

Physics and the Economy: Measuring the value of physics-based industries in England

A Cebr report for the Institute of Physics

November 2021

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London, November 2021

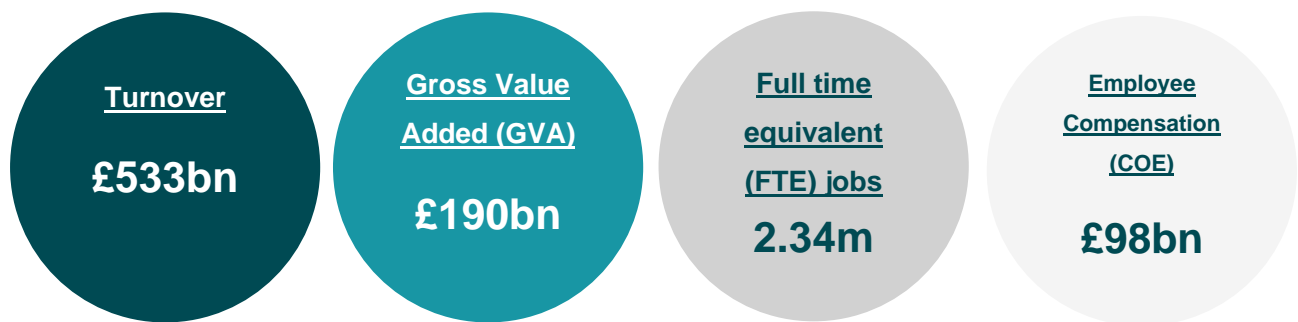
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Economic impact of the PBIs in England

Headline findings

- This is a report by the Centre for Economics and Business Research (Cebr), on behalf of the Institute of Physics, detailing the **economic contribution of physics-based industries (PBIs) in England, to the English economy**.
- In the graphic below, we present the economic impact of the PBIs in England in 2019, although our analysis also covers trends over the nine preceding years.
- In 2019, it is estimated that in England, PBIs directly contributed to the English economy:



- In 2019, the economic footprint of PBIs was greatest in London (£40.73 billion in direct GVA), the South East (£35.80 billion) and the North West (£23.66 billion).
- The latest data suggests a £190 billion GVA contribution in 2019 – 10.0% of the total English economy and 82.9% of the total contribution from the physics sector across all the UK nations to the UK-wide economy.
- Across England, the biggest PBI sub-sector in terms of GVA was Physics Manufacturing, which contributed £62.81 billion, followed by Physics Science & Technology (£59.7 billion) and Telecommunications (£28.62 billion).
- There were 305,445 PBI enterprises operating in England. The regions with the greatest number of enterprise entities were London (63,525), the South East (56,690) and the North West (37,065). Similarly, these regions employed the most people, with 344,670, 402,920 and 306,500 full-time employees, respectively.
- In 2019 Physics Science & Technology was the PBI sub-sector with the greatest number of enterprises; 225,305 in England (74.1% of all PBI enterprises).
- 92% of PBI enterprises were classified as micro enterprises. Of the remainder, 6.6% of enterprises were defined as small (10-49 employees), with the remaining 1.4% medium (50-249 employees) or large (250+). In England as a whole, 89.6% of all enterprises were micro, 8.5% were small, and 1.9% were medium or large.
- Throughout the decade, the turnover of PBIs grew by 27.4% in nominal terms, from £418 billion to £533 billion. The highest absolute growth was experienced by the Physics Science & Technology sub-sector, which went up from £82 billion to £138 billion (68.7%), while the Space Transport & Air Transport Services sub-sector nearly doubled its initial value (from £4.99 billion to £9.77 billion, 95.6%).

- Three sub-sectors had their turnover rates shrink significantly over the assessed period: Physics Machine Sales (from £2.92 billion to £2.17 billion, 25.4%), Defence (£5.25 billion to £3.89 billion, 25.9%), and Oil & Gas Extraction (£12.34 billion to £5.88 billion, 52.3%).
- FTE employment in the PBIs topped more than 2.33 million in 2019, which contributed almost 86% of the total UK physics sector, and 10.1% of English employment. Employment growth averaged 1.4% annually.
- Physics Science & Technology is the sub-sector which had the largest share of employees in England in 2019; 41.7% of total English PBI FTE employment. The Physics Manufacturing sub-sector had the second largest share, with 36.7%.
- In earlier years, the Physics Manufacturing sub-sector was the biggest employer, but over the period, it was overtaken by the Physics Science & Technology sub-sector.
- PBIs experienced a steady growth of 3.2% in yearly average COE, from £74 billion to £98 billion over the period. This is a much higher growth rate compared to employment.
- COE per FTE worker increased overall across PBIs to £42,000, resulting in a 16.3% growth. The main driver of this was the Physics Manufacturing sub-sector with a growth of 31.3% over the period, reaching £44,500 by 2019.
- The PBIs are generally very productive: average GVA per FTE worker increased by 8.6% from almost £75,000 to more than £81,000. This was higher than the productivity of the Construction (£72,000), the Transport & Storage (£71,000) and the Retail (£36,000) sectors.

1. Introduction

This report by the Centre for Economics and Business Research (Cebr) on behalf of the Institute of Physics (IOP), considers the contribution and importance of physics-based industries (PBIs) to the English economy, an analysis that spans the period of 2010 to 2019. This report forms part of a series of six reports, which quantify the impact of the PBIs to the UK and Irish economies.

1.1 Background and general purpose of the study

According to the IOP's definition, PBIs are those where either:

- Ongoing research and development (R&D) in the industry consistently makes use of physics knowledge in a way that can be expected to affect the fortunes of businesses within the industry

Or

- The underlying technology supporting the industry requires significant physics knowledge for continued operation.

In other words, PBIs can be thought of as those industries in which the industrial and technical activities associated with the industry require physics knowledge.

This research provides up-to-date insights on the size and performance of the UK and Irish physics sectors, presenting a range of analyses which demonstrate different aspects of the economic value brought by the PBIs. The intention of this is to empower the IOP with a thorough and comprehensive knowledge and evidence base, such that they can support and advocate for the sector across the UK and Ireland.

An important task has been to develop an in-depth understanding of PBIs. To produce a robust study, it is necessary to analyse the available data to ensure that it captures the full range of activities that should be included in establishing the total economic 'footprint' of the industry. Following the collation of the necessary data capturing these activities, the values of key economic indicators were established to demonstrate the impact of the sector. The key macroeconomic indicators include:

- GVA¹ contributions to England and constituent regional GDP generated by the PBIs
- Full-time equivalent (FTE) jobs supported by the sector²
- The value of the turnover of the PBIs

¹ GVA, or gross value added, is a measure of the value of production in the national accounts. Conceptually it can be considered the value of what is produced, less the value of intermediate goods and services used to produce it. GVA is distributed in three directions – to employees, to shareholders and to government. It is often used as the proxy for the contribution of a sector or industry to GDP: strictly this relationship is $GVA + \text{Tax on products} - \text{Subsidies on products} = \text{GDP}$.

² The calculation of full-time equivalent (FTE) is an employee's scheduled hours divided by the employer's hours for a full-time workweek. When an employer has a 40-hour workweek, employees who are scheduled to work 40 hours per week are 1.0 FTEs. Employees scheduled to work 20 hours per week are 0.5 FTEs. We considered all part-time workers to work 20 hours per week. Lastly, we subtracted the number of employees from the number of employment in order to get the number of self-employed individuals.

- The value of COE³ generated by PBIs, representing the total remuneration of employees operating in the sector
- The productivity of the PBIs
- The number of PBI businesses operating in England.

In addition to the core modelling and analysis, we also undertake a range of comparisons to contextualise the findings, including:

- How the economic indicators vary over the period 2010-2019
- How the economic indicators vary across different categories or groupings of the PBIs
- How the economic indicators for the PBIs vary between the UK nations
- How the indicators for the PBIs compare with other important sectors of the English economy.

Mapping English PBIs

Here we set out how PBIs have been defined for the purposes of the study. The PBIs consist of over 120 four and five-digit SIC codes, in which ongoing R&D in the industry consistently makes use of physics knowledge, or the underlying technology supporting the industry requires significant physics knowledge for continued operation. The full list of SIC codes used within this study can be found in Appendix I: **SIC-based definition of PBIs and sectoral alignment**.

For the purpose of this report, these SIC codes are then aggregated into 11 sub-sectors.⁴ These are:

- Oil & Gas Extraction
- Physics Manufacturing
- Physics Machine Services
- Energy Production, Transmission & Distribution
- Physics Waste & Recovery
- Physics Machine Sales
- Medical Equipment Sales
- Space Transport & Air Transport Services
- Telecoms
- Physics Science & Technology
- Defence

³ Compensation of employees (COE) or employee compensation, is the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter. This consists of wages paid to employees; employers' actual social contributions (excluding apprentices); employers' imputed social contributions (excluding apprentices); and employers' social contributions for apprentices.

⁴ In order to visualise the data better, and avoid some volatility, we aggregated several of these smaller sub-sectors into an 'Other' category'. 'Other' consists of: Oil & Gas Extraction; Physics Machine Services; Physics Waste & Recovery; Physics Machine Sales; Medical Equipment Sales; Space Transport and Air Transport Services; and Defence

1.2 Earlier research

The IOP previously commissioned Cebr in 2016 to produce studies focused on measuring the impact of the PBIs to the UK and to the Irish economies.

In this suite of six reports, we go beyond the 2016 project and present a range of new materials, including assessment of:

- How the full range of economic indicators for the PBIs varies across the UK nations and English regions, as well as the Republic of Ireland
- How the economic indicators for the PBIs vary between the UK and Ireland and other international comparable countries
- How the indicators for the PBIs compare with other important sectors in the UK and Ireland (such as Construction or Transportation & Storage), and how they are broken down by the UK's constituent nations and regions.

In addition, the definition of the PBIs has been updated since the 2016 research; therefore, figures between reports in the two series are not directly comparable.

This report focuses on England specifically.

2. Enterprises in the English-based PBIs

This section provides an assessment of the importance of PBIs to England in terms of turnover and business demographics over the period 2010-2019.

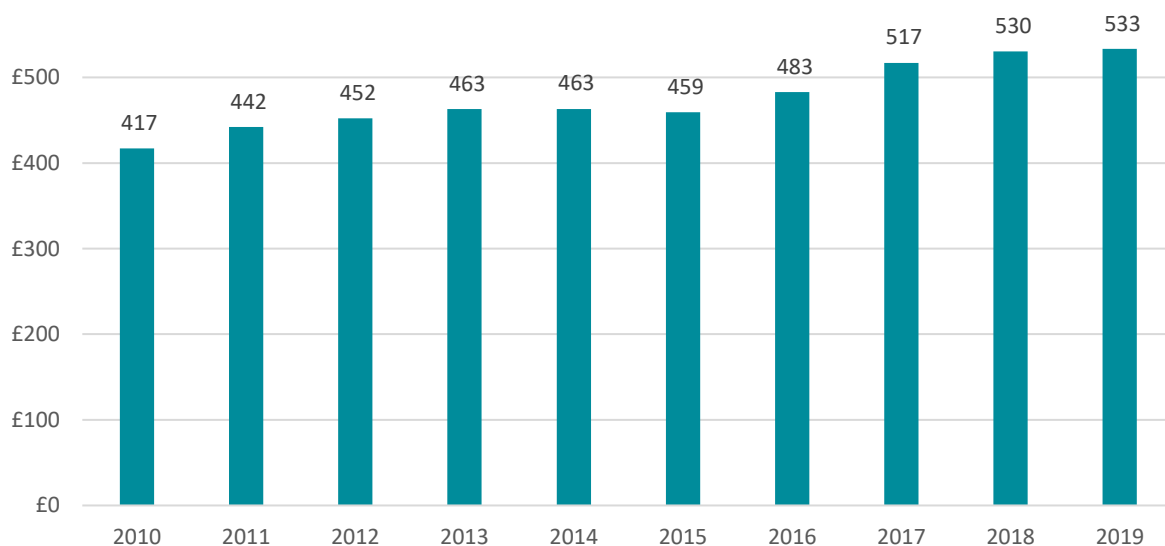
2.1 Turnover

We firstly present the contribution of PBIs to the English economy in terms of the turnover generated by those industries. Throughout the timeline, PBI turnover in England experienced an increase of £116 billion, which means a 27.8% rise across the decade. Figure 1 shows that in 2019, England's physics-based industries collectively had a turnover of £533 billion. England's contribution to the UK turnover experienced an upward trend, from 81.7% to 84.1%, and it was the largest contributor to UK PBI turnover.

The majority of the observed growth occurred over the 2016-2018 period, and the largest single increase was in 2017, when the turnover jumped £35.5 billion (7.4%). That was a strong year for the Physics Science & Technology sub-sector, which increased by almost £13 billion (11%).

Nonetheless, the physics sector in England still had an average yearly increase of 2.8%, which is slightly higher than the average UK-wide PBI sector yearly turnover rise of 2.4%. This difference is largely driven by significant turnover declines in the Oil & Gas Extraction sub-sector, which constitutes a much larger share of total turnover in Scotland (and therefore also the UK), than in England.

Figure 1: Turnover in PBIs, £ billions, 2010-2019



Source: ABS, Cebr analysis

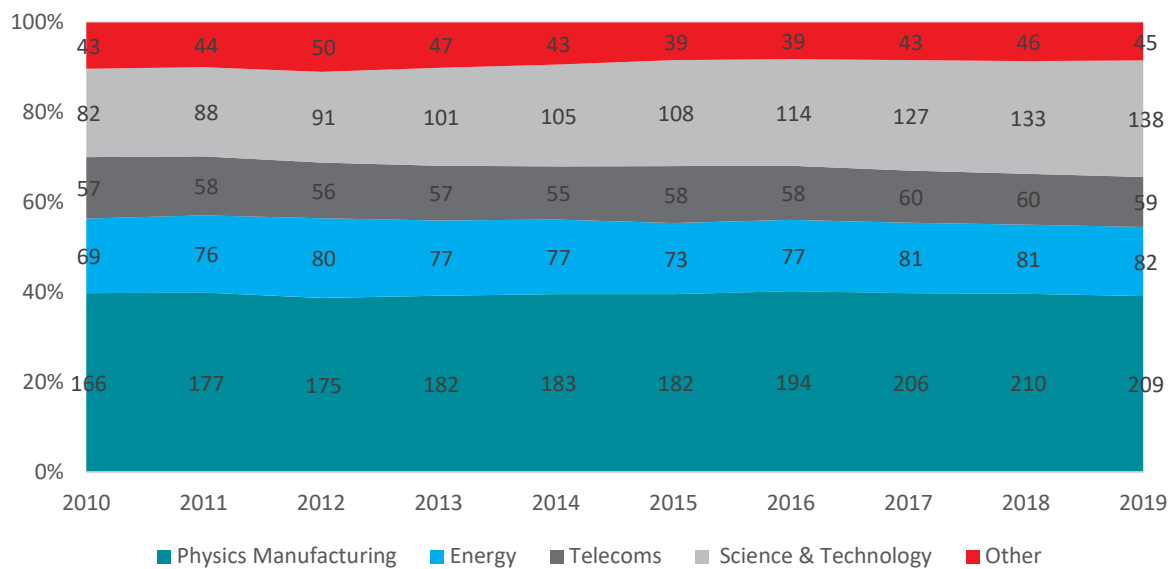
Figure 2: Turnover in the different sub-sectors of PBIs in England, presents a comparison of the different sub-sectors of PBIs.⁵ Their composition changed slightly throughout the 2010-

⁵ See Table 14 in Appendix II: Supplementary figures and tables for a full breakdown of the contribution to total turnover by English PBIs, disaggregated by all industries.

2019 period. Those PBIs that are engaged in the Physics Manufacturing sub-sector occupied the largest share, around 39.6% on average over the period, followed by those engaged in Physics Science and Technology activities, approximately 22.8%.

The Physics Science & Technology sub-sector saw growth across the decade. In 2010, the sub-sector contributed 19.6% of all PBI turnover; by 2019, this share had increased to 25.9%. In the 'Other' sub-sector, turnover fluctuated because three sub-sectors' turnover rates shrunk significantly: Physics Machine Sales (from £2.92 billion to £2.17 billion, 25.4%), Defence (£5.25 billion to £3.89 billion, 25.9%), and Oil & Gas Extraction (£12.34 billion to £5.90 billion, 52.2%). The other sub-sectors within the category increased but weren't able to make up for the loss in every specific year. In 2010, these three sub-sectors represented almost 5% of PBI-related activities, but in 2019, they produced only 2.2% of the overall turnover, making the 'Other' category shrink to 9%.

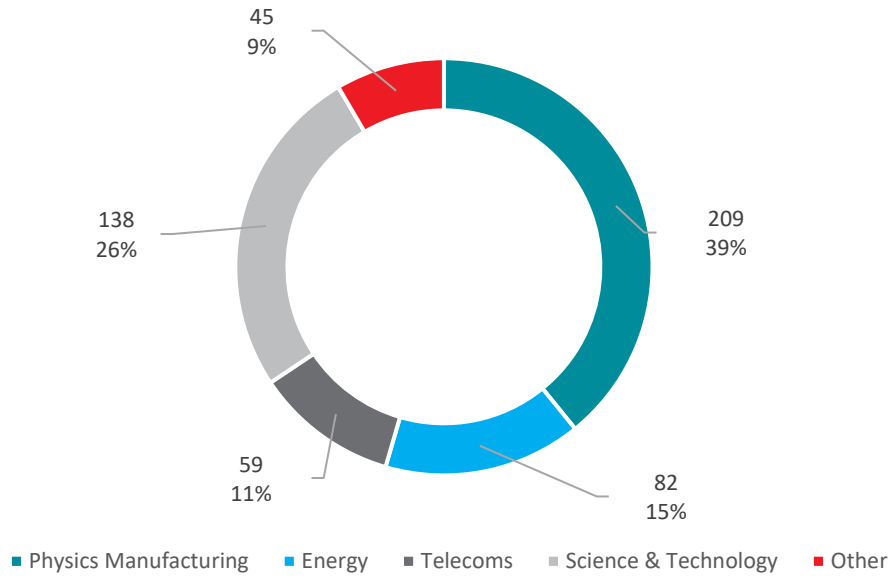
Figure 2: Turnover in the different sub-sectors of PBIs in England, % of PBI total (LHS axis) and monetary value (£ billions), 2010-2019



Source: ABS, Cebr analysis

Figure 3 below visualises the breakdown of turnover in 2019.

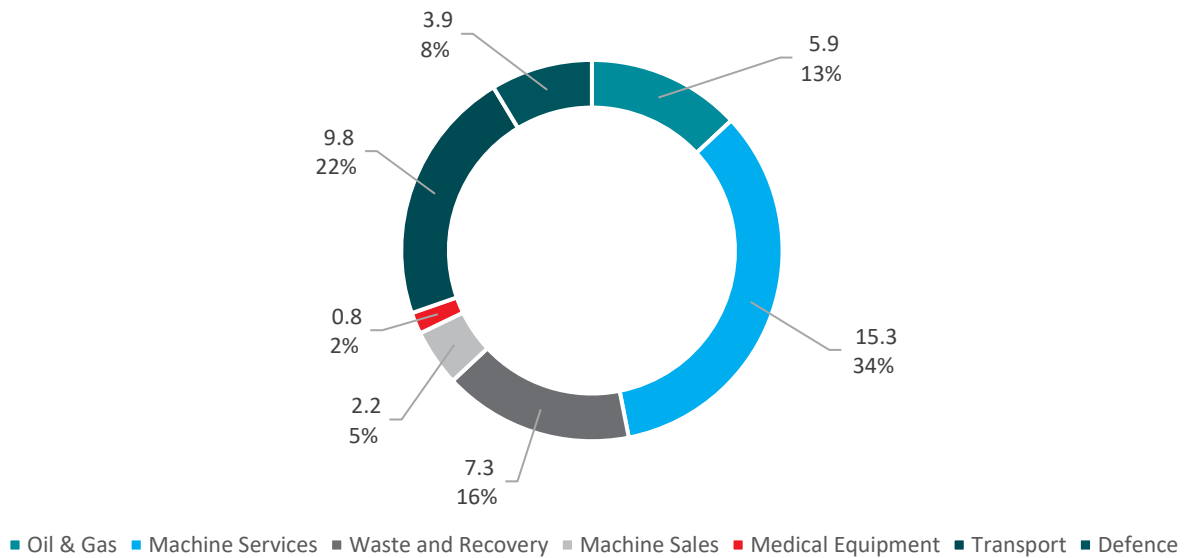
Figure 3: Turnover in the different categories of PBIs in England, % of total, £ billions, 2019



Source: ABS, Cebr analysis

Figure 4 below shows the full breakdown of the industries included within the ‘Other’ category.

Figure 4: Breakdown by turnover of industries included within ‘Other’, % of ‘Other’ total, £ billions, 2019



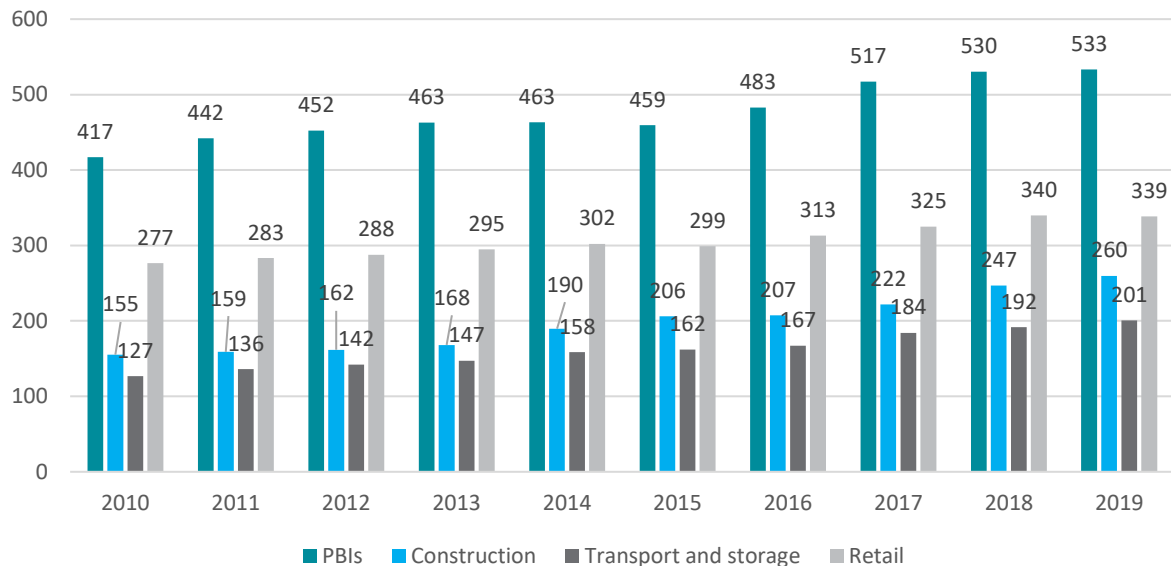
Source: ABS, Cebr analysis

Industry comparison

The turnover of the entire PBI sector is much larger than any of the other three sectors shown for comparison in

Figure 5, showing the importance of the physics sector to the UK economy.⁶ The PBI sector topped retail by almost £200 billion, and was more than double the values of the Construction and Transport & Storage sectors in 2019.

Figure 5: Turnover in selected English sectors, £ billions, 2010-19



Source: ABS, Cebr analysis

2.2 Business demography

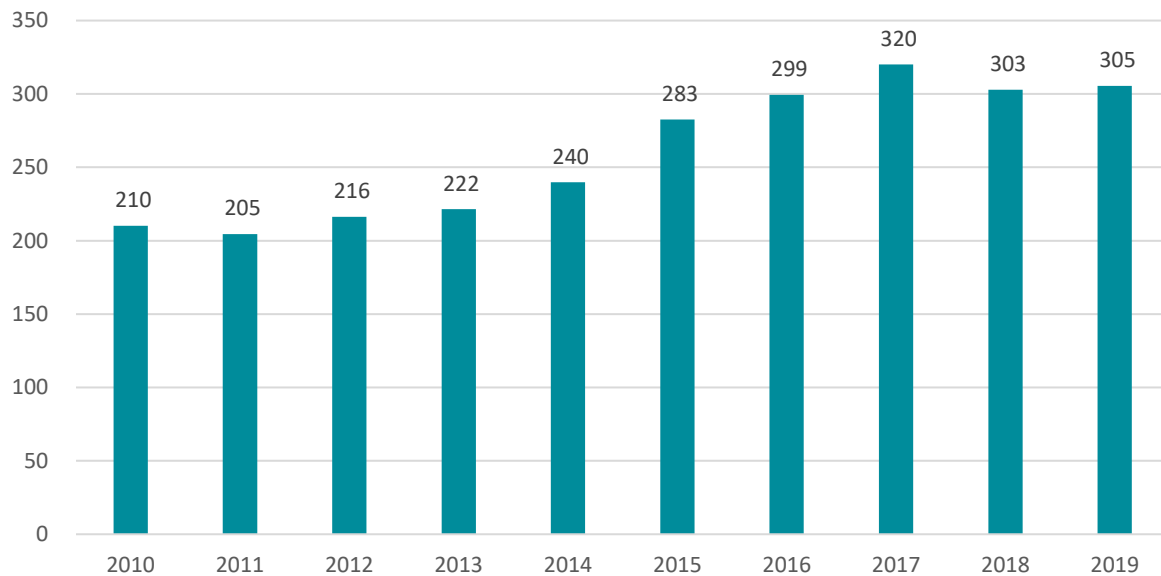
Business count⁷

By 2019, more than 305,000 enterprises were present in the PBI sector in England, resulting in a share of 12.9% of all English enterprises and 87.2% of all PBI enterprises in the UK. The PBI enterprise count rose 45.4%: well above the national average of 31.3% across all sectors. The Physics sector experienced a steady upward trend in terms of the number of PBI enterprises operating between the period 2010-2017. In 2010, there had been more than 210,000 enterprises counted, which increased to more than 320,000 by 2017. The greatest change was seen in 2015, when the number jumped from 240,000 to 283,000 (17.9% increase).

⁶ These sectors are selected for comparison, as three of the larger SIC sections, which do not already have significant overlap with the PBIs.

⁷ Due to a lack of data, we didn't include the Defence sector in the business demography analysis. SIC 84.22 is dominated by very few large companies, therefore omitting it doesn't alter the data on a significant level.

Figure 6: Number of physics-based enterprises in England, thousands, 2010-2019



Source: Nomis, Cebr analysis

After this steady growth, however, the sum of enterprises dropped to 303,000 in 2018 and only increased marginally in 2019, as shown in Figure 6. Nonetheless, the overall result of the decade can still be considered as positive; England's PBIs enjoyed extremely strong levels of enterprise registrations in the middle of the decade. Physics industries accounted for almost 17 in every 100 additional enterprises added to the economy between 2010 and 2019.

It is further notable that the trends for enterprise numbers in the physics sector broadly mirror those seen for turnover, with moderate growth in the first half of the decade but strong growth in the middle and later in the decade. However, while the number of PBI enterprises increased significantly in 2015 (nearly an 18% single year increase), turnover actually declined slightly in the same year, before increasing significantly from 2015 through 2018. This lag between enterprise growth and turnover growth is intuitive, as it takes time for businesses to establish a significant footprint.

However, this may also be a potential cause for concern moving forwards; the decline in enterprise numbers from 2017 through 2019 began being reflected by PBI turnover tapering off over the same period but have not yet been reflected in declining economic performance to the same extent. Further identifying the potential continuation or otherwise of this trend is likely to be challenging, given the overwhelming impact of Covid-19 which would be expected to be observed in 2020 data onwards, but it is worth being mindful of, as enterprise numbers might be useful indicator of the health and vitality of the sector post-Covid and a sign of the strength of the recovery. Significant declines in enterprise numbers over the Covid-19 period may signpost a slower post-Covid recovery.

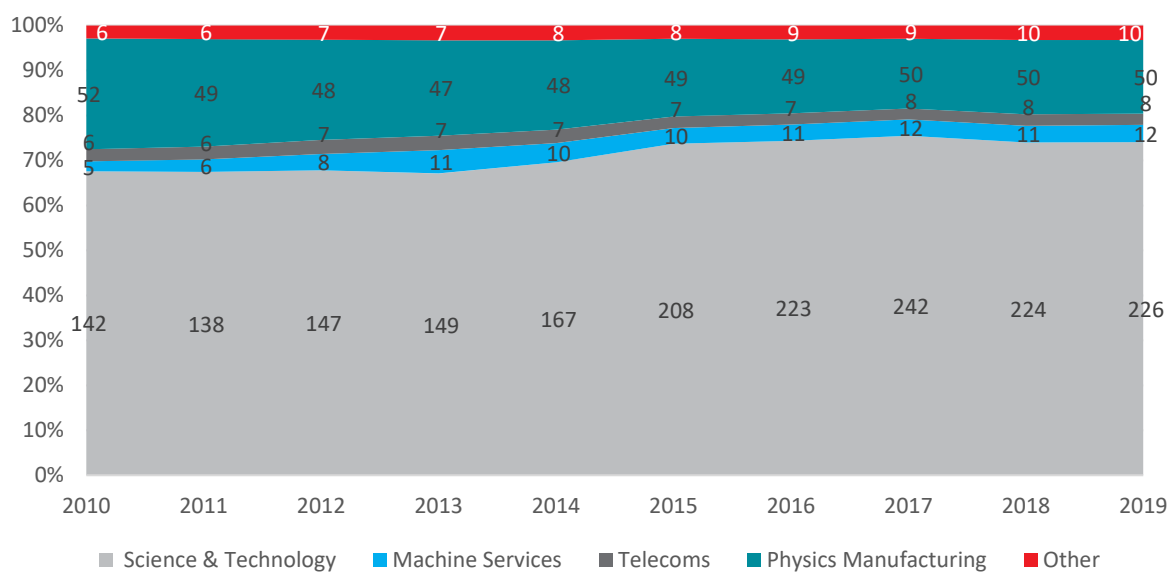
Figure 7⁸ shows the composition of the number of PBI enterprises in England by sub-sector. The Physics Science & Technology sub-sector provided the significant majority of enterprises, with this trend especially pronounced during the second half of the period. This is due to this sub-sector having a higher share of microbusinesses, which have a smaller average economic

⁸ Here we included the Energy sector to the 'Other' category, as it had few enterprises present.

footprint. On average, this sub-sector contributed 71.7% of all physics-related enterprises, and this ratio peaked in 2017 with 75.5%. In fact, 88.4% of the growth in the number of enterprises over the decade is attributable to the Physics Science & Technology sub-sector. In addition, this sub-sector is responsible for the slight decline of PBI enterprise numbers in 2018, when after a large increase in 2017 it dropped back to its 2016 level.

The Physics Manufacturing sub-sector, the largest sub-sector in terms of turnover and GVA, had a share of 18.9% in all PBI enterprises, reflecting that this sub-sector has a slightly larger average business size and fewer smaller enterprises (and therefore average higher turnover per business).

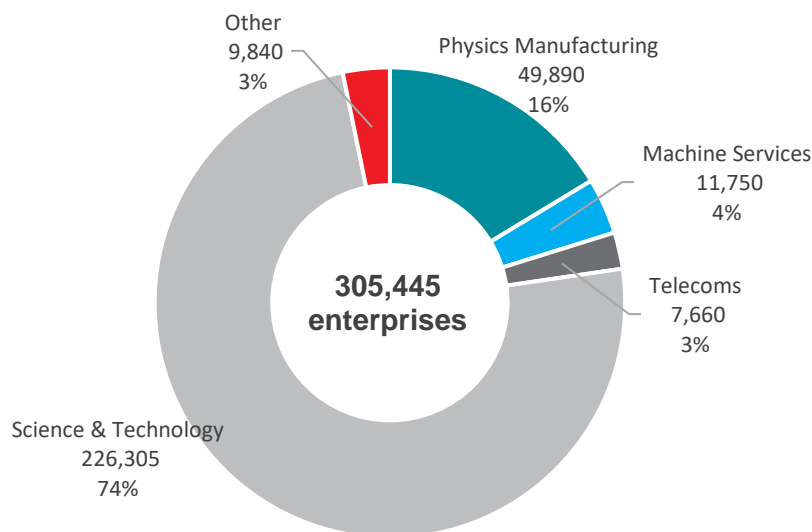
Figure 7: Number of enterprises in selected PBIs in England, % of PBI total (LHS axis) and value (thousands), 2010-2019



Source: Nomis, Cebr analysis

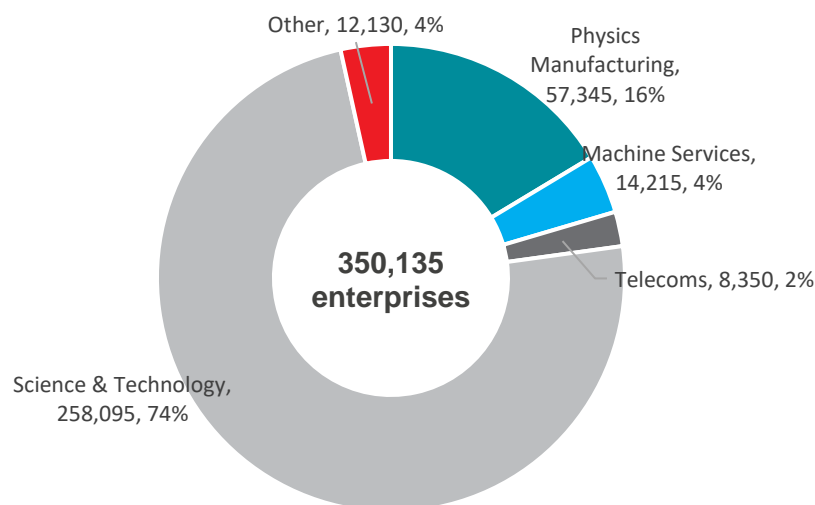
Figure 8 visualises the distribution of enterprises within the PBI by sub-sectors for 2019, while Figure 9 shows the UK breakdown as a comparison. As would be expected, the two distributions are very similar.

Figure 8. Distribution of enterprises across PBIs in England, thousands, 2019



Source: Nomis, Cebr analysis

Figure 9: Distribution of enterprises across all UK PBIs, thousands, 2019



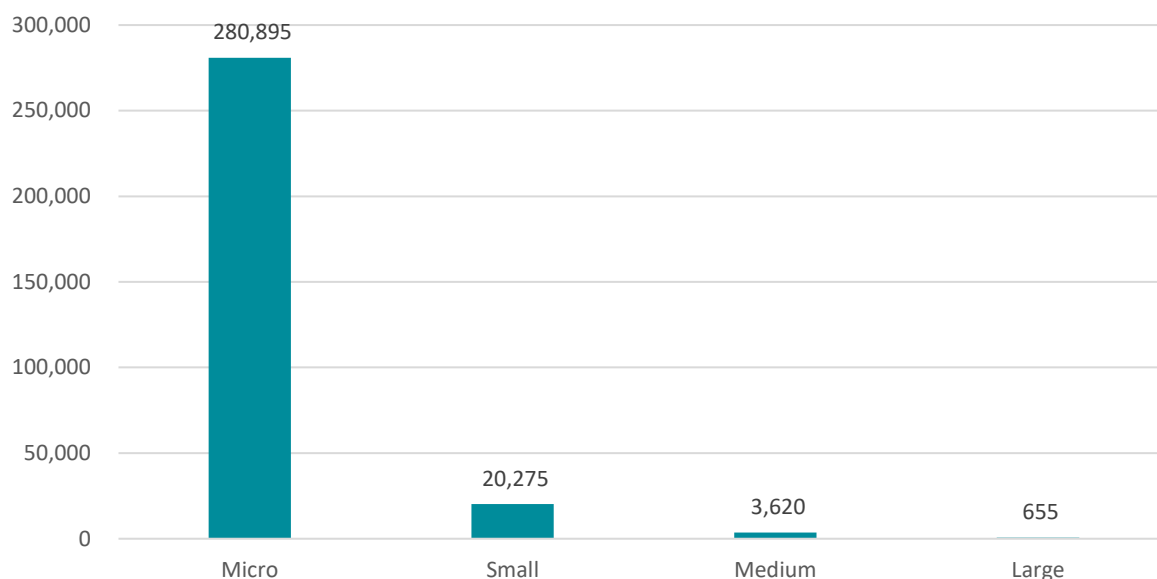
Source: Nomis, Cebr analysis

Size of enterprises

This section is focused on the size of PBI enterprises in England in 2019. Consistent with wider trends in the economy, the PBIs were dominated by enterprises which employ a maximum of nine people: 92% (280,895) of PBIs were considered micro enterprises. Of the remainder, 6.6% (20,275) were defined as small (10-49 employees), with the remaining 1.4% (4,275) medium (50-249 employees) or large (250+). This aligns with the UK shares of PBI enterprise sizes, as 92.0% were micro, 6.6% were small, and 1.4% were medium or large. By comparison, in the same year in the wider English economy, 89.5% of enterprises were micro enterprises, 8.6% were small, and the remaining 2.0% were medium or large. Physics sector

enterprises on average are therefore slightly smaller than those across the English economy, although this trend does not significantly differ from the average.

Figure 10: Number of enterprises in PBIs in England, distinguished by size, 2019



Source: Nomis, Cebr analysis

In 2019, the Physics Science & Technology sub-sector had the most small and micro sized enterprises relatively, as 95% (215,065) of all related enterprises were accounted as micro. As discussed, this relatively small average business size is a key driver for the share of total enterprises being higher than the wider economic contribution of this sub-sector. The Physics Waste & Recovery sub-sector had the fewest micro-sized enterprises proportionally (79%), while Oil & Gas Extraction had the most 'large' enterprises (10%). For the 20,275 'small' PBI enterprises in England for 2019, Physics Science & Technology accounted for 9,685 of them (48%). In 2019, there were 3,620 'medium' sized enterprises in English PBIs, of which the Physics Manufacturing sub-sector accounted for the greatest share (1,930, 53%). Physics Manufacturing and Physics Science & Technology combined shared 545 out of the 655 'large' PBI enterprises in England for 2019 (83%).

Table 1: Division of enterprises in PBIs in England, distinguished by size, 2019

Sub-sector	Micro	Small	Medium	Large
Physics Manufacturing	39,760	7,935	1,930	265
Physics Machine Services	10,670	920	135	25
Telecoms	6,835	630	150	45
Physics Science & Technology	215,065	9,685	1,275	280
Other	8,565	1,105	130	40
Total	280,895	20,275	3,620	655

Source: Nomis, Cebr analysis

3. Economic contribution of PBIs to the English economy

This section provides an assessment of the importance of PBIs to England in terms of GVA, employment and COE over the period 2010-2019.

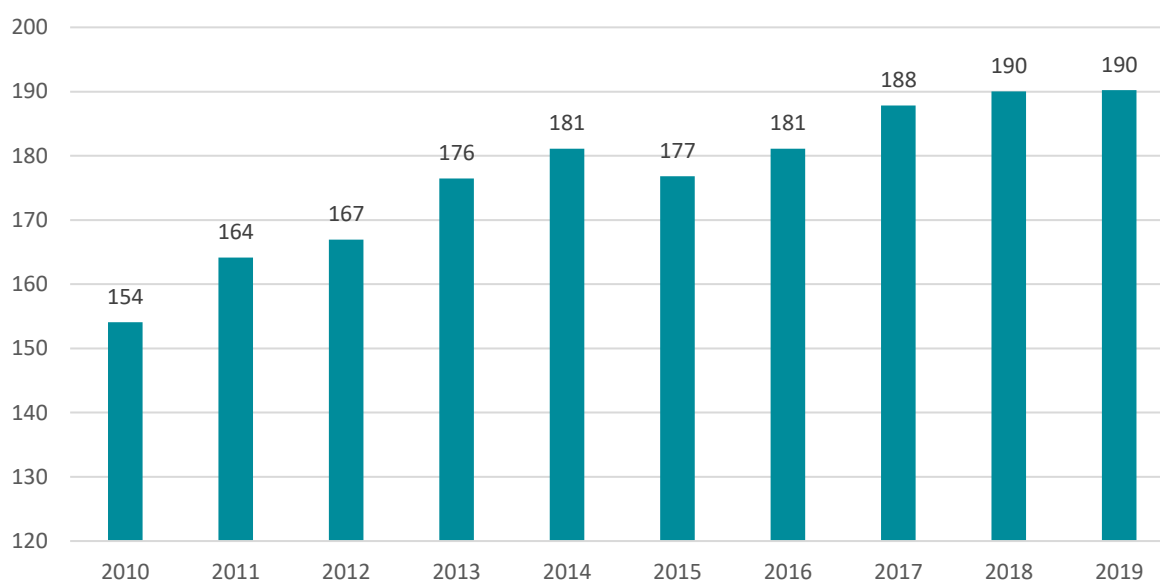
3.1 Gross value added (GVA)

We now focus on the economic contribution of the PBIs to the English economy in terms of their GVA contributions to GDP. GVA is a measure of the economic output of a sector, industry or economy; that is, the value of what they produce or provide after subtracting the inputs of goods and services required to do so.

England was also the biggest contributor to UK GVA by PBIs in 2019, with 82.9% (Scotland was at 12.4%, compared to 3.2% and 1.5% for Wales and Northern Ireland, respectively). England's share was relatively constant during the period.

We present our estimates of the English PBIs' GVA contributions to GDP in Figure 11. The latest data suggests a £190 billion GVA contribution in 2019 – 82.9% of the contributions from the physics sector across all the UK nations to the UK-wide economy, and 10% of the total English economy. Annual nominal growth averaged 2.4% between 2010 and 2019 but was strongest in 2011 at 6.5%.

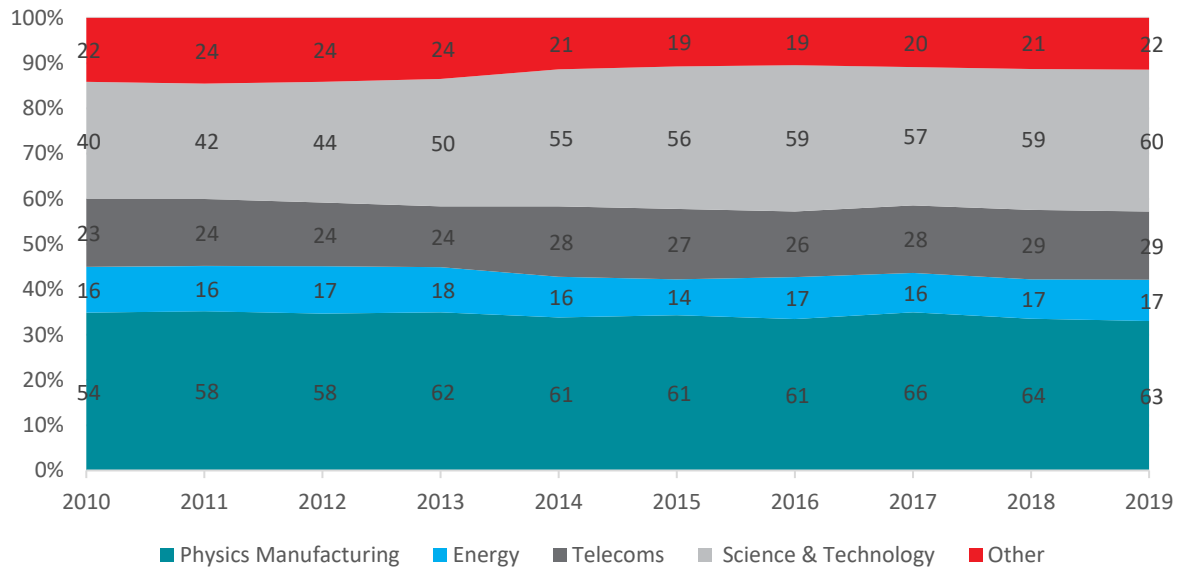
Figure 11: GVA in PBIs, £ billions, 2010-2019



Source: ABS, Cebr analysis

Physics Manufacturing was the sub-sector with the largest contribution to PBI GVA, as illustrated in Figure 12, contributing on average 34.2% over the period 2010-2019. The next largest contributor was the Physics Science & Technology sub-sector, which accounted for around 29.5%. However, the difference between the two largest sub-sectors has been narrowing: while GVA in Physics Manufacturing increased by 17% from £54 billion to £63 billion, Physics Science & Technology rose by 50%, from £40 billion to £60 billion. The same three sub-sectors experienced a decline in their GVA as seen in the turnover section: Defence (22.3%), Physics Machine Sales (46.1%), and Oil & Gas Extraction (50%).

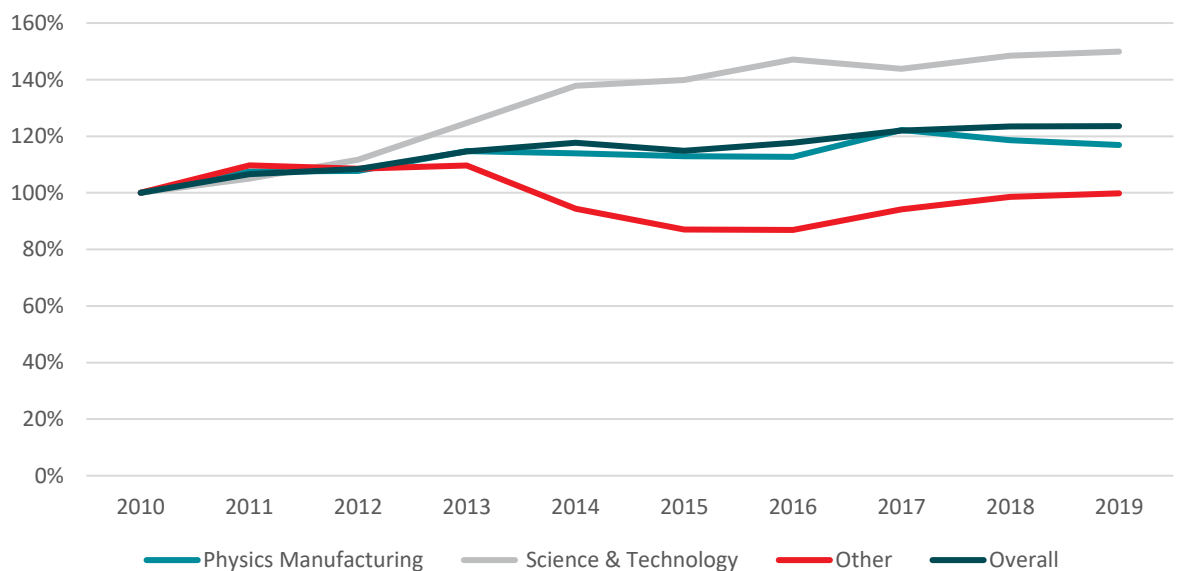
Figure 12: GVA in selected PBIs in England, % of PBI total (LHS axis) and monetary value (£ billions), 2010-2019



Source: ABS, Cebr analysis

Figure 13 shows the annual GVA growth of the two biggest and the ‘Other’ sub-sectors, and the overall PBI sector growth, with 2010 being 100%. Full results by sub-sector can be seen in Appendix II: [Supplementary figures and tables](#). Figure 13 further demonstrates the trend observed above; the growth rate in the Physics Science & Technology sector significantly exceeds that of the overall PBI average and has been a key driver in PBI GVA growth over the last decade in England.

Figure 13: GVA in selected PBIs in England, % of 2010 value, 2010-2019



Source: ABS, Cebr analysis

We note the significantly smaller range in the GVA contributions of these categories of PBIs than was observed for turnover. Using figures taken for 2019, this is driven by a relatively low rate of GVA generated per pound of turnover in the large Physics Manufacturing sub-sector

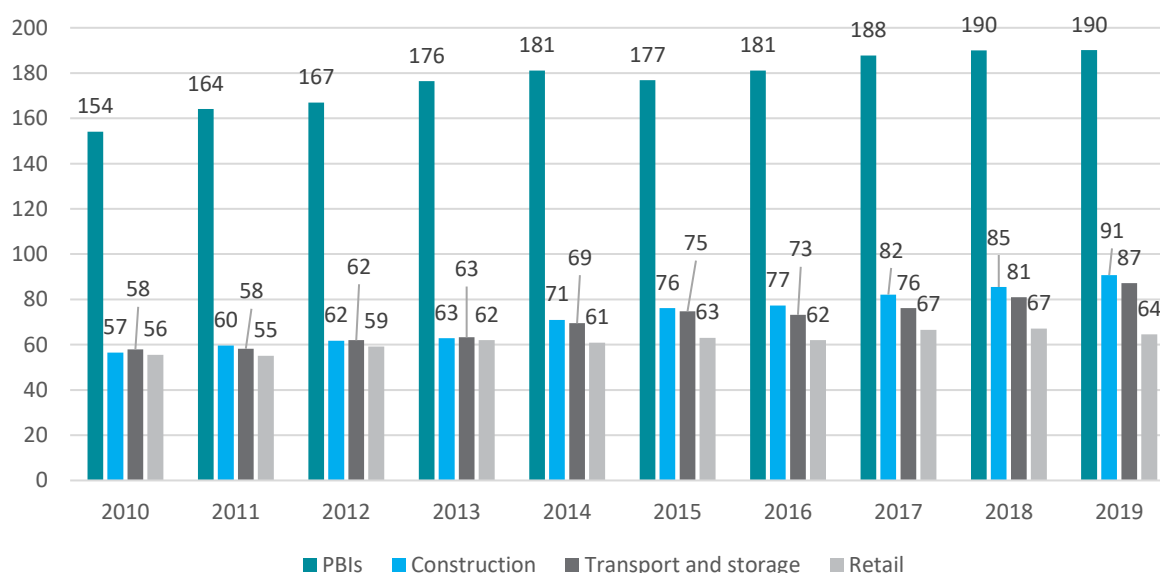
(£0.30) compared to the overall average of £0.43 of GVA generated per pound of turnover. The industry with the highest GVA contribution per pound of turnover was Telecoms at £0.48.

Industry comparison

The GVA contributions of the entire PBI sector is compared with the same three other sectors in Figure 14 below. On this measure, the gap is even wider between the PBI sector and the other sectors: the PBIs directly generated more than twice the GVA of all three sectors across the entire period.

However, in terms of the rate of GVA contributed per pound of turnover, PBIs did not perform as well as some of the other comparators. The average rate of GVA contributed per pound of turnover was £0.37 over 2010-2019 for PBIs. This was higher than in Retail (£0.20), but the Construction sector matched this value and the Transport & Storage sector displayed higher rates of GVA per pound of turnover than PBIs, averaging £0.43 across the period.

Figure 14: GVA comparison for selected sectors of the English economy, £ billions, 2010-2019



Source: ABS, Cebr analysis

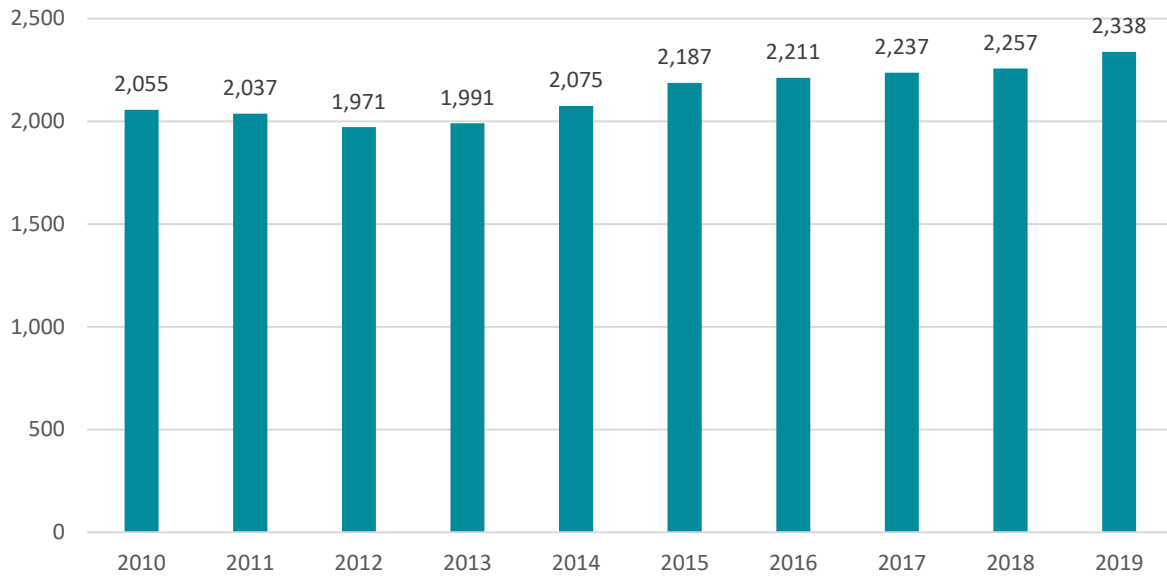
3.2 Employment

Cebr's estimates suggest that FTE employment in the PBIs was more than 2.33 million in 2019, which contributed almost 86% of the total UK physics sector, and 10.1% of English employment as a whole (per Annual Population Survey data). Employment growth averaged 1.4% annually between 2010 and 2019 but was strongest in 2015 at 5.4%.

Compared to the other three home nations, the PBIs in England played a strong role in supporting employment (10.1% of all English employment). They accounted for a similar share of national FTE employment than in Scotland (9.8%), Wales (9.8%) and the UK total (10.0%), but higher than in Northern Ireland (6.8%).

The increase of FTE employment in the PBIs across the UK was 13.2%; slightly lower than England's 13.8%. However, the nation's share of UK PBI employment remained similar; 86.0% in 2019 and 85.5% in 2010.

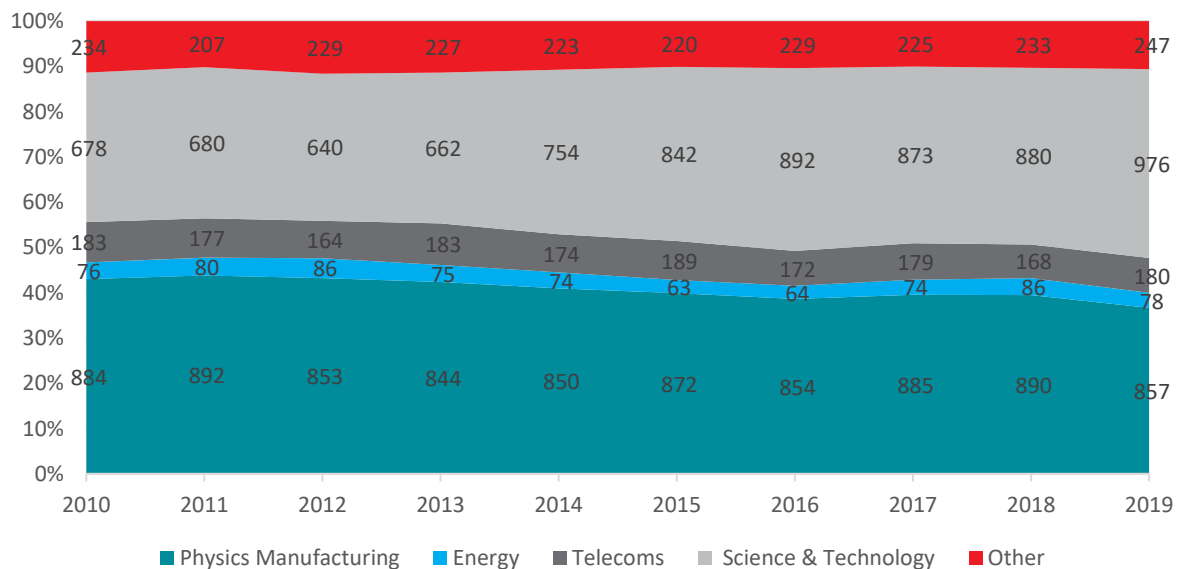
Figure 15: Physics-based employment in England, FTEs, thousands, 2010-19



Source: BRES, Cebr analysis

Large shares of employment in the PBIs are accounted for by the Physics Manufacturing and Physics Science & Technology sub-sectors (36.7% and 41.7% recorded in 2019, respectively). However, while the employment of the Physics Manufacturing sub-sector has been relatively steady (around 850,000 – 890,000 FTEs over the whole period), the Physics Science & Technology sub-sector grew significantly, from 678,000 to 976,000 (44%). In fact, this sub-sector grew more than the PBIs overall (298,000 compared to 283,000), making it a key contributor to total PBI sector employment growth. Over the decade, PBI employment growth in England was almost entirely driven by the Physics Science & Technology sub-sector.

Figure 16: FTE employment in selected PBIs in England, % of PBI total (LHS axis) and value (thousands), 2010-2019



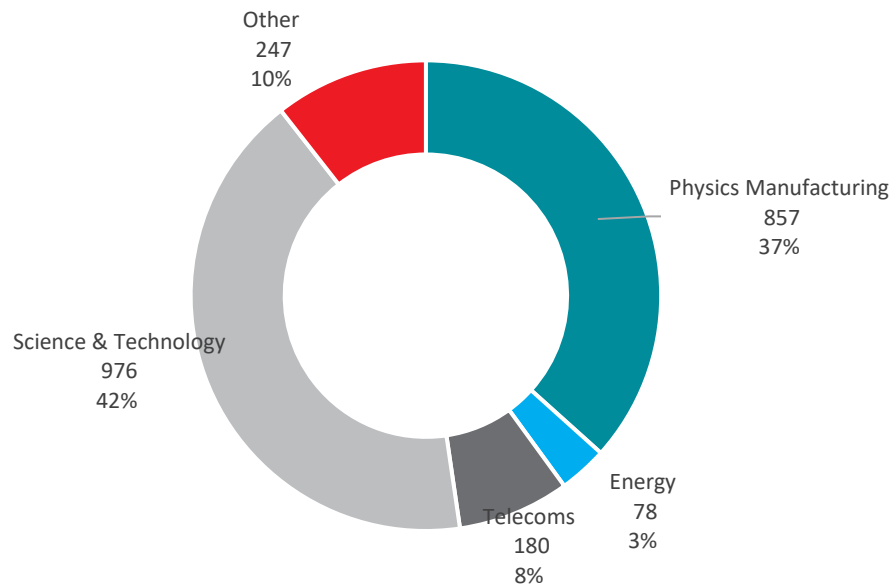
Source: BRES, Cebr analysis

Energy Production, Transmission & Distribution Production (at 3.3%) and Telecommunication (at 7.7%) are the other sub-sectors of note contributing significant shares of employment within the PBIs. As Figure 16 above demonstrates, however, despite low shares of employment,

these sub-sectors collectively contributed a more significant share of the PBIs' GVA contributions, with Energy Production, Transmission & Distribution accounting for 9.1% and Telecoms accounting for 15% in 2019.

Figure 17 shows the number and share of FTE employment across the most prominent sub-sectors for English PBIs in 2019. See Table 18 in [Appendix II: Supplementary figures and tables](#) for a full breakdown of FTE employment estimates for all industries.

Figure 17: FTE employment across PBIs in England, thousands FTE jobs and %, 2019

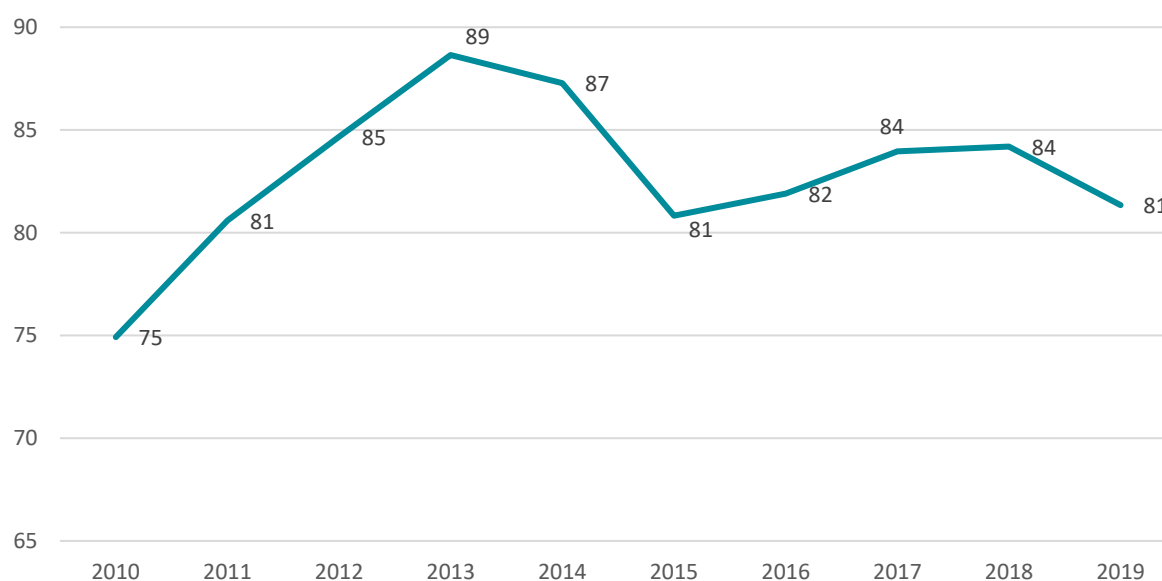


Source: BRES, Cebr analysis

Labour productivity

Labour productivity is defined as annual GVA over the number of FTE workers in the same year, or output per worker per year. For English PBIs, Figure 18 shows the evolution of this metric over the period. It is a fluctuating trend but between 2010 and 2019, labour productivity increased by 8.6% from £75,000 to £81,300. There was a local peak in 2013 at £88,600 of output per worker.

Figure 18: Overall labour productivity for PBIs in England, £ thousands, 2010-2019



Source: ABS, BRES, Cebr analysis

Table 2 presents a comparison between the share of total FTE employment in English PBIs for each PBI and the share of the total GVA that is contributed by that respective sub-sector. In 2019, we find that these shares were broadly proportional, with the exception of four industries: Oil & Gas Extraction, Energy Production, Transmission & Distribution, Telecoms, and Physics Science & Technology. The Physics Science & Technology sub-sector's employment share was more pronounced than its GVA contribution, while in the Oil & Gas Extraction, Energy Production, Transmission & Distribution and Telecoms sub-sectors, contributions to the total GVA generated by English PBIs was greater than their respective shares of FTE employment. This suggests that labour productivity – defined as GVA per FTE employee – is higher in these three sub-sectors than in the Physics Science & Technology sub-sector.

Table 2: Comparison between the shares of GVA and FTE employment by English PBIs, 2019

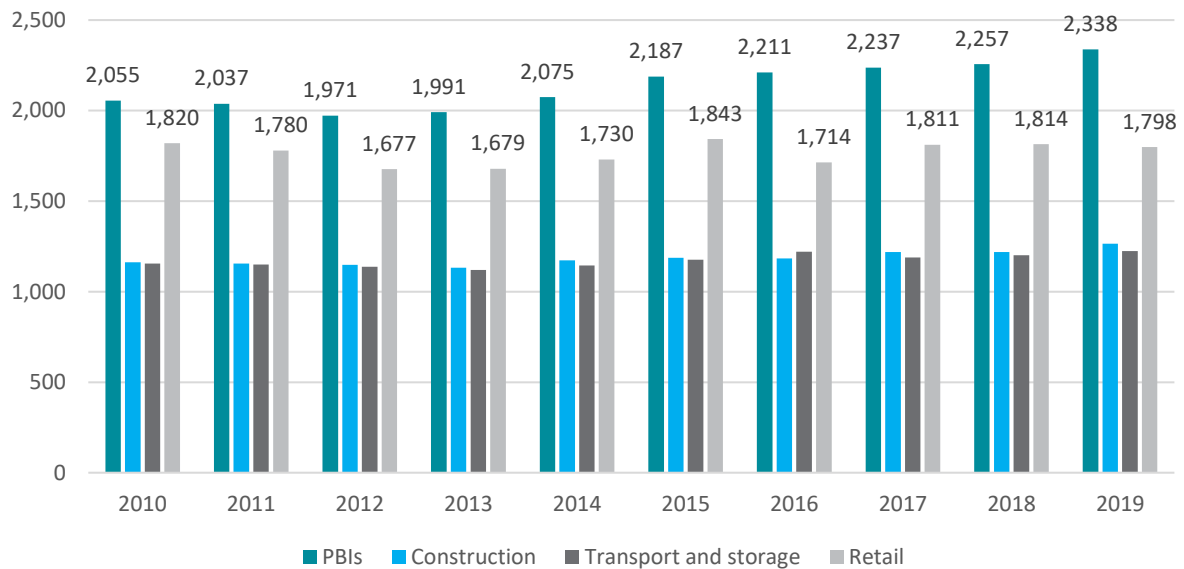
Sub-sector	Share of 2019 GVA	Share of 2019 employment
Oil & Gas Extraction	2.1%	0.1%
Physics Manufacturing	33.0%	36.7%
Physics Machine Services	3.3%	4.8%
Energy Production, Transmission & Distribution	9.1%	3.3%
Physics Waste & Recovery	1.1%	1.2%
Physics Machine Sales	0.3%	0.3%
Medical Equipment Sales	0.2%	0.3%
Space Transport & Air Transport Services	3.2%	2.0%
Telecoms	15.0%	7.7%
Physics Science & Technology	31.4%	41.7%
Defence	1.2%	1.9%

Source: ABS, BRES, Cebr analysis

Industry comparison

Compared to the same three external sectors, the PBI sector contributed the greatest share of employment, as seen in Figure 19. However, this trend is not as pronounced as when considering turnover and GVA (see industry comparisons in Sections 2.1 and 3.1), suggesting a labour productivity advantage of the PBIs over the other sectors. For a similar share of English employment, the PBIs generated a greater GVA contribution than the retail sector, construction, and transport and storage sectors.

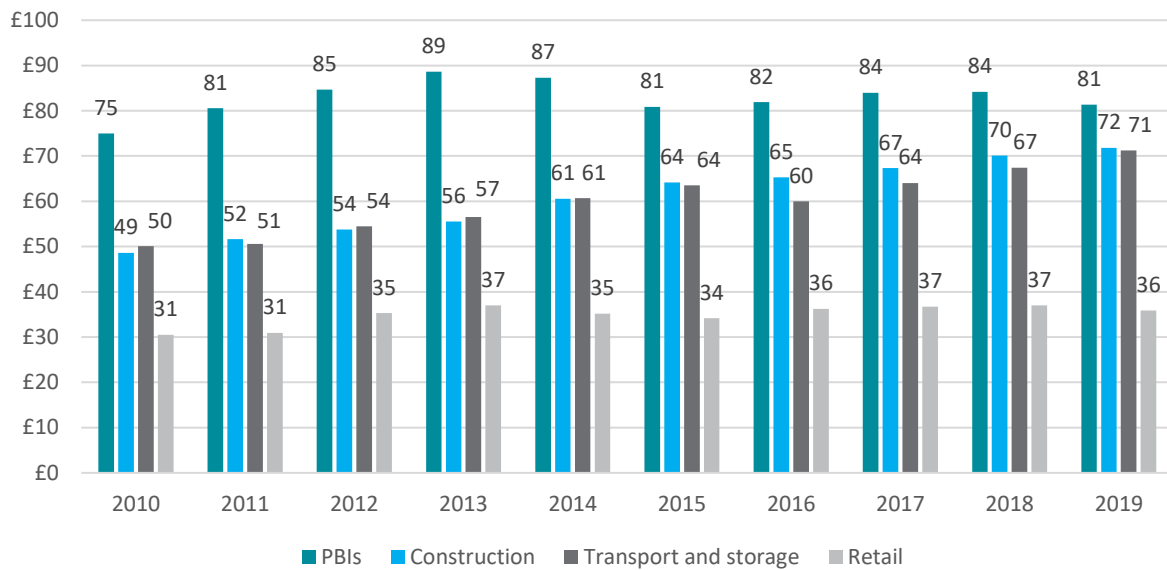
Figure 19: Employment in selected English sectors, thousands, 2010-2019



Source: BRES, Cebr analysis

Figure 20 compares labour productivity in the selected English comparison sectors. The PBIs have the greatest productivity, and it increased by 8.6% from almost £75,000 to more than £81,000 over the period. However, the PBIs had the smallest relative growth compared to Construction's 47.7%, Transport's 42.2% and Retail's 17.5%. This is due to the decreasing productivity trends in the Physics Manufacturing and the Physics Science & Technology sub-sectors from 2014 onwards, especially in 2016, where the former dropped by 3.5%, and the latter by 9.2%.

Figure 20: Labour productivity in selected English sectors, thousands, 2010-2019

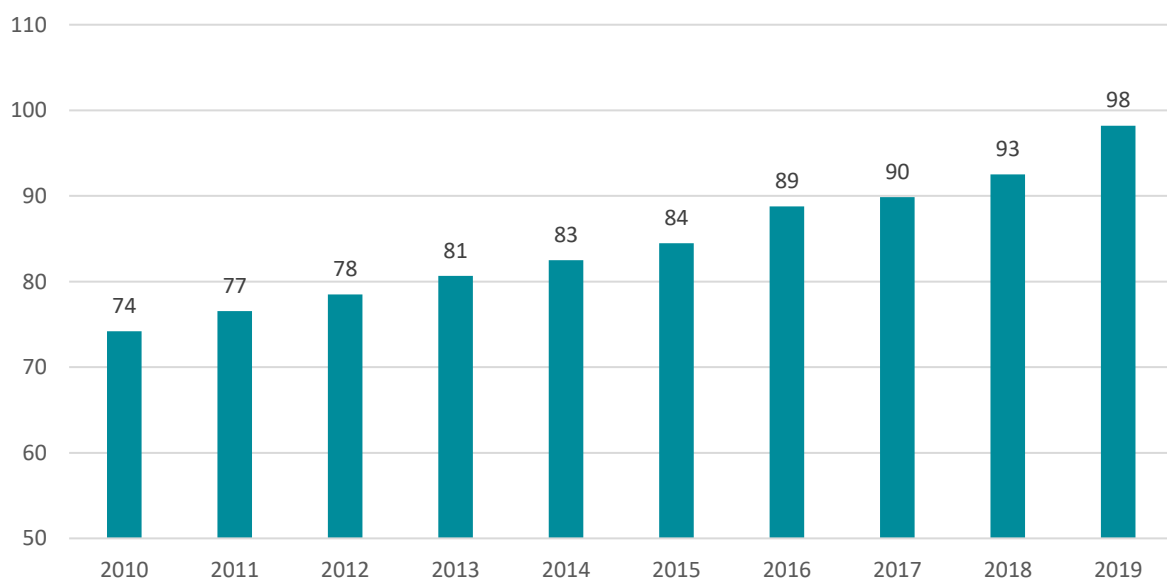


Source: ABS, BRES, Cebr analysis

3.3 Compensation of employees (COE)

When it comes to compensation of employees (COE), PBIs experienced a steady growth of 32.3% across the decade, or 3.2% on a yearly average, from £74 billion to £98 billion over the period. This was a much higher growth rate relative to employment, meaning that the average compensation per FTE worker increased throughout the period. Specifically, average COE/FTE increased from £36,103 to £41,990 (16.3%) in the PBIs. However, this growth was broadly consistent with wider wage growth of 15.9% over the same period for full-time workers in England, per data from the Annual Survey of Hours and Earnings. This COE value meant an 85.9% share of the total UK COE for PBIs, which is 0.6 percentage points higher than in 2010.

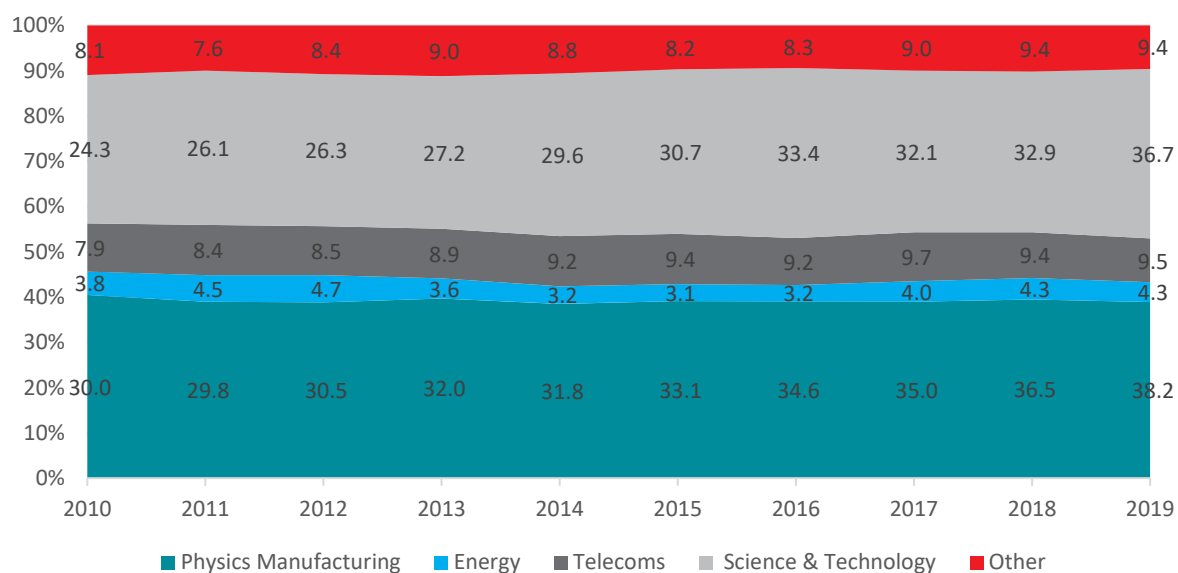
Figure 21: Physics-based COE in England, £ billions, 2010-19



Source: ABS, Cebr analysis

The Physics Manufacturing sub-sector provided 39.2% of all PBI COE on average. The Physics Science & Technology sub-sector had the second largest share, with 35.4%. The third largest was Telecoms, with a 10.7% share of the total employment costs. Unsurprisingly, these largely mirror the distribution of employment (seen below in Table 3).

Figure 22: COE in selected PBIs in England, % of PBI total (LHS axis) and monetary value (£ billions), 2010-19



Source: ABS, Cebr analysis

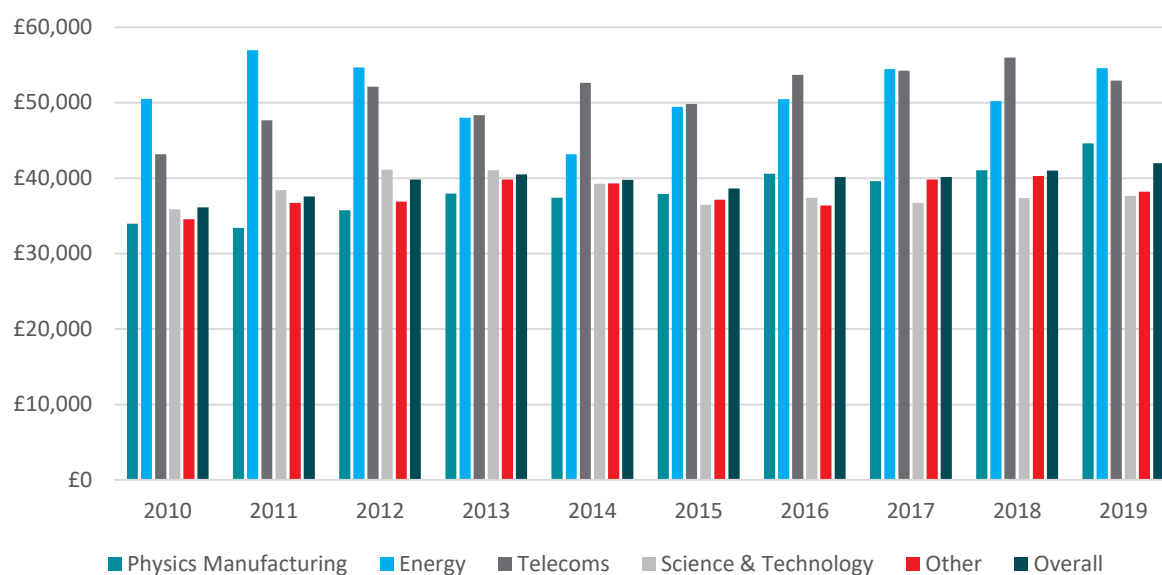
Table 3: Comparison between the shares of COE and FTE employment by English PBIs, 2019

Sub-sector	Share of 2019 COE	Share of 2019 employment
Oil & Gas Extraction	0.5%	0.1%
Physics Manufacturing	38.9%	36.7%
Physics Machine Services	3.5%	4.8%
Energy Production, Transmission & Distribution	4.3%	3.3%
Physics Waste & Recovery	1.1%	1.2%
Physics Machine Sales	0.2%	0.3%
Medical Equipment Sales	0.2%	0.3%
Space Transport & Air Transport Services	2.4%	2.0%
Telecoms	9.7%	7.7%
Physics Science & Technology	37.4%	41.7%
Defence	1.6%	1.9%

Source: ABS, BRES, Cebr analysis

The average compensation per FTE worker increased overall across the PBIs. The Physics Manufacturing sub-sector particularly saw significant growth, 31.3% overall, or 3.1% on average. Out of the highlighted sub-sectors, Energy Production, Transmission & Distribution and Telecoms had the largest average COE: more than £53,000 in 2019 for both. Aggregated, the PBIs experienced 16.3% growth in terms of the ratio.

Figure 23. COE per FTE in selected English PBI sub-sectors, 2010-2019



Source: ABS, BRES, Cebr analysis

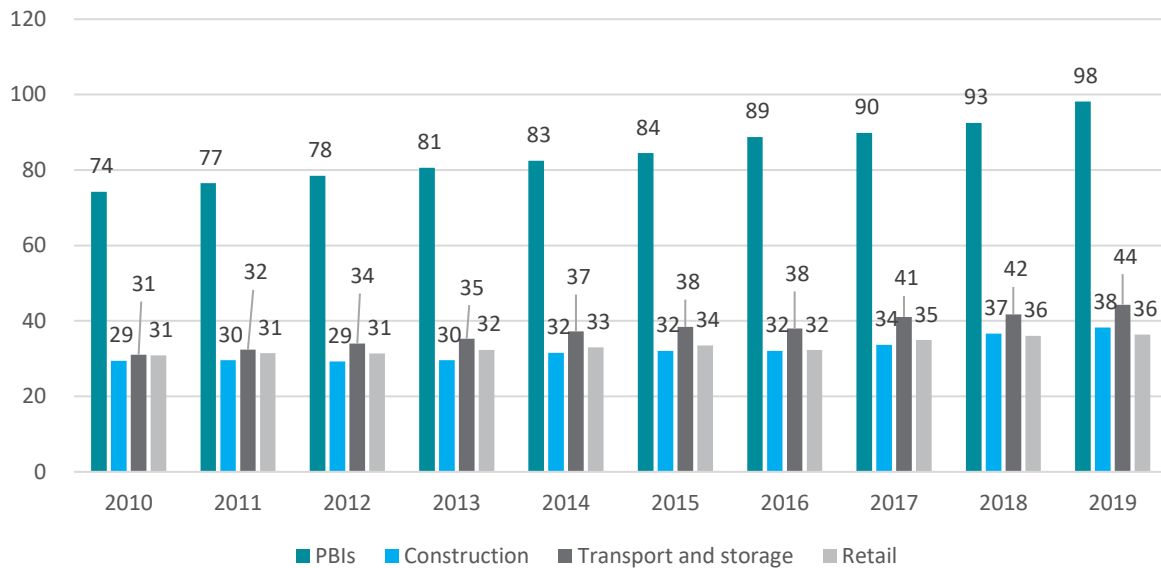
It is notable that while employment growth as a whole in England's physics sector over the period was predominantly driven by the Physics Science & Technology sub-sector (total employment growth over the period of 298,000 FTEs, compared to just 283,000 for the aggregated PBIs), this increased demand for employees in the sub-sector did not result in a significant increase in average COE. Average COE/FTE in the Physics Science & Technology sub-sector grew by just 4.9% (£1,755) over the period, well below the average COE/FTE growth in the wider PBIs of 16.3%.

Perhaps explaining this, labour productivity in the sub-sector only increased by 4.2% (£2,466) over the decade. This could be a function of the growth in the sector in absolute terms being supported by an increased labour supply rather than an increase in capital investment (an expanded capital base per worker typically increases labour productivity), but further research would be required to identify this with confidence.

Industry comparison

Figure 24 shows the COE of the PBIs and the comparator sectors. Unsurprisingly, the trend is very similar to that seen for GVA. While the number of employees was also greater in the PBI sector, the difference was not as big. This suggests that the average COE/employment ratio is much higher compared to the other three sectors. Furthermore, both Construction and Retail had a smaller yearly average growth than PBIs: 2.9% and 1.9%, respectively. Only the Transport & Storage sector growth exceeded the PBIs, with 4% average growth, meaning the gap between the two got smaller.

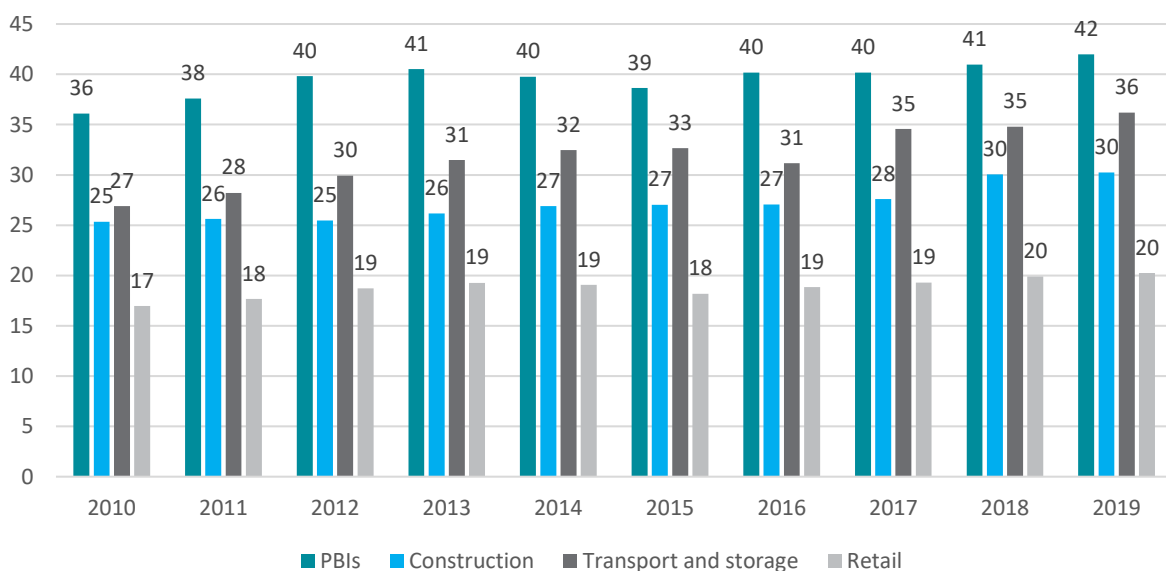
Figure 24: COE in selected English sectors, £ billions, 2010-19



Source: ABS, Cebr analysis

As with productivity, the PBI sector had a higher average COE per FTE worker than the comparator sectors, with slightly more than £42,000 in 2019. Interestingly, while the Construction and Transport sectors had a very similar growth rate and values for employment (Figure 19), Figure 25 shows that while their initial rate was almost the same, by 2019 the latter outran the former, and was close to the PBI's average COE. The Retail sector is again the last on the list out of these four.

Figure 25: Compensation per FTE in selected English sectors, thousands, 2010-2019



Source: ABS, BRES, Cebr analysis

4. Contribution to the national and regional economies

This section provides an assessment of the importance of PBIs to the English regions in terms of employment, turnover, GVA and business demographics over the period 2010-2019. We present results in terms of contextual comparisons between English regions, as well as national comparisons between England and the other three UK nations.

4.1 Turnover

Table 4 provides a detailed regional breakdown of the PBIs' turnover on a yearly basis. The greatest contributor up until 2018 was the South East, with 19.4% of the total turnover on average, while PBIs in London contributed around 18% of English PBI turnover. Since 2018, PBIs in London contributed slightly more turnover than those in the South East, and London is now considered the most significant English region in terms of PBI turnover.

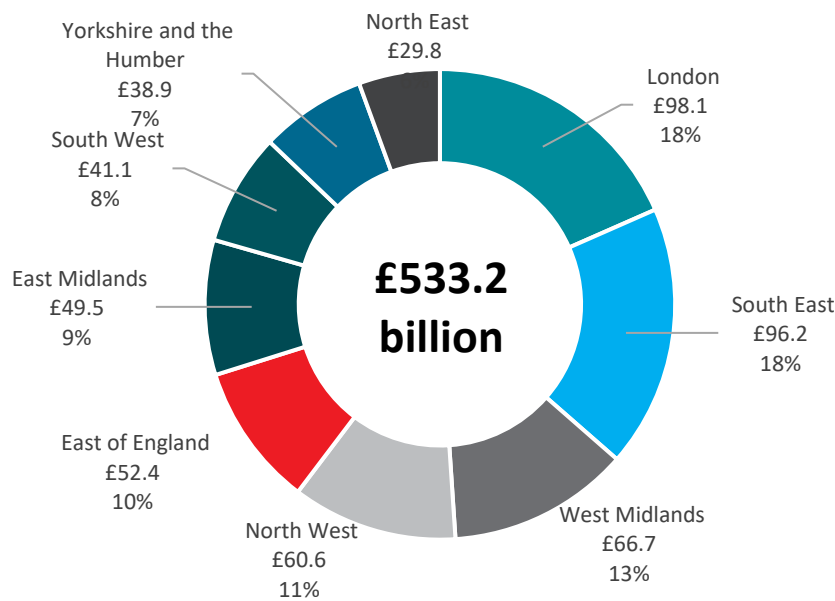
Table 4: Turnover in PBIs in England, distinguished between regions, £ billions, 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
East of England	39.7	42.6	40.7	42.4	40.9	44.4	50.9	48.8	53.5	52.4
East Midlands	30.9	33.3	36.2	36.2	38.2	40.4	37.4	46.2	46.4	49.5
London	73.8	78.3	85.5	85.8	89.4	80.5	82.9	90.9	97.6	98.1
North East	23.3	33.9	30.3	34.3	34.3	31.2	32.2	32.6	31.5	29.8
North West	47.0	52.9	49.9	52.5	52.2	53.6	57.7	65.0	65.0	60.6
South East	97.3	92.0	90.0	92.4	86.9	81.8	96.4	95.4	95.2	96.2
South West	35.2	38.6	35.9	39.0	39.0	44.4	41.1	46.3	38.9	41.1
West Midlands	39.0	40.3	47.2	47.1	46.0	48.8	52.2	57.6	63.3	66.7
Yorkshire and the Humber	30.9	30.1	35.7	33.0	35.9	34.2	32.1	34.3	38.8	38.9

Source: ABS, BRES, Cebr analysis

Figure 26 sets out the proportion of turnover generated in each region by the PBIs in 2019.

Figure 26: Turnover in the different regions of PBIs in England, £ billions, 2019



Source: ABS, BRES, Cebr analysis

Regarding the national comparisons, Table 5 provides a national breakdown of the PBIs' turnover on a yearly basis, with England highlighted. Over the period, turnover generated by English PBIs grew by 27.8%, above the UK average growth of 24.1% between 2010 and 2019. England's 2019 contribution to the total UK turnover generated in PBIs was 84.1% (£533.2 billion out of £633.7 billion). For context, in the same year, England represented 86% of PBI employment over the period (2.3 million out of 2.7 million), hence its turnover contribution is slightly less than proportional to its employment share. On top of this, in terms of the number of PBI enterprises in the UK, England accounted for a larger share still, at 87.2% in 2019 (305,445 out of 350,135).

Table 5: Turnover in UK PBIs, distinguished between nations, £ billions, 2010-2019

Nation	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
England	417.1	442.1	452.3	462.9	463.2	459.3	482.9	517.1	530.2	533.2
Scotland	65.9	70.8	58.1	64.0	62.8	59.5	60.8	58.4	60.4	63.8
Wales	19.6	23.5	23.2	25.9	25.6	30.4	26.1	30.2	26.7	26.7
Northern Ireland	8.0	8.9	9.1	9.4	11.5	11.1	9.6	9.7	9.6	10.1

Source: ABS, BRES, Cebr analysis

4.2 GVA

Table 6 below presents the regions' PBI GVA annually. The greatest contributor was London, with the South East following. Since the South East had a significantly higher turnover than the capital until 2018, we can draw the conclusion that London has a much higher GVA-turnover ratio than the South East. In fact, over the period, London had the highest ratio among the regions: 43.1% on average.

Table 6: GVA in PBIs in England, distinguished between regions, £ billions, 2010-2019

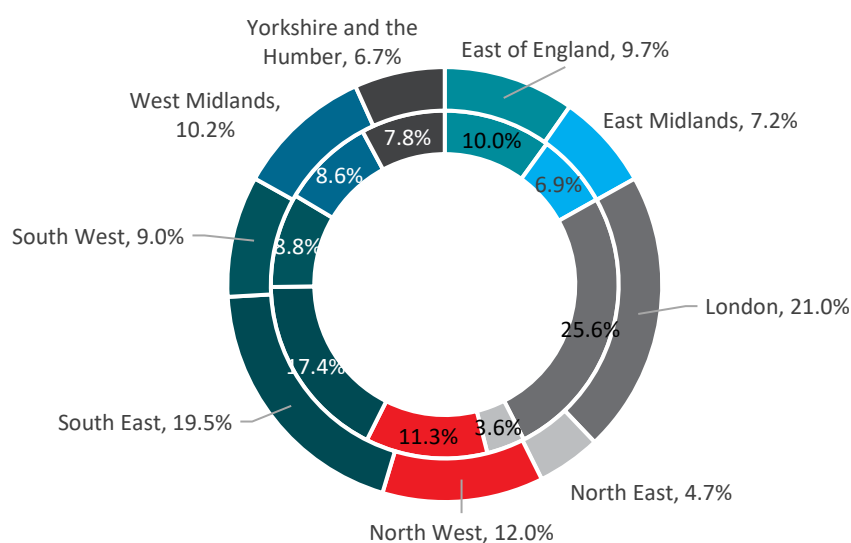
Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
East of England	14.6	15.7	16.8	17.1	17.4	16.1	18.1	18.6	19.0	19.0
East Midlands	10.8	11.6	12.1	12.5	12.9	13.2	11.9	14.8	13.6	13.2
London	30.8	34.4	34.1	37.7	38.7	37.3	38.2	38.6	41.3	40.7
North East	7.7	7.9	8.0	8.5	9.0	8.6	8.3	9.2	8.3	8.3
North West	17.9	20.2	18.9	20.5	21.5	21.6	21.8	23.3	22.9	23.7
South East	32.7	33.5	34.6	35.3	34.7	32.4	35.5	33.8	35.3	35.8
South West	14.5	15.1	14.9	15.9	15.6	16.5	16.2	17.4	16.3	16.8
West Midlands	13.9	14.9	16.2	17.6	19.5	18.9	19.4	19.8	20.2	19.9
Yorkshire and the Humber	11.1	11.0	11.4	11.5	11.8	12.0	11.8	12.4	13.2	13.0

Source: ABS, BRES, Cebr analysis

Every region saw its GVA value increase during the period. The West Midlands in particular had a very high, 42.9% rise, from £13.9 billion to almost £20 billion. The PBIs in the East of England, London, and the North West also increased by more than 30%. The lowest growth was seen in the North East's physics sector, but even there a 7.5% increase was experienced, from £7.7 billion to £8.3 billion, showing the consistent increase in value brought by the PBIs, across the English regions.

The following figure presents a comparison between the GVA contributions across regions in England for all industries, versus the GVA contribution by region for only the PBIs. **The inner ring represents all industries, while the outer ring represents PBIs only.**

Figure 27: Comparison of the regional contribution to England's GVA by all industries (inner) and by PBIs (outer), average %, 2010-2019



Source: ABS, BRES, ONS, Cebr analysis

One important takeaway from this is that the highly London-centric nature of England's (and indeed the UK's) economy is muted when evaluating only the GVA contributions by PBIs. On average, London accounted for over a quarter of England's total GVA between 2010 and 2019, while in PBIs, London's contributions were just over a fifth. This suggests that PBIs are contributing to the Government's levelling-up agenda in England.

Table 7 presents the national breakdowns for GVA contributions by PBIs in the UK between 2010 and 2019. In line with the trends observed for turnover contributions, England's representation out of the total GVA generated in UK PBIs is slightly below its share of total UK PBI employment (averaging 83.1% and 85.3%, respectively). Therefore, English PBI productivity (£82,833 GVA per FTE) is marginally below the UK PBI average (£84,975 GVA per FTE).

Table 7: GVA in UK PBIs, distinguished between nations, £ billions, 2010-2019

Nation	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
England	153.9	164.1	166.9	176.5	181.1	176.8	181.1	187.8	190.1	190.2
Scotland	27.2	27.7	24.1	24.9	25.0	22.2	21.4	25.9	26.6	28.4
Wales	6.1	6.6	6.9	7.6	8.2	8.2	7.3	8.1	8.2	7.3
Northern Ireland	2.4	2.7	2.7	3.2	3.0	3.4	3.1	2.9	3.3	3.5

Source: ABS, BRES, Cebr analysis

4.3 Employment

Table 8: Employment in UK PBIs, distinguished between nations, FTEs, thousands, 2010-2019

Nation	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
England	2,055	2,037	1,971	1,991	2,075	2,187	2,211	2,237	2,257	2,338
Scotland	203	197	193	196	217	211	207	218	220	220
Wales	104	106	105	109	123	131	118	119	125	113
Northern Ireland	40	44	41	44	43	52	44	41	48	49

Source: ABS, BRES, Cebr analysis

Table 8 presents the FTE employment levels in the PBIs for the four UK nations. In 2019, England represented 86.0% of UK PBI employment (2.3 million out of 2.7 million). This is slightly above the 84.9% of total UK FTE employment that England accounts for (23.1 million out of 27.2 million), suggesting that in 2019 PBI employees were, on average, slightly over-represented in England compared to the rest of the UK.

Regarding the English regions specifically, the South East had the highest level of PBI employment: 17.7% on average during the period (see Table 9).

Table 9: Employment in PBIs in England, distinguished between regions, thousands, 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
East of England	228	223	227	221	230	231	257	250	260	266
East Midlands	174	170	168	161	179	196	171	197	190	194
London	266	271	251	274	281	306	326	323	324	345
North East	102	107	95	95	107	123	112	124	105	108
North West	262	273	249	253	271	278	279	291	290	306
South East	378	362	357	362	370	370	398	374	396	403
South West	239	236	221	222	229	246	241	236	231	251
West Midlands	229	220	227	227	229	248	245	257	262	271
Yorkshire and the Humber	176	174	176	176	179	189	182	187	197	193

Source: ABS, BRES, Cebr analysis

London saw a 29.4% increase in terms of FTE employment, from 266,000 to 345,000. The West Midlands and the North West also grew by almost 20%, and employment growth exceeded 5% in all regions. Both the South East and London had a higher relative contribution in terms of turnover and GVA, meaning the turnover - FTE ratio and the productivity rate were very high compared to the other geographies.

In fact, PBI employees were highly productive in London (consistent with broader economic trends across other sectors); this was the most productive region, with an average of £118,000 GVA per FTE worker. Figure 28 shows the average labour productivity rate in the PBIs, in each English region.

Figure 28: Productivity rate in English regions, £ thousands, 2010-2019



Source: ABS, BRES, Cebr analysis

4.4 COE

COE was the highest in London, with 21.3% of the total value on average, while in line with the productivity results, it also had the highest COE/FTE ratio (£56,000). The region with the second-greatest employee compensation was again the South East, with 20.6%, and the second highest ratio (£43,000). The remaining regions had average COE of between £36,000-£42,000. The total COE paid to workers in the PBIs in each region can be seen in Table 10, with the average employee compensation per FTE worker below in Figure 29.

Table 10: COE in PBIs in England, distinguished between regions, £ billions, 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
East of England	7.8	7.5	8.5	8.2	8.1	8.2	9.1	9.0	9.6	10.3
East Midlands	5.4	5.4	5.4	5.8	6.2	6.3	6.3	7.0	7.1	7.1
London	14.3	15.5	14.9	16.3	16.1	16.5	17.3	17.1	17.5	19.3
North East	3.4	4.1	3.7	3.9	4.3	4.7	4.4	5.0	4.0	4.5
North West	8.6	9.8	9.3	9.1	9.9	10.7	11.7	11.8	12.1	12.1
South East	14.8	14.6	14.9	15.5	15.8	15.4	17.0	16.5	17.2	17.5
South West	7.6	7.8	7.9	7.9	8.4	8.6	8.6	8.7	9.0	9.6
West Midlands	6.9	6.6	7.7	7.8	7.7	7.8	8.5	8.6	9.5	10.7
Yorkshire and the Humber	5.4	5.4	6.2	6.0	5.9	6.3	6.0	6.1	6.6	7.0

Source: ABS, BRES, Cebr analysis

Figure 29: COE per FTE worker in English regions, thousands, 2010-2019



Source: ABS, BRES, Cebr analysis

With regards to comparisons between UK nations, England performs strongly, with total COE growing by 32.4% between 2010 and 2019, from £74.2 billion to £98.2 billion, which is slightly above the UK average of 31.4%. In terms of the share of UK PBI COE, England accounted for 85.9% in 2019 (£98.2 billion out of £114.3 billion), which was only 0.1 percentage point below England's 86.0% employment share in the same year.

Table 11: COE in UK PBIs, distinguished between nations, £ billions, 2010-2019

Nation	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
England	74.2	76.5	78.5	80.6	82.5	84.5	88.8	89.9	92.5	98.2
Scotland	8.8	8.7	8.4	9.1	10.0	9.7	9.7	10.0	10.0	10.4
Wales	2.9	3.1	3.4	3.6	3.7	4.2	4.5	4.8	4.4	4.1
Northern Ireland	1.2	1.3	1.3	1.3	1.5	1.7	1.5	1.7	1.7	1.7

Source: ABS, BRES, Cebr analysis

4.5 Business demography

In the first half of the decade, the South East had the largest number of PBI enterprises, but by 2014, strong growth in London-registered PBI enterprises saw the capital overtake the South East. However, across the period, both regions represent strong hubs for PBI enterprises. In 2019, London hosted 63,525 enterprises (20.8% of England's 305,445), and 56,690 were registered in the South East (18.6%).

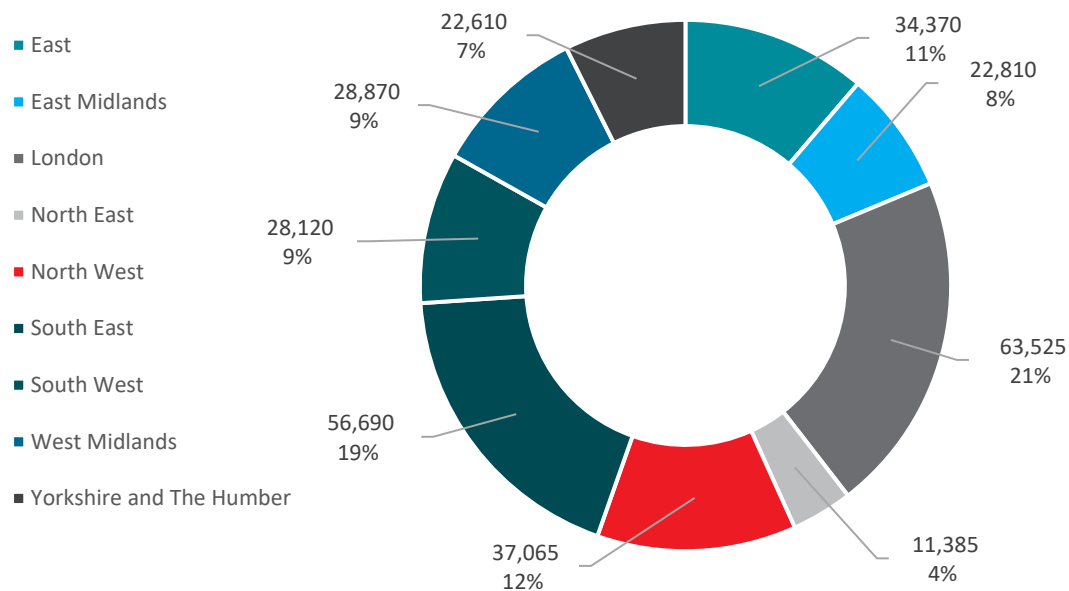
Due to the similar turnover value and number of enterprises, these two regions had a similar turnover/enterprise value (£1.8 million per enterprise in London, £1.9 million in the South East). Interestingly, the North East had the highest turnover/enterprise, with £3.3 million turnover per enterprise. Furthermore, this region saw a large increase in its number of enterprises by 55.6% from 7,315 to 11,385, which was the second highest growth rate among the regions. London increased by 82.3% from 34,840 to 63,525, which was mainly due to the Physics Science & Technology growth being based mostly there. Figure 30 shows the composition of the number of enterprises in 2019.

Table 12: Division of enterprises in PBIs in England, distinguished between regions, thousands, 2010-2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
East of England	26.0	25.0	26.1	26.4	28.2	31.8	34.0	41.2	33.7	34.4
East Midlands	16.6	16.1	16.8	17.1	18.4	21.7	24.3	23.7	23.3	22.8
London	34.8	34.2	37.8	40.9	46.3	57.4	62.1	67.1	62.4	63.5
North East	7.3	7.2	7.8	8.0	9.1	11.0	11.4	11.9	11.3	11.4
North West	25.5	24.6	25.5	26.0	28.3	33.5	35.0	37.0	37.5	37.1
South East	41.5	40.6	42.9	43.3	45.7	51.8	53.8	55.5	54.7	56.7
South West	21.0	20.6	21.6	21.8	23.3	26.7	27.6	29.7	27.9	28.1
West Midlands	21.5	20.7	21.3	21.5	22.8	26.3	28.2	30.1	29.8	28.9
Yorkshire and the Humber	15.9	15.6	16.3	16.5	17.7	22.5	23.0	23.9	22.4	22.6

Source: Nomis, Cebr analysis

Figure 30: Number of PBI enterprises in the different regions of England, 2019



Source: Nomis, Cebr analysis

Lastly, in terms of the distribution of firm sizes in PBIs between the UK nations, there is little variation. Table 13 shows the sizes of firms in national PBIs, highlighting the similarities between the nations regarding firm size in PBIs for 2019. The majority were micro

enterprises (0–9 employees) and only a fraction of a percentage were large enterprises (250+ employees).

Table 13: Division of enterprises in UK PBIs, distinguished between nation and size, %, 2019

Nation	Micro	Small	Medium	Large	Total
UK average	92.0%	6.6%	1.2%	0.2%	100%
England	92.0%	6.6%	1.2%	0.2%	100%
Scotland	93.2%	5.5%	1.0%	0.2%	100%
Wales	91.9%	6.6%	1.4%	0.1%	100%
Northern Ireland	90.5%	7.8%	1.6%	0.1%	100%

Source: Nomis, Cebr analysis

Appendix I: SIC-based definition of PBIs and sectoral alignment

Code	Description	Code	Description
Oil & Gas Extraction			
06.1	Extraction of crude petroleum	06.2	Extraction of natural gas
Physics Manufacturing			
13.95	Manufacture of non-wovens and articles made from non-wovens, except apparel	26.511	Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment
13.96	Manufacture of other technical and industrial textiles	26.512	Manufacture of electronic industrial process control equipment
13.99	Manufacture of other textiles nec ⁹	26.513	Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment
18.129	Printing (other than printing of newspapers and printing on labels and tags) nec	26.514	Manufacture of non-electronic industrial process control equipment
20.12	Manufacture of dyes and pigments	26.52	Manufacture of watches and clocks
20.13	Manufacture of other inorganic basic chemicals	26.6	Manufacture of irradiation, electromedical and electrotherapeutic equipment
20.17	Manufacture of synthetic rubber in primary forms	26.701	Manufacture of optical precision instruments
20.301	Manufacture of paints, varnishes and similar coatings, mastics and sealants	26.702	Manufacture of photographic and cinematographic equipment
20.302	Manufacture of printing ink	26.8	Manufacture of magnetic and optical media
20.51	Manufacture of explosives	27.11	Manufacture of electric motors, generators and transformers
20.59	Manufacture of other chemical products nec	27.12	Manufacture of electricity distribution and control apparatus
23.11	Manufacture of flat glass	27.2	Manufacture of batteries and accumulators
23.12	Shaping and processing of flat glass	27.31	Manufacture of fibre optic cables
23.13	Manufacture of hollow glass	27.32	Manufacture of other electronic and electric wires and cables
23.14	Manufacture of glass fibres	27.33	Manufacture of wiring devices
23.19	Manufacture and processing of other glass, including technical glassware	27.4	Manufacture of electric lighting equipment
23.2	Manufacture of refractory products	27.51	Manufacture of electric domestic appliances
23.31	Manufacture of ceramic tiles and flags	27.9	Manufacture of other electrical equipment
23.43	Manufacture of ceramic insulators and insulating fittings	28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
23.44	Manufacture of other technical ceramic products	28.21	Manufacture of ovens, furnaces and furnace burners
23.49	Manufacture of other ceramic products	28.23	Manufacture of office machinery and equipment (except computers and peripheral equipment)
24.1	Manufacture of basic iron and steel and of ferro-alloys	28.25	Manufacture of non-domestic cooling and ventilation equipment

⁹ 'Nec' means not elsewhere classified.

24.2	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	28.41	Manufacture of metal forming machinery
24.31	Cold drawing of bars	28.49	Manufacture of other machine tools
24.32	Cold rolling of narrow strip	28.91	Manufacture of machinery for metallurgy
24.33	Cold forming or folding	28.922	Manufacture of earthmoving equipment
24.34	Cold drawing of wire	28.94	Manufacture of machinery for textile, apparel and leather production
24.41	Precious metals production	28.95	Manufacture of machinery for paper and paperboard production
24.46	Processing of nuclear fuel	28.96	Manufacture of plastics and rubber machinery
25.11	Manufacture of metal structures and parts of structures	28.99	Manufacture of other special-purpose machinery nec
25.12	Manufacture of doors and windows of metal	29.1	Manufacture of motor vehicles
25.21	Manufacture of central heating radiators and boilers	29.31	Manufacture of electrical and electronic equipment for motor vehicles
25.29	Manufacture of other tanks, reservoirs and containers of metal	29.32	Manufacture of other parts and accessories for motor vehicles
25.3	Manufacture of steam generators, except central heating hot water boilers	30.11	Building of ships and floating structures
25.4	Manufacture of weapons and ammunition	30.12	Building of pleasure and sporting boats
25.5	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	30.2	Manufacture of railway locomotives and rolling stock
25.61	Treatment and coating of metals	30.3	Manufacture of air and spacecraft and related machinery
25.62	Machining	30.4	Manufacture of military fighting vehicles
26.11	Manufacture of electronic components	30.91	Manufacture of motorcycles
26.12	Manufacture of loaded electronic boards	30.92	Manufacture of bicycles and invalid carriages
26.2	Manufacture of computers and peripheral equipment	30.99	Manufacture of other transport equipment nec
26.301	Manufacture of telegraph and telephone apparatus and equipment	32.5	Manufacture of medical and dental instruments and supplies
26.309	Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	32.99	Other manufacturing nec
26.4	Manufacture of consumer electronics	33.16	Repair and maintenance of aircraft and spacecraft
Physics Machine Services			
33.11	Repair of fabricated metal products	33.17	Repair and maintenance of other transport equipment
33.12	Repair of machinery	33.19	Repair of other equipment
33.13	Repair of electronic and optical equipment	33.2	Installation of industrial machinery and equipment
33.14	Repair of electrical equipment	33.15	Repair and maintenance of ships and boats
Energy Production, Transmission & Distribution			
35.11	Production of electricity	35.13	Distribution of electricity
35.12	Transmission of electricity	35.22	Distribution of gaseous fuels through mains
Physics Waste & Recovery			
38.12	Collection of hazardous waste	38.32	Recovery of sorted materials
38.22	Treatment and disposal of hazardous waste	39	Remediation activities and other waste management services
38.31	Dismantling of wrecks		
Physics Machine Sales			
46.14	Agents involved in the sale of machinery, industrial equipment, ships and aircraft		

Medical Equipment Sales			
47.741	Retail sale of hearing aids in specialised stores	47.749	Retail sale of medical and orthopaedic goods (other than hearing aids) nec, in specialised stores
Space Transport & Air Transport Services			
51.22	Space transport	52.23	Service activities incidental to air transportation
Telecoms			
61.1	Wired telecommunications activities	61.3	Satellite telecommunications activities
61.2	Wireless telecommunications activities	61.9	Other telecommunications activities
Physics Science & Technology			
71.121	Engineering design activities for industrial process and production	72.19	Other research and experimental development on natural sciences and engineering
71.122	Engineering related scientific and technical consulting activities	74.1	Specialised design activities
71.129	Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	74.9	Other professional, scientific and technical activities nec
71.2	Technical testing and analysis	82.99	Other business support service activities nec
72.11	Research and experimental development on biotechnology		
Defence			
84.22	Defence activities		

Appendix II: Supplementary figures and tables

Table 14: Turnover in the different categories of PBIs in England, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	12	13	18	12	9	6	4	5	6	6
Physics Manufacturing	166	177	175	182	183	182	194	206	210	209
Physics Machine Services	10	9	11	13	13	12	14	15	15	15
Energy Production, Transmission & Distribution	69	76	80	77	77	73	77	81	81	82
Physics Waste & Recovery	7	8	7	7	7	6	7	9	8	7
Physics Machine Sales	3	3	3	2	2	2	2	2	2	2
Medical Equipment Sales	0	1	1	1	1	1	1	1	1	1
Space Transport & Air Transport Services	5	6	6	7	7	8	8	9	9	10
Telecoms	57	58	56	57	55	58	58	60	60	59
Physics Science & Technology	82	88	91	101	105	108	114	127	133	138
Defence	5	4	4	4	4	4	3	3	4	4
Physics Total	417	442	452	463	463	459	483	517	530	533

Source: ABS, BRES, Cebr analysis

Table 15: Number of enterprises in the different sub-sectors of PBIs in England, thousands, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Physics Manufacturing	51.8	48.9	48.3	47.0	47.6	48.7	49.2	49.6	50.0	49.9
Physics Machine Services	4.6	5.6	7.9	11.4	10.3	9.8	10.9	11.7	11.3	11.8
Energy Production, Transmission & Distribution	0.3	0.4	0.8	1.2	1.6	2.2	2.9	3.1	3.3	3.3
Physics Waste & Recovery	1.8	2.0	2.2	2.3	2.4	2.4	2.4	2.4	2.5	2.5
Physics Machine Sales	2.2	2.1	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.9
Medical Equipment Sales	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3
Space Transport & Air Transport Services	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9
Telecoms	5.7	5.9	6.7	7.1	7.1	7.3	7.4	7.7	7.7	7.7
Physics Science & Technology	142.0	138.1	146.6	148.7	166.8	208.5	222.7	241.6	224.2	226.3
Total	210.1	204.6	216.2	221.5	239.8	282.7	299.4	320.1	302.9	305.4

Source: Nomis, Cebr analysis

Table 16: Division of enterprises in PBIs in England, distinguished between size, 2019

Sub-sector	Micro	Small	Medium	Large
Oil & Gas Extraction	70	15	5	10
Physics Manufacturing	39,760	7,935	1,930	265
Physics Machine Services	10,670	920	135	25
Energy Production, Transmission & Distribution	2,945	325	10	5
Physics Waste & Recovery	1,945	455	60	5
Physics Machine Sales	1,705	140	10	-
Medical Equipment Sales	1,195	85	5	-
Space Transport & Air Transport Services	705	85	40	20
Telecoms	6,835	630	150	45
Physics Science & Technology	215,065	9,685	1,275	280
Total	280,825	20,260	3,615	645

Source: Nomis, Cebr analysis

Table 17: GVA in the different categories of PBIs in England, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	8.0	9.7	8.8	7.0	4.4	3.4	2.7	3.2	4.0	4.0
Physics Manufacturing	53.7	57.8	57.8	61.6	61.2	60.7	60.5	65.6	63.7	62.8
Physics Machine Services	4.4	4.4	5.2	6.3	5.8	5.5	5.6	5.9	6.0	6.3
Energy Production, Transmission & Distribution	15.7	16.4	17.5	17.7	16.3	14.1	16.8	16.3	16.6	17.4
Physics Waste & Recovery	1.8	1.9	1.8	1.9	2.0	1.8	2.1	2.6	2.3	2.0
Physics Machine Sales	1.1	0.9	0.9	0.9	0.7	0.5	0.7	0.6	0.7	0.6
Medical Equipment Sales	0.2	0.2	0.2	0.3	0.2	0.1	0.2	0.3	0.3	0.4
Space Transport & Air Transport Services	3.3	4.3	4.4	5.2	5.2	5.5	5.8	6.0	5.8	6.2
Telecoms	23.1	24.3	23.5	23.6	28.2	27.5	26.3	28.1	29.2	28.6
Physics Science & Technology	39.8	41.8	44.5	49.7	54.9	55.7	58.6	57.3	59.1	59.7
Defence	2.9	2.4	2.2	2.2	2.2	2.1	1.8	2.0	2.3	2.2
Physics Total	153.9	164.1	166.9	176.5	181.1	176.8	181.1	187.8	190.1	190.2

Source: ABS, BRES, Cebr analysis

Table 18: FTE in the different categories of PBIs in England, thousands, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	4	5	6	6	5	5	5	3	4	3
Physics Manufacturing	884	892	853	844	850	872	854	885	890	857
Physics Machine Services	90	71	88	90	88	88	106	95	101	112
Energy Production, Transmission & Distribution	77	80	86	75	74	63	64	74	86	78
Physics Waste & Recovery	27	28	30	30	30	32	27	34	29	28
Physics Machine Sales	7	7	7	7	8	7	6	6	5	6
Medical Equipment Sales	5	4	5	6	4	5	5	5	5	7
Space Transport & Air Transport Services	38	36	37	39	40	41	42	44	46	48
Telecoms	183	177	164	183	174	189	172	179	168	180
Physics Science & Technology	678	680	640	662	754	842	892	873	880	976
Defence	64	56	56	48	47	42	38	38	43	44
Physics Total	2,055	2,037	1,971	1,991	2,075	2,187	2,211	2,237	2,257	2,338

Source: BRES, Cebr analysis

Table 19: COE in the different categories of PBIs in England, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	0.7	0.7	1.2	1.0	0.9	0.6	0.5	0.5	0.6	0.5
Physics Manufacturing	30.0	29.8	30.5	32.0	31.8	33.1	34.6	35.0	36.5	38.2
Physics Machine Services	2.5	2.5	2.8	3.3	3.1	3.0	3.3	3.4	3.5	3.5
Energy Production, Transmission & Distribution	3.9	4.5	4.7	3.6	3.2	3.1	3.2	4.0	4.3	4.3
Physics Waste & Recovery	0.7	0.7	0.8	0.8	0.9	0.8	1.0	1.1	1.1	1.1
Physics Machine Sales	0.6	0.4	0.3	0.4	0.4	0.3	0.2	0.2	0.3	0.2
Medical Equipment Sales	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Space Transport & Air Transport Services	1.4	1.4	1.6	1.8	1.9	1.9	1.9	2.1	2.2	2.4
Telecoms	7.9	8.4	8.5	8.9	9.2	9.4	9.2	9.7	9.4	9.5
Physics Science & Technology	24.3	26.1	26.3	27.2	29.6	30.7	33.4	32.1	32.9	36.7
Defence	2.1	1.8	1.6	1.6	1.6	1.4	1.2	1.4	1.6	1.6
Physics Total	74.2	76.5	78.5	80.6	82.5	84.5	88.8	89.8	92.5	98.2

Source: ABS, BRES, Cebr analysis

Appendix III: Methodology

The following section lays out our methodology, broken down by our approach to the overall impacts and the national impacts. In order to estimate the impact of the PBIs in England and its regions, we first needed to estimate the impact of the sector across the UK as a whole. The methodology for both stages can be found in this section.

Economic impact of the PBIs in the UK as a whole

In order to provide a well-rounded summary of the PBIs in the UK (including a disaggregation across the four nations that make up Great Britain and Northern Ireland), we worked with the turnover, GVA, total full-time employees and COE, as well as with the number of enterprises. For these, we used the Annual Business Survey (ABS) from the Office of National Statistics (ONS), the Business Register and Employment Survey from Nomis (which also comes from ONS) and the UK enterprise counts from Nomis.

ABS provides a very detailed database on a UK level, but there have been cases when some of the values were missing. When this occurs, we estimated the data we needed in order to provide a more exact summary and not omit anything. If an employment data was missing, we used the average of the employment in the industry one year earlier and one year later. In cases where the turnover, GVA or COE was not written, the turnover-FTE, the GVA-FTE or the COE-FTE ratio for the previous year where we had the full data was used. Whenever we encountered a SIC 5-digit level industry, where ABS had no data, we used the 3- or 4-digit level values and the ratio of the 5- and 3-digit level BRES FTE values in order to estimate the specific data on these:

$$5 \text{ digit } GVA_i = 3 \text{ digit } GVA_i \times \frac{5 \text{ digit } FTE_i}{3 \text{ digit } FTE_i}$$

Where again GVA_i is the gross value added in year i , and FTE_i is the number of full-time employees in year i .

Once we had all the data, we aggregated the industries into 11 sub-sectors. These are: Oil & Gas Extraction; Physics Manufacturing; Physics Machine Services; Energy Production, Transmission & Distribution; Physics Waste & Recovery; Physics Machine Sales; Medical Equipment Sales; Space Transport & Air Transport Services; Telecoms; Physics Science & Technology; and lastly, Defence. Appendix I shows which industries belong to which sub-sector.

Economic impact of the PBIs in England

After finishing the gathering and modelling of data of the UK impacts, we were able to estimate the International Territorial Levels Level 1 (ITL1) regional values. Aggregating the nine English regions gives the combined national footprint.

First, we used BRES again to estimate the share of FTEs in each of the nine English ITL1 regions in a given industry, thus getting the implied number of FTE employees. We modelled the GVA by using the UK industrial GVA/FTE ratio, multiplying it by the regional productivity differential (from ONS) and the implied number of employees in the region. In order to estimate the COE and the turnover, we used the ABS 2-digit SIC code level regional data to find the COE-GVA and the GVA-turnover ratio in a given year. After that, we were able to estimate both from the GVA and the relevant ratio. Since we already had the overall direct impacts, we scaled back to that in order to avoid any differences between that and the regional values.

In some cases, ABS was missing one of the regional values we needed to calculate the ratios. If there were only one or two years of data missing, we averaged the earlier and later years to estimate the value of the missing year. If the lack of data was more frequent, we used the UK-level ratios to estimate the regional values. In a few cases we had the ABS values, but they provided a great volatility in the COE-GVA ratios, for example, going from 15% in a region to 80%, or even higher. In order to control for this, we have adjusted the methodology in such cases and used the COE/GVA ratio across the UK to estimate the regional COE. For most industries, using the bespoke regional ratio is more accurate, as it adjusts for regional differences in industry/firm structure, but sometimes the regional volatility is so significant that it is no longer worth the trade-off.

