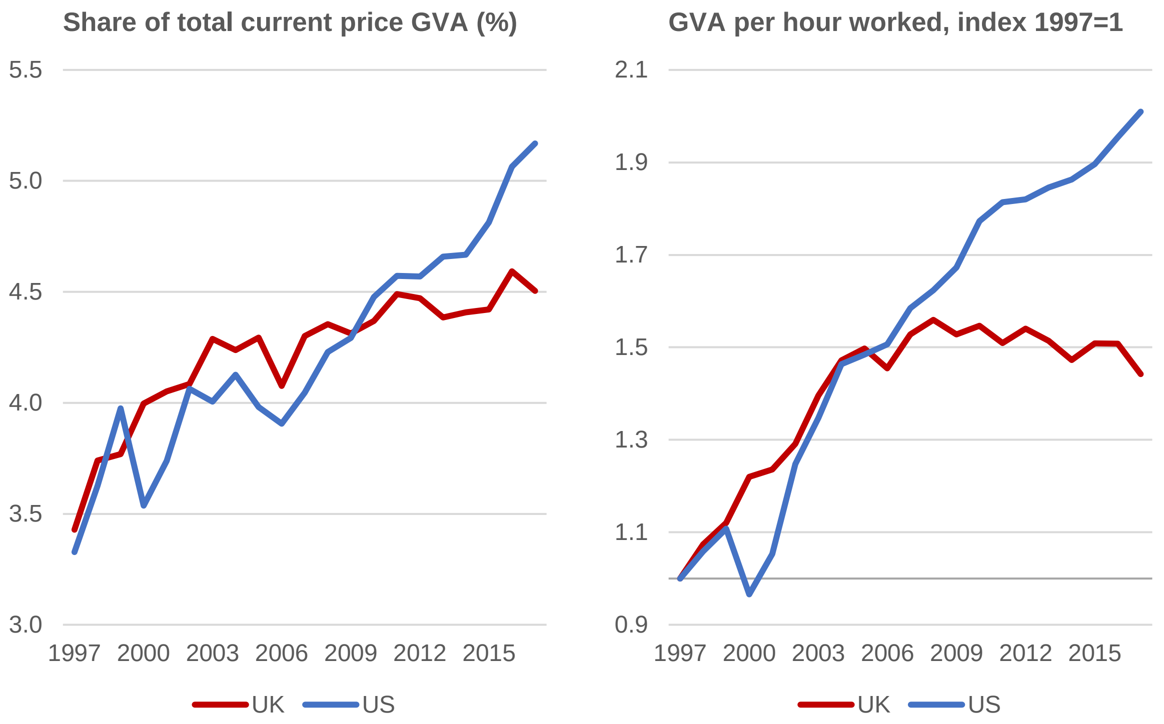
Source: Authors' calculations using data from the BLS Occupational Employment and Wage Statistics and ONS Annual Survey of Hours and Earnings (ASHE).
Note: The left panel shows the average level over 2012-2019 for the US and 2012-2021 for the UK. The right panel shows the change in these shares relative to their average over 2004-2011. For the UK, estimates are based on UK SOC 2000 code 2132; and UK SOC 2010 codes 2135, 2136, and 2139. For the US, estimates based on US SOC 2000 codes 15-1021, 15-1031, 15-1032, 15-1051; US SOC 2010 codes 15-1121, 15-1131, 15-1132, 15-1133; and SOC 2018 codes 15-1211, 15-1251, and 15-1256. See Table A.1 in the Appendix for industry groupings.

4.2. A more productive software industry

We turn to investigating more differences in the IT services industry. Figure 10 shows the size of the IT services industry in the UK and US, measured by its share in current price GDP (left panel), and the productivity of the industry, measured by GVA per hour worked (right panel). The share of the industry in current price GDP is similar in both countries, at around 3.5% in the late 1990s, rising to around 4% in the early 2000s, and 4.5% around 2010. However, the industry's share of GDP then increased much faster in the US since the 2010s, reaching over 5% of GDP in the US by 2016, while in the UK the industry remained at around 4.5% of GDP. The divergence coincides with the period over which purchased investment started to increase faster in the US than in the UK (Figure 2a).

This period also coincides with much faster productivity gains in the US industry than in the UK industry (Figure 10, right panel). This could suggest a relatively more productive US software development industry, specialized in developing pre-packaged or customised software, which is increasingly able to sell its products to US firms. However, the reasons for the divergence between the countries are not entirely clear. The implied GVA deflator of the IT industry in the US falls about 8% between 1997 and 2017, with most of that fall coming after 2008; whereas for the UK the deflator rises 15% over the same period, especially after 2008 (Figure A.7 in the Appendix). These differential price trends may be justified, or may reflect measurement inconsistencies.

Figure 10 – Size and labour productivity of the IT services industry, UK and US, 1997-2017



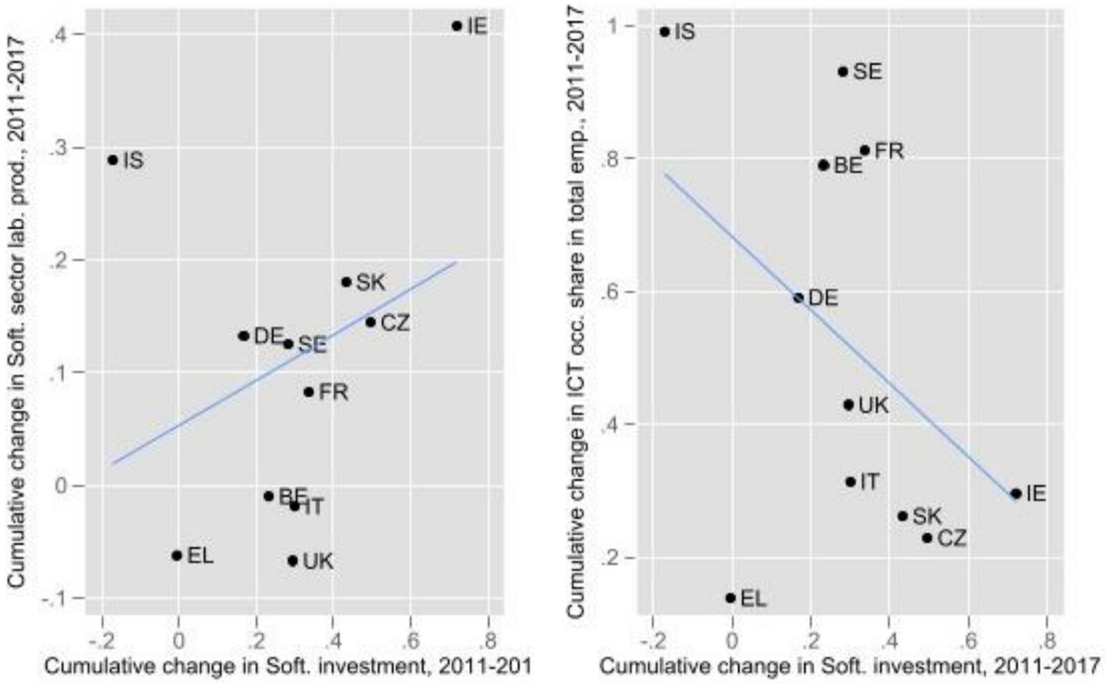
Source: Authors' calculations using data from ONS and BEA.
Notes: IT services industry is NACE industry divisions J58, J62, J63, corresponding to UK SIC 2007 divisions 58, 62 and 63, and US NAICS codes 511, 518-519, 5415 (see footnote 6). Labour productivity measured by GVA (chained volume measures) per hour worked, indexed to 1997=1.

Finally, we look at cross-country evidence on software investment. We do not have the split of software investment into purchased and own-account for countries other than the US and the UK. As such, we look at two proxies.

Figure 11 shows scatterplots of the growth in total software investment (i.e. own-account and purchased combined) in current prices between 2011 and 2017, with 1) the change in labour productivity of the IT services industry over the same period (left panel), and 2) the change in the share of total software occupations in employment in the country over the same period (right panel). The countries included are selected European countries for which data are available.

In the left panel, we find a positive correlation between the increase in current price software investment and productivity growth in the IT services industry. In the right panel, we find a negative correlation between the increase in current price software investment and the change in the share of total software occupations in employment in the country. Both findings are based on only 11 countries for which data are available, so these findings should be interpreted cautiously. However, we could relate greater employment of software occupations to increased own-account software investment (right panel), and relate faster productivity growth in IT services industries with more efficient development of pre-packaged and customised software, as we see in the US. If so, these correlations might suggest that for countries experiencing a faster rise in software investment in Europe over the past two decades, this rise was driven by purchased software (as in the US) more so than by own-account software.

Figure 11 – Scatterplots of the change in current total software investment in current prices, against change in IT services industry labour productivity (left), and against change in share of software occupations in total employment (right), selected European countries, 2011-2017



Source: Authors' calculations using OECD STAN (productivity and investment) and Eurostat (ICT occupations). Notes: Countries included, based on data availability, are: Belgium (BE), Czechia (CZ), Germany (DE), Greece (EL), France (FR), Ireland (IE), Iceland (IS), Italy (IT), Sweden (SE), Slovakia (SK), United Kingdom (UK).

5. Discussion

The official data on software investment presented in section 2 suggest a striking difference between the UK and the US – despite investing similar amounts in software as a share of GDP overall (Figure 1), the US appeared to invest far more in purchased software (Figure 2a, Figure 3a) and the UK far more in own-account software (Figure 2b, Figure 3b). The differences appear widespread across industries (Figure 4). The extent of the difference is narrowed considerably once measurement of own-account software is harmonised (section 3). But a structural difference remains.

Why two developed economies would have such different relationships with software investment is unclear. Indeed, the different compositions of software investment may run counter to expectations. Large US-based tech firms and multinational enterprises might be expected to invest heavily in proprietary (own-account) software, giving them competitive advantage (Bessen, 2020), and leading to rising mark-ups, declining business dynamisms and reduced innovation diffusion (De Ridder, 2024; Aghion et al., 2023). Haskel and Westlake (2017) note that intangibles are scalable, have synergies, generate spillovers, and represent sunk costs. Proprietary intangibles will still be scalable and have synergies, good for the firm that owns them, but generate limited spillovers, bad for aggregate productivity growth. As such, a preponderance of proprietary intangibles might be expected to lead to increased productivity dispersion, and increased market power for the firms that own them.

All of these trends (declining dynamics, rising mark-ups, increased productivity dispersion) are thought to be more pronounced in the US than most other developed countries (Bajgar et al., 2023). Indeed, some of these trends are not apparent in the UK – for instance, in contrast to the well-known decline in the labour share of income in the US, the UK (and many other developed economies) have seen a relatively flat labour share since the turn of the century (Gutiérrez and Piton, 2020). Thus, one might expect relatively *more* investment in proprietary intangibles in the US, yet the data says otherwise. Garner et al. (2021) report "surprise" that the role of own-account software is not larger in growth accounting analysis for US industries, and speculate that the larger role they find for pre-packaged and customised software is due to the widespread nature of the investment.

More research is warranted, and considerably more progress would be made with more data. We approached contacts at the national statistical institutes of ten European countries to ask for the split of software investment into purchased and own-account components in office data. The necessary data were not public in any case, and were unavailable to be shared in most. From two we received unpublished data, for which we are grateful, but in both cases with short time series, and many supressions, making it largely unusable. We also obtained unpublished data for Canada. To make progress in this important area for understanding the modern economy and macroeconomic dynamics, we call for greater transparency in these data. The issue of own-account intangible investment is particularly relevant in advance of the update to the System of National Accounts, due in 2025. This will treat data as a produced asset, which will be estimated by the sum of costs method as for software. Greater transparency of current methods and estimates will enable improved international comparability of data on investment and productivity.

Turning to measurement, one outstanding issue is price indices. Section 4.2 highlighted the differential trends in the productivity of the IT services industry, which may in part reflect different trends in deflators for industry output (see Figure A.7 in the Appendix). Interestingly, the price indices for own-account and purchased software investment are quite similar between the UK and US (see Figure A.8 in the Appendix), with own-account software seeing slow price increases, and purchased software seeing sharp deflation. The total software investment deflator is somewhat different between countries on account of the differing composition. Yet the implied deflator for the output of the IT services industry is very different (Figure A.7), suggesting other factors. This paper has not studied these price indices in detail, but other literature has.

Another potential measurement issue relates to industry classification and the application of sales adjustment factors. Recall that sales adjustment factors are applied in the sum of costs method for own-account software, to remove the costs associated with developing software for sale, and thus to avoid double-counting with purchased software investment. The ONS and BEA have different methods for such adjustments, but both aim to identify industries that produce software for sale and adjust these industries.

Any industry-based method for sales adjustments will be sensitive to the industry classification in the data being used, and thus potentially sensitive to the type of business unit to which the data relate. For instance, data relating to individual sites (establishments, local units) might identify a site as operating in the software industry, while its parent firm (enterprise) might be in another industry. Thus, changes in the degree of separation of software development activities from other activities in the firm, might interact with the method for sales adjustments.

In the extreme, a software team could be ‘spun out’ to create an independent subsidiary within the same enterprise group that specialises in software development. The new unit would presumably be classified to the software industry, while the rest of the enterprise might be classified to another industry, say manufacturing. Where previously the sum of costs method would have seen software workers in the manufacturing industry, and likely not applied a sales adjustment, now it will see the same workers in the software industry, and so likely apply a sales adjustment. The new software firm might sell software to other units within the enterprise group, which may be recorded as purchased software investment. Thus, increased separation of software teams from their parent enterprise could result in reduced recording of own-account software and increased recording of purchased software. If this pattern is more prevalent in the US than the UK, or if the sum of costs method is applied to different types of business units, this might in part explain the different composition of software investment seen between the two countries. Ding et al. (2022) report a rise in non-manufacturing employment in firms classified to the manufacturing industry in the US.

A further potential measurement issue is the treatment of software subscription services, or “software as a service” (SaaS). This pricing model has become increasingly popular over time, with products such as Microsoft Office now often purchased on subscription rather than a lifetime copy on a CD or download. It is unclear the extent to which software subscriptions will be recorded as purchased software investment or intermediate consumption on a computer services product. Indeed, the theoretically appropriate treatment is somewhat unclear. Whether this pricing model is relatively more common in the US or UK, and the treatment of such payments in the official data of the two countries, are unknown. Either way, the blurring lines between investment and intermediate consumption in this area motivates increased use of KLEMS-type productivity analysis instead of GVA-based growth accounting, since KLEMS-type analysis will make more visible such software services payments.

Another factor that might drive a structural difference between the countries is relative prices. It is possible that purchased software is relatively more expensive in the UK than the US. If much generic software is developed in the US, investing firms in the UK might find it relatively more expensive on account of exchange rates and import tariffs. There may also be non-tariff barriers, such as differences in default settings that make investment in US-made software relatively more costly to implement for UK firms than US firms. In turn, this would reduce purchased investment in software by UK firms relative to US firms, pushing UK firms towards own-account investment.

A related cost factor could be treatment of software investment for tax or accounting purposes. Differential tax rules for purchased and in-house software investment could motivate firms to invest in one type or the other. If these rules then differ between the UK and the US, these incentives could vary and lead to different investment strategies. More research is needed on this.

One implication for UK policymakers, if the data are to be believed, is that UK firms might not be making as much use as they could of buying software from specialist software firms. Such specialist firms might have some advantages over in-house staff in developing sophisticated software cheaply, allowing the investing firm to acquire a higher-quality capital asset at a lower cost.[9] Then again, external firms might not as easily be able to design software that integrates with the rest of the investing firm's technology landscape, while in-house staff might have a better grasp of the needs of, and constraints to, new software. Firms might prefer to use in-house development to prevent issues when integrating the new software into the firm, by ensuring that the necessary expertise remain on hand. Coyle et al. (2019) find that in-house software investment is associated with higher productivity than purchased software investment amongst UK firms, though this might reflect selection effects.

6. Conclusion

This paper presents evidence that calls into question the common assumption in the literature that most software assets are proprietary. Official data from the BEA suggest that little software investment in the US is own-account (proprietary) and that the growth over time is driven by purchased software. This contrasts with the UK, where official data from the ONS suggest that most software investment is own-account. We argue that this disparity likely reflects a combination of measurement differences relating to own-account software, structural differences relating to the size and productivity of the specialist software industry, other untested factors such as relative prices, and untested measurement issues including industry classification.

We take two key takeaways. First, economic measurement is critical for understanding this complex and important area. The measurement of own-account software investment depends on choices in methods that have previously received relatively little attention, but have potentially big implications for cross-country comparability of official data. In particular, the sales adjustment factors appear to be more important than previously considered. With the forthcoming inclusion of data as a produced capital asset in the update to the System of National Accounts, due in 2025, these parameter choices deserve greater attention. This also seems particularly important as the current debates on the adoption of AI technologies, as well as their diffusion and their productivity impacts, will increase focus on software investment.

Second, further research in this area is needed. The literature largely considers intangible assets to be mostly proprietary, which we have shown is contradicted in the official US data. To the extent that current findings in the literature are based on inconsistent cross-country data on intangible investment, they may benefit from review.

Further research would benefit from greater availability of data that separates own-account and purchased software investment. These two types of investment and resulting types of assets may have different economic properties and thus different implications for growth and productivity. Since they are usually measured very differently (own-account investment via modelling, purchased investment via business surveys), this should be feasible for many national statistical institutes to provide. It would also allow easier comparison across countries on a like-for-like (or not) basis.

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[9] We do find in Figure A.8 in Appendix that investment deflators decline by significantly more for purchased than for in-house software investment, which could be indicative of relative quality improvements. However, the price indices or the two types of software are estimated in very different ways, and likely do not reveal much about relative quality changes.

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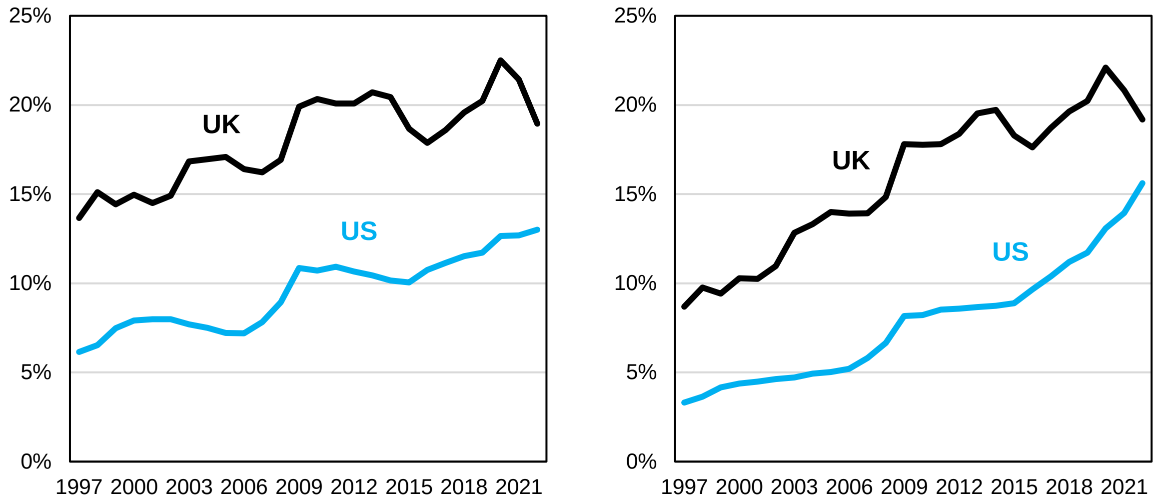
Appendix

Additional results

Figure A.1 – Share of software investment in total investment, UK and US, 1997-2022

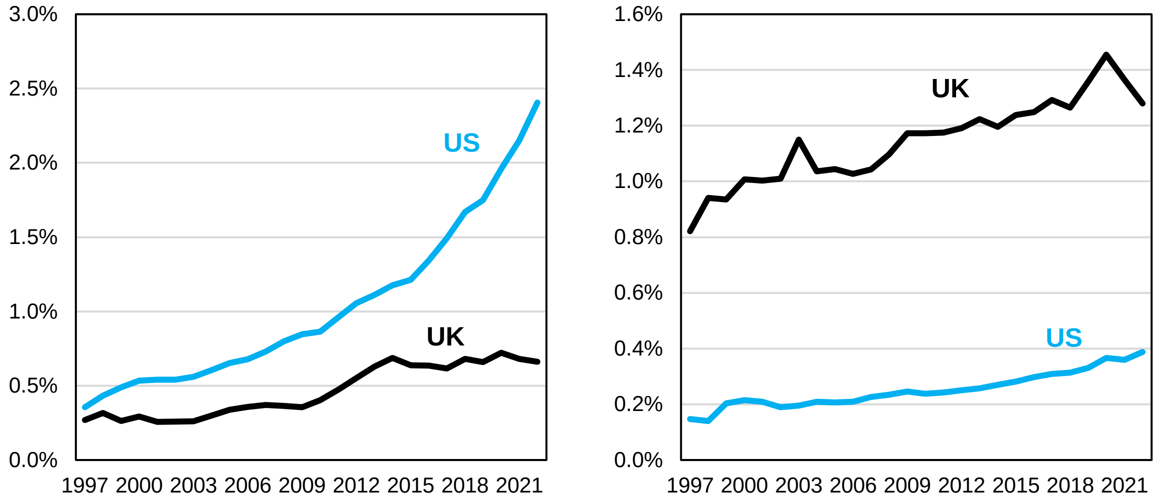
Figure A.1a – Current prices *Figure A.1b – Chained volume measures*



Source: Authors' calculations using ONS and BEA data.
Notes: In left panel, numerator and denominator both in current prices; in right panel, numerator and denominator both in chained volume measures.

Figure A.2 – Share of software investment in GDP in CVMs, UK and US, 1997-2022

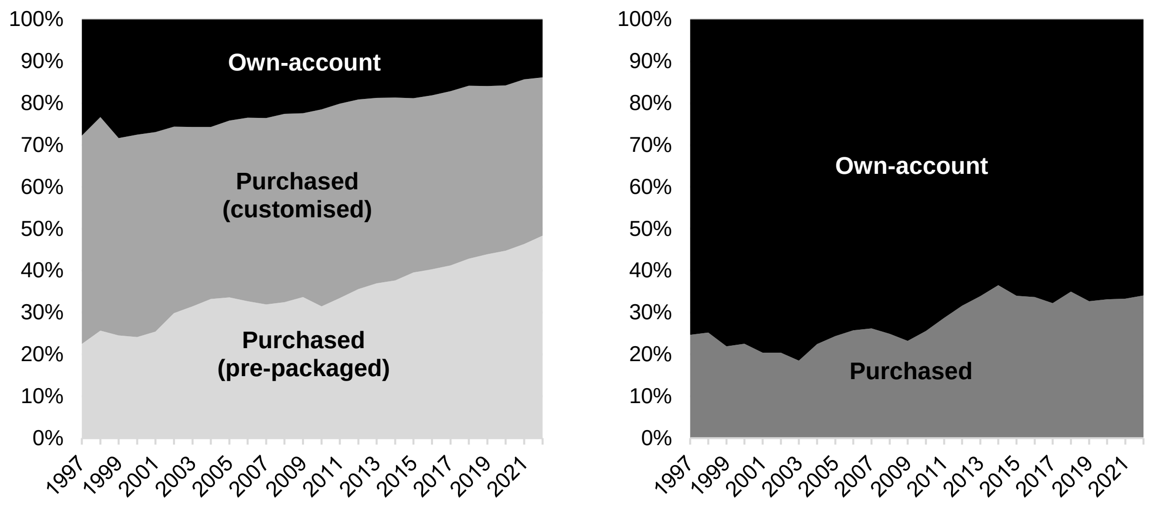
Figure A.2a – Purchased software *Figure A.2b – Own-account software*



Source: Authors' calculations using ONS and BEA data.
Notes: In both panels, numerator and denominator both in CVMs. Figure 2 in the main test shows the equivalent in current prices.

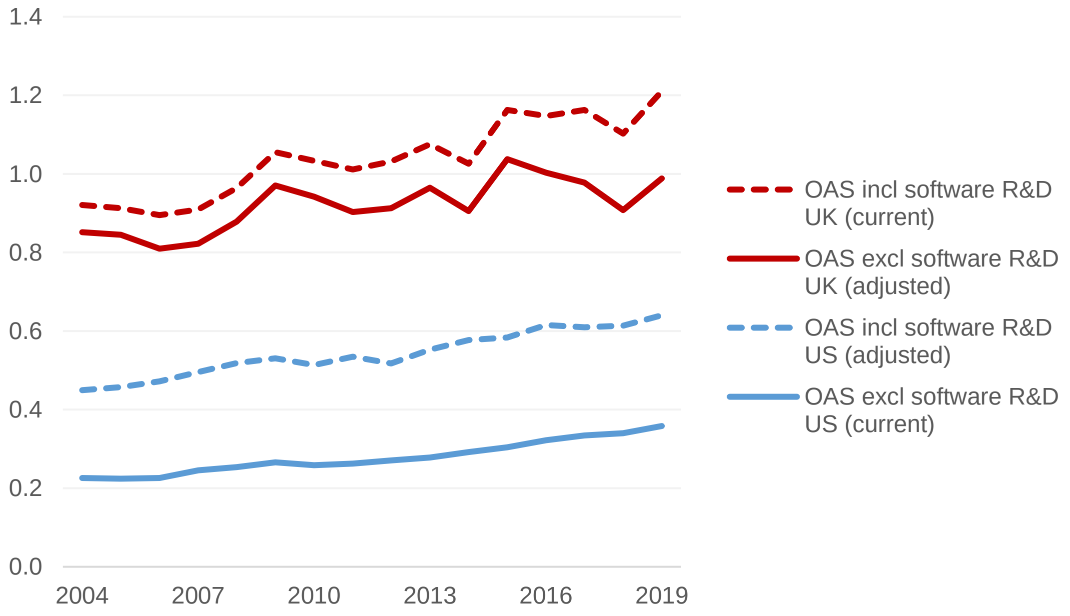
Figure 3 – Composition of total software investment in chained volume measures, 1997-2022

Figure 3a – United States *Figure 3b – United Kingdom*



Source: Authors' calculations using ONS and BEA data.
Notes: In both panels, total software and software components all in CVMs (Figure 3 in the main text is in current prices). Split of purchased software investment into customised and pre-packaged not available for the UK.

Figure A.4 – Own-account software investment as a share of GDP CVM, including and excluding software R&D, UK and US, 2004-2019



Source: Authors calculations based on data from BEA and ONS.
Notes: Red lines are estimates for the UK; blue lines are estimates for the US. Solid lines exclude software R&D; dashed lines include software R&D. Thus, the red and blue solid lines have consistent scope and can be compared; and likewise the red and blue dashed lines can be compared. Numerators and denominators all in CVMs (Figure 5 in the main text uses current prices).

Figure A.5 – Comparing measurement approaches for US own-account software investment, 2004-2019

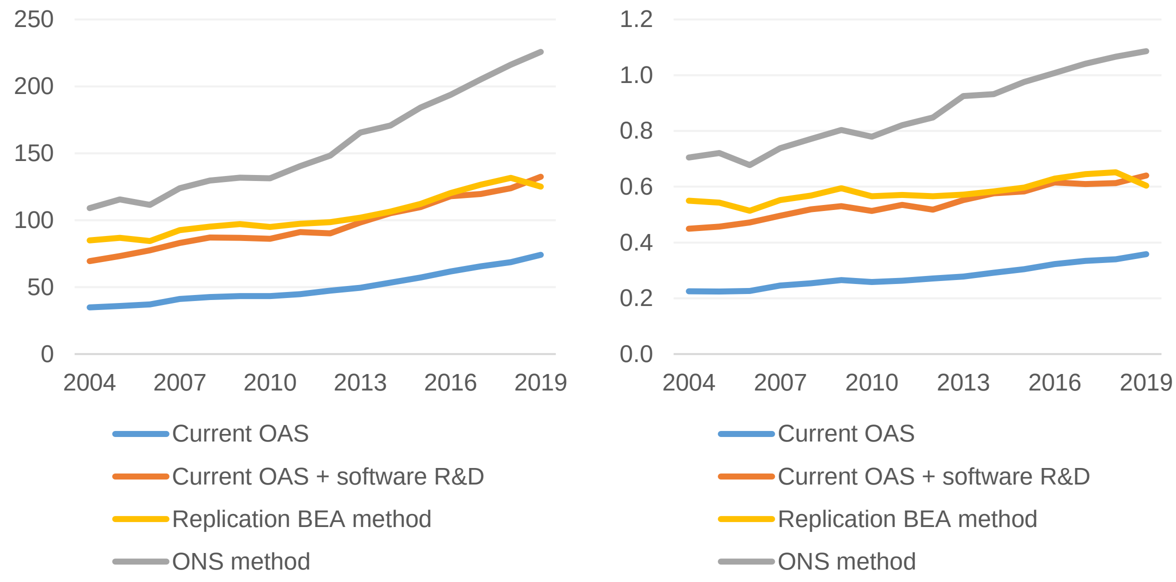


Figure A.5a – CVMs, $bn (2017) *Figure A.5b – Share of GDP CVM (%)*

Source: Authors' calculations using BLS OES, based on ONS, BEA.
Notes: Replication uses US SOC 2010 up to 2018, and US SOC 2018 for 2019, causing a minor discontinuity. Numerators and denominators all in CVMs (Figure 6 in the main text uses current prices). GDP adjusted for additional own-account investment in "ONS method".

Figure A.6 – Comparing measurement approaches for UK own-account software investment, 2004-2019

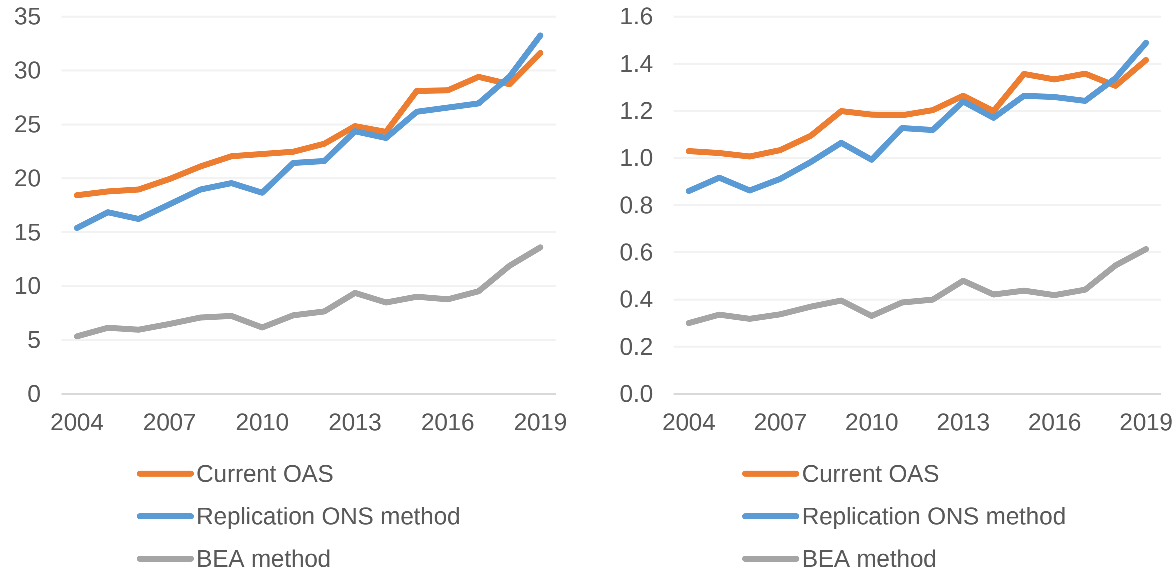
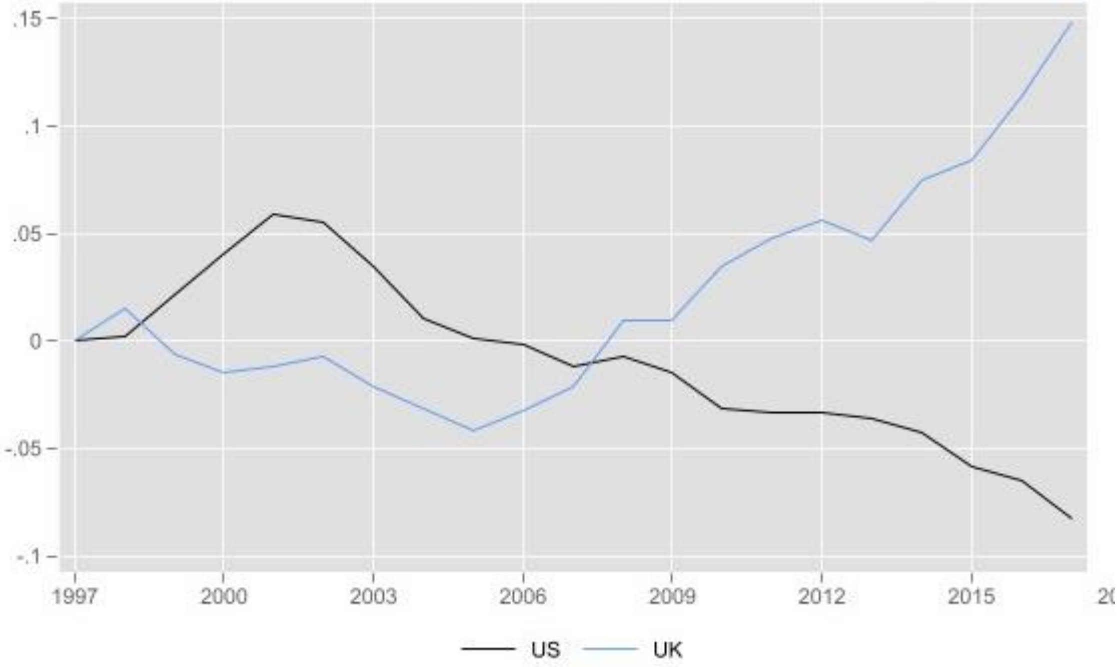


Figure A.6a – CVMs, £m (2019) *Figure A.6b – Share of GDP CVM (%)*

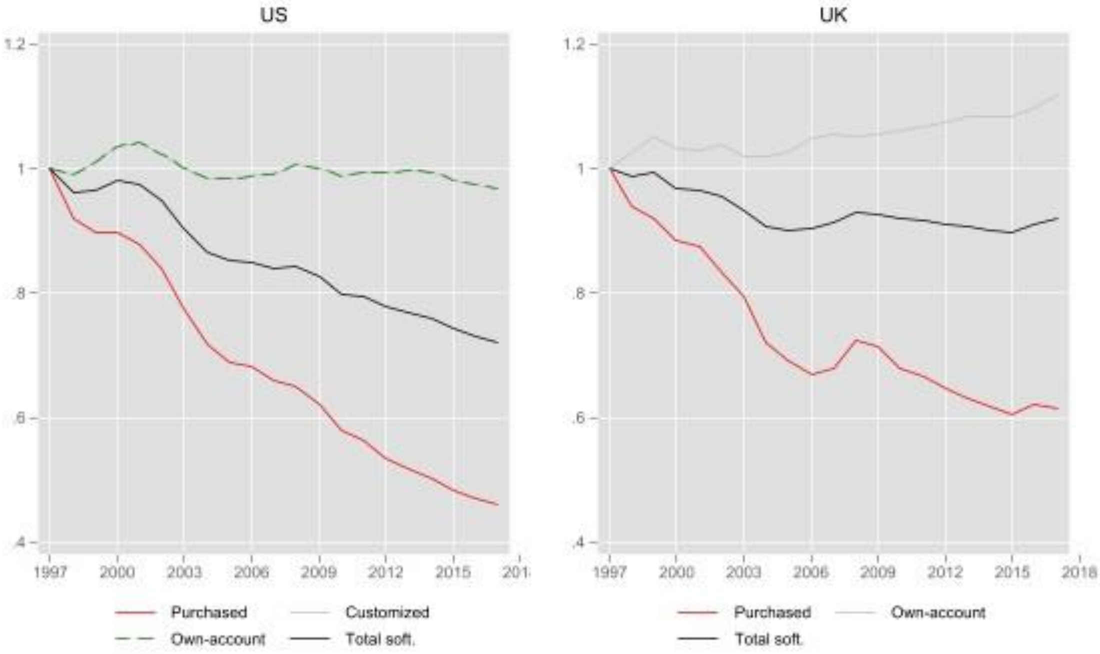
Source: Authors' calculations using LFS, based on ONS, BEA; Martin (2022).
Notes: "Replication ONS method" and "BEA method" use UK SOC 2000 up to 2010, and UK SOC 2010 from 2011, with the two series splices together in 2011. "Replication ONS method" data from Martin (2022). Numerators and denominators all in CVMs (Figure 7 in the main text uses current prices). GDP adjusted for lower own-account investment in "BEA method".

Figure A.7 – IT services industry implied GVA deflator, index 1997=1



Source: Authors calculations based on data from BEA and ONS.

Figure A.8 – Software investment implied deflators, by type of software, index 1997=1



Source: Authors calculations based on data from BEA and ONS.

Industry groupings used in the main text

Table A.1 – Industry groupings used in the main text with corresponding UK SIC 2007 and US NAICS codes

Industry group name	UK SIC 2007 codes	US NAICS codes
Utilities, mining	B, D, E	21, 22, 562
Manufacturing	C	31-33
Wholesale, retail	G	42, 44-45
Transport services	H	48-49
Telecoms, broadcasting	J59, J60, J61	512, 515, 517
IT services, publishing	J58, J62, J63	511, 518-519, 5415
Finance and insurance	K	52
Prof. services, science	M	5411-5414, 5416-5419, 55
Admin services	N	532-533, 561
Other services	F, I, L, P, Q, R, S, T	23, 531, 61, 62, 71, 72, 81

Note: Industry group names used in Figures 4 and 9 in the main text.

Own-account software investment measurement literature in the US and UK

Software investment has been included in Gross Fixed Capital Formation (GFCF) in the National Accounts since SNA 1993 and ESA 1995. Most countries made attempts to measure it from the late 1990s, but by the early 2000s there were concerns that these estimates were markedly different across countries. Ahmad (2003) describes work to compare methods and estimates across countries, and encouraged harmonisation of methods, especially with regards to own-account software investment. Oulton (2001) suggested that the ONS should increase estimates of UK software investment by a factor of 3, on the basis of analysis with US data.

Improved software investment estimates for the UK were made by Chesson and Chamberlin (2006) and Chamberlin et al. (2007), which came remarkably close to the earlier proposal by Oulton (2001). Estimates in 2006-2007, first implemented in the UK National Accounts in 2007, were the first to use the now-agreed “sum of costs” method (see section 2 for more on this). Subsequent updates were made to official UK estimates over the years, most recently in 2019 (ONS, 2019). See Martin (2022) for further discussion of UK methods and history.

For the US, official estimates are produced by the Bureau of Economic Analysis (BEA). Early work was by Parker and Grimm (2000) and Moylon (2001), who used the sum of costs approach, and software was capitalised in the US national accounts from the 1999 comprehensive update. Estimates were improved, and software originals explicitly captured, in the 2003 comprehensive update (Moylan and Robinson, 2003). R&D was brought into the accounts as a produced asset in the 2013 comprehensive update (BEA, 2013), but software was not revised, as R&D on software products was included in own-account software investment already. This was changed in the 2018 comprehensive update (Chute et al., 2018), with software R&D now being treated as investment in R&D – this was to bring national accounts estimates into line with the R&D source data and the R&D satellite account. The 2023 comprehensive update (McCulla et al., 2023) expands the measurement of own-account software to include additional occupations, including those relating to “web developers and digital interface designers, database administrators and architects, network and computer systems administrators, computer network architects, and computer and information research scientists”. This revision is only taken back to 2013 (McCulla et al., 2023) but seems to have had surprisingly little effect on estimates of own-account software;

indeed, there are downward revisions to own-account software in some years which seems inconsistent with the expansion of occupations included in the method.

Software types

We refer to four types of software in this paper:

- Purchased software comprises customised and pre-packaged software:
    - Customised software refers to software purchased from an external provider, which is created for the investing business specifically. It is bespoke and unique.
    - Pre-packaged software refers to software purchased from an external provider, which is a generic software product, available to all customers. Also known as “off-the-shelf software”.
- Own-account investment is software developed in-house for use by the firm that develops it. By its nature, it will be unique and customised to the business’ needs, so shares some similarities to purchased customised software.

Table A.2 illustrates how these concepts fit together. Purchased software investment in UK data explicitly includes both off-the-shelf (generic) software products and customised purchased software. So for comparison, we can compare purchased investment for the UK with the sum of pre-packaged and customised software investment for the US

Table A.2 – Software categorisation

Product code (CPA rev2.1)	**Software category (US)**	**Software category (UK)**
58.2	Pre-packaged	Purchased
62.01	Customised	
	Own-account	Own-account

Software and databases

The National Accounts asset is in fact “software and databases”, where databases are “Files of data organised to permit resource-effective access and use of the data” (ESA 2010, Annex 71. p.184). Examples of such investment include structuring, formatting, sorting, classifying data. The database management software is software, and therefore still capitalised but as software rather than part of databases. However, the data in the database is, for the most part, not capitalised.

Both purchases and in-house development of databases are included in capital investment in the National Accounts. Purchased databases is a very small component as measured in the UK. In purchased database investment, the value of the information content within the purchased database is included in the investment value (OECD, 2010). However, in own-account databases, the value of the data is not included. The exclusion (and thus the inconsistency with purchased databases) is mostly on practical grounds – it was thought, at the time the current National Accounting guidelines were developed, that it would not be possible to reliably estimate the value of data created in-house. However, purchased databases contain a market price for the data, and thus this could be reliably valued, and so was included.

A forthcoming revision to the System of National Accounts, due in 2025, will treat data as a produced asset. Estimates based on a sum of costs approach are likely to be recommended to NSIs. This improves consistency within the definition of capital, but only serves to enhance the importance of understanding the methods used to estimate own-account intangible investment.

Own-account software measurement harmonisation methods

Table A.3 – Mapping of relevant UK SOC 2010 codes to US SOC 2010 for use in own-account software harmonisation analysis

Note: Some codes are assumed to have a near one-for-one conversion, such as 2137 Web design and development professions and 15-1134 Web Developers. Other codes are assumed to have a more complex mapping. Broadly similar codes are grouped in the Table, and separated from other codes by double horizontal lines.

UK SOC 2010 code	UK SOC 2010 description	Time factor (%)	Mapped US SOC 2010 code	Mapped US SOC 2010 description	Mapped time factor (%)	Notes
1136	Information technology and telecoms directors	10	11-3021	Computer and Information Systems Managers	20	Covering 1136, 2133 and 2134
2133	IT specialist managers	30	15-1199	Computer Occupations, All Other	30	Covering 2133, 2134 and 2139
2134	IT project and programme managers	30				
2135	IT business analysts, architects and systems designers	35	15-1111	Computer and Information Research Scientists	35	
			15-1121	Computer Systems Analysts	35	Included in BEA method
2136	Programmers and software development professionals	50	15-1131	Computer Programmers	50	Included in BEA method
			15-1132	Software Developers, Applications	50	Included in BEA method
			15-1133	Software Developers, Systems Software	50	Included in BEA method
2137	Web design and development professions	35	15-1134	Web Developers	35	
2139	Information technology and telecoms professionals n.e.c.	25	15-1122	Information Security Analysts	20	Since some goes to 15-1199 with 30% time factor, 15-1122 gets 20% time factor
2423	Management consultants and business analysts	10	13-1081	Logisticians	10	
			13-1111	Management Analysts	10	
2425	Actuaries, economists and statisticians	10	15-2011	Actuaries	10	
			15-2021	Mathematicians	10	

			15-2031	Operations Research Analysts	10	
			15-2041	Statisticians	10	
			19-3011	Economists	10	
3131	IT operations technicians	20	15-1141	Database Administrators	20	
			15-1142	Network and Computer Systems Administrators	20	
			15-1152	Computer Network Support Specialists	20	
			43-9011	Computer Operators	10	Some of 3131 maps to 15-1134 with higher time factor, so downgrade here
3132	IT user support technicians	15	15-1151	Computer User Support Specialists	15	
3539	Business and related associate professionals n.e.c.	10	15-2091	Mathematical Technicians	10	
			15-2099	Mathematical Science Occupations, All Other	10	
			19-4061	Social Science Research Assistants	10	
			43-9111	Statistical Assistants	10	
4217	Typists and related keyboard occupations	5	43-9021	Data Entry Keyers	5	
5245	IT engineers	5	49-2011	Computer, Automated Teller, and Office Machine Repairers	5	

Table A.4 – Mapping of relevant US SOC 2010 codes to UK SOC 2010 for use in own-account software harmonisation analysis

Note: Some codes are assumed to have a near one-for-one conversion. Other codes are assumed to have a more complex mapping. Broadly similar codes are grouped in the Table, and separated from other codes by double horizontal lines.

US SOC 2010 code	US SOC 2010 description	Time factor (%)	Mapped UK SOC 2010 code	Mapped UK SOC 2010 description	Mapped time factor (%)	Notes
15-1121	Computer Systems Analysts	50	2135	IT business analysts, architects and systems designers	50	2135 has a time factor of 35% in the ONS method
15-1131	Computer Programmers	50	2136	Programmers and software development professionals	50	All three US codes assumed to map to 2136
15-1132	Software Developers, Applications	50				
15-1133	Software Developers, Systems Software	50				

Table A.5 – Mapping of relevant UK SIC 2007 codes to NAICS for use in own-account software harmonisation analysis

Note: All codes assumed to have a broadly one-for-one conversion. A sales adjustment factor of 90% means that 90% of the value is excluded to avoid double-counting, leaving 10% to be included in the own-account software investment estimates.

UK SIC 2007 code	**UK SIC 2007 description**	**Sales adjustment factor (%)**	**Mapped NAICS code**	**Mapped NAICS description**	**Sales adjustment factor (%)**
26	Manufacture of computer, electronic and optical products	95	334	Computer and Electronic Product Manufacturing	95
27	Manufacture of electrical equipment	90	335	Electrical Equipment, Appliance, and Component Manufacturing	90
62	Computer programming, consultancy and related activities	92.5	5415	Computer Systems Design and Related Services	92.5